Sant Gadge Baba Amravati University, Amravati

THREE /FOUR YEAR DEGREE OF BACHELOR OF SCIENCE

Bachelor of Science

SUBJECT: CHEMISTRY

FACULTY: SCIENCE AND TECHNOLOGY

(Courses effective from Academic Year 2026-2027)
Under Uniform NEP 2020

SYLLABUS

Semester I and II
Semester III and IV
Semester V and VI

Contents

Preamble:

The syllabus of Chemistry for the First year has been redesigned as per National Education Policy 2020 under Choice based Credit System (CBCS) to be implemented from 2024-2025. In CBCS pattern semester system has been adopted for FY, SY, and TY which includes Discipline Specific Core Course (DSC) at F. Y. level, Ability Enhancement Compulsory Course (AEC), Discipline Specific Elective Course (DSE), and Open Elective Course (OE), Skill Enhancement Course (SEC), Indian Knowledge Science (IKS), Vocational Skill course (VSC), etc.

It imbibes the guidelines verbalized by the UGC, UGC LOCF, NEP-2020, and the Government of Maharashtra for all its Undergraduate programmes. The Board of Study in Chemistry of the SGB Amravati University prepared the syllabus for the first year of the undergraduate programme in Chemistry. The new curriculum of B. Sc. (Chemistry) and B. Sc. (Honors with Research) Chemistry offers courses in the areas of Physical Chemistry, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry, Polymer Chemistry, Industrial Chemistry, Green Chemistry, Nanoscience and Nanotechnology etc. All the courses have defined objectives and learning outcomes, which will help prospective students choose the elective courses to broaden their skills in chemistry and interdisciplinary areas. The courses will train students with sound theoretical and experimental knowledge that suits the need of academia and industry. The courses also offer ample skills to pursue research as career in the field of chemistry and allied areas.

Programme Attributes of a Chemistry Graduate

Attributes of chemistry graduates under the outcome-based teaching-learning framework may encompass the following:

- **Core competency:** The chemistry graduates are expected to know the fundamental concepts of chemistry and applied chemistry. These fundamental concepts would reflect the latest understanding of the field, and therefore, are dynamic in nature and require frequent, regular, and time-bound revisions.
- **Communication skills:** Chemistry graduates are expected to possess minimum standards of communication skills expected of a science graduate in the country. They are expected to read and understand documents with in-depth analyses and logical arguments. Graduates are expected to be well-versed in speaking and communicating their ideas/findings/concepts to a wider audience.
- **Critical thinking:** Chemistry graduates are expected to know the basics of cognitive biases, mental models, logical fallacies, scientific methodology, and constructing cogent scientific arguments.
- **Psychological skills:** Graduates are expected to possess basic psychological skills required to face the world at large, as well as the skills to deal with individuals and students of various sociocultural, economic and educational levels. Psychological skills may include feedback loops, self-compassion, self-reflection, goal-setting, interpersonal relationships, and emotional management.
- **Problem-solving:** Graduates are expected to be equipped with problem-solving philosophical approaches that are pertinent across the disciplines.
- **Analytical reasoning:** Graduates are expected to acquire formulate cogent arguments and spot logical flaws, inconsistencies, circular reasoning etc.
- **Research skills:** They are expected to be keenly observant about what is going on in the natural surroundings to awaken their curiosity. Graduates are expected to design a scientific experiment through statistical hypothesis testing and other *a priori* reasoning including logical deduction.
- **Teamwork:** Graduates are expected to be team players, with productive cooperations involving members from diverse socio-cultural backgrounds.

- **Digital Literacy:** Graduates are expected to be digitally literate for them to enroll and increase their core competency via e-learning resources such as MOOC and other digital tools for lifelong learning. Graduates should be able to spot data fabrication and fake news by applying rational skepticism and analytical reasoning.
- **Moral and ethical awareness:** Graduates are expected to be responsible citizen of India and be aware of moral and ethical baseline of the country and the world. They are expected to define their core ethical virtues good enough to distinguish what construes as illegal and crime in Indian constitution. Emphasis be given on academic and research ethics, including fair Benefit Sharing, Plagiarism, Scientific Misconduct and so on.
- **Leadership readiness:** Graduates are expected to be familiar with decision making process and basic managerial skills to become a better leader. Skills may include defining objective vision and mission, how to become charismatic inspiring leader and so on.

Qualification Descriptors

The qualification descriptors for a Bachelor's degree in Chemistry may include following:

i. Systematic and fundamental understanding of chemistry as a discipline.
ii. Skill and related developments for acquiring specialization in the subject.
iii. Identifying chemistry related problems, analysis and application of data using appropriate methodologies.
iv. Applying subject knowledge and skill to solve complex problems with defined solutions.
v. Finding opportunity to apply subject-related skill for acquiring jobs and self-employment.
vi. Understanding new frontiers of knowledge in chemistry for professional development.
vii. Applying subject knowledge for solving societal problems related to application of chemistry in day-to-day life.
viii. Applying subject knowledge for sustainable environment friendly green initiatives.
ix. Applying subject knowledge for new research and technology.

(Source: Learning Outcomes based Curriculum Framework (LOCF) for (B.Sc. with Chemistry) Undergraduate Programme 2020 https://www.ugc.gov.in/pdfnews/0614691_LOCF-chemistry.pdf)

Program Outcomes for BSc

POs:

At the time of graduation, Students would be able to

PO1.Critical Thinking: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.

PO2.Effective Communication: Speak, read, write, and listen clearly in person and through electronic media in English and in one Indian language, and make meaning of the world by connecting people, ideas, books, media, and technology.

PO3. Social Interaction: Elicit views of others, mediate disagreements, and help reach conclusions in group settings.

PO4. Effective Citizenship: Demonstrate empathetic social concern and equity centred national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering.

PO5. Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.

PO6. Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.

PO7. Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological change.

Program Specific Outcomes for BSc (Chemistry)

PSOs:

Upon completion of the programme successfully, the learners would be able to-

1. Understand the scope, methodology and application of modem chemistry.
2. Apply theoretical and practical concepts of instruments that are commonly used-in thr most of the chemistry field.
3. Plan and conduct scientific experiments and record the results of such experiments.
4. Get acquainted with the safety of chemicals, transfer, and measurements of chemicals, preparation of solutions, and using physical properties to identify compounds and chemical reactions.
5. Describe how chemistry is useful to solve the social, economic, and environmental problems and issues facing our society in energy, medicine, and health

Employability Potential of the Programme:

A degree in Chemistry is an intelligent choice for future employability and earning potential for learners. Degree program with Chemistry offers the necessary knowledge, develop skills and nurture creativity to achieve success in virtually any field that's even distantly related in some way to chemistry. A degree in chemistry is recognized as a symbol of quality and commitment by employers both inside and outside the chemical industries. Chemistry provides jobs in cutting-edge technologies within science and research as well as in many fields of distant relations. Chemistry graduates apply their skills within the areas of environmental sciences, medical fields, scientific equipment sales, science communication, teaching or academic research, a few to mention. Thus, a degree in chemistry widens numerous prospects and opportunities for a wide variety of careers in many different fields like science, research, business and health care, etc. Chemistry inculcates excellent analytical and mathematical skills, which lead to enhanced problem-solving abilities and critical thinking. This improves the likelihoods to secure job in other fields too. Some important skills and abilities honed by chemistry learners include:

- Cutting-edge scientific and numerical skills
- Curiosity to understand and solve
- Attention to collect and analyse details
- Patience and determination
- Research and development skills
- Analytical skills
- Use of ICT enabled techniques
- Written and oral communications skills

The thriving and widely recognized branches of chemistry like Organic, Inorganic, Physical, Analytical, etc. not only expand critical thinking and the ability to understand other scientific and engineering concepts more easily, but also open new horizons to pursue career in different fields. Organic chemistry offers research and development of organic materials, modify and study carbon-based materials to develop a product having a specific purpose for wider use. They also accomplish various scientific studies to identify or find applications for compounds for society. Many industries like pharmaceuticals, agriculture, paints, dyes, and many more prefer to employ organic chemists. Inorganic chemistry has a greater potential in the fields of metallurgy, synthesis of new materials from different elements, bioinorganic, etc. It focusses on solving the fundamental problems associated with structure of atoms, molecules and their properties. Analytical chemists find their role for toxicology examinations, quality control and assessment, analysis of pharmaceuticals, investigations for forensic analysis, development of equipment, etc. Analytical

chemists work for a particular private or government laboratory or organization, and also develop particular specialties like food technology, forensics or toxicology, to name a few. Physical chemistry enhances critical ability and inculcates problem-solving skills among the learners. All industries rely heavily on physical parameters for manufacturing and quality assurance of products. Apart from the technical and specific skills, a chemistry graduate also acquires fundamental professional skills throughout the degree program to pursue careers not directly related to the field. These skills include:

- Effective listening and communication skills
- Presentation and interaction skills
- Data collection, analysis, and reporting skills
- Modern ICT enabled skills
- Aptitude to work proficiently independently or in a team

Future scope for B.Sc. Chemistry graduates:

- Prestigious institutions like IIT, NIT, IISER, IISc, BARC, and TIFR, a few to mention, offer higher studies such as M.Sc. and Ph.D.
- Likewise, foreign Universities also accept chemistry graduates for higher studies.
- Chemistry students can become small or medium scale entrepreneurs (own industry).
- Union and State Public service commissions like UPSC, MPSC, Bank Probationary officers, other competitive examinations, etc. offer a multitude of jobs and positions like Drug Inspector, Lab chemist, forensic analyst, etc. for chemistry graduates.
- Students can take teaching jobs at Kendriya Vidyalaya, Navodaya Vidyalaya, and High Schools after completing B.Ed. or respective eligibility criteria.
- Laboratory technician in various Public Sector Units like ONGC, IOCL, NTPC, BARC, and Private sector industries.
- Students can become Content Developer for IT industries.
- Students can become Quality Control Chemists/ Food Inspector at Food Co-operation of India, Food Safety and Standards etc
- Laboratory technicians to look after sophisticated instruments like NMR, Mass Spectrometer,
- UV-Visible Spectrophotometer, Single crystal machines, XRD, SEM, AAS, TEM, etc. in research laboratory of academic institutions as well as private sector companies.
- Research Scientist/ Operations Manager/ Chemists / Quality Manager / Research Manager at various industries like Pharmaceuticals, Cement, Plastic, Drugs, Paint, Dyes, Agricultural sector, etc.
- Employee at Security Printing and Minting co-operation of India
- Employee at Office of Controller General of Patent Design and Trade work.

Credit Distribution

Three/Four-year UG Degree Programme (Level 4.5 to 5.5)

Vertical	Vertical Type	I	II		III	IV	V	VI	Total Credits	Grand Total
	(i) Three-year UG Degree Programme (Level 4.5.to 5.5)									
A	**Major**	4	4	Major	6	8	8	8	38	**48**
	DSC (60–64)			IKS	2				2	
	(Minimum 50% of Total Credits)	0	0	Elective	0	0	4	4	8	
B	**Minor (from same faculty of DSC) (18–24)**	4	4		4	4	4	4	24	**24**
C	**Generic/Open Elective (OE)** (Faculty-wise basket other than Major/Minor faculty) (10–12)	4	4		2	2	0	0	12	**12**
D(i)	**Vocational Skill Courses (VSEC)** corresponding to Major/Minor (8–10)	0	2		2	2	2	2	10	**16**
D(ii)	**Skill Enhancement Courses (SEC)**	2	2		0	0	2	0	6	
E(i)	**Ability Enhancement Courses (AEC)** (English + Modern Indian Language)	1+1	1+1		1+1	1+1	0	0	8	**14**
E(ii)	**Indian Knowledge System (IKS) 2 Generic**	2	0		0	0	0	0	2	
E(iii)	**Value Education Courses (VEC)** (Understanding India, EVS, Digital & Technological Solution) 4	2	2		0	0	0	0	4	
F(i)	**Internship / Apprenticeship** corresponding to Major 8 **(OJT)**	0	0		0	0	0	4	4	**18**
F(ii)	**Field Projects / Community Engagement & Service (CEP)** corresponding to Major 4-6	0	0		2	2	2	0	6	
F(iii)	**Co-curricular Courses (CC)** (health & wellness, yoga education, sports, fitness, cultural activities, NSS/ NCC & Fine/ Applied/ Visual/ Performing Arts **8**	2	2		2	2	0	0	8	
	Total Credits per Semester	**22**	**22**		**22**	**22**	**22**	**22**	**132**	**132**

(ii) Four-year UG Degree programme (Level 6.0) Honors Degree in Major or Minor A. Honors Degree in Major or Minor					
	Vertical Type		Semester VII	Semester VIII	
	Major (Offered at Three-year UG Programme)	**Mandatory**	**12-14(2*4+2*2 or 3*4+2)**	**12-14(2*4+2*2 or 3*4+2)**	**28**
		Elective	4	4	8
	Research Methodology (RM)		4	0	8
	On the Job Training (OJT)		0	4	4
	Total		**22**	**22**	**44**
	Cumulative		**(132+44) 176**		
(ii) Four-year UG Degree Programme (Level 6.0) B. Honors with Research Degree in Major or Minor					
	Major (Offered at Three-year UG Programme)		**Semester VII**	**Semester VIII**	
		Mandatory	8-10 (*24+2 or 24*)	8-10 (*24+2 or 24*)	20
		Elective	4	4	8
	Research Methodology (RM)		4	0	4
	Research Project (RP)		4	8	12
	Total		**22**	**22**	**44**
	Cumulative		**(132+44) 176**		

Sant Gadge Baba Amravati University, Amravati

Teaching and Learning Scheme: for the Degree of Bachelor of Science

FACULTY: SCIENCE AND TECHNOLOGY

TLE Scheme for FIRST YEAR: SEMESTER – I (Chemistry) (Level 4.5)

(As per uniform NEP Scheme)

The Vertical	Type of Course	Course Code	Course Title	Credits	Workload	Theory/Practical				Theory/Pract (Total)	
						External		Internal			
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks
Major / Minor	Theory	108200	General Chemistry-1	2	2	30	9	20	6	50	20
	Lab/Practical	108201	Chemistry Lab 1	2	4	25	10	25	10	50	20
Minor / Major	Theory	-	-	2	2	30	9	20	6	50	20
	Lab/Practical	-	-	2	4	25	10	25	10	50	20
Generic/Open Elective	Theory	108202	Chemistry in Everyday Life	2	2	30	9	20	6	50	20
	Theory	108203	Pollution & Remedies	2	2	30	9	20	6	50	20
VSC	-	-	-	-	-	-	-	50	20	50	20
SEC	Lab/Practical	108204	Chemistry Lab 2 (Calibration and Standardization Essentials)	2	4	-	-	50	20	50	20
AEC - English	Theory		Refer University basket	1	1						
AEC –MIL	Theory		Refer University basket	1	1						
IKS-Generic	Theory		Refer University basket	2	2						
VEC	Theory		Refer University basket	2	2						
CC	Outdoor		Separate SOP will be released	2	4						
TOTAL				**22**	**30**						

TLE Scheme for FIRST YEAR: SEMESTER – II (Level 4.5)

The Vertical	Type of the Course	Course Code	Course Title	Credits	Workload	Theory/Practical				Theory/Pract (Total)	
						External		Internal			
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks
Major / Minor	Theory	108205	General Chemistry-2	2	2	30	9	20	6	50	20
	Lab/Practical	108206	Chemistry Lab 3	2	4	30	9	20	6	50	20
Major / Minor	Theory		-	2	2	25	10	25	10	50	20
	Lab/Practical		-	2	4	30	9	20	6	50	20
Generic/ Open Elective	Theory	108207	Food Safety, Adulteration and Detection	2	2	25	10	25	10	50	20
	Theory	108208	Entrepreneurship in Chemistry	2	2	30	9	20	6	50	20
VSC	Lab/Practical	108209	Chemistry Lab 4 (Chemical Laboratory Practices)	2	4	-	-	50	20	50	20
SEC	Lab/Practical	108210	Chemistry Lab 5 (IT Skills for Chemists)	2	4	-	-	50	20	50	20
AEC - English			Refer University basket	1	1	-	-	50	20	50	20
AEC –MIL			Refer University basket	1	1	-	-	50	20	50	20
VEC			Refer University basket	2	2						
CC			Separate SOP will be released	2	4						
TOTAL				**22**	**32**						

*** Important:**

- VSC Should be Complementary to Major/Minor
- SEC has to be selected from the Basket Provided by University, from the same Faculty/Discipline of the Major/Minor

TLE Scheme for SECOND YEAR: SEMESTER – III (Level 5.0)

Subject	The Vertical	Course Code	Course Title	Credits	Workload	Theory/Practical				Theory/Pract (Total)	
						External		Internal			
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks
Chemistry	Major-T	108211	General Chemistry-3	2	2	30	9	20	6	50	20
Chemistry	Major-T	108212	Inorganic Chemistry-1	2	2	30	9	20	6	50	20
Chemistry	IKS-T	108213	IKS in Chemistry	2	2	30	9	20	6	50	20
Chemistry	Major-P	108214	Chemistry Lab 6	2	4	25	10	25	10	50	20
Chemistry	Minor-T	108215	Minor Chemistry-1	2	2	30	9	20	6	50	20
Chemistry	Minor-P	108216	Minor Chemistry Lab 7	2	4	25	10	25	10	50	20
Chemistry	GOEC-T	108217	Chemistry for Competitive Examinations	2	2	30	9	20	6	50	20
Chemistry	VSC-P	108218	Chemistry Lab -8 (Preparation of Commercial products)	2	4	-	-	50	20	50	20
Chemistry	FP/CES	108219	Chemistry Lab 9 (FP/ CEP in Chemistry - I)	2	4	-	-	50	20	50	20
Chemistry	CC		Separate SOP will be released	2	4	-	-	50	20	50	20

Important: * VSC Should be Complementary to Major ** SEC has to be selected from the Basket Provided by University, from the same Faculty/Discipline of the Major/Minor

TLE Scheme for SECOND YEAR: SEMESTER – IV (Level 5.0)

Subject	The Vertical	Course Code	Course Title	Credits	Workload	Theory/Practical				Theory/Pract (Total)	
						External		Internal			
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks
Chemistry	Major-T	108220	Organic Chemistry-1	2	2	30	9	20	6	50	20
Chemistry	Major-T	108221	Physical Chemistry-1	2	2	30	9	20	6	50	20
Chemistry	Major-T*	108229*	Analytical Chemistry	2	2	30	9	20	6	50	20
Chemistry	Major-P	108222	Chemistry Lab 10	2	4	25	10	25	10	50	20
Chemistry	Minor-T	108223	Minor Chemistry 2	2	2	30	9	20	6	50	20
Chemistry	Minor-P	108224	Minor Chemistry Lab 11	2	4	25	10	25	10	50	20
Chemistry	GOEC-T	108225	Chemistry for Sustainable Agriculture	2	2	30	9	20	6	50	20
Chemistry	VSC-P	108226	Chemistry Lab 12 (Synthesis and extraction of industrial products)	2	4	-	-	50	20	50	20
Chemistry	SEC-P#	108227#	**Chemistry Lab 13 (Basic Cheminformatics)** **(Discontinued from 2026-27)**	2	4	-	-	50	20	50	20
Chemistry	FP/CES	108228	**Chemistry Lab 14 (FP/ CEP in Chemistry - II)**	2	4	-	-	50	20	50	20
Chemistry	CC		Separate SOP shall be consulted from University website	2	4	-	-	50	20	50	20

* To be implemented w.e.f. academic session 2026-27 # - Only applicable up to academic session 2025-26

Important: VSC Should be Complementary to Major and SEC has to be selected from the Basket Provided by University, from the same Faculty/Discipline of the Major/Minor

TLE Scheme for THIRD YEAR: SEMESTER – V (Level 5.5)

Level	The Vertical	Course Code	Course Title	Credits	Workload	Theory/Practical Marks				Theory/Pract (Total) Marks	
						External		Internal			
						Max.	Min.	Max.	Min.	Max.	Min.
5.5	Major-T	108230	InorganicChemistry-2	2	2	30	9	20	6	50	20
5.5	Major-T	108231	Organic Chemistry-2	2	2	30	9	20	6	50	20
5.5	Major-T	108232	Physical chemistry 2	2	2	30	9	20	6	50	20
5.5	Major-P	108233	Chemistry Lab 15	2	4	25	10	25	10	50	20
5.5	Major-Elective T1	108234	Elective Chemistry-1 (Spectroscopy I)	2	2	30	9	20	6	50	20
5.5	Major-Elective P1	108235	Chemistry Lab 16 A (Elective Chemistry-1)	2	4	25	10	25	10	50	20
OR											
5.5	Major-Elective T2	108236	Elective Chemistry-2 (Spectroscopy II)	2	2	30	9	20	6	50	20
5.5	Major-Elective P2	108237	Chemistry Lab 16 B (Elective Chemistry-2)	2	4	25	10	25	10	50	20
OR											
5.5	Major-Elective T3	108238	Elective Chemistry-3 (Biomolecules)	2	2	30	9	20	6	50	20
5.5	Major-Elective P3	108239	Chemistry Lab 16 C (Elective Chemistry-3)	2	4	25	10	25	10	50	20
5.5	Minor-T	108240	Minor Chemistry-3	2	2	30	9	20	6	50	20
5.5	Minor-P	108241	Minor Chemistry Lab 17	2	4	25	10	25	10	50	20
5.5	VSC-P	108242	Chemistry Lab -18 (Oil and Milk Analysis)	2	4	-	-	50	20	50	20
5.5	SEC-P1	107243	Chemistry Lab 19 (ICT Tools in Chemistry)	2	4	-	-	50	20	50	20
5.5	FP/CEP	108244	Chemistry Lab 20 (FP/ CES in Chemistry - III)	2	4	-	-	50	20	50	20
5.5	Non Credit		Foundation of Artificial Intelligence	NC	2			30+20	9+6	50	20

Important:

- **VSC Should be Complementary to Major**
- **SEC must be selected from the Basket Provided by University, from the same Faculty/Discipline of the Major/Minor**
- As per Sant Gadge Baba Amravati University, Amravati Extra-Ordinary Notification No. No. 241/2025 Dated 24/12/2025 “Foundation of Artificial Intelligence” is the mandatory **Non Credit Course** compulsory course for all the UG students in fifth semester of all undergraduate programs of all faculties in Sant Gadge Baba Amravati University, Amravati to earn their degree
- NC is Non Credit Course
- Students must select **Any One** of the Major-Elective Courses (T1 to T3) with respective Practical Course in Semester V**.**

TLE Scheme for THIRD YEAR: SEMESTER – VI (Level 5.5)

Level	The Vertical	Course Code	Course Title	Credits	Workload	Theory/Practical Marks				Theory/Pract (Total) Marks	
						External		Internal			
						Max.	Min.	Max.	Min.	Max.	Min.
5.5	Major-T	108245	Inorganic Chemistry 3	2	2	30	9	20	6	50	20
5.5	Major-T	108246	Organic Chemistry 3	2	2	30	9	20	6	50	20
5.5	Major-T	108247	Physical Chemistry 3	2	2	30	9	20	6	50	20
5.5	Major-P	108248	Chemistry Lab 21	2	4	25	10	25	10	50	20
5.5	Major-Elective T1	108249	Elective Chemistry 4 (Organic Spectroscopy)	2	2	30	9	20	6	50	20
5.5	Major-Elective P1	108250	Chemistry Lab 22 A (Elective Chemistry 4)	2	4	25	10	25	10	50	20
OR											
5.5	Major-Elective T2	108251	Elective Chemistry 5 (Green Chemistry and Nanochemistry)	2	2	30	9	20	6	50	20
5.5	Major-Elective P2	108252	Chemistry Lab 22 B (Elective Chemistry 5)	2	4	25	10	25	10	50	20
OR											
5.5	Major-Elective T3	108253	Elective Chemistry 6 (Chemistry of Consumer and Industrial Products)	2	2	30	9	20	6	50	20
5.5	Major-Elective P3	108254	Chemistry Lab 22 C (Elective Chemistry 6)	2	4	25	10	25	10	50	20
5.5	Minor-T	108255	Minor Chemistry 4	2	2	30	9	20	6	50	20
5.5	Minor-P	108256	Minor Chemistry Lab 23	2	4	25	10	25	10	50	20
5.5	VSC-P	108257	Chemistry Lab 24 (Water and Soil Analysis)	2	4	-	-	50	20	50	20
5.5	Intern/Apprenticeship	108258	Chemistry Lab 25 (Internship / Apprenticeship)	4	8	-	-	50	20	50	20

Important:

- VSC Should be Complementary to Major has to be selected from the Basket Provided by University, from the same Faculty/Discipline of the Major/Minor
- **Students** must select **Any One** of the Major-Elective Courses (T1 to T3) with respective Practical Course in Semester VI**.**

Examination and Assessment Process:

i. The basic principle of the Credit framework is that Credits are a function of the successful completion of a program of study/ vocational education/ training and assessment. No Credit can be earned by the student unless the student is assessed for the achievement of the desired competencies and outcome of a program.

ii. Exit options are provided with Certificate, Diploma and Basic Bachelor's degrees to the students at the end of the second, fourth and sixth semesters of a Four Years Multidisciplinary Degree Programme. Students will receive a Bachelor's degree with Honors/ Research on successfully completing of all eight semesters of the UG Program either at a stretch or with opted exits and re-entries.

iii. For the smooth success of four-year degree programme with multiple entry and exit systems, the examination mode should be based on the combination of innovative trends in formative (informal and formal tests administered during the learning process) and summative (evaluation of students learning at the end of an instructional unit) examination modes in line with the UGC Report on 'Evaluation Reforms in Higher Educational Institutions (2019).

Examination, Evaluation and Assessment Scheme

The total marks for each Course shall be based on Continuous Assessment and Semester End Examination. Each theory course of Major, Minor, GE/OE, AEC, IKS, VEC as mentioned in **Teaching Learning Scheme** prepared by the Board of Studies shall be evaluated as per the scheme as mentioned in the following table

Examination, Evaluation and Assessment Scheme

Vertical No.	The Vertical	Mode of Examination, Evaluation & Assessment	Theory				Theory (Total)		Practical				Practical (Total)	
			External		Internal				External		Internal			
			Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks
A	Major	External & Internal	30/60	9/18	20/40	6/12	50/100	20/40	25/50	10/20	25/50	10/20	25/50	10/20
B	Minor		30/60	9/18	20/40	6/12	50/100	20/40	25/50	10/20	25/50	10/20	25/50	10/20
C	Generic/ Open Elective	Internal			50	20	50	20	--	--	50	20	50	20
D	VSC	Internal			50	20	50	20			50	20	50	20
	SEC	Internal	--	--	50	20	50	20			50	20	50	20
e	AEC (Eng. & One MIL Composite)	Internal			50	20	50	20						
	IKS (Generic)	Internal			50	20	50	20						
	VEC	Internal			50	20	50	20						
F	Internship/ Apprenticeship	Internal	Assessment of these verticals shall be based on various activities/practices. The evaluation/assessment shall be done by appointing external examiner by principal from Industry/Organisation/Academia. The mentor faculty shall be the internal examiner. It shall be evaluated by giving maximum 50 marks per 2 Credit Course with separate activity weightages/levels. A detailed SOP for this assessment process shall be prescribed separately.											
	FP/CEP													
	CC													

Continuous Assessment Tests (CAT)

For internal assessment, the Continuous Assessment Tests (CAT) shall be conducted as under-

i. Three CAT each of 8 / 10 Marks (Theory) as applicable and 10 Marks (Practical).
   - First on completion of 25% Syllabus of the course or on completion of 25 teaching days,
   - Second on completion of 50% Syllabus of the course or on completion of 50 teaching days,
   - Third on completion of 75% Syllabus of the course or on completion of 75 teaching days.

ii. Each concurrent assessment (CAT-I, II & III) will be mapped to relevant Course Learning Outcome.
iii. Total Performance in CAT (i.e.40 %) shall be based on the **best two out of three** in CAT examinations
iv. Internal assessment (CAT) shall be carried out by the respective course teacher by choosing variety of assessment tools/methods such as class test, record book, seminar, case study, field work, mini project work, quiz or any innovative method, which may be deemed to be appropriate for assessing the relevant course outcome.

Conduction of the Examination:

As per the scheme of teaching, learning, examination and evaluation, theory/practical examinations of Semester-I, II, III, IV, V, VI, VII and VIII shall be conducted by the University (except for Internal Examinations as applicable) at the end of each semester.

The theory/practical examinations of all the Semesters shall be held as per the following Schedule

Sr.No.	Name of the Examination	End Sem Examination	Supplementary Examination*
1	Semester-I, III, V and VII	Winter	Summer
2	Semester-II, IV, VI and VIII	Summer	Winter

*****The University may evolve mechanism for conducting repeat end semester examination. Such repeat examinations shall have to be conducted within one month of the regular even semester examination and on demand examination.

1. The practical examination of all semesters shall be conducted by the University at the end of each semester. The HEI shall conduct the Practical examination of odd semesters as per the schedule announced by the University. **However, the appointment of the External and Internal Examiners shall be done by the Head or Principal of respective HEI to conduct external examination of the odd semester and the same should be communicated to the University before commencement of the practical examination.** The University shall conduct the external practical examination of all even semester by appointing external and internal examiners.
2. The examinations specified above shall be held twice in a year at such places and on such dates as may be prescribed by the University.
3. An applicant to an examination specified above, shall pursue a regular course of study in courses prescribed for the examination concerned for not less than one semester in a particular semester in a College/Institute/University department.
4. Provided that the student shall be eligible to appear for examination if -
   a. He/she complies with the provisions of the Ordinance pertaining to the Examination in general from time to time.
   b. He/she has prosecuted a regular course of study in a university department/college affiliated to the University.

c. He/she has in the opinion of the Principal shown satisfactory progress in his/her studies.

5. The provisions of Ordinance No. 6 and Ordinance No. 9 shall be *mutatis-mutandis* applicable to every collegiate/non-collegiate student.
6. The fees for each theory examination and practical examination conducted by the university shall be as prescribed by the University, from time to time

Sant Gadge Baba Amravati University, Amravati

Semester-wise Course Structure, Course Code and Credit Distribution and Syllabus for

Faculty of Science and Technology

Degree of Bachelor of Science

Chemistry

Semester I and II

FACULTY: SCIENCE AND TECHNOLOGY

(Courses effective from Academic Year 2026-27)
Under NEP 2020 (As per Uniform NEP Scheme)

Contents

Sant Gadge Baba Amravati University, Amravati

Teaching and Learning Scheme: for the Degree of Bachelor of Science

FACULTY: SCIENCE AND TECHNOLOGY

TLE Scheme for FIRST YEAR: SEMESTER – I (Chemistry) (Level 4.5)

(As per uniform NEP Scheme)

The Vertical	Type of Course	Course Code	Course Title	Credits	Workload	Theory/Practical				Theory/Pract (Total)	
						External		Internal			
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks
Major / Minor	Theory	108200	General Chemistry-1	2	2	30	9	20	6	50	20
	Lab/Practical	108201	Chemistry Lab 1	2	4	25	10	25	10	50	20
Minor / Major	Theory	-	-	2	2	30	9	20	6	50	20
	Lab/Practical	-	-	2	4	25	10	25	10	50	20
Generic/Open Elective	Theory	108202	Chemistry in Everyday Life	2	2	30	9	20	6	50	20
	Theory	108203	Pollution & Remedies	2	2	30	9	20	6	50	20
VSC	-	-	-	-	-	-	-	50	20	50	20
SEC	Lab/Practical	108204	Chemistry Lab 2 (Calibration and Standardization Essentials)	2	4	-	-	50	20	50	20
AEC - English	Theory		Refer University basket	1	1						
AEC –MIL	Theory		Refer University basket	1	1						
IKS-Generic	Theory		Refer University basket	2	2						
VEC	Theory		Refer University basket	2	2						
CC	Outdoor		Separate SOP will be released	2	4						
TOTAL				**22**	**30**						

TLE Scheme for FIRST YEAR: SEMESTER – II (Level 4.5)

The Vertical	Type of the Course	Course Code	Course Title	Credits	Workload	Theory/Practical				Theory/Pract (Total)	
						External		Internal			
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks
Major / Minor	Theory	108205	General Chemistry-2	2	2	30	9	20	6	50	20
	Lab/Practical	108206	Chemistry Lab 3	2	4	30	9	20	6	50	20
Major / Minor	Theory		-	2	2	25	10	25	10	50	20
	Lab/Practical		-	2	4	30	9	20	6	50	20
Generic/ Open Elective	Theory	108207	Food Safety, Adulteration and Detection	2	2	25	10	25	10	50	20
	Theory	108208	Entrepreneurship in Chemistry	2	2	30	9	20	6	50	20
VSC	Lab/Practical	108209	Chemistry Lab 4 (Chemical Laboratory Practices)	2	4	-	-	50	20	50	20
SEC	Lab/Practical	108210	Chemistry Lab 5 (IT Skills for Chemists)	2	4	-	-	50	20	50	20
AEC - English			Refer University basket	1	1	-	-	50	20	50	20
AEC –MIL			Refer University basket	1	1	-	-	50	20	50	20
VEC			Refer University basket	2	2						
CC			Separate SOP will be released	2	4						
TOTAL				**22**	**32**						

*** Important:**

- VSC Should be Complementary to Major/Minor
- SEC has to be selected from the Basket Provided by University, from the same Faculty/Discipline of the Major/Minor

Examination and Assessment Process:

i. The basic principle of the Credit framework is that Credits are a function of the successful completion of a program of study/ vocational education/ training and assessment. No Credit can be earned by the student unless the student is assessed for the achievement of the desired competencies and outcome of a program.

ii. Exit options are provided with Certificate, Diploma and Basic Bachelor's degrees to the students at the end of the second, fourth and sixth semesters of a Four Years Multidisciplinary Degree Programme. Students will receive a Bachelor's degree with Honors/ Research on successfully completing of all eight semesters of the UG Program either at a stretch or with opted exits and re-entries.

iii. For the smooth success of four-year degree programme with multiple entry and exit systems, the examination mode should be based on the combination of innovative trends in formative (informal and formal tests administered during the learning process) and summative (evaluation of students learning at the end of an instructional unit) examination modes in line with the UGC Report on 'Evaluation Reforms in Higher Educational Institutions (2019).

Examination, Evaluation and Assessment Scheme

The total marks for each Course shall be based on Continuous Assessment and Semester End Examination. Each theory course of Major, Minor, GE/OE, AEC, IKS, VEC as mentioned in **Teaching Learning Scheme** prepared by the Board of Studies shall be evaluated as per the scheme as mentioned in the following table

Examination, Evaluation and Assessment Scheme

Vertical No.	The Vertical	Mode of Examination, Evaluation & Assessment	Theory				Theory (Total)		Practical				Practical (Total)	
			External		Internal				External		Internal			
			Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks
A	Major	External & Internal	30/60	9/18	20/40	6/12	50/100	20/40	25/50	10/20	25/50	10/20	25/50	10/20
B	Minor		30/60	9/18	20/40	6/12	50/100	20/40	25/50	10/20	25/50	10/20	25/50	10/20
C	Generic/ Open Elective	Internal			50	20	50	20	--	--	50	20	50	20
D	VSC	Internal			50	20	50	20			50	20	50	20
	SEC	Internal	--	--	50	20	50	20			50	20	50	20
E	AEC (Eng. & One MIL Composite)	Internal			50	20	50	20						
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   - Third on completion of 75% Syllabus of the course or on completion of 75 teaching days.

ii. Each concurrent assessment (CAT-I, II & III) will be mapped to relevant Course

Learning Outcome.

iii. Total Performance in CAT (i.e.40 %) shall be based on the **best two out of three** in CAT examinations

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Course Category: **Major/ Minor (Theory)**

108200 General Chemistry-1

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
4.5	I	108200	General Chemistry-1	2	30	2 Hrs	30+20=50

Course Objectives:	1. To understand the basics of atomic structure and arrangement of elements in long form of periodic table. 2. To develop critical thinking about chemical properties of metals and non-metals. 3. Students will learn General Organic Chemistry
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Recall the postulates of Bohr's atomic theory. 2. Identify the quantum numbers associated with the describe shapes of atomic orbitals. 3. To write electronic configurations of elements and their classifications accordingly. 4. Explain the screening effect and its relevance to atomic properties. 5. Analyze the variation of periodic properties in periods and groups. 6. Evaluate the electronegativity trends using Pauling's and Mulliken's scales. 7. Differentiate between inductive, electromeric, resonance, and mesomeric effects. 8. Assess the relative strengths of organic acids and bases 9. Describe the structure of benzene and its stability 10. Apply Huckel's rule of aromaticity.

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	***A) Atomic Structure:*** Bohr atomic theory: Postulates and Limitations, quantum numbers, concept of atomic orbital, shapes of s, p and d orbitals, Aufbau principle, Pauli's exclusion principle and Hund's rule of maximum multiplicity. Electronic Configuration of elements. ***B) Long form of Periodic Table:*** Classification of elements as metals, non-metals and metalloids, main group, transition and inner-transition elements. Positions of elements in periodic table on the basis of electronic configuration. Atomic radius and its types, ionic radius, comparison of atomic and ionic radius.	8 Hrs	8 Marks	1. **Interactive Lectures:** Use multimedia presentations, interactive slides, and animations to illustrate structure of atom. 2. **Hands-On Models**: use of model to understand electronic configuration of elements and geometry of molecules. 3. **Problem-Solving Sessions**: Organize regular problem-solving sessions to know the properties of elements and their reactivity. 4. Explore virtual labs and simulations to enhance understanding of periodic table 5. **Flip-Class:**. 6. Ask students to create concept maps that illustrate the relationships between different concepts. 7. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and
Unit II	***Periodicity in Properties*:** The screening effect, Slater's rule, Effective nuclear charge with some numerical. Variation of atomic radii in periods and groups. Ionization enthalpy: Definition, factors affecting ionization energy and variation in periodic table. Electron gain enthalpy or electron affinity: Definition and variation in periodic table. Electronegativity: Definition, Pauling's, and Mulliken's scales of electronegativity, Variation in periodic table. Electronegativity and partial ionic character in covalent bond.	7 Hrs	7 Marks	
Unit III	A) **Organic Compounds**: Classification, and Nomenclature, Hybridization, shapes of Methane, Ethane, Ethylene and acetylene, Bond lengths, bond angles and bond energies. Hydrogen bonding in organic compounds (with reference to alcohol, phenols, amines, acids) and **c**onsequences. B) **Electronic Displacements**: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength with emphasis on factors affecting pKa values.	8 Hrs	8 Marks	
Unit IV	A) Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity B) Types, shape and relative stabilities of reaction intermediates (Carbocations, Carbanions, Free radicals, Carbenes and	7 Hrs	7 Marks	

	Nitrenes). Organic Reaction and their mechanism: Addition , Elimination and Substitution Reaction C) Structural Isomerism: Definition, classification with examples. Aromaticity- Criteria for Aromaticity, Huckel Rule. Benzenoid and non-benzenoid compounds. Antiaromatic and Non-aromatic compounds. Modern theory of Aromaticity.			research. 8. **Any other innovative pedagogy as applicable**

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2. Inorganic Chemistry by A.K. De, Wiley East Ltd.
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21. Organic Chemistry by S.K. Ghosh.
22. Reaction Mechanism in Organic Chemistry by S.M. Mukharjee and S.P. Singh.
23. Stereochemistry and mechanism through solved problems by P.S. Kalsi.
24. Organic Chemistry by TWG Solomons, 8th edition, John Wiley
25. Organic Chemistry by R. K. Bansal
26. Programmed Review of Organic Chemistry: Nomenclature, Olaf Allan Runquist, Burgess Publishing Company, 1965.

Web resources:

1. Basics of Inorganic Chemistry - https://nptel.ac.in/courses/104101121
2. Structure and Bonding: https://javalab.org/en/alkane_compound_en/
3. Introductory Organic Chemistry I- https://nptel.ac.in/courses/104106119

Model Questions:

Short Type (At least 8)

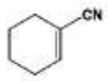
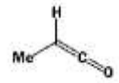
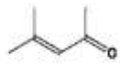
1) Define the terms i) atomic orbital ii) quantum numbers.
2) State i) Aufbau principle ii) Pauli's exclusion principle iii) Hund's rule of maximum multiplicity.
3) Why cation is smaller than corresponding atom?
4) Define i) ionization enthalpy ii) electron gain enthalpy
5) How atomic radius of elements vary in period and group of long form of periodic table?
6) Write two examples of metalloids.
7) Why the elements belonging to the same group do have similar chemical properties?
8) What are the formal charges on the N atom in the CH_3NO_2 molecule?
9) Arrange the following in increasing order of boiling point.
   (i) n-pentane, (ii) isopentane and (iii) neopentane
10) Define Inductive effect with suitable examples.
11) Define the term: Chain isomer or Chain Isomerism.
12) Define the terms : Positional isomer or Positional isomerism.
13) Which type of isomerism is shown by the following pair?

CH_3-CH_2-**OH** & CH_3-**O**-CH_3

Long Type (At least 4)

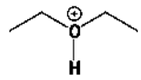
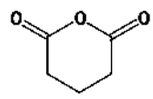
1) Write the postulates of Bohr atomic model.
2) State Pauli's exclusion principle and explain it by taking example of electrons of Helium atom.
3) Explain the variations in the pKa values for the different Hydrocarbons ex. Alkanes, Alkenes & Alkynes.

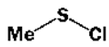
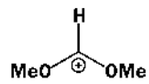
4) Mention the hybridization state of each carbon atom in these molecules?

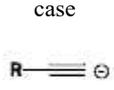
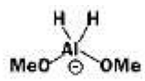
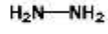
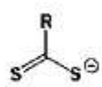
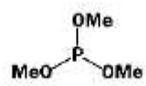
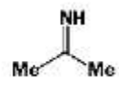
CO_2, $CH_2{=}NCH_3$, CHF_3, $CH_2{=}C{=}CH_2$, $(CH_2)_2O$

5) Each of these molecules is electrophilic. Identify the electrophilic atom and draw a mechanism for reaction with a generalized nucleophile Nu–, giving the product in each case.

6) Each of these molecules is nucleophilic. Identify the electrophilic atom and draw a mechanism for reaction with a generalized electrophile E+, giving the product in each case

7) What is Inductive effect? Explain –I & +I effects with suitable examples.
8) Explain Electromeric effect with suitable example.
9) Explain the term: Resonance effect with suitable example.
10) Explain the term: Hyperconjugation or No Bond Resonance or Hyperconjugative effect with a suitable example.
11) What are carbocations? How are they obtained? Write their stability order.
12) What is Carbanion ion? Give one preparation of it and explain the structure of carbanion ion.
13) What is/are free radicals? Explain their stability on the basis of resonance effect.
14) Explain Homolytic fission & Heterolytic fission.

MCQs for Internal Assessment (At least 8)

1) No two electrons in the same atoms can have identical set of four quantum numbers". This statement is known as -
A) Pauli's exclusion principle B) Hund's rule
C) Aufbau principle D) Heisenberg uncertainty principle

2) Principal Quantum number describes
A) shape of orbital B)size of the orbital
C) spin of electron D) orientation of in the orbital electron cloud.

3) In modern periodic table, the period number indicates the :
A) atomic number B) atomic mass
C) principal quantum number D) azimuthal quantum number

4) Across period atomic size decreases due to
A) shielding effect B) increase in nuclear force of attraction
C) photoelectric effect D) decrease in nuclear force of attraction

5) Which of the following can exist as diasteromers?
A) Lactic acid B)**2-butene** C) 2-butanol D) propane

6) Which of the following order is correct regarding the -I effect of the substituents?
A) -NR2 > -OR > -F B) -NR2 > -OR < -F
C) -NR2 < -OR < -F D) -NH2 > -OR > -F

7) +I effect (inductive effect) is shown by
(a) -CH_3 (b) -OH (c) -F (d) -C_6H_5

8) Which of the following statements about inductive effect is correct?
(a) It involves electrons in σ-bond (b) The electron pair is only slightly displaced during the +I effect
(c) It is diminishing effect (becoming smaller) **(d) All are correct**

9) In benzyl amine amino group is a
(a) – I group (b) + M group (c) + I group (d) both (a) and (b)

10) Arrange the following in the decreasing order of basic strength
(i) Pyrrole (ii) Pyridine (iii) Aniline
(a) i > ii > iii **(b) ii > iii > i** (c) ii = iii = i (d) iii > ii > i

11) Which of the following is strongest – I group
(a) – F (b) – Cl (c) – Br (d) – I

12) Inductive effect refers to –
(a) Electron displacement along a carbon chain through σ-bond
(b) Complete transfer of one of the shared pair of electrons to one of the atoms joined by a double bond
(c) Complete transfer of unshared electrons (d) None of the above

13) Which of the following groups has the highest inductive effect?
(a) -CH_3 (b) CH_3CH_2- (c) $(CH_3)_2CH$- **(d) $(CH_3)_3C$-**

14) Shifting of electrons of a multiple bond under the influence of a reagent is called_____.
(a) I-effect (b) M-effect **(c) E-effect** (d) T-effect

Course Category: **Major Lab-1**

108201 Chemistry Lab 1

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
4.5	I	108201	Chemistry Lab 1	2	60	4 h	25+25= 50

Course Objectives:	Develop practical skills in qualitative analysis of acids and basic radicals, organic compound purification, and accurate determination of physical constants (melting and boiling points) through hands-on laboratory experiments, fostering a comprehensive understanding of key techniques in analytical and organic chemistry.
Course Outcomes:	At the end of this course students will be able to: 1. Identify common acids and basic radicals through qualitative analysis techniques 2. Perform precipitation, gas evolution, and flame tests. 3. Acquire skills in common techniques for the purification of organic compounds. 4. Assess the effectiveness of purification techniques 5. Develop precision in measuring and recording physical constants 6. Analyze the relationship between melting/boiling points and purity. 7. Develop skills in recording and reporting experimental procedures and results.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	1. Introduction to common laboratory glassware and instruments used in practical course 2. SOPs for instruments used in practical course 3. Importance of Calibration with reference to accuracy, precession and minimization of errors	• By combining hands-on experiments, discussions, and real-world applications, students will gain a comprehensive understanding of chemistry lab practices. A few suggested pedagogies are: • Students should be given suitable **pre- and post-lab** assignments and explanation revising the theoretical aspects of laboratory experiments prior to and after the conduct of each experiment. • **Hands-On Laboratory Sessions:** Provide regular hands-on laboratory sessions where students can directly apply theoretical knowledge to practical experiments. • **Demonstrations and Simulations:** Use virtual simulations for certain experiments to enhance accessibility and understanding. • **Flipped Classroom Model:** Encourage students to come to class prepared, promoting active participation. • **Interactive Workshops:** Provide opportunities for students to engage in discussions, ask questions, and seek clarification. • **Technology Integration:** Incorporate digital tools for data analysis and presentation. • **Guest Lectures and Industry Connections:** Establish connections with professionals in the field to provide students with a broader perspective on chemical lab practices. • **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. • **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge
Inorganic Chemistry practical	***Qualitative analysis of simple salts:*** 1. Semi-micro inorganic qualitative analysis of a sample containing two anions (acidic radicals) of two different groups amongst Group I: CO_3^{2-}, SO_3^{2-}, S^{2-}, NO_2^- Group II: Cl^-, Br^-, I^-, NO_3^- Group III: SO_4^{2-}, PO_4^{3-}. (At least four mixtures of different combinations to be given) ***Probable mixture combination*:** i) Carbonate + chloride/bromide/iodide (no sulphite) ii) Sulphite + chloride/bromide/iodide iii) Sulphide + nitrate/sulphate/phosphate (no chloride/bromide/iodide) iv) Nitrite + chloride/bromide/iodide (no nitrate) v) Nitrate + sulphate/sulphite/phosphate (no bromide/iodide/nitrite) 2. Identification of cations (basic radicals) in simple salts by flame tests. (simple chloride salts to be given to the students containing Na^+, Ba^{++}, Cu^{++}, Pb^{++}, Sr^{++}, Sn^{2+} and Bi^{3+} ions) 3. Identification of cations (basic radicals) in colored salts by borax bead tests. (simple salts to be given to the students containing Cr^{3+}, Fe^{++}or Fe^{3+}, Cu^{++}, Mn^{++}, Co^{++} and Ni^{2+} ions.) 4. Identification of group I basic radicals (Pb^{2+}, Ag^+ or Hg_2^{2+})present in given sample solution by adding dil. HCl as a group reagent followed by treatment with ammonium hydroxide and NaOH or KI or Potassium chromate. (Mixture of Lead nitrate, silver nitrate and mercurous nitrate should be given to the students) **5.** Spot test analysis of some basic radicals in given sample. Following group cations may used for spot test Group IIA: Cu^{2+},(Rubeanic acid test), Cd^{2+}(1,5-diphenyl carbazide test), Bi^{3+} (thiourea test) Group IIB: As^{3+}(Silver nitrate test) Group III: Fe^{3+}(ammonium thiocyanate test)), Group IV: Mn^{2+}, Co^{2+}(ammonium thiocyanate test), Zn^{2+}(Ammonium mercury thiocyanate solution test), Ni^{2+}(DMG test/ Rubeanic acid test) Group V: Ba^{2+},(Potassium chromate test) Special group: Ammonium ion.(Test with dil NaOH)	

	6. Separation of mixture of Group I and II basic radicals by using dilute HCl and identification of the radicals present in the mixture by spot tests only. (At least two mixtures, each containing one group I and one group II cation, are to be given to the students) Probable mixture combination: i) Lead nitrate + Copper nitrate/sulfate ii) Lead nitrate + Bismuth nitrate iii) Silver nitrate + Copper nitrate/sulfate iv) Silver nitrate + Bismuth nitrate v) Mercurous salt(except chloride) + Copper nitrate/Bismuth nitrate 7. Separation of mixture of Group II and III basic radicals by using ammonium hydroxide and identification of the radicals present in the mixture by spot tests only. (At least two mixtures, each containing one from group II and one from group III cation, are to be given to the students) Probable mixture combination: i) Copper nitrate/sulfate + Ferric chloride/nitrate ii) Bismuth nitrate + Ferric chloride/nitrate iii) Arsenic nitrate + Ferric chloride/nitrate	
Organic Chemistry Practical	*I.* ***Purification Techniques*** **Exercise-** 1. To select suitable solvent from distilled water and rectified spirit for the recrystallization of benzoic acid. 2. To select suitable solvent from distilled water and rectified spirit for the recrystallization of naphthalene. 3. To select suitable solvent from distilled water and rectified spirit for the recrystallization of salicylic acid. 4. Purification of organic compounds by sublimation. 5. Purification of organic liquid by distillation (demonstration). ***II. Determination of Physical Constant- Melting point and boiling point.*** **Exercise-** 1. To determine the melting point of urea. 2. To determine the melting point of benzoic acid 3. To determine the boiling point of ethyl acetate. 4. To determine the boiling point of chlorobenzene. 5. Criteria of purity determination of melting and boiling points. (Any two organic compounds) 6. Effect of impurities on the melting point – mixed melting point of two organic compounds (urea and cinnamic acid or benzoic acid and mandelic acid).	
References	1. Vogel-A text book of qualitative inorganic analysis. 2. Practical Chemistry (for B.Sc. I, II and III year students) – O P Pandey, D. N. Bajpaiand S. Giri (S Chand and company Ltd 3. Kolthoff and Sandell-Text book of qualitative inorganic analysis 4. Ahluwalia, V.K.; Dhingra, S. (2004),Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press. 5. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R.(2012),Vogel's Textbook of Practical Organic Chemistry, Pearson. 6. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press. **Web resources:** 1. https://vlab.amrita.edu/?sub=2 2. https://chemcollective.org/vlabs 3. https://chem.libretexts.org/	
Model Questions:	**NA**	

Distribution of Marks and the scheme of Practical Examination (Major/Minor):

Section 1: Internal Assessment

- Attendance 05 Marks
- Active participation in activities as a part of CAT (At least three tests) * 10 Marks
- Submission of duly certified record and assignment 05 Marks
- Internal Viva-voce 05 Marks

Total **25 Marks**

*Note: Based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Inorg. Chem Practical) 10 Marks
- Exercise 2 (Org. Chem Practical) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **GE/OE-1**

108202 Chemistry in Everyday Life

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
4.5	**I**	**108202**	**Chemistry in Everyday Life**	2	30	2 Hrs	30+20 =50

Course Objectives:	The objectives of the course are: 1. Awareness about various nutrients, appropriate personal care products and household products. 3. Awareness basic medicinal chemistry. 4. Reduce use of harmful chemical products.			
Course Outcomes:	By the end of this course, the students will be able to: 1. choose appropriate personal care product for themselves and others. 2. choose proper food products as per their requirements. 3. recognize nature friendly polymers and dyes. 4. assess the benefits and challenges associated with the use of agrochemicals in modern agriculture. 5. realize basics of medications			
Unit System	**Contents**	**Workload Allotted**	**Weightage of Marks Allotted**	**Incorporation of Pedagogies**
Unit I	**Chemistry of Food & Nutrition** a) Understanding the composition of food. b) Digestion and absorption of nutrients c) Energy production from macronutrients d) Functions of vitamins and minerals	8 Hrs	8 Marks	1. **Interactive Lectures:** Combines elements of traditional lectures with interactive activities to engage students. 2.**Project-Based Learning:** Assign project that involves solving a real-world problem. 3. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. 4. **Differentiated Instruction:** Tailor instruction to meet individual student needs, considering learning styles, interests, and readiness. 5. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. 6. **Role-Playing:** Act out scenarios.
Unit II	**Chemistry of Personal Care Products** a) pH and its importance in the selection of personal care products b) Role of shampoos and conditioners c) Role of cleansers and moisturizers d) Role of sunscreen and anti-aging products	7 Hrs	7 Marks	
Unit III	**Chemistry of Medicine** a) Common diseases and their causes b) Concept of Analgesics, Antibiotics, Antidepressants, Antihypertensives, Antipyretics and Anticoagulants c) Concept of Bronchodilators, Vaccines, Antacids and Diuretics d) Drug Metabolism-Absorption, distribution, metabolism, and excretion (ADME)	8 Hrs	8 Marks	
Unit IV	**Chemistry of Household Products & Agrochemicals** a) Concept of surfactants and their role in cleaning b) Synthetic and natural polymers c) Synthetic and natural dyes d) Benefits and challenges associated with agrochemical use	7 Hrs	7 Marks	
References:	1. Indian Superfoods: Change the Way You Eat by Rujuta Diwekar, Publisher: Juggernaut Books (2016) 2. Food Chemistry by Owen R. Fennema, Publisher: CRC Press (1996) 3. Food Chemistry: Principles and Applications by H.-D. Belitz, Werner Grosch, and Peter Schieberle, Publisher: Springer (2014) 4. Introduction to Food Chemistry, Richard Owusu-Apenten, CRC Press (2014) 5. Chemistry and Technology of Surfactants by Richard J. Farn, Publisher: Blackwell Publishing (2006) 6. The Chemistry and Manufacture of Cosmetics by Maison G. deNavarre, Publisher: Van Nostrand Reinhold (1975) 7. Cosmetic and Toiletry Formulations, Vol. 8 by Ernest W. Flick, Publisher: Noyes Publications/William Andrew Publishing (2000) 8. Medicinal Chemistry: Principles and Practice by Foye, Lemke, Williams, Publisher: Lippincott Williams & Wilkins (2012) 9. Medicinal Chemistry by Graham L. Patrick, Publisher: Oxford University Press (2009) 10. Medicinal Chemistry: The Modern Drug Discovery Process by Erland Stevens, Christopher J. Rhodes, Publisher: Pearson (2017) 11. Handbook for Cleaning/Decontamination of Surfaces by Philippe Cognard, Publisher: William Andrew (2007) 12. Introduction to Polymer Science and Chemistry: A Problem-Solving Approach by Manas Chanda, Publisher: CRC Press (2006)			

	13. Polymer Chemistry by P. M. Visakh and Yoshihiko Arao, Publisher: Springer (2013) 14. Dyes and Dyeing: A Handbook by Charles E. Pellew, Publisher: Asian Educational Services (2000) 15. Introduction to Agrochemicals by P. Pramanik, Publisher: New India Publishing Agency (2007) 16. Agrochemicals and Sustainable Agriculture by R. E. Hoagland, Publisher: American Chemical Society (1993) 17. Agrochemicals: Preparation and Mode of Action by G. Zweig and J. Sherma, Publisher: CRC Press (1990) Web Resources 1. MIT OpenCourseWare 2. TED 3. TEDx Talks
Model Questions:	**Short Type** 1. What are the main macronutrients found in food? 2. Can you explain the difference between saturated and unsaturated fats in food? 3. How do vitamins contribute to the chemical composition of various foods? 4. What are the essential minerals commonly found in food? 5. What are the common chemical components found in sunscreens? 6. What protective measures can be taken to minimize the harmful effects of UV radiation on the skin? 7. What are antacids, and how do they provide relief from acidity and heartburn? 8. What are the emerging trends in medicinal chemistry, particularly in the context of drug discovery? 9. Define synthetic polymers and provide examples of commonly used synthetic polymers. 10. Name some common natural sources of dyes and their colors? 11. What role do agrochemicals play in modern agriculture, and how do they contribute to crop protection? 12. What are surfactants, and how do they contribute to the cleaning process?
	Long Type 1. Write the classification and functions of vitamins and minerals. 2. Explain the effect of UV radiation on human body? 3. Explain drug metabolism in humans. 4. What are agrochemicals? Write its classification. 5. Explain various food preservation methods.
	MCQs 1. What is the primary role of surfactants in cleaning products? a) Emulsification b) Color enhancement c) Odor masking d) Thickening 2. Which chemical reaction is commonly involved in stain removal using cleaning agents? a) Oxidation b) Reduction c) Precipitation d) All of the above 3. What is an example of a synthetic polymer commonly used in everyday products? a) Cellulose b) Rubber c) Polyethylene d) Starch 4. What is the outermost layer of the skin called? a) Dermis b) Epidermis c) Hypodermis d) Subcutis 5. Which skin type benefits most from oil-free cleansers? a) Dry skin b) Oily skin c) Combination skin d) Normal skin 6. Which of the following is a common anti-aging ingredient known for promoting collagen production? a) Hyaluronic acid b) Retinol c) Salicylic acid d) Alpha hydroxy acid 7. Which macronutrient is primarily responsible for providing energy during high-intensity physical activities? a) Proteins b) Carbohydrates c) Fats d) Minerals 8. Which chemical analysis method is commonly used to determine the protein content of food? a) Chromatography

	b) Spectroscopy c) Titration d) Kjeldahl method 9. Antibiotics are primarily used to treat_____. a) Viral infections b) Fungal infections c) Bacterial infections d) Parasitic infections 10. What is a key goal in the development of cancer drugs? a) Increase blood pressure b) Enhance appetite c) Selectively kill cancer cells d) Boost serotonin levels 11. What does ADME stand for in drug metabolism? a) Anticipate, Develop, Monitor, Evaluate b) Absorption, Distribution, Metabolism, Elimination c) Acquire, Digest, Modify, Expel d) Analyze, Document, Manage, Execute 12. Why are ethical considerations important in drug discovery? a) They increase the cost of drug development b) They ensure fair distribution of drugs c) They address safety concerns d) They have no impact on the drug discovery process

Course Category: **GE/OE-2**

108203 Pollution & Remedies

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
4.5	**I**	**108203**	**Pollution & Remedies**	2	30	2 Hrs	30 +20 = 50

Course Objectives:	The objectives of the course are: 1. to aware risks due to pollution. 2. to use appropriate steps to reduce pollution. 3. to aware rules and regulations related to pollution and its control. 4. to gain a holistic understanding of pollution and remedies.			
Course Outcomes:	By the end of this course, the students will be able to: 1. recognize difference between polluted environment and clean environment. 2. prevent nearby society from pollution generating activities. 3. evaluate the environmental, social, and economic impacts of pollution. 4. design a pollution prevention plan for a specific industry or community. 5. develop educational materials to raise awareness about pollution and its remedies. 6. propose innovative solutions for reducing pollution and promoting sustainability.			
Unit System	**Contents**	**Workload Allotted**	**Weightage of Marks Allotted**	**Incorporation of Pedagogies**
Unit I	**Idea of Pollution** a) Introduction to pollution, classification of pollutants b) Causes of pollution, harmful effects of pollution c) Sustainable ways of living, rules and regulations to mitigate pollution d) Central Pollution Control Board and its work	8 Hrs	8 Marks	1. **Interactive Lectures:** Combines elements of traditional lectures with interactive activities to engage students. 2.**Project-Based Learning:** Assign project that involves solving a real-world problem. 3. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. 4. **Differentiated Instruction:** Tailor instruction to meet individual student needs, considering learning styles, interests, and readiness. 5. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. 6. **Role-Playing:** Act out scenarios.
Unit II	**Air Pollution, Water Pollution and Soil Pollution** a) Air Pollution: Causes and effects of air pollution; prevention of air pollution b) Water Pollution: Sources and effects of water pollution c) Soil Pollution: Sources and effects of soil pollution d) Activities: Activities to reduce air pollution, water pollution and soil pollution.	7 Hrs	7 Marks	
Unit III	**Noise Pollution, e-Waste Pollution and Plastic Pollution** a) Noise Pollution: causes and effects of noise pollution; prevention of noise pollution. b) e-Waste Pollution: causes and effects of e-waste pollution; prevention of e-waste pollution. c) Plastic Pollution: causes and effects of plastic pollution; prevention of plastic pollution; microplastics. d) Activities: activities to reduce noise pollution, e-waste pollution and plastic pollution	8 Hrs	8 Marks	
Unit IV	**Light Pollution, Radioactive Pollution and Space Pollution** a) Light Pollution: causes and effects of light pollution; prevention of light pollution. b) Radioactive Pollution: causes and effects of radioactive pollution; prevention of radioactive pollution; nuclear weapons; nuclear power plants; Chernobyl disaster. c) Space Pollution: causes and effects of space pollution; prevention of space pollution. d) Activities: activities to reduce light pollution, radioactive pollution and space pollution	7 Hrs	7 Marks	

References:	1. Breathing Here is Injurious to Your Health: The Human Cost of Air Pollution by Jyoti Pande Lavakare, Publisher: Speaking Tiger (2020) 2. Water Chemistry by Mark M. Benjamin, Publisher: McGraw-Hill Education (2002) 3. Soil Pollution: Origin, Monitoring & Remediation by M. N. V. Prasad, Publisher: Elsevier(2017) 4. The Story of Plastic by Izabella Teixeira, Catherine Clark, Publisher: Melville House (2019) 5. The End of Night: Searching for Natural Darkness in an Age of Artificial Light by Paul Bogard, Publisher: Little, Brown and Company (2013) 6. Radioactive Pollution of the Environment by Alexey V. Yablokov, Publisher: Springer (2009) 7. Debris: A History of the Human Space Age by Lisa Ruth Rand, Publisher: Harvard University Press (2021) 8. Environmental Pollution by N. Manivasakam, Publisher: National Book Trust (1984) 9. Environmental Noise Pollution by P.N. Prasad and T.R. Amarnath, Publisher: Crescent Publishing Corporation (2010) 10. Environmental Chemistry by H. Kaur, Publisher: Pragati Prakashan (2015) 11. Pollution Control Acts, Rules & Notifications Issued Thereunder Published by Central Pollution Control Board (2021) Web resources: 1. https://youtu.be/OQWmaYjyolE 2. https://youtu.be/MQLadfsvfLo 3. https://youtu.be/fephtrPt6wk 4. https://youtu.be/Hnfdq2htoKU 5. https://youtu.be/ODni_Bey154 6. https://youtu.be/GPux33UVG_c 7. https://youtu.be/V_A78zDBwYE 8. https://youtu.be/MEb7nnMLcaA 9. https://youtu.be/w_PWL0oZzOc **10.** MIT OpenCourseWare
Model Questions:	**Short Type** 1. What are the primary sources of air pollution? 2. How can nutrient runoff contribute to water pollution? 3. Identify major sources of soil pollution. 4. Define decibel and its relevance to noise pollution. 5. How can prolonged exposure to loud noises affect human health? 6. Name one astronomical observation affected by light pollution. 7. How does excessive artificial light impact ecosystems? 8. What are microplastics, and how do they contribute to ocean pollution? 9. Name a radioactive element commonly associated with nuclear accidents.
	Long Type 1. Explain the major sources of air pollution and their impact on human health and the environment. 2. Discuss the consequences of water pollution on aquatic ecosystems and human populations. 3. Define soil pollution and describe the common pollutants that degrade soil quality. 4. Examine the concept of noise pollution and its effects on human well-being. 5. Explain the sources of plastic waste, including single-use plastics, microplastics, and improper waste disposal.
	MCQs 1. What is the primary source of anthropogenic (human-caused) air pollution? a. Volcanic eruptions b. Industrial emissions c. Natural wildfires d. Oceanic emissions 2. Which of the following is a common non-point source of water pollution? a. Industrial discharges b. Sewage treatment plants c. Agricultural runoff d. Oil spills 3. Noise pollution is measured in units called: a. Decibels (dB) b. Hertz (Hz) c. Watts (W) d. Newtons (N) 4. What is a significant contributor to soil pollution in urban areas? a. Agricultural runoff b. Pesticides and herbicides c. Industrial waste d. Deforestation 5. What is the main consequence of light pollution on ecosystems? a. Increased biodiversity b. Disruption of sleep patterns in animals c. Improved visibility for nocturnal species d. Enhanced photosynthesis in plants 6. Which type of plastic is most commonly associated with environmental pollution? a. Polyethylene b. Polypropylene

	c. Polystyrene d. Polyvinyl chloride (PVC) 7. The Chernobyl disaster is an example of: a. Noise pollution b. Air pollution c. Water pollution d. Radioactive pollution 8. What is the proper disposal method for electronic waste to prevent pollution? a. Landfill disposal b. Incineration c. Recycling d. Dumping in water bodies 9. Which of the following gases is a major contributor to the greenhouse effect? a. Oxygen (O_2) b. Nitrogen (N_2) c. Carbon dioxide (CO_2) d. Hydrogen (H_2)

Course Category: **Skill Enhancement Course SEC-1**

108204 Lab- 2 (Calibration and Standardization Essentials)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
4.5	I	108204	Lab- 2 (Calibration and Standardization Essentials)	2	60	4 Hrs	50

Course Objectives:	The intended objectives are: 1. To introduce glassware and instruments used in a Chemistry laboratory. 2. To understand the importance of calibration of glassware and instruments in tune with concepts of precision and accuracy. 3. To develop awareness about safety measures for handling chemicals.	
Course Outcomes:	At the end of this course students will be able: 1. To define the importance of calibration and standardization in analytical processes 2. To demonstrate techniques for calibrating various glassware used in laboratories. 3. To implement calibration procedures for diverse instruments to ensure accuracy. 4. Emphasize the importance of maintaining accurate records and documentation 5. To identify common calibration issues and implement troubleshooting techniques. 6. To instill a mindset of continuous improvement in calibration techniques	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	1. Introduction, types of chemical analysis, general analytical method, primary standard and secondary standard substances. 2. Calibration of Laboratory Glassware: Burettes, Pipettes, Volumetric Flask, thermometer etc. 3. Calibration of laboratory instruments: pH meter, conductometer, potentiometer and colorimeter.	By combining hands-on experiments, discussions, and real-world applications, students will gain a comprehensive understanding of chemistry lab practices. A few suggested pedagogies are: • Students should be given suitable **pre- and post-lab** assignments and explanation revising the theoretical aspects of laboratory experiments prior to and after the conduct of each experiment. • **Hands-On Laboratory Sessions:** Provide regular hands-on laboratory sessions where students can directly apply theoretical knowledge to practical experiments. • **Demonstrations and Simulations:** Use virtual simulations for certain experiments to enhance accessibility and understanding. • **Flipped Classroom Model:** Encourage students to come to class prepared, promoting active participation. • **Interactive Workshops:** Provide opportunities for students to engage in discussions, ask questions, and seek clarification. • **Technology Integration:**
Calibration of Glassware	1. Calibration of Burette 2. Calibration of Pipette 3. Calibration of Standard Measuring Flask 4. Calibration of Thermometer (Demonstration)	
Calibration of instruments	1. Calibration of pH meter 2. Calibration of Conductometer 3. Calibration of Colorimeter 4. Calibration of Potentiometer (Demonstration)	
Standardization of solution	1. Preparation of standard solution of an acid (oxalic acid) by weighing and calculation of concentrations in terms of strength, normality, molarity and molality. 2. Preparation of standard solution of a base (sodium carbonate) by weighing and calculation of concentrations in terms of strength, normality, molarity and molality. 3. Prepare 1 % NaOH solution and find its exact normality using standard oxalic acid solution. 4. Determine molarity and strength of unknown hydrochloric acid with the help of standard 0.05M sodium carbonate solution. 5. Standardization of given NaOH solutions using standard 0.02 N Na_2CO_3 6. Prepare 0.1 N H_2SO_4 solution and find out its exact normality using NaOH as an intermediate solution and 0.1 N Oxalic acid as standard solution.	

References:	1. Instrumental Analysis by Douglas A. Skoog, F. James Holler, Stanley R. Crouch (2006) 2. Fundamental of Analytical Chemistry by Douglas A. Skoog, West, F. James Hollers'. Crouch (2009) 3. Modern Analytical Chemistry by David Harvey, McGraw-Hill Higher Education (1999) 4. S.M. Khopkar, "Basic Concepts of Analytical Chemistry", IInd Edition New Age International Publisher (2004) 5. Principles of Instrumental Analysis, D. A. Skoog, F. James Holler, Stanley R. Crouch (2007) 6. Vogel's Textbook of quantitative chemical analysis, 5th edition (1989), Instrumental method of analysis, B.K. Sharma, Goel publishing house. Miscellaneous methods (2005) **Weblinks:** 1. https://vlab.amrita.edu/?sub=2 2. https://chemcollective.org/vlabs	Incorporate digital tools for data analysis and presentation. • **Guest Lectures and Industry Connections:** Establish connections with professionals in the field to provide students with a broader perspective on chemical lab practices. • **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. • **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge • **Any other innovative pedagogy as applicable**
Model Questions	**3. NA**	

Distribution of Marks and the scheme of (SEC) Practical Examination is as follows:

Section I: Continuous Internal Assessment (CIE)

- Attendance 05 Marks
- Active participation in activities as a part of CAT (At least three tests) * 15 Marks
- Submission of duly certified practical record 05 Marks

Total 25 Marks

*Note: Based on the best two out of three in CAT examinations

Section II: End Semester Examination (Internal only)

- Exercise 1 20 Marks
- Viva-Voce (internal) 05 Marks

Total 25 Marks

Total (Section I And II) 50 Marks

Course Category**: Major (Theory)-2**

108205 General Chemistry-2

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
4.5	II	108205	General Chemistry-2	2	30	2 Hrs	30+20=50

Course Objectives:	Students will learn Periodic trends in Main group elements. Students will learn Fundamentals of Physical chemistry w.r.t. Thermodynamics, Gaseous state,
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Analyze the variation of periodic properties in periods and groups. 2. Compare the properties of groups 13, 14, and 15 elements. 3. Explain the inert pair effect and its consequences. 4. Predict the types and structures of interhalogen compounds. 5. Apply Fajan's rules to predict the nature of polar bonds 6. Discuss the concept of entropy as a measure of disorder and randomness. 7. Solve different numerical of varying difficulty associated with thermodynamics, liquid state and gaseous state. 8. Explain the deviation of real gases from ideal behavior. 9. Apply mathematical relationships to real-world scenarios involving gases and liquids

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	***A] s-Block elements:*** Electronic configuration, ionization potential, oxidation states, reducing properties and metallic properties, reactivity and flame coloration. Diagonal relationship between Li and Mg. ***B] p-Block: Group 13 to 15 elements:*** Comparative study of groups 13, 14 and 15 with respect to atomic and ionic radii, ionization potential, electronegativity, oxidation states and inert pair effect. Diagonal relationship between Be and Al. Allotropes of carbon. Structure and bonding in diborane.	8 Hrs	8 Marks	1. **Interactive Lectures:** Use multimedia presentations, interactive slides, and animations to illustrate complex concepts. 2. **Hands-On Models**: Use digital modeling software for virtual three-dimensional visualization. 3. **Problem-Solving Sessions**: Organize regular problem-solving sessions where students can apply theoretical knowledge to solve stereochemistry and bonding problems. 4. Explore virtual labs and simulations to enhance understanding of molecular structures and reactions. 5. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive
Unit II	***A] p-Block: Group 16 & 17 elements:*** Comparative study of 16^{th} and 17^{th} group elements with reference to electronic configuration, ionization energy and oxidation states. oxidizing properties of halogens with reference to oxidation potential. Interhalogen compounds: Types and their structure. ***B] Polarisation*** - Definition, polarising power, polarizability, effect of polarization on nature of bond. Fajan's rules of polarization and its applications.	7 Hrs	7 Marks	
Unit III	***Thermodynamics:*** First law of Thermodynamics and its limitations, Need of Second law. Carnot's heat engine, derivation of expression for the work done and efficiency of Carnot's engine. Statements of Second law of thermodynamics. Concept of Entropy, Physical significance of Entropy, Derivation of expression for the Entropy change for an ideal gas in terms of pressure, temperature and volume. Entropy change for an ideal gas for isothermal, isoberic and isochoric processes, Entropy of fusion, sublimation, vapourization, transition and its calculations. Entropy change for reversible and irreversible processes. Entropy change as a criteria for spontaneity. Numerical.	8 Hrs	8 Marks	
Unit IV	**Gaseous State:** Postulates of kinetic theory of gases, Maxwell-Boltzmann distribution of velocities (only qualitative treatment),	7 Hrs	7 Marks	

	RMS velocity, Average velocity, Most probable velocity, Relationship between RMS velocity and Average velocity, RMS velocity and Most probable velocity, Mean free path, Collision diameter, Collision number or Collision frequency, Deviation of real gases from ideal behaviour, Explanation of deviations, Derivation of Van der Waal's equation for real gases. Critical phenomenon, Andrew's experiment (isotherms of carbon dioxide). Critical constants. Derivation of relationship between Critical constants (Pc, Tc, Vc) and Van der Waal's constant (a, b). Derivation of reduced equation of state, statement and derivation of Law of corresponding state. Numerical. **Liquid State:** Definition of surface tension, its SI unit and effect of temperature on surface tension, Derivation of expression for relative surface tension by stalagmometer method. Applications of surface tension. Viscosity, definition of coefficient of viscosity, Its SI unit and effect of temperature on viscosity, Derivation of expression for relative viscosity by Ostwald's viscometer method, Applications of viscosity. Numerical.			discussions and problem-solving. 6. Ask students to create concept maps that illustrate the relationships between different concepts in organic chemistry. 7. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. 8. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. 9. **Any other innovative pedagogy as applicable**
References:	4. Concise Inorganic Chemistry J.D.Lee. Wiley India Edition 5. Inorganic Chemistry by A.K. De, Wiley East Ltd. 6. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry- Principles of 7. Advanced Inorganic Chemistry, Vol-I, Satya Prakash, Madan, Tuli, Basu. 8. Selected Topics In Inorganic Chemistry: W.U. Malik, G.D. Tuli & R.D. Madan (S. Chand Publications) 9. B.R. Puri, L.R Sharma and K.C. Kalia, Principles of Inorganic Chemistry, Vishal publication, 2016 10. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J.(1994),Concepts and Models of Inorganic 11. Chemistry, John Wiley & Sons. 12. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010),Shriver Inorganic Chemistry, 5th Edition, Oxford University Press. 13. Wulfsberg, G (2002), Inorganic Chemistry, Viva Books Private Limited. 14. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson. 15. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989),Vogel's Textbook of Quantitative 16. Chemical Analysis, John Wiley and Sons. 17. Svehla, G. (1996), Vogel's Qualitative Inorganic Analysis. 18. Physical Chemistry: Walter, J. Moore, 5th edn., New Delhi. 19. Physical Chemistry: G.M. Barrow, McGraw Hill, Indian Edn. 20. Principles of Physical Chemistry: Maron and Prutton. 21. Principles of Physical Chemistry: Puri, Sharma, and Pathania. 22. Physical Chemistry: P.W. Atkins, 6th Edn. 23. Physical Chemistry: Levine 24. A Textbook of Physical Chemistry, Kapoor, K.L. (2019), Vol.7, 1st Edition, McGraw Hill Education **Web resources:** 25. Basics of Inorganic Chemistry - https://nptel.ac.in/courses/104101121 26. Structure and Bonding: https://javalab.org/en/alkane_compound_en/ 27. Introductory Organic Chemistry I- https://nptel.ac.in/courses/104106119			
Model Questions:	**Short Type** 1. Write the sub-shell electronic configuration of i) Magnesium and ii) Potassium 2. What is polarization of bond? 3. What are inter-halogen compounds? 4. Define critical temperature of gas. 5. State law of corresponding state. 6. Define Collision frequency. 7. Define Mean free path.			

	8. What is critical temperature of carbon dioxide? 9. Define surface tension. 10. Define Viscocity. 11. What is the effect of temperature on surface tenstion on liquid? 12. What is the effect of rise in temperature on viscocity of liquid? 13. What is the SI unit of viscocity? 14. Define entropy? 15. State any one statement of second law of thermodynamics. 16. Define Entropy of fusion. 17. what is phase transition? 18. Define entropy of sublimation.
	Long Type 1. Give the diagonal relationship between Li and Mg 2. How polarizing power of cation and polarizability of anion introduce covalent character in ionic bond? Explain. 3. Discuss the oxidizing properties of Halogens. 4. Write the electronic configuration of 16^{th} group elements. 5. Give assumptions of kinetic theory of gases. 6. Explain Maxwell's Boltzmann law for distribution of velocities. 7. Explain Andrew's experiment of liquification of CO_2 gas. 8. Derive relationship between VanderWaal's constants and critical constants. 9. Derive Vander Waal's equation of state. 10. Explain the measurment of surface tention by drop number method. 11. Explain how will you determine relative viscocity of liquid by Ostwald viscometer. 12. Give applications of surfce tension. 13. Give applications of viscocity. 14. The coefficient of viscocity of two liquids at 298 K is 1.408 x 10^{-3} Kg m^{-1} s^{-1} and 1.594 x 10^{-3} Kg m^{-1} s^{-1} and their densities are 8.07x 10^2 Kg m^{-3} and 10.17 x10^2 Kg m^{-3} respectively. If the time of flow for the first liquid is 100 seconds, calculate the time of flow for second liquid. 15. Explain need of second law of thermodynamics. 16. Give various statements of second law of thermodynamics. 17. Explain physical significance of entropy. 18. Explain four strokes of carnot heat engine. 19. Show that entropy change for irreversible preocess always takes place with increase in entropy.
	MCQs for Internal Assessment 1) If the valence shell electronic configuration is ns^2np^0, the element will belong to A) alkali metals B) halogens C) alkaline earth metals D) Chalcogens 2) Which of the following element catch fire when exposed to air? A) Helium B) Copper C) Sodium D) Aluminium 3) Which of the following shows most prominent inert pair effect? A) Carbon B) Silicon C) Germanium D) Lead 4) Haber process is used for the preparation of A) Nitrogen B) Hydrogen C) Iron D) Ammonia 5) The geometry of IF_3 molecule is A) trigonal planar B) tetrahedral C) triginal bipyramidal D) octahedral 6) Both of elements of I period contain valence electrons in A) M shell B) N shell C) K shell D) S shell 7) The addition of HBr on 2-butene in presence of peroxide follows (a) Electrophilic addition **(b) Free radical addition** (c) Nucleophilic addition (d) None of these 8) The average distance travelled by molecule between two successive collision is called as … a) Average free path b) Partial free path c) Mean free path d) None of these 9) The condotions required for the ideal gas behavour …. a) Molecules in gaseous state should not attract or repell to each other b) Volume of a gas molecule must be negligible c) Both a and b d) None of these 10) Real gases behaves ideally at…… a) Low temp. and high pressure b) Low temp. and Low pressure c) High temp. and high pressure d) high temp. and low pressure 11) Kinetic theory of gases was proposed by…. a) Boyle's b) Joule c) Bernoulli d) Vander Waal 12) The SI unit of surface tension is…..

a) Nm^{-1}
b) Ncm^{-1}
c) $N^{-1}m$
d) None of these

13) The apparatus used to determine surface tension is called as…
a) Ostwald viscometer
b) Thermometer
c) Stalagmometer
d) conductometer

14) The apparatus used to determine viscocity is called as…
a) Ostwald viscometer
b) Thermometer
c) Stalagmometer
d) conductometer

15) The force of attraction between dissimilar molecules is called as…
a) Adhesive
b) Cohesive
c) Magnetic force
d) Gravitational force.

16) The force of attraction between same molecules is called as…
a) Adhesive
b) Cohesive
c) Magnetic force
d) Gravitational force

17) Which thermodynamic process were heat is not exchanged with the surrounding is
a) Isothermal
b) Adiabatic
c) Isobaric
d) Isochoric

18) Which of the following is correct
a) For an isolated system $dS > 0$
b) For a reversible process $dS = 0$
c) For an irreversible process $dS > 0$
d) All of the above

19) Entropy is a measure of
a) Order
b) Disorder
c) Temperature
d) Pressure

20) Efficiency of heat engine is 100% when
a) Temperature of sink is zero
b) Temperature of sink is 100
c) Temperature of source is zero
d) Temperature of source is 100

21) The expression of work done for n mole of gas in reversible isothermal expansion is
a) $w = -2.303nRT \log_{10} V2/V1$
b) $w = -2.303RT \log_{10} V2/V1$
c) $w = -2.303nR \log_{10} V2/V1$
d) $w = -2.303nT\log_{10} V2/V1$

Course Category: **Major Lab-3**

108206 Chemistry Lab- 3

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
4.5	II	108206	Chemistry Lab- 3	2	60	--	25+25= 50

Course Objectives:	The intended objectives are: 1. Develop proficiency in fundamental chemical laboratory techniques. 2. Follow established SOPs for various experiments based on physical and Inorganic chemistry. 3. Analyze experimental data and draw meaningful conclusions. 4. Apply critical thinking to troubleshoot and optimize experimental procedures.	
Course Outcomes:	At the end of the Lab/Practical course, students will be able to 1) Skillfully prepare different concentrations of solutions. 2) Determine the strength of commercial samples. 3) Apply volumetric analysis for the estimation of acids and bases in commercial samples. 4) Determine the heat of solution 5) Calculate different thermodynamic parameters 6) Determine surface tension and cleaning ability of detergents and other liquids 7) Determine coefficient of viscosity for different liquids	
Unit System	**Contents**	**Incorporation of Pedagogies**
Inorganic Chemistry Experiments	1. Determine the strength of acetic acid present in commercial vinegar solution (perform at least two exercises by using different sample solutions). 2. Determine the strength of commercial HCl acid sample. 3. Determine the strength of commercial H_2SO_4 acid sample. 4. Estimate the amount of sodium carbonate present in commercial sample. 5. Estimate the amount of sodium bicarbonate present in commercial sample. 6. Prepare 0.1 N standard oxalic acid solution and find out the acid neutralizing capacity (ANC) of an antacid using NaOH as an intermediate solution (perform at least two different samples) 7. Determine the amount of citric acid present in fruit juices (perform at least two exercises by using different sources of fruit juices like orange, lemon, grapefruit, white grape or lime juice, etc.)	By combining hands-on experiments, discussions, and real-world applications, students will gain a comprehensive understanding of chemistry lab practices. A few suggested pedagogies are: • Students should be given suitable **pre- and post-lab** assignments and explanation revising the theoretical aspects of laboratory experiments prior to and after the conduct of each experiment. • **Hands-On Laboratory Sessions:** Provide regular hands-on laboratory sessions where students can directly apply theoretical knowledge to practical experiments. • **Demonstrations and Simulations:** Use virtual simulations for certain experiments to enhance accessibility and understanding. • **Flipped Classroom Model:** Encourage students to come to class prepared, promoting active participation. • **Interactive Workshops:** Provide opportunities for students to engage in discussions, ask questions, and seek clarification. • **Technology Integration:** Incorporate digital tools for data analysis and presentation. • **Guest Lectures and Industry Connections:** Establish connections with professionals in the field to provide students with a broader perspective on chemical lab practices. • **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. • **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge • **Any other innovative pedagogy as applicable**
Physical Chemistry Experiments	1. Determination of thermodynamic values (ΔS°, ΔH°, and ΔG°) from the dissociation of a weak acid. 2. To determine transition temperature of $MnCl_2.4H_2O$. 3. To determine surface tension of a given unknown liquid by stalagmometer. 4. To determine parachor value of $-CH_2-$ group by stalagmometer. 5. To compare the cleaning power of detergents samples by stalagmometer. 6. To determine coefficient of viscosity of unknown liquid by Ostwald's viscometer. 7. To determine the relative viscosity of given liquid at room temperature by Ostwald's viscometer. 8. To determine heat of solution of KNO_3	

References:	1. Chemistry Lab manual: Pradeep singh and J S Bedi, Evergreen publication Jalandhar. 2. Vogel-A text book of quantitative inorganic analysis. 3. Kolthoff and Stenger- Volumetric analysis-Intersience 4. Kolthoff and Sandell-Text book of qualitative inorganic analysis 5. Vogel-A text book of qualitative inorganic analysis. 6. Practical Chemistry (for B.Sc. I, II and III year students) – O P Pandey, D. N. Bajpaiand S. Giri (S Chand and company Ltd 7. Kolthoff and Sandell-Text book of qualitative inorganic analysis 8. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press. 9. Practicals in physical chemistry a modern approach: P S Sindhu, 1st edition New Delhi. 10. Practical Physical Chemistry: Palit and De. 11. Systematic Experimental Physical Chemsitry: S W Rajbhoj and T K Chondekar, Third Edition, Aurangabad. 12. Advanced Practical Physical Chemistry, J B Yadav, 29Th edition Meerut. 13. Advanced Physical Chemistry Experiments, J N Gurtu and Amit Gurtu, 4th Revised Edition Meerut. 14. Chemistry Lab manual: Pradeep singh and J S Bedi, Evergreen publication Jalandhar. **Web resources:** 1. https://vlab.amrita.edu/?sub=2 2. https://chemcollective.org/vlabs 3. https://chem.libretexts.org/ 4. https://benthambooks.com/book/9781681089102/preface/
Model Questions:	**NA**

Distribution of Marks and the scheme of Practical Examination (Major/Minor):

Section 1: Internal Assessment

- Attendance 05 Marks
- Active participation in activities as a part of CAT (At least three tests) * 10 Marks
- Submission of duly certified record and assignment 05 Marks
- Internal Viva-voce 05 Marks

Total **25 Marks**

*Note: Based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Inorganic Chem Practical) 10 Marks
- Exercise 2 (Physical Chem Practical) 10 Marks
- Viva-Voce (External) 05 Marks

Total **25 Marks**

Generic /Open Elective- 3

108207 Food Safety, Adulteration, and Detection

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
4.5	**II**	**108207**	**Food Safety, Adulteration, and Detection**	2	30	2 Hrs	30 +20 = 50

Course Objectives:	The objectives of the course are: 1. to make aware about healthy food. 2. to make aware about risk of adulterated food. 3. to aware about detection of adulteration in some food items. 4. to aware about rules and regulations related to adulteration in foods.
Course Outcomes:	By the end of this course, the students will be able to: 1. recognize difference between adulterated and unadulterated food. 2. encourage society to use healthy food. 3. evaluate the economic and health impact of food adulteration. 4. propose innovative solutions for food safety and security. 5. develop educational materials to raise food safety awareness .

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	***Introduction to Food Safety*** a) Introduction- Food, Components of food. b) Importance of safe food for public health. c) Key regulatory bodies working for food safety and their roles. d) GMP (Good Manufacturing Practices) and GHP (Good Hygienic Practices)	8 Hrs	8 Marks	1. **Interactive Lectures:** Combines elements of traditional lectures with interactive activities to engage students. 2.**Project-Based Learning:** Assign project that involves solving a real-world problem. 3. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. 4. **Differentiated Instruction:** Tailor instruction to meet individual student needs, considering learning styles, interests, and readiness. 5. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. 6. **Role-Playing:** Act out scenarios.
Unit II	**Adulteration in Food** a)Definition and Types of Food Adulteration-Adulteration vs. contamination b)Foodborne Hazards-Microbial contaminants (bacteria, viruses, fungi), Chemical contaminants (pesticides, additives, preservatives), Physical contaminants (foreign objects) c) Causes of adulteration in food d) Consequences of adulteration in food	7 Hrs	7 Marks	
Unit III	**Detection Food Adulteration** a) Detection of- water in milk, detergent in milk b) Detection of other oils in coconut oil c) Detection of- sugar solution in honey, chalk powder in sugar d)Detection of Aluminium leaves in silver leaves e) Detection of- foreign resin in asafetida (hing), papaya seeds in black pepper f)Artificial colour in chilli powder, saw dust in chilli powder g) Detection of chalk in common salt h) Differentiation of common salt and iodized salt	8 Hrs	8 Marks	
Unit IV	**Food Safety Communication and Consumer Awareness** a) Importance of Communication in Food Safety-Communicating risks and preventive measures, Crisis communication in case of food safety issues b) Consumer Education and Empowerment-Promoting awareness about food safety, Understanding food labels and certifications c) Case Studies and Real-life Examples-Analyzing past incidents of food safety issues, Learning from success stories in ensuring food safety d) Future Trends in Food Safety-Discussing upcoming challenges and solutions, Integrating technology and policy for continuous improvement	7 Hrs	7 Marks	

References:	1. Food Safety: The Science of Keeping Food Safe by Ian C. Shaw, Publisher: Wiley (2018) 2. Food Safety Management: A Practical Guide for the Food Industry by Yasmine Motarjemi, Huub Lelieveld, Publisher: Academic Press (2014) 3. Food Safety: A Reference Handbook by Nina E. Redman, Publisher: ABC-CLIO(2018) 4. Food Safety and Standards: Acts, Rules and Regulations by Ashish Kumar Singh, Publisher: Wolters Kluwer (2018) 5. FAO/WHO guidance to governments on the application of HACCP in small and/or less-developed food businesses -FAO FOOD AND NUTRITION PAPER (86) by World Health Organization and Food and Agriculture Organization of the United Nations 6. Detect Adulteration with Rapid Test (DART) Booklet by Food Safety and Standards Authority of India 7. Food Safety: The Science of Keeping Food Safe by Ian C. Shaw, Publisher: Wiley-Blackwell (2019) 8. Food Safety Handbook by Richard L. Linton, L. Jean Dunn, and Gerald J. Cox, Publisher: Wiley (2016) 9. Food Adulteration and Food Fraud by John Spink and PhD Douglas C. Moyer, Publisher: Wiley (2016) 10. Food Adulteration: Incidents, Concerns, and Solutions by P.V. Ramesh and P. Venkatesh, Publisher: CRC Press (2019) 11. Food Fraud Prevention: Introduction, Implementation, and Management by John W. Spink, Publisher: Academic Press (2019) 12. Food Adulteration and Consumer Awareness by Suvendu Bhattacharya, Publisher: Springer (2014) **Web Resources:** 1. www.fssai.gov.in 2. https://youtu.be/eA0gmP4A8Z4 3. https://youtu.be/b6no4afqS6Q 4. https://youtu.be/X9eWJvbQN24 5. https://youtu.be/JEcQv8p708I 6. https://youtu.be/3xLHjXA1Sxw
Model Questions:	**Short Type** 1. What is the primary function of carbohydrates in the human body? 2. Why is safe food important for public health? 3. What is HACCP and why is it important in the food industry? 4. What is food adulteration? 5. What is food contamination? 6. How to detect adulteration of water in milk? 7. How to detect adulteration of artificial color in turmeric? 8. How to differentiate common salt from iodized salt? 9. What is the primary goal of GHP (Good Hygiene Practices)? 10. What is crisis communication in food safety?
	Long Type 1. What is the importance of communication in food safety? 2. What do you understand from food labels? 3. What are the key principles of GMP (Good Manufacturing Practices)? 4. What are the different factors in consumer education for food safety? 5. What are the consequences of food adulteration?
	MCQs 1. What is the primary function of carbohydrates in the body? a. Provide long-term energy storage b. Build and repair tissues c. Regulate body temperature d. Support immune function 2. What does GHP stand for? a. Good Handling Practices b. Good Hydration Practices c. Good Hygiene Practices d. Good Harvesting Practices 3. What does HACCP stand for? a) Hazardous Analysis and Critical Control Points b) Hygiene and Control in Food Production c) Hazard Analysis and Critical Control Points d) High Accuracy in Cooking and Culinary Procedures 4. Which of the following is an example of chemical contaminants? a) Virus b) Bacteria c) Fungi d) Pesticides 5. What is the primary purpose of ensuring food safety? a) To enhance the taste of food b) To prevent food spoilage c) To protect public health d) To increase food production 6. Why is it important to check the expiration date on food products? a) To ensure the food is at the peak of freshness b) To prevent overconsumption c) To reduce food waste d) To avoid consuming expired or spoiled food that may cause illness 7. Generally, papaya seeds are used as adulterant in _____. a) Black pepper b) Chili powder c) Milk d) Hing

	8. Generally, Aluminum leaves are used as adulterant in _____. a) Tea leaves b) Silver leaves c) Coffee powder d) Chili powder 9. Which health organization often advocates for the iodization of salt to address iodine deficiency globally? a) World Health Organization (WHO) b) International Monetary Fund (IMF) c) United Nations Educational, Scientific and Cultural Organization (UNESCO) d) Centers for Disease Control and Prevention (CDC) 10. What is the primary goal of consumer education? a) To increase product prices b) To enhance consumer spending c) To empower consumers to make informed choices d) To promote impulse buying

Generic/ Open Elective – 4

108208 Entrepreneurship in Chemistry

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
4.5	II	**108208**	**Entrepreneurship in Chemistry**	2	30	2 Hrs	30+20 =50

Course Objectives:	The objectives of the course are: 1. to develop an entrepreneurial mindset 2. to identify business opportunities 3. to explore case studies 4. to analyze industry trends			
Course Outcomes:	By the end of this course, the students will be able to: 1. analyze market trends and consumer demands to make informed business decisions. 2. assess the viability and feasibility of a proposed chemical business model. 3. evaluate funding options and choose the most suitable for a given chemical startup. 4. generate innovative ideas for new chemical products or processes. 5. develop a comprehensive business plan for a unique chemical startup.			
Unit System	**Contents**	**Workload Allotted**	**Weightage of Marks Allotted**	**Incorporation of Pedagogies**
Unit I	***Introduction to Entrepreneurship in Chemistry*** a) a) Understanding entrepreneurship in the context of chemistry b) Importance of entrepreneurship in the field of chemistry c) Examining successful entrepreneurial stories in the history of chemistry d) Case Studies-Analyzing case studies of successful chemical entrepreneurs	8 Hrs	8 Marks	1. **Interactive Lectures:** Combines elements of traditional lectures with interactive activities to engage students. 2. **Project-Based Learning:** Assign project that involves solving a real-world problem or creating a product. 3. **Case-Based Learning:** Analyze and discuss real or hypothetical cases to apply theoretical knowledge. 4. **Differentiated Instruction:** Tailor instruction to meet individual student needs, considering learning styles, interests, and readiness. 5. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research.
Unit II	***Identifying Opportunities in Chemistry*** a) Understanding market trends and demands b) Identifying niche markets and gaps in the chemical sector c) Assessing the role of technology in chemical entrepreneurship d) Identifying opportunities for innovation in chemical processes	7 Hrs	7 Marks	
Unit III	***Planning and Launching a Chemical Venture*** a) Developing a business plan for a chemical venture b) Exploring funding options for chemical startups c) Environmental and safety considerations d) Creating compelling presentations for investors and stakeholders.	8 Hrs	8 Marks	
Unit IV	***Managing and Scaling in the Chemical Entrepreneurship*** a) Efficient management of chemical production processes b) Supply chain optimization and logistics c) Strategies for marketing chemical products d) Building a strong brand identity in the chemical sector	7 Hrs	7 Marks	
References:	1. Entrepreneurship Development in Chemical Science by Kishore R. Chadha, Publisher: PHI Learning Private Ltd, 2009 2. Entrepreneurship in Chemical Engineering by Ravindra Kumar Gupta, Publisher: I.K. International Publishing House Pvt. Ltd., 2007 3. Chemical Engineering Entrepreneurship by S. N. Upadhyay, Publisher: I.K. International Publishing House Pvt. Ltd., 2009 4. Chemical Entrepreneurship by William F. Cooper, Publisher: Oxford University Press, 2013 5. Entrepreneurship in the Chemical and Biotechnology Industries by Shlomo Maital and Sivan Fuchsmann , Publisher: Edward Elgar Publishing, 2007 6. The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail by Clayton M. Christensen, Publisher: Harvard Business Review Press, 1997 7. Starting a Tech Business: A Practical Guide for Anyone Creating or Designing Applications or Software by Alex Cowan, Publisher: Wiley, 2012			

	8. Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers by Alexander Osterwalder and Yves Pigneur, Publisher: Wiley, 2010 9. The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses by Eric Ries, Publisher: Crown Business, 2011 10. Intellectual Property in the New Technological Age by Robert P. Merges and Peter S. Menell, Publisher: Wolters Kluwer, 2019 11. Bioprocess Engineering Principles by Pauline M. Doran, Publisher: Academic Press, 2019 12. The Art of the Start 2.0: The Time-Tested, Battle-Hardened Guide for Anyone Starting Anything by Guy Kawasaki, Publisher: Portfolio, 2015 13. Chemical Engineering in the Pharmaceutical Industry: R&D to Manufacturing by Michael Levin, Publisher: Wiley, 2011 14. MIT OpenCourseWare
Model Questions:	**Short Type** 1. What is the role of entrepreneurship in the field of chemistry? 2. How does an entrepreneurial mindset benefit a chemist? 3. Why is market analysis important in chemical entrepreneurship? 4. What role does intellectual property play in chemical entrepreneurship? 5. Explain the concept of the business model canvas in the context of chemical entrepreneurship. 6. How can chemical entrepreneurs secure funding for their ventures? 7. Why is supply chain management important in chemical entrepreneurship? 8. What challenges do chemical entrepreneurs face in scaling up their ventures? 9. How does branding contribute to the success of a chemical venture? 10. What are some common exit strategies for chemical entrepreneurs?
	Long Type 1: Describe the key challenges faced by entrepreneurs in the chemical industry and discuss strategies to overcome these challenges. 2: Explain the role of intellectual property (IP) in entrepreneurship within the field of chemistry. Provide examples of how entrepreneurs can protect their innovations. 3: Discuss the impact of technological advancements on entrepreneurship in the chemical industry. Provide examples of how technology has driven innovation and business growth in this sector. 4: Explain the scenario of chemical industry in India.
	MCQs for Internal Assessment 1. What does the term "Entrepreneurship" in chemistry refer to? a) Discovering new chemical elements b) Starting and managing chemical businesses c) Conducting research in chemistry laboratories d) Teaching chemistry in academic institutions 2. Which of the following is a key trait of successful chemical entrepreneurs? a) Avoiding all types of risks b) Resisting change and innovation c) Having an entrepreneurial mindset d) Preferring theoretical knowledge over practical experience 3. Why is market analysis crucial in chemical entrepreneurship? a) To memorize market trends b) To identify niche markets and demands c) To avoid competition d) To focus only on local markets 4. What is the role of intellectual property in chemistry entrepreneurship? a) To limit the dissemination of scientific knowledge b) To discourage innovation c) To protect chemical innovations through patents d) To hinder collaboration in the industry 5. What is the purpose of a business model canvas in chemical entrepreneurship? a) To create abstract art related to chemistry b) To visualize and plan the key elements of a business c) To measure chemical reactions in a laboratory d) To design chemical experiments 6. Why is scalability important in the context of chemical entrepreneurship? a) To limit the growth of a chemical venture b) To ensure a small and manageable operation c) To handle increased demand and growth d) To avoid entering global markets 7. What legal and regulatory considerations are important for chemical entrepreneurs? a) Ignoring regulations for faster growth b) Complying with environmental and safety regulations c) Avoiding legal processes for cost reduction d) Focusing only on international regulations 8. What does the term "exit strategy" mean in the context of chemical entrepreneurship? a) A plan to close the business permanently b) A strategy to avoid competition c) A plan to exit a market segment d) A planned way to leave or cash out of a business

	9. In the context of chemical entrepreneurship, what does "Lean Startup" methodology emphasize? a) Focusing on traditional and time-consuming methods b) Efficient use of resources and quick adaptation c) Ignoring customer feedback d) Avoiding innovation and experimentation 10. How can technology and innovation contribute to chemical entrepreneurship? a) By hindering progress and traditional practices b) By making chemical processes more complex c) By providing opportunities for new and improved products and processes d) By isolating chemical entrepreneurs from the technological advancements

Course Category: **Vocational Skill Course VSC-1**

108209 Lab- 4 (Chemical Laboratory Practices)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
4.5	II	108209	Lab- 4 (Chemical Laboratory Practices)	2	60	--	50

Course Objectives:	The intended objectives are: 1. Aware the students about the essential safety protocols in a chemical laboratory. 2. Develop proficiency in fundamental chemical laboratory techniques. 3. Follow established SOPs for various chemical experiments.
Course Outcomes:	At the end of this course students will be able: 1. To implement fundamental safety protocols, ensuring a secure working environment in the chemical laboratory. 2. To consistently follow established SOPs for various chemical experiments. 3. To prepare solution of desired concentration.. 4. To maintain accurate and thorough records of experimental data, and analyze results to draw meaningful conclusions. 5. To apply critical thinking skills to identify and address challenges that may arise during experiments, showcasing the ability to troubleshoot and optimize procedures. 6. To gain insights into how chemical lab practices are applied in professional research or industrial settings, preparing them for future careers in diverse scientific and industrial fields. 7. Students will demonstrate ethical conduct in all aspects of laboratory work, emphasizing integrity, responsibility, and professionalism. 8. To gain insights into how chemical lab practices are applied in professional research or industrial settings, preparing them for future careers in diverse scientific and industrial fields.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	1. Introduction to common laboratory glassware and instruments used in practical course 2. SOPs for instruments used in practical course 3. Importance of Calibration with reference to accuracy, precession and minimization of errors.	By combining hands-on experiments, discussions, and real-world applications, students will gain a comprehensive understanding of chemistry lab practices. A few suggested pedagogies are: • Students should be given suitable **pre- and post-lab** assignments and explanation revising the theoretical aspects of laboratory experiments prior to and after the conduct of each experiment. • **Hands-On Laboratory Sessions:** Provide regular hands-on laboratory sessions where students can directly apply theoretical knowledge to practical experiments. • **Demonstrations and Simulations:** Use virtual simulations for certain experiments to enhance accessibility and understanding. • **Flipped Classroom Model:** Encourage students to come to class prepared, promoting active participation. • **Interactive Workshops:** Provide opportunities for students to engage in discussions, ask questions, and seek clarification. • **Technology Integration:** Incorporate digital tools for data analysis and presentation. • **Guest Lectures and Industry Connections:** Establish
Lab Safety demonstrations	1. Recognition of Safety symbols, chemical packings and instruments together with the conception of MSDS. 2. Introduction to pictogram of chemical used. (Acids, Bases, Solvents and Salts) 3. Material Safety Data Sheets with reference to hazardous chemicals like $K_2Cr_2O_7$, Benzene, Cadmium nitrate, β-naphthol, CCl_4 and Mercury. 4. Precautions in handling of hazardous substances like conc. acids, ammonia, organic solvents like ether and alcohol. 5. Demonstration of first aid measures for chemical accidents. 6. Demonstration of preventive measures for chemical spills. 7. Demonstration of first aid measures, when chemical materials entered in human body through Eye, Mouth and Skin.	
Solution preparation skills	1. Preparation of 0.1 N solution of oxallic acid and calculate its molarity. 2. Preparation of 0.1 N solutions of sulfuric acid and calculate its molarity. 3. Prepare a stock solution of 1 M NaOH. Prepare 0.5 M, 0.1 M, 0.01 M, and 0.05 M by dilution method using the stock solution. 4. Preparation of 0.1 M and 0.01 M solutions of HCl. 5. Prepare a stock solution of 100 ppm $KMnO_4$. And prepare its 10 ppm and 1 ppm solutions by dilution method. 6. Preparation of 1 or 2% w/v solutions of NaOH/ NaCl, 7. Preparation of 1 or 2% v/v solutions of Acetic acid, HCl, HNO_3, H_2SO_4. 8. Preparation of 0.1 M solutions of ammonia.	

	9. Preparation of a buffer solution of pH= 4. 10. Preparation of a buffer solution of pH= 7. 11. Preparation of a buffer solution of pH= 9.2.	connections with professionals in the field to provide students with a broader perspective on chemical lab practices.
References	1. Instrumental Analysis by Douglas A. Skoog, F. James Holler, Stanley R. Crouch (2006) 2. Fundamental of Analytical Chemistry by Douglas A. Skoog, West, F. James Hollers'. Crouch (2009) 3. Modern Analytical Chemistry by David Harvey, McGraw-Hill Higher Education (1999) 4. S.M. Khopkar, "Basic Concepts of Analytical Chemistry", IInd Edition New Age International Publisher (2004) 5. Principles of Instrumental Analysis, D. A. Skoog, F. James Holler, Stanley R. Crouch (2007) 6. Vogel's Textbook of quantitative chemical analysis, 5th edition (1989), Instrumental method of analysis, B.K. Sharma, Goel publishing house. Miscellaneous methods (2005) **Web resources:** 1. https://vlab.amrita.edu/?sub=2 2. https://chemcollective.org/vlabs	
Model Questions:	**NA**	

Distribution of Marks and the scheme of (VSC) Practical Examination is as follows:

Internal Assessment

• Active participation in activities	15 Marks
• Continuous Assessment Tests (CAT) (At least three tests) *	20 Marks
• Submission of duly certified practical record	10 Marks
• Internal examiner viva-voce	05 Marks
Total	**50 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Course Category: **Skill Enhancement Course SEC-2**

108210 Lab- 5 (IT Skills for Chemists)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
4.5	II	108210	Lab- 5 (IT Skills for Chemists)	2	60	--	50

Course Objectives:	The intended objectives are: 1. Develop proficiency in utilizing IT tools and software relevant to the field of chemistry. 2. Gain hands-on experience in utilizing IT resources for laboratory experiments and simulations in the realm of chemistry. 3. Enhance problem-solving capabilities by integrating IT skills into various aspects of chemical research and analysis. 4. Explore the application of IT in chemical modelling, visualization, and computational chemistry. 5. Cultivate a proactive and adaptive mindset towards emerging technologies in the intersection of IT and chemistry.
Course Outcomes:	At the end of this course students will be able: 1. To demonstrate utilization of IT tools and software applications relevant to the field of chemistry. 2. To utilize IT resources effectively in laboratory experiments and simulations, enhancing experimental design and data visualization capabilities. 3. To design and perform experiments to use IT techniques for chemistry problems and research. To promote interdisciplinary collaboration through the use of IT tools to enhance communication and cooperation among professionals in chemistry and related fields. 4. To exhibit competence in using IT tools for efficient information retrieval, literature review, and staying updated on the latest developments in the field of chemistry. 5. To develop a proactive and adaptive mindset towards emerging technologies.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	1. Introduction to IT in Chemistry • Overview of IT tools and software in chemistry • Importance of IT skills in modern chemical research 2. Introduction to Molecular modeling and simulations using IT tools 3. Stoichiometry Tutorials: Making a Standard Solution from Another Solution: Dilution 4. Introduction to the fundamentals and advanced applications of ISIS Draw/ChemSketch/KingDraw/ChemDraw, including drawing chemical structures, reactions and collaborative features, to equip students with essential skills for chemical research and communication.	By combining hands-on training, discussions, and real-world applications, students will acquire comprehensive understanding regarding various IT tools in chemistry. A few suggested pedagogies are: • **Hands-On Workshops:** Conduct workshops where chemists actively use software like ChemDraw, molecular modeling tools, and databases. Allow them to perform tasks such as drawing structures, predicting properties, and retrieving information. • **Demonstrations and Simulations:** Use virtual simulations for certain experiments to enhance accessibility and understanding. • **Problem-Based Learning (PBL):** Foster problem-solving skills by applying IT tools to real-world chemical challenges. • **Flipped Classroom:** Assign pre-class readings or video lectures on IT tools and reserve class time for discussions, problem-solving, and collaborative use of software tools. • **Collaborative Learning:** Assign group projects that require chemists to collectively use IT tools. This promotes knowledge sharing, problem-solving discussions, and a collaborative approach to learning and applying IT skills. • **Interactive Workshops:** Provide opportunities for students to engage in discussions, ask
Experiments on PhET Simulation Tools	1. To investigate factors that affect reaction rates, such as concentration, temperature, and surface area in Chemical Reactions 2. To study how changing temperature, pressure, or volume affects gas properties. 3. To investigate how changing the number and arrangement of atoms influences molecular geometry. 4. To study the impact of temperature and concentration on solubility.	
Experiments on ChemCollective and Amrita Virtual Lab	1. Determine the absolute viscosity of organic liquids. 2. To determine the amount of substance in a solution of unknown concentration using various titrimetric methods. 3. To estimate the amount of barium in the whole of the given solution of barium chloride. 4. Determine the concentration of an unknown HCl solution using NaOH. 5. Determining the solubility of copper chloride at different temperatures. 6. Determine the concentration of unknown silver nitrate solution.	

Experiments on Structure drawing Software such as ChemSketch, ISIS draw, KingDraw, Chemdraw (Windows or Android)	1. Generate structural isomers for a given molecular formula:C_5H_{12}, draw all the possible isomers of pentane. 2. Illustrate the complete curly arrow mechanism of a chemical reaction. Choose a reaction (e.g., nucleophilic substitution, addition reaction) and draw the step-by-step mechanism, including any intermediates and transferring it to MS Word and/or MS PowerPoint (Overall Reaction and its mechanism expected). 3. Draw enantiomers and diastereomers for a given compound. Highlight the stereocenters and demonstrate how the isomers differ. 4. Select a molecule with rotatable bonds and draw its various conformations. Emphasize the most stable conformation and explain the reasons behind its stability. (Drawing 2D- structures of conformations of ethane, butane, and cyclohexane.) 5. Draw a coordination complex with a transition metal center and ligands. Specify the coordination number and geometry of the complex. 6. Drawing 2D- structures of ten heterocyclic compounds and their bi- and tri-substituted derivatives (four derivatives each) 7. Drawing the 2D-structures of at least three marketed drugs and reporting their IUPAC name, usage, and mechanism of action. 8. Conversion of 2D- structures of compounds drawn in Experiment 7 and 8 to their SMILES notations and transferring it to MS Excel spreadsheet in a tabular format. 9. Conversion of 2D- structures of compounds drawn in experiments 7 and 8 to 3D- optimized structures using MMFF94 forcefield and saving as .sdf or .mol file format. 10. Drawing the 2D- structures of five and six membered monosaccharides (Glucose and ribose). 11. Drawing well labelled diagram of simple distillation assembly using ChemSketch.	questions, and seek clarification. • **Technology Integration:** Incorporate digital tools for data analysis and presentation. • **Guest Lectures and Industry Connections:** Establish connections with professionals in the field to provide students with a broader. • **Guest Lectures and Industry Connections:** Establish connections with professionals in the field to provide students with a broader perspective on chemical lab practices. • **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. • **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge.
Effective use of MS excel	1. Use of excel sheets to develop formulae to calculate normality, molarity, molality, etc. 2. Use of MS Excel to draw scatter plot between molecular weight and number of total atoms, molecular weight and number of carbons atoms, molecular weight and number of hydrogen atoms 3. To create a database of drugs used for a disease using ISIS draw and MS Excel	
References:	**Web resources:** 3. https://vlab.amrita.edu/?sub=2 4. https://chemcollective.org/vlabs 5. https://phet.colorado.edu/ 6. https://chemdrawdirect.perkinelmer.cloud/js/sample/index.html	
Model Questions:	**NA**	

Distribution of Marks and the scheme of (SEC) Practical Examination is as follows:

Internal Assessment

The 50 marks fragmentation as follows:

- Active participation in activities 15 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 20 Marks
- Submission of duly certified practical record 10 Marks
- Internal examiner viva-voce 05 Marks

Total **50 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

SANT GADGE BABA AMRAVATI UNIVERSITY, AMRAVATI

Degree of Bachelor of Science

Chemistry

Semester III and IV

FACULTY: SCIENCE AND TECHNOLOGY

(Courses effective from Academic Year 2026-27)
Under NEP 2020 (As per Uniform NEP Scheme)

SYLLABUS

Contents

TLE Scheme for SECOND YEAR: SEMESTER – III (Level 5.0)

Subject	The Vertical	Course Code	Course Title	Credits	Workload	Theory/Practical				Theory/Pract (Total)	
						External		Internal			
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks
Chemistry	Major-T	108211	General Chemistry-3	2	2	30	9	20	6	50	20
Chemistry	Major-T	108212	Inorganic Chemistry-1	2	2	30	9	20	6	50	20
Chemistry	IKS-T	108213	IKS in Chemistry	2	2	30	9	20	6	50	20
Chemistry	Major-P	108214	Chemistry Lab 6	2	4	25	10	25	10	50	20
Chemistry	Minor-T	108215	Minor Chemistry-1	2	2	30	9	20	6	50	20
Chemistry	Minor-P	108216	Minor Chemistry Lab 7	2	4	25	10	25	10	50	20
Chemistry	GOEC-T	108217	Chemistry for Competitive Examinations	2	2	30	9	20	6	50	20
Chemistry	VSC-P	108218	Chemistry Lab -8 (Preparation of Commercial products)	2	4	-	-	50	20	50	20
Chemistry	FP/CES	108219	Chemistry Lab 9 (FP/ CEP in Chemistry - I)	2	4	-	-	50	20	50	20
Chemistry	CC		Separate SOP will be released	2	4	-	-	50	20	50	20

Important: * VSC Should be Complementary to Major ** SEC has to be selected from the Basket Provided by University, from the same Faculty/Discipline of the Major/Minor

TLE Scheme for SECOND YEAR: SEMESTER – IV (Level 5.0)

Subject	The Vertical	Course Code	Course Title	Credits	Workload	Theory/Practical				Theory/Pract (Total)	
						External		Internal			
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks
Chemistry	Major-T	108220	Organic Chemistry-1	2	2	30	9	20	6	50	20
Chemistry	Major-T	108221	Physical Chemistry-1	2	2	30	9	20	6	50	20
Chemistry	Major-T*	108229*	Analytical Chemistry	2	2	30	9	20	6	50	20
Chemistry	Major-P	108222	Chemistry Lab 10	2	4	25	10	25	10	50	20
Chemistry	Minor-T	108223	Minor Chemistry 2	2	2	30	9	20	6	50	20
Chemistry	Minor-P	108224	Minor Chemistry Lab 11	2	4	25	10	25	10	50	20
Chemistry	GOEC-T	108225	Chemistry for Sustainable Agriculture	2	2	30	9	20	6	50	20
Chemistry	VSC-P	108226	Chemistry Lab 12 (Synthesis and extraction of industrial products)	2	4	-	-	50	20	50	20
Chemistry	SEC-P#	108227#	**Chemistry Lab 13 (Basic Cheminformatics)** **(Discontinued from 2026-27)**	2	4	-	-	50	20	50	20
Chemistry	FP/CES	108228	**Chemistry Lab 14 (FP/ CEP in Chemistry - II)**	2	4	-	-	50	20	50	20
Chemistry	CC		Separate SOP shall be consulted from University website	2	4	-	-	50	20	50	20

* To be implemented w.e.f. academic session 2026-27 # - Only applicable up to academic session 2025-26

Important: VSC Should be Complementary to Major and SEC has to be selected from the Basket Provided by University, from the same Faculty/Discipline of the Major/Minor

Examination and Assessment Process:

i. The basic principle of the Credit framework is that Credits are a function of the successful completion of a program of study/ vocational education/ training and assessment. No Credit can be earned by the student unless the student is assessed for the achievement of the desired competencies and outcome of a program.

ii. Exit options are provided with Certificate, Diploma and Basic Bachelor's degrees to the students at the end of the second, fourth and sixth semesters of a Four Years Multidisciplinary Degree Programme. Students will receive a Bachelor's degree with Honors/ Research on successfully completing of all eight semesters of the UG Program either at a stretch or with opted exits and re-entries.

iii. For the smooth success of four-year degree programme with multiple entry and exit systems, the examination mode should be based on the combination of innovative trends in formative (informal and formal tests administered during the learning process) and summative (evaluation of students learning at the end of an instructional unit) examination modes in line with the UGC Report on 'Evaluation Reforms in Higher Educational Institutions (2019).

Examination, Evaluation and Assessment Scheme

The total marks for each Course shall be based on Continuous Assessment and Semester End Examination. Each theory course of Major, Minor, GE/OE, AEC, IKS, VEC as mentioned in **Teaching Learning Scheme** prepared by the Board of Studies shall be evaluated as per the scheme as mentioned in the following table

Examination, Evaluation and Assessment Scheme

Vertical No.	The Vertical	Mode of Examination, Evaluation & Assessment	Theory				Theory (Total)		Practical				Practical (Total)	
			External		Internal				External		Internal			
			Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks
A	Major	External & Internal	30/60	9/18	20/40	6/12	50/100	20/40	25/50	10/20	25/50	10/20	25/50	10/20
B	Minor		30/60	9/18	20/40	6/12	50/100	20/40	25/50	10/20	25/50	10/20	25/50	10/20
C	Generic/ Open Elective	Internal			50	20	50	20	--	--	50	20	50	20
D	VSC	Internal			50	20	50	20			50	20	50	20
	SEC	Internal	--	--	50	20	50	20			50	20	50	20
e	AEC (Eng. & One MIL Composite)	Internal			50	20	50	20						
	IKS (Generic)	Internal			50	20	50	20						
	VEC	Internal			50	20	50	20						
F	Internship/ Apprenticeship	Internal	Assessment of these verticals shall be based on various activities/practices. The evaluation/assessment shall be done by appointing external examiner by principal from Industry/Organisation/Academia. The mentor faculty shall be the internal examiner. It shall be evaluated by giving maximum 50 marks per 2 Credit Course with separate activity weightages/levels. A detailed SOP for this assessment process shall be prescribed separately.											
	FP/CEP													
	CC													

Continuous Assessment Tests (CAT)

For internal assessment, the Continuous Assessment Tests (CAT) shall be conducted as under-

i. Three CAT each of 8 / 10 Marks (Theory) as applicable and 10 Marks (Practical).
   - First on completion of 25% Syllabus of the course or on completion of 25 teaching days,
   - Second on completion of 50% Syllabus of the course or on completion of 50 teaching days,
   - Third on completion of 75% Syllabus of the course or on completion of 75 teaching days.

ii. Each concurrent assessment (CAT-I, II & III) will be mapped to relevant Course

Learning Outcome.

iii. Total Performance in CAT (i.e.40 %) shall be based on the **best two out of three** in CAT examinations

iv. Internal assessment (CAT) shall be carried out by the respective course teacher by choosing variety of assessment tools/methods such as class test, record book, seminar, case study, field work, mini project work, quiz or any innovative method, which may be deemed to be appropriate for assessing the relevant course outcome.

Conduction of the Examination:

As per the scheme of teaching, learning, examination and evaluation, theory/practical examinations of Semester-I, II, III, IV, V, VI, VII and VIII shall be conducted by the University (except for Internal Examinations as applicable) at the end of each semester.

The theory/practical examinations of all the Semesters shall be held as per the following Schedule

Sr.No.	Name of the Examination	End Sem Examination	Supplementary Examination*
1	Semester-I, III, V and VII	Winter	Summer
2	Semester-II, IV, VI and VIII	Summer	Winter

*****The University may evolve mechanism for conducting repeat end semester examination. Such repeat examinations shall have to be conducted within one month of the regular even semester examination and on demand examination.

1. The practical examination of all semesters shall be conducted by the University at the end of each semester. The HEI shall conduct the Practical examination of odd semesters as per the schedule announced by the University. **However, the appointment of the External and Internal Examiners shall be done by the Head or Principal of respective HEI to conduct external examination of the odd semester and the same should be communicated to the University before commencement of the practical examination.** The University shall conduct the external practical examination of all even semester by appointing external and internal examiners.
2. The examinations specified above shall be held twice in a year at such places and on such dates as may be prescribed by the University.
3. An applicant to an examination specified above, shall pursue a regular course of study in courses prescribed for the examination concerned for not less than one semester in a particular semester in a College/Institute/University department.
4. Provided that the student shall be eligible to appear for examination if -
   a. He/she complies with the provisions of the Ordinance pertaining to the Examination in general from time to time.
   b. He/she has prosecuted a regular course of study in a university department/college affiliated to the University.

c. He/she has in the opinion of the Principal shown satisfactory progress in his/her studies.

5. The provisions of Ordinance No. 6 and Ordinance No. 9 shall be *mutatis-mutandis* applicable to every collegiate/non-collegiate student.
6. The fees for each theory examination and practical examination conducted by the university shall be as prescribed by the University, from time to time.

Course Category: **Major (Theory)**

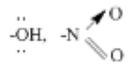
108211 General Chemistry-3

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	III	108211	General Chemistry-3	2	30	2 Hrs	30+20=50

Course Objectives:	1. Students will learn Fundamentals of organic chemistry and functional group approach for hydrocarbons. 2. To make the students proficient in thermodynamic principles and their mathematical formulations, preparing them for advanced studies in physical chemistry 3. To equip the students with a comprehensive understanding of colligative properties, enabling them to apply theoretical concepts and experimental techniques to real-world chemical systems.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Compare the reactivity of Hydrocarbons. 2. Explain the mechanisms of E1, E2, and E1cB reactions. 3. Rationalize for regioselectivity in addition and elimination reactions 4. Describe the structure of benzene and its stability 5. Write the mechanism of ArES reactions 6. Predict and rationalize the directive influence of a group in ArES. 7. Define Colligative Properties and associated terms 8. Apply Thermodynamic Principles to Colligative Properties 9. Solve numerical related to Thermodynamics and Colligative properties.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	***Aliphatic Hydrocarbons:*** ***A) Alkanes****:* Formation of alkanes, Wurtz Reaction, Wurtz- Fittig Reactions, Free radical substitutions: Halogenation - relative reactivity and selectivity. ***B) Alkenes:*** Formation of alkenes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), Reactions of alkenes: Oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-& 1,4-addition reactions in Dienes, Diels-alder reaction. Allylic and benzylic bromination. ***C) Alkynes:*** Preparation of alkynes: by Double Dehydrohalogenation of vicinal and geminal dihalides. Acidity of terminal alkynes. Reactions: Addition of halogens, hydrogen halides and hydration	8 Hrs	8 Marks	**1. Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. 2. **Hands-On Models**: use of model 3. **Problem-Solving Sessions**: Organize regular problem-solving sessions. 4. Explore virtual labs and simulations to enhance understanding of the topic. 5. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. 6. Ask students to create concept maps that illustrate the relationships
Unit II	***A) Arenes:*** Introduction**,** derivatives of benzene and their nomenclature (mono, di and tri substituted benzenes). Structure of benzene: Kekules, Resonance Structures, and Molecular orbital picture. ***B)*** **Reactivity of benzene**: Mechanism of Electrophilic substitution reactions: Nitration, Sulphonation, Nuclear Halogenation and Friedel - Crafts reaction with mechanism, oxidation of side chain, reduction of benzene. **Orientation Effect**: Effects of substituent groups (o/p and meta	7 Hrs	7 Marks	

	directing groups), activating and deactivating groups. Directive influence of various groups (-OH, CH_3, - Cl, -NO_2) on the basis of modern electronic theory. ***C)*** **Polynuclear Hydrocarbons:** Definition and Classification **Naphthalene:** Haworth Synthesis. Resonance structure and Molecular orbital picture of Naphthalene. Orientation of Electrophilic Substitution in Naphthalene. **Chemical Reactions-** Electrophilic substitution reaction: Halogenation, Nitration, Sulphonation, Friedel-Crafts Alkylation, Friedel-Crafts Acylation, Chloro-methylation			between different concepts. 7. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. 8. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. 9. **Any other innovative pedagogy as applicable.**
Unit III	**Thermodynamics:** Introduction, Important terms: Gibbs and Helmholtz free energy (Work function). Physical significance of Gibbs free energy and Helmholtz free energy, Derivation of variation of Gibbs free energy with temperature and Pressure, Derivation of variation Helmholtz free energy with temperature and volume, Change in free energy as a criterion of spontaneity and equilibrium, Derivation of Gibbs-Helmholtz equation and its applications, Nernst heat theorem, Statement of third law, Numerical.	8 Hrs	8 Marks	
Unit IV	**Colligative Properties of Dilute Solutions:** Introduction, Important terms: Colligative properties, Lowering of Vapour pressure, Relative lowering of vapor pressure, Elevation of boiling point, Depression of freezing point and Osmotic pressure. Importance and applications of colligative properties. Raoult's law of relative lowering of vapour pressure. **Elevation of boiling point**: Thermodynamic derivation of the relationship between elevation of boiling point and the molar mass of non-volatile solute. Cottrell's method for the determination of elevation of boiling point and hence the molar mass of solute. **Depression of freezing point**: Thermodynamic derivation of the relationship between depression of freezing point and the molar mass of non-volatile solute. Rast's method for the determination of molar mass of solute. **Osmotic Pressure, and osmosis**: Determination of Molecular weight of solute by osmotic pressure. Isotonic solutions. **Abnormal behavior of solution:** Vant Hoff's factor 'i'. Determination of degrees of association and degree of dissociation from Van't Hoff's factor. Numericals.	7 Hrs	7 Marks	
References:	1. Organic Chemistry Vol. I, II and III by Mukharjee, Singh and Kapoor- Wiley Eastern. 2. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 3. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007) 4. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008). 5. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford Universitiy Press. 6. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher, (2000). 7. Organic Chemistry by S.K. Ghosh. 8. Reaction Mechanism in Organic Chemistry by S.M. Mukharjee and S.P. Singh. 9. Stereochemistry and mechanism through solved problems by P.S. Kalsi. 10. Organic Chemistry by TWG Solomons, 8th edition, John Wiley 11. Organic Chemistry by R. K. Bansal 12. Physical Chemistry: Walter, J. Moore, 5th edn., New Delhi. 13. Physical Chemistry: G.M. Barrow, McGraw Hill, Indian Edn. 14. Principles of Physical Chemistry: Maron and Prutton. 15. Principles of Physical Chemistry: Puri, Sharma, and Pathania.			

	16. Physical Chemistry: P.W. Atkins, 6th Edn. 17. Physical Chemistry: Levine **Web resources:** 1. Introductory Organic Chemistry I- https://nptel.ac.in/courses/104106119 2. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Hydrocarbons/Arenes 3. https://nowgonggirlscollege.co.in/attendence/classnotes/files/1631169122.pdf 4. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Basic_Principles_of_Organic_Chemistry_(Roberts_and_Caserio)/22%3A_Arenes_Electrophilic_Aromatic_Substitution/22.08%3A_Substitution_Reactions_of_Polynuclear_Aromatic_Hydrocarbons 5. https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Chemistry_-_The_Central_Science_(Brown_et_al.)/19%3A_Chemical_Thermodynamics 6. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/The_Live_Textbook_of_Physical_Chemistry_(Peverati)/14%3A_Properties_of_Solutions/14.02%3A_Colligative_Properties
Model Questions:	**Short Type (At least 8)** 1. Arrange the following in increasing order of boiling point. (i) n-pentane, (ii) isopentane and (iii) neopentane 2. Comment on Saytzeff rule 3. Comment on Hofmann elimination reaction 4. Define activating group. 5. Name the intermediate involved in ArES. 6. Which of the following groups are ortho-para directing and meta directing? -COOH, -CHO, -CH_3, -NH_2, -Cl, -SO_3H  7. Define Gibbs Free energy 8. Define boiling point 9. What is Vant Hoff's factor?
	Long Type (At least 4) 1. Explain the Formation of alkanes using Wurtz Reaction, Wurtz- Fittig Reactions, 2. Explain Mechanism of E_1, E_2 and E_1cB reactions with suitable example. 3. Explain the acidity of terminal hydrogen in alkyne. 4. What are ring activating and ring deactivation groups? Explain with suitable examples. 5. Discuss the mechanism of acetylation of benzene 6. How does benzene react with - i) H_2 in presence of nickel catalyst ii) Cl_2 in presence of halogen carrier iii) Conc. HNO_3 and Conc. H_2SO_4 iv) CH_3Cl in presence of anhydrous $AlCl_3$ 7. How will you obtain the following from benzene? i) Toluene ii) Acetophenone iii) Chlorobenzene iv) Nitrobenzene. 8. Derive Gibbs-Helmholtz equation. 9. Derive Gibb's-Duhem equation 10. Derive Vant Hoff's reaction isotherm
	MCQs for Internal Assessment (At least 8) 1. The addition of HBr on 2-butene in presence of peroxide follows (a) Electrophilic addition **(b) Free radical addition** (c) Nucleophilic addition (d) None of these 2. During debromination of meso-dibromobutane, the major compound formed is (a) n-butane (b) 1-butene (c) cis-2-butene **(d) trans-2-butene** 3. Toluene on reaction with Cl_2 in presence of $FeCl_3$ gives predominantly- a) Benzoyl chloride b) Benzyl chloride c) o- and p- chloro toluene d) m-chlorotoluene 4. Which of the following is o-p directing group? a) –NH_2 b) –CN c) –CHO d) –NO_2 5. Chlorine substituent is_____. a) o,p- directing b) m-directing c) both (a) and (b) d) None of these 6. Benzene on reduction with sodium in liquid ammonia gives. a) Cyclohexane b) n-hexane c) 1, 4 cyclohexadiene d) 1, 4 hexadiene 7. Naphthalene preferably undergoes ArES at___position. a) 1 b)2 c)3 d)1 or 2 8. For a reaction to occur spontaneously a) $\Delta G < 0$ b) $\Delta G > 0$ c) $\Delta S < 0$ d) $\Delta H = 0$ 9. In association of solute, the Van't Hoff factor is __ a) 1 b) >1 c) <1 d) zero 10. In dissociation of solute, the Van't Hoff factor is __ a) 1 b) >1 c) <1 d) zero

Course Category: **Major (Theory)**

108212 Inorganic Chemistry-1

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	III	108212	Inorganic Chemistry-1	2	30	2 Hrs	30+20=50

Course Objectives:	1. To develop a comprehensive understanding of bonding theories and are able to apply theoretical principles to analyze and predict molecular structures. 2. To develop the fundamental theoretical understanding of quantitative chemistry
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Describe Born-Haber's cycle. 2. Predict molecular geometries using hybridization 3. Predict shapes of molecules and ions using VSEPR theory 4. Explain core postulates of MO theory and apply the LCAO approximation to construct bonding and antibonding orbitals. 5. Construct and interpret MO energy level diagrams for diatomic molecules and calculate bond orders and predict magnetic properties. 6. Define the mole in terms of mass, volume, and number of particles. 7. Solve problems on concentrations (molarity, normality, molality, mole fraction). 8. Explain the requirements for standard solutions and primary standard substances. 9. Explain the terms like titrant, titrate, endpoint, equivalence point, and indicators in volumetric analysis.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Ionic bonding:** Definition of ionic bond, Factors affecting ionic bond formation (energetic of ionic bond formation ionization energy, electron affinity and lattice energy). Born-Haber's cycle to determine lattice energy. **Covalent bonding:** Directional nature of covalent bond. Valance Bond Theory (VBT), Limitations of VBT, Hybridization, Need of Hybridization, Types of hybridization to explain geometries of $BeCl_2$, BF_3, CH_4, $PC1_5$, SF_6 and IF_7.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative**
Unit II	**VSEPR Theory:** Postulates of Valence Shell Electron Pair Repulsion (VSEPR) theory. Prediction of shapes of following species: $BeCl_2$, BF_3, CH_4, NH_4^+, PCl_5, SF_6, IF_7, $SnCl_2$, NH_3, H_2O, PCl_3, SF_4, SF_2, ClF_3, BrF_5, CO_2, SO_2, XeF_6, XeF_4, & XeF_2. Limitations of VSEPR theory.	7 Hrs	7 Marks	
Unit III	**Molecular Orbital (MO) Theory**. Postulates of MO theory. LCAO approximation Method, Rules for LCAO for the formation of bonding and antibonding MOs. MO energy level diagram of homonuclear diatomic molecules namely H_2, He_2, N_2 and O_2, with bond order and magnetism. Stability sequence of species of O2 i.e. O_2, O_2^+, O_2^{2+}, O_2^- and O_2^{2-} on the basis of bond order. MO structure of CO (Coulson's structure) and NO.	8 Hrs	8 Marks	
Unit IV	**A) The mole concept** Definition of mole in terms of mass, volume and number of particles. Avogadro's law, Atomic mass, average atomic mass and Molar Mass, Terms to express concentrations of solutions namely- molarity, normality, molality, mole fraction (Simple numerical expected). **B] Volumetric Analysis:** Important terms: titrant, titrate, end point, equivalence point, indicator, etc.	7 Hrs	7 Marks	

	Requirements and advantages of volumetric analysis. Definition of standard solution, Primary standard substance and its requirements			**pedagogy as applicable.**

References:

1. Principles of Inorganic Chemistry by Puri, Sharma and Kalia- S. Naginchand & Co., Delhi.
2. Inorganic Chemistry by A.K. De, Wiley East Ltd.
3. Selected Topics in Inorganic Chemistry by Malik, Tuli and Madan, S. Chand & Co.
4. Concise Inorganic Chemistry by J.D. Lee, ELBS.
5. Inorganic Chemistry by J.E. Huheey- and Kettle, Harper & Row.
6. Advanced Inorganic Chemistry, Vol-I, Satya Prakash, Madan, Tuli, Basu.
7. Advanced Practical Inorganic Chemistry by Gurdeep Raj, Goel Pulishing House, Meerut.

Web resources:

1. https://wou.edu/chemistry/courses/online-chemistry-textbooks/ch105-consumer-chemistry/chapter-3-ionic-covelent-bonding/
2. https://gchem.cm.utexas.edu/bonding/index.php
3. https://chem.libretexts.org/Courses/East_Tennessee_State_University/CHEM_3110%3A_Descriptive_Inorganic_Chemistry/03%3A_Bonding_Theories?
4. https://courses.lumenlearning.com/suny-mcc-introductorychemistry/chapter/formula-mass-and-mole-concept-from-che100/?
5. https://chemistry.coach/general-chemistry-1/
6. MIT OpenCourseWare: https://ocw.mit.edu
7. Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry

Model Questions:

Short Type (At least 8)

1. Define ionic bond
2. What is lattice energy?
3. Identify the hybridization of central atom in the following: $BeCl_2$, BF_3, CH_4, $PC1_5$, SF_6 and IF_7
4. Predict the of shapes of following species (any one): $BeCl_2$, BF_3, CH_4 , NH_4^+, PCl_5, SF_6, IF_7, $SnCl_2$, NH_3, H_2O, PCl_3, SF_4, SF_2, ClF_3, BrF_5, CO_2, SO_2, XeF_6, XeF_4, & XeF_2,
5. What is the bond order in (any one) O_2, O_2^+, O_2^{2+}, O_2^- and O_2^2
6. Sate Avogadro's law
7. What is standard solution?
8. Name any two primary standard acids.

Long Type (At least 4)

1. Describe Born-Haber's cycle to determine lattice energy
2. Explain geometries of (any one) $BeCl_2$, BF_3, CH_4, $PC1_5$, SF_6 and IF_7 using concept of hybridization**.**
3. Predict of shapes of following species (any one): $BeCl_2$, BF_3, CH_4 , NH_4^+, PCl_5, SF_6, IF_7, $SnCl_2$, NH_3, H_2O, PCl_3, SF_4, SF_2, ClF_3, BrF_5, CO_2, SO_2, XeF_6, XeF_4, & XeF_2 using VSEPR theory
4. Explain MO energy level diagram of (any one) N_2, O_2, CO and calculate its bond order.
5. Calculate the normality of 0.1 M H_2SO_4
6. Calculate the mole fractions of H_3PO_4 and water in a solution of 14.5 g of H_3PO_4 in 125 g of water?

MCQs for Internal Assessment (At least 8)

1. The hybridization of P in $PC1_5$__
   a) sp3 b) sp3d c) sp3d2 d) sp2
2. The hybridization of S in SF_6 is___
   a) sp3 b) sp3d c) sp3d2 d) sp2
3. The hybridization of I in IF_7 is —
   a) sp3 b) sp3d3 c) sp3d2 d) sp2
4. According to VSEPR theory, the shape of NH_3 is__
   a) Tetrahedral b) pyramidal c) trigonal bipyramidal d) trigonal planar
5. According to VSEPR theory, the shape of SF_4 is _
   a) Tetrahedral b) pyramidal c) 'see-saw' shaped d) trigonal planar
6. According to VSEPR theory, the shape of SO_2, is__
   a) 'V' shaped b) pyramidal c) 'see-saw' shaped d) trigonal planar
7. According to VSEPR theory, the shape of XeF_4 is_
   a) Tetrahedral b) square planar c) 'see-saw' shaped d) trigonal planar
8. The mole is used in chemistry to represent ____of something
   a) 6.022×10^{23} b) 6.23×10^{23} c) 8.022×10^{23} d) 6.022×10^{32}

Course Category: **Major (Theory)**

108213 Indian Knowledge System in Chemistry

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	III	108213	Indian Knowledge System in Chemistry	2	30	2 Hrs.	30+20=50

Course Objectives:	To help the students to bridge the gap between ancient Indian chemical knowledge and modern scientific inquiry, providing them a holistic understanding of the subject.
Course Outcomes:	Upon completion of this course, students will be able to: 1. Explain the importance and scope of IKS in chemistry. 2. Describe the knowledge about the Indian scholars and their contribution to chemistry. 3. Analyze vedic metallurgical techniques and their impact on material sciences. 4. Explore the chemistry behind natural dyes and pigments used in historical contexts. 5. Describe different chemical processes used in ancient chemistry. 6. Rationalize the knowledge of plant used in Ayurveda and its chemical composition. 7. Compare various apparatus and different methods used in ancient and modern chemistry. 8. Evaluate the relevance of ancient chemical knowledge in contemporary scientific research.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**A) Introduction to Indian Alchemy (Rasa Shastra)** Overview of alchemy in ancient India and its evolution: Vedic Chemistry and the terms used therein., Overview of Indian Chemistry in post Vedic period. CSIR National Chemical Laboratory: History and milestones. **B) Indian Scholar in Chemistry and Indian literature** Contributions of ancient and medieval Indians in the area of chemistry**:** Nagarjuna, Maharshi Kanada, Prafulla Chandra Ray, CNR Rao, Har Gobind Khorana, Govardhan Mehata, Shanti Swarup Bhatnagar and Venkataraman Ramakrishnan	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning,
Unit II	A) Concepts of acid and bases in Indian chemistry from organic fruit, vegetable-based. acids, plant-ash-based bases to mineral acids of the medieval period. B) Chemistry of dyes, pigments, and other coloring materials used in paintings, fabrics, beads, and other day-to-day utilities since ancient times and their constant evolution through different periods of time.	7 Hrs	7 Marks	
Unit III	A) Vedic Metallurgy- Introduction, Sources of Vedic metallurgy (Rigveda, Yajurveda, Atharvaveda), Metal known to Vedic Indian (Copper, Iron, Lead, Zinc, Gold and Silver). B) Processing of gold, silver, copper, iron, tin, mercury, lead and zinc as mentioned in the Indian texts in the ancient and medieval period. Zinc distillation as	8 Hrs	8 Marks	

	mentioned in Rasārṇava and Rasaratnasamukāyā. C) Metallurgical processes (smelting, alloying, Forging, Casting), Application of Vedic Metallurgy.			investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit IV	**Introduction to traditional Indian System of medicine** Definition of Ayurvedic Drugs, Classification of Ayurvedic Drugs, Plant parts used in Ayurveda, Good Agricultural Practices, Methods of extraction, purification and formulation processes. Chemical procedures- Distillation, sublimation, alloying, purifying substances as described in Indian scriptures (Ancient apparatus and methods of chemical processes). Unique Traditional Practices in Ayurveda and Applied Traditional Knowledge, traditional guideline & regulations.	7 Hrs	7 Marks	
References:	1. R.M. Pujari, Pradeep Kolhe, N. R. Kumar, 'Pride of India: A Glimpse into India's Scientific Heritage', Samskrita Bharati Publication. 2. 'Indian Contribution to science', compiled by Vijnana Bharati. 3. A Concise History of Science in India, ed. D M Bose, S N Sen and B V Subbarayappa; INSA; 2009 4. Science and Technology in Medieval India - A Bibliography of Source Materials in Sanskrit, Arabic and Persian by A Rahman, M A Alvi, S A Khan Ghori and K V Samba Murthy; 1982. 5. Science and Technological Exchanges between India and Soviet Central Asia (Medieval Period), ed B V Subbarayappa;1985 6. Scientific and Technical Education in India, 1781-1900 by S N Sen; 1991 7. History of Technology in India, Vol. I, ed. A K Bag (1997); Vol III, ed. K V Mital (2001); Vol-II by Harbans Mukhia (2012). 8. AcharyaPrafulla Chandra Ray, A History of Hindu Chemistry, 1902, republ., Shaibya Prakashan Bibhag, centenary edition, Kolkata, 2002 9. R. Balasubramaniam, Delhi Iron Pillar: New Insights, Indian Institute of Advance Study, Shimla & Aryan Books International, New Delhi, 2002 10. R. Balasubramaniam, Marvels of Indian Iron through the Ages, Rupa& Infinity Foundation, New Delhi, 2008. 11. Mahadevan, B., Bhat, V. R., & Nagendra, P. R. N. (2022). *Introduction to Indian Knowledge System: Concepts and Applications*. PHI Learning Pvt. Ltd. 12. Kapoor, K., & Singh, A. (2021). *Indian Knowledge Systems* (Vols. I & II). Indian Institute of Advanced Study. 13. Frawley, D., & Ranade, S. (2001). *Ayurveda, Nature's Medicine*. Lotus Press. 14. Dharmapal. (1971). *Indian Science and Technology in the Eighteenth Century*. Other India Press. **Web resources:** 1. Vedic Chemistry: https://www.puranavedas.com/vedic-chemistry/ 2. Indian Alchemy as a yogic practices: https://youtu.be/ozuT0Az9_Lk 3. Savrikar, S. S., & Ravishankar, B. (2011). Introduction to 'Rasashaastra' the Iatrochemistry of Ayurveda. *African journal of traditional, complementary, and alternative medicines: AJTCAM*, *8*(5 Suppl), 66–82. https://doi.org/10.4314/ajtcam.v8i5S.1 https://artsandculture.google.com/story/rasashala-ancient-indian-alchemical-lab-national-council-of-science-museums/VAVBaP1RF0y-KQ?hl=en 4. CSIR NCL:https://www.ncl-india.org/files/AboutNCL/HistoryMilestones/Default.aspx.			
Model Questions:	**Short Type (At least 8)** 1. What is the significance of Vedic chemistry in the evolution of Indian alchemy? 2. How did Nagarjuna influence the development of Indian chemistry? 3. How did Prafulla Chandra Ray contribute to inorganic chemistry? 4. Explain the role of Ayurveda in shaping early chemical practices in India. 5. How were plant ashes utilized to produce alkaline substances in early Indian chemistry? 6. How was lime (calcium hydroxide) used as a base in ancient India?			

	7. What are the key differences between organic and mineral pigments used in Indian paintings? 8. How did ancient Indian artisans ensure the durability of their pigments on paintings and fabrics? 9. How was gold processed in ancient India according to Vedic texts? 10. What were the primary applications of lead in Vedic metallurgy? 11. What role did mercury play in alchemical processes in medieval India? 12. What were the key metallurgical techniques used for iron processing in ancient India? 13. What is the definition of Ayurvedic drugs? 14. What is the significance of purification in Ayurvedic formulations? 15. What is the role of distillation in Ayurvedic medicine preparation? 16. What are some purification techniques described in Indian scriptures? 17. What are the key principles of formulation in Ayurveda? 18. How do traditional guidelines ensure the efficacy of Ayurvedic medicines? 19. How are Ayurvedic drugs classified? 20. Name three plant parts commonly used in Ayurveda.
	Long Type (At least 4) 1. Explain how modern Indian scientists like CNR Rao and Venkatraman Ramakrishnan have contributed to global chemistry. 2. What are the key contributions of Indian chemists to global scientific advancements? 3. Describe the evolution of Indian chemistry from the Vedic period to the post-Vedic period. 4. Explain the role of plant ash in the production of bases and its applications in ancient Indian industries. 5. Describe the chemistry behind natural dye extraction and how Indian artisans perfected the dyeing process over centuries. 6. Discuss the significance of indigo dye in Indian history and its chemical composition. 7. Discuss the contributions of Rigveda, Yajurveda, and Atharvaveda in shaping early Indian metallurgy. 8. Describe the role of gold and silver in ancient Indian economy and craftsmanship 9. Explain the role of Rasārṇava and Rasaratnasamukāyā in documenting metallurgical advancements. 10. Discuss the importance of Good Agricultural Practices (GAP) in Ayurveda for ensuring medicinal plant quality. 11. Analyze the role of distillation, sublimation, and alloying in the Ayurvedic system of medicine. 12. Discuss the significance of applied traditional knowledge in the evolution of Indian medicine.
	Multiple Choice Questions (MCQ): (At least 8) 1. Which ancient Indian text extensively discusses Rasa Shastra? a) Charaka Samhita b) Sushruta Samhita c) Rasaratnakara d) Arthashastra 2. Who among the following is known as the "Father of Indian Chemistry"? a) Prafulla Chandra Ray b) Nagarjuna c) CNR Rao d) Har Gobind Khorana 3. Maharshi Kanada is known for proposing which of the following concepts in chemistry? a) Atomic theory b) The periodic table c) The structure of DNA d) Thermodynamics 4. Which Indian scientist is known for his pioneering work in solid-state and materials chemistry? a) CNR Rao b) Prafulla Chandra Ray c) Har Gobind Khorana d) Govardhan Mehta 5. Which of the following natural substances was traditionally used as a source of acid in ancient Indian chemistry? a) Tamarind b) Turmeric c) Ashwagandha d) Sandalwood

	6. Which mineral acid was commonly prepared and used in medieval Indian alchemy? a) Nitric acid b) Sulfuric acid c) Hydrochloric acid d) All of the above 7. Which of the following traditional Indian substances is **not** acidic? a) Lemon juice b) Tamarind extract c) Turmeric paste d) Amla juice 8. The blue dye extracted from Indigofera tinctoria is chemically classified as: a) A flavonoid b) A carotenoid c) An organic nitrogen compound d) A polysaccharide 9. What was the primary source of black ink in ancient Indian manuscripts? a) Charcoal and gum b) Indigo extract c) Hematite powder d) Copper sulfate 10. The Rasaratnasamukāyā and Rasārṇava texts provide detailed knowledge about the distillation of which metal? a) Copper b) Iron c) Zinc d) Gold 11. The lost-wax casting technique (used for making metal sculptures) was widely practiced in: a) Vedic period b) Harappan civilization c) Medieval India d) Modern India 12. Which alloy, widely used in ancient Indian metallurgy, is a mixture of copper and tin? a) Brass b) Bronze c) Pewter d) Bell metal

Course Category: **Major Lab**

108214 Chemistry Lab 6

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	III	108214	Chemistry Lab 6	2	60	4 h	25+25= 50

Course Objectives:	1. To develop a strong conceptual understanding of fundamental principles in Inorganic and Physical Chemistry through hands-on experimental work. 2. To enhance analytical and problem-solving skills by applying theoretical knowledge to laboratory-based tasks, including synthesis, titration, calorimetry, and cryoscopic measurements.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. **Predict Molecular Structures & Bonding** – Visualize and predict molecular geometries using VSEPR theory and molecular orbital concepts. 2. **Analyze Buffer Systems** – Prepare buffer solutions and compare theoretical vs. experimental pH values. 3. **Apply Stoichiometry in Quantitative Analysis** – Utilize the mole concept and volumetric analysis for determining unknown concentrations in chemical mixtures. 4. **Perform Redox Titrations** – Accurately determine iron (Fe^{2+}) and oxalate concentrations using standard solutions of $KMnO_4$ and $K_2Cr_2O_7$. 5. **Synthesize and Characterize Inorganic Compounds** – Prepare and confirm synthesized inorganic compounds through qualitative tests. 6. **Evaluate Thermodynamic Parameters** – Calculate enthalpy changes for various chemical processes, including neutralization and ionization reactions. 7. **Determine Molecular Properties** – Use cryoscopic and refractive index methods to find molecular weights and association behavior in solutions. 8. **Enhance Lab Safety and Documentation Skills** – Follow proper laboratory safety protocols and accurately record experimental data for interpretation and reporting.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	1. Molecular Structure and Bonding: Apply VSEPR theory using molecular models to predict geometries. Construct MO diagrams to determine bond order and magnetic properties of diatomic molecules. 2. Buffer Preparation and Quantitative Analysis: Prepare and analyze acetate buffer solutions. Perform volumetric estimations of acid-base mixtures and synthesize inorganic compounds, confirming identities through qualitative tests. 3. Thermochemistry and Phase Transitions: Measure enthalpy changes using calorimetry. Determine transition temperatures of salts and analyze phase behavior. 4. Molecular Properties and Determinations: Determine molecular weights via cryoscopy. Measure refractive indices and calculate molar refraction. Study solubility variations with temperature.	• **Experiential Learning:** Hands-on experimentation using molecular model kits facilitates understanding of VSEPR geometries. Synthesis and qualitative confirmation of inorganic compounds enhance practical skills, while titrations and calorimetric measurements reinforce theoretical concepts. • **Inquiry-Based Learning:** Students hypothesize molecular structures and validate predictions using models. Discrepancies in experimental pH values of buffer solutions are analyzed, fostering critical thinking. Investigation of phase transitions and enthalpy changes promotes a deeper understanding of thermodynamic principles. • **Collaborative Learning:** Group-based synthesis and titration experiments encourage teamwork and peer learning. Discussions on molecular orbital theory and reaction mechanisms enhance conceptual clarity and knowledge retention. • **Technology-Enhanced Learning:** Digital tools, including molecular simulation software, pH meters, and digital thermometers, improve
Inorganic Chemistry practical	1. To visualize and predict the shapes of simple molecules based on VSEPR theory. (Use molecular model kits to construct models of various molecules (e.g., $BeCl_2$, BF_3, CH_4, NH_3, H_2O). Identify the number of bonding pairs and lone pairs around the central atom. Predict the molecular geometry based on electron pair repulsion and confirm by comparing with the constructed models.) 2. To understand the formation of molecular orbitals of simple diatomic molecules like H_2, He_2, N_2, and O_2 and predict their magnetic properties and bond orders. (Draw molecular orbital diagrams of these molecules. Fill in the electrons according to the Aufbau principle, Pauli exclusion principle, and Hund's rule. Calculate bond	

	orders and predict magnetic properties (paramagnetic or diamagnetic) based on unpaired electrons.) **3.** Calculate amount of sodium acetate (0.1M) and acetic acid (0.1M) for the preparation of acetate buffer of pH = 4.0, 4.5, 5.0, 5.5 and 6. Prepare series of acetate buffer and determination of their pH by pH-meter. Compare observed value with theoretically expected values. Calculate H^+ ion conc. in each of these solution **Experiments: (At least 4)** 4. Application of mole concept in determining the molar mass of an unknown acid through titration. 5. Estimation of sodium carbonate and sodium bicarbonate present together in a mixture volumetrically. 6. Estimation of sodium carbonate and sodium hydroxide present together in a mixture volumetrically. 7. Determination the percentage of calcium carbonate in precipitated chalk volumetrically by acid-base titration. 8. Estimation of oxalic acid using standardized KMnO4 as an intermediate solution. 9. Estimation of Fe(II) (FAS) using standardized KMnO4 as an intermediate solution. 10. Estimation of Fe(II) (FAS) with K2Cr2O7 using internal (diphenylamine, anthranilic acid) or external indicator potassium ferricyanide. 11. Determination of equivalent weight of oxidizing agent $KMnO_4$ or $K_2Cr_2O_7$ by titration with standard Fe(II) (FAS) solution **Inorganic preparations (At least 2)** **(Note:** In synthesized compound student must confirm the particular Cation and anion by performing qualitative tests) 1. Synthesis of Mohr's Salt (FAS), $\{FeSO_4.(NH_4)_2SO_4•6H_2O\}$ from ferrous sulphate and ammonium sulphate. 2. Synthesis of potash alum, $\{K_2SO_4.Al_2(SO_4)_3.24H_2O\}$ from aluminum sulphate or scrap aluminum metal. 3. Synthesis of $FeSO_4•7H_2O$ either from iron or ferrous sulphate (Kipp's waste) 4. Preparation of cuprous oxide, Cu_2O: a dark red inorganic pigment, from copper sulphate using glucose.	precision in data collection and analysis. Virtual simulations supplement experimental learning, providing additional insights into complex concepts. • **Reflective and Analytical Learning:** Maintaining laboratory records supports systematic documentation of observations, calculations, and deviations. Post-experiment discussions encourage critical evaluation and correlation of experimental results with theoretical principles and real-world applications. **Any other innovative pedagogy as applicable.**
Physical Chemistry Practical	**(At least 6 experiments)** 1. To determine the enthalpy of displacement reaction of Cu from $CuSO_4$ by Zn metal. 2. To determine the transition temperature of $MnCl_2$. 3. To determine the transition temperature of $Na_2SO_4.10H_2O$ by thermometric method. 4. To find the water equivalent of the calorimeter and find out the heat of dilution of H_2SO_4 5. To determine the heat of neutralization of NaOH and HCl by calorimetry. 6. To determine solubility of benzoic acid at different temperature and heat of solution. 7. To determine the enthalpy of ionization of	

	acetic acid by calorimetric method. 8. To determine the molecular weight of nonvolatile solute by Rast's method. 9. To find out molecular weight of sulphur/ α-naphthol by freezing point method using naphthalene as solvent. 10. To determine the molecular weight of solute by cryoscopy using benzene as a solvent. 11. To determine the degree of hydrolysis of sodium acetate near 0° C by cryoscopy. 12. To study the association of benzoic acid in benzene/ cyclohexane by cryoscopy. (Note: For Cryoscopic measurement a digital thermometer (-40 to 250 ° C) can be used instead of Beckmann's Thermometer) 13. To find refractive index of the given liquid samples and find Molar refraction and specific refraction. A) Ethyl Alcohol and Water. B) Sugar solution and Water. C) Oil and Water.	
References	1. Advanced Practical Physical Chemistry – J.B. Yadav, Goel Publishing House. 2. Experimental Physical Chemistry – R.C. Das, B. Behera, McGraw Hill. 3. *Advanced Practical Inorganic Chemistry* – Gurdeep Raj, Goel Publishing. 4. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Inorganic Chemistry: Qualitative Analysis, University Press. 5. Vogel's Textbook of Quantitative Chemical Analysis – J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, Pearson. 6. Practical Chemistry (For B.Sc. I, II and III Year Students). By Pandey O.P. & Bajpai D.N. & Giri S., S.Chand. 7. *Handbook of Organic Analysis: Qualitative and Quantitative* – H. T. Clarke, CBS Publishers. 8. Krishna's Advanced Practical Physical Chemistry – J. B. Yadav. 9. Advanced Physical Chemistry Experiments by J. N. Gurtu, Amit Gurtu, Pragati Prakashan. **Web resources:** 1. MIT OpenCourseWare: https://ocw.mit.edu 2. Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry 3. ChemCollective Virtual Labs: http://chemcollective.org 4. NPTEL (IIT Online Courses): https://nptel.ac.in/courses/104 5. LibreTexts Chemistry: https://chem.libretexts.org 6. PhET Interactive Simulations (University of Colorado Boulder): https://phet.colorado.edu	
Model Questions:	**NA**	

Distribution of Marks and the scheme of Practical Examination is as follows:

Distribution of Marks and the scheme of Practical Examination (Major/Minor):

Section 1: Internal Assessment

- Attendance 05 Marks
- Active participation in activities as a part of CAT (At least three tests) * 10 Marks
- Submission of duly certified record and assignment 05 Marks
- Internal Viva-voce 05 Marks

Total **25 Marks**

*Note: Based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Organic Chem Practical) 10 Marks
- Exercise 2 (Physical Chem Practical) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **Minor (Theory)**

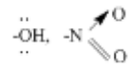
108215 Minor Chemistry-1

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5	III	108215	Minor Chemistry-1	2	30	2 Hrs	30+20=50

Course Objectives:	1. To aware the students about Fundamentals of organic chemistry and functional group approach for hydrocarbons. 2. To make the students proficient in thermodynamic principles and their basic mathematical formulations. 3. To equip the students with a basic understanding of colligative properties
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Compare the reactivity of Hydrocarbons. 2. Rationalize for regioselectivity in addition 3. Describe the structure of benzene and its stability 4. Write the mechanism of ArES reactions 5. Predict and rationalize the directive influence of a group in ArES. 6. Derive Gibbs-Helmholtz equation 7. Define Colligative Properties and associated terms 8. Apply Thermodynamic Principles to Colligative Properties 9. Solve numerical related to Thermodynamics and Colligative properties.

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit-I	**Aliphatic Hydrocarbons:** A) **Alkanes**: Formation of alkanes, Wurtz Reaction, Free radical substitutions: Halogenation - relative reactivity and selectivity. B) **Alkenes:** Formation of alkenes by elimination reactions, Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti-Markownikoff addition). 1,2-& 1,4-addition reactions in Dienes, Diels-alder reaction. Allylic and benzylic bromination reactions. C) **Alkynes:** Preparation of alkynes: by Double Dehydrohalogenation of vicinal and germinal dihalides. Acidity of terminal alkynes. Reactions: Addition of halogens, hydrogen halides and hydration.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit-II	A) ***Arenes:*** Introduction**,** derivatives of benzene and their nomenclature (mono, di and tri substituted benzenes). Structure of benzene: Kekules, Resonance Structures, and Molecular orbital picture. B) **Reactivity of benzene**: Mechanism of Electrophilic substitution reactions: Nitration, Sulphonation, Nuclear Halogenation and Friedel - Crafts reaction with mechanism, oxidation of side chain, reduction of benzene. C) **Orientation Effect**: Effects of	7 Hrs	7 Marks	

	substituent groups (o/p and meta directing groups), activating and deactivating groups. Directive influence of various groups (-OH, -CH_3, -Cl, -NO_2) on the basis of modern electronic theory.		
Unit-III	**Thermodynamics:** Introduction, Important terms: Gibbs and Helmholtz free energy (Work function). Physical significance of Gibbs free energy and Helmholtz free energy, change in free energy as a criterion of spontaneity and equilibrium, Derivation of Gibbs-Helmholtz equation and it's applications, Nernst heat theorem, Statement of third law, Derivation of Vant Hoff's reaction isotherm, Numericals.	8 Hrs	8 Marks
Unit-IV	**Colligative Properties of Dilute Solutions:** Introduction, Important terms: Colligative properties, Lowering of Vapor pressure, Relative lowering of vapor pressure, Elevation of boiling point, Depression of freezing point and Osmotic pressure. Importance and applications of colligative properties. Rault's law of relative lowering of vapor pressure. **Elevation of boiling point**: Thermodynamic derivation of the relationship between elevation of boiling point and the molar mass of non-volatile solute. Cottrell's method for the determination of elevation of boiling point and hence the molar mass of solute. **Depression of freezing point**: Relationship between depression of freezing point and the molar mass of non-volatile solute (only equation). Rast's method for the determination of molar mass of solute. **Osmotic Pressure, and osmosis**: Determination of Molecular weight of solute by osmotic pressure. Measurement of Osmotic pressure by Berkeley and Hartley's Method, Isotonic solutions. Numericals.	7 Hrs	7 Marks
References	**References:** 1. Organic Chemistry Vol. I, II and III by Mukharjee, Singh and Kapoor- Wiley Eastern. 2. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 3. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007) 4. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008). 5. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford Universitiy Press. 6. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and 7. mechanism, Kluwer Academic Publisher, (2000). 8. Organic Chemistry by S.K. Ghosh. 9. Reaction Mechanism in Organic Chemistry by S.M. Mukharjee and S.P. Singh.		

	10. Stereochemistry and mechanism through solved problems by P.S. Kalsi. 11. Organic Chemistry by TWG Solomons, 8th edition, John Wiley 12. Organic Chemistry by R. K. Bansal 13. Physical Chemistry: Walter, J. Moore, 5th edn., New Delhi. 14. Physical Chemistry: G.M. Barrow, McGraw Hill, Indian Edn. 15. Principles of Physical Chemistry: Maron and Prutton. 16. Principles of Physical Chemistry: Puri, Sharma, and Pathania. 17. Physical Chemistry: P.W. Atkins, 6th Edn. 18. Physical Chemistry: Levine **Web resource:** **1.** Introductory Organic Chemistry I- https://nptel.ac.in/courses/104106119 **2.** **https://chem.libretexts.org** **3.** **https://nowgonggirlscollege.co.in/attendence/classnotes/files/1631169122.pdf** **4.** **https://epgp.inflibnet.ac.in/Home/ViewSubject** **5.** **https://tech.chemistrydocs.com/Books/Physical/Physical-chemistry-by-R-L-Madan.pdf**
Model Questions:	**Short Type (At least 8)** 1. Arrange the following in increasing order of boiling point. n-pentane, (ii) isopentane and (iii) neopentane 2. Comment on Saytzeff rule 3. Comment on Hofmann elimination reaction 4. Define activating group. 5. Name the intermediate involved in ArES. 6. Which of the following groups are ortho-para directing and meta directing? -COOH, -CHO, -CH_3, -NH_2, -Cl, -SO_3H  **7.** Define Gibbs Free energy **8.** Define boiling point
	Long Type (At least 4) 1. Explain the Formation of alkanes using Wurtz Reaction, Wurtz- Fittig Reactions, 2. Explain Mechanism of E_1, E_2 and E_1cB reactions with suitable example. 3. Explain the acidity of terminal hydrogen in alkyne. 4. What are ring activating and ring deactivation groups? Explain with suitable examples. 5. Discuss the mechanism of acetylation of benzene 6. How does benzene react with - i) H_2 in presence of nickel catalyst ii) Cl_2 in presence of halogen carrier iii) Conc. HNO_3 and Conc. H_2SO_4 iv) CH_3Cl in presence of anhydrous $AlCl_3$ 7. How will you obtain the following from benzene? i) Toluene ii) Acetophenone iii) Chlorobenzene iv) Nitrobenzene. 8. Derive Gibbs-Helmholtz equation. 9. Derive Gibb's-Duhem equation 10. Derive Vant Hoff's reaction isotherm
	MCQs for Internal Assessment (At least 8) 1. The addition of HBr on 2-butene in presence of peroxide follows (a) Electrophilic addition **(b) Free radical addition** (c) Nucleophilic addition (d) None of these 2. During debromination of meso-dibromobutane, the major compound formed is (a) n-butane (b) 1-butene (c) cis-2-butene **(d) trans-2-butene** 3. Toluene on reaction with Cl_2 in presence of $FeCl_3$ gives predominantly- a) Benzoyl chloride b) Benzyl chloride c) o- and p- chloro toluene d) m-chlorotoluene 4. Which of the following is o-p directing group? a) –NH_2 b) –CN c) –CHO d) –NO_2 5. Chlorine substituent is_____. a) o,p- directing b) m-directing c) both (a) and (b) d) None of these 6. Benzene on reduction with sodium in liquid ammonia gives. a) Cyclohexane b) n-hexane c) 1, 4 cyclohexadiene d) 1, 4 hexadiene 7. Toluene preferably undergoes ArES at___position. a) ortho b) meta c) para d) either ortho or para 8. For a reaction to occur spontaneously a) $\Delta G < 0$ b) $\Delta G > 0$ c) $\Delta S < 0$ d) $\Delta H = 0$

Course Category: **Minor Lab**

108216 Minor Chemistry Lab 7

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	III	108216	Minor Chemistry Lab 7	2	60	4 h	25+25= 50

Course Objectives:	Develop preliminary skills in qualitative analysis of organic compounds, organic preparations, thermochemical and colligative properties measurements through hands-on laboratory experiments, fostering a comprehensive understanding of key techniques in organic and physical chemistry.
Course Outcomes:	At the end of this course students will be able to: 1. Identify extra elements through qualitative analysis techniques 2. Perform preparations of simple organic compounds. 3. Acquire skills in common techniques for the purification and identification of organic compounds. 4. Develop precision in measuring and recording physical properties. 5. Analyze the relationship between colligative properties with melting and boiling points of solution. 6. Develop skills in recording and reporting experimental procedures and results.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	1. Introduction to qualitative analysis of organic compounds 2. Importance of thermochemistry and colligative properties	• By combining hands-on experiments, discussions, and real-world applications, students will gain a comprehensive understanding of chemistry lab practices. A few suggested pedagogies are: • Students should be given suitable **pre- and post-lab** assignments and explanation revising the theoretical aspects of laboratory experiments prior to and after the conduct of each experiment. • **Hands-On Laboratory Sessions:** Provide regular hands-on laboratory sessions where students can directly apply theoretical knowledge to practical experiments. • **Demonstrations and Simulations:** Use virtual simulations for certain experiments to enhance accessibility and understanding. • **Flipped Classroom Model:** Encourage students to come to class prepared, promoting active participation. • **Interactive Workshops:** Provide opportunities for students to engage in discussions, ask questions, and seek clarification. • **Technology Integration:** Incorporate digital tools for data analysis and presentation. • **Guest Lectures and Industry Connections:** Establish connections with professionals in the field to provide students with a broader perspective on chemical lab practices. • **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. • **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge
Organic Chemistry practical	1. Identification of extra elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid, amides and amines, etc. of compounds. **(At least 6 compounds)** 2. **Organic Preparations** (Collected solid samples may be used for recrystallization, melting point and TLC) **(At least 4 preparations)** i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) (Using conventional method) ii. Benzolyation of one of the amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) iii. Oxidation of ethanol/ isopropanol (Iodoform reaction). iv. Bromination of (either a or b) a. Acetanilide by conventional methods b. Acetanilide using green approach (Bromate-bromide method) v. Nitration of (either a or b) a. Acetanilide by conventional method b. Salicylic acid by green approach (using ceric ammonium nitrate). vi. Hydrolysis of benzamide. vii. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde. viii. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid). ix. Aldol condensation with either conventional or green method.	
Physical Chemistry Practical	**(At least 6 experiments)** 1. To determine the enthalpy of displacement reaction of Cu from $CuSO_4$ by Zn metal 2. To determine the transition temperature of $MnCl_2$ 3. To determine the transition temperature of $Na_2SO_4.10H_2O$ by thermometric method 4. To find the water equivalent of the calorimeter and find out the heat of dilution of H_2SO_4 5. To determine the heat of neutralization of NaOH and HCl by calorimetry. 6. To determine solubility of benzoic acid at different temperature and heat of solution. 7. To determine the enthalpy of ionization of acetic acid by calorimetric method. 8. To determine the molecular weight of nonvolatile	

	solute by Rast's method. 9. To find out molecular weight of sulphur/ α-naphthol by freezing point method using naphthalene as solvent. 10. To determine the molecular weight of solute by cryoscopy using benzene as a solvent. 11. To determine the degree of hydrolysis of sodium acetate near 0° C by cryoscopy. 12. To study the association of benzoic acid in benzene/ cyclohexane by cryoscopy. **(Note: For Cryoscopic measurement a digital thermometer (-40 to 250 ° C) can be used instead of Beckmann's Thermometer)** 13. Preparation of a buffer solution of pH= 4 and its measurement by pH meter. 14. Preparation of a buffer solution of pH= 7 and its measurement by pH meter. 15. Preparation of a buffer solution of pH= 9.2 and its measurement by pH meter.	
References	1. Practical Chemistry (for B.Sc. I, II and III year students) – O P Pandey, D. N. Bajpaiand S. Giri (S Chand and company Ltd 2. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press. 3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R.(2012),Vogel's Textbook of Practical Organic Chemistry, Pearson. 4. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press. 5. Advanced practical Organic Chemistry: O P Agrawal 6. Advanced Physical Chemistry Experiments: J N Gurtu and Amit Gurtu (Pragati Prakashan) 7. Experimental Physical Chemistry: V D Athawale and Parul Mathur (New Age Int. Publishers) 8. Advanced Practical Physical Chemistry: J B Yadav 9. Experiments in Chemistry: D V Jahagirdar **Web resources:** 1. https://vlab.amrita.edu/?sub=2 2. https://chemcollective.org/vlabs 3. https://chem.libretexts.org/ 4. To set up calorimeter using Styrofoam cups watch: https://youtu.be/3s8G_hK7dsE 5. MIT OpenCourseWare: https://ocw.mit.edu 6. Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry	
Model Questions:	**NA**	

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Organic Chem Practical) 10 Marks
- Exercise 2 (Physical Chem Practical) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **GE/OE-3**

108217 Chemistry for Competitive Examinations

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	**III**	**108217**	**Chemistry for Competitive Examinations**	2	30	2 Hrs	30+20 =50

Course Objectives:	This course aims to provide a fundamental understanding chemistry for competitive examinations, with a special focus on elements and classification, carbon and its compounds, physical and chemical changes; acids, bases and salts. Students will apply this knowledge in competitive examinations conducted by UPSC, MPSC etc.			
Course Outcomes:	By the end of this course, the students will be able to: 1. Explain meaning of basic terms in chemistry like element, compounds etc 2. Classify elements 3. Explain the Carbon and its compounds. 4. Analyze how baking soda, washing soda useful in daily life. 5. Evaluate the importance of pH in everyday life. 6. Explain the phenomenon of rusting of iron and galvanization			
Unit System	**Contents**	**Workload Allotted**	**Weightage of Marks Allotted**	**Incorporation of Pedagogies**
Unit I	**Elements and Classifications** Introduction, Definition of Element, Attempts at the classification of elements, The Modern Periodic Table, Position of Elements in the Modern Periodic Table, Some Periodic Properties-Atomic Size and Ionization Potential, Metals, Non-metals, Metalloids, Extraction of metals, Corrosion.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-on Activity:** Collection of allotropes of Carbon. **Case Study:** Find out harmful effects caused by drinking illegal liquor. Read the daily newspapers and make a report. **Field Study:** Survey minimum 10 household to find out which brand of washing powder people use in your neighborhood. To correlation relevance of theoretical knowledge with real world. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Practical-Based Learning:** Compare samples of Bleaching powder, Baking soda, Washing soda and Plaster of Paris available in market. Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit II	**Carbon and its Compounds** Introduction, Definition of Compound, Covalent bond, Allotropes of Carbon, Saturated and Unsaturated Carbon Compounds, Homologous Series, Nomenclature of Carbon Compounds, Chemical Properties of Carbon Compounds, Some Important Carbon Compounds-Ethanol and Ethanoic acid, Soaps and Detergents.	7 Hrs	7 Marks	
Unit III	**Acids, Bases and Salts** Introduction, Definitions of Acid, Base and Salt, Reactions of Acids and Bases with Metals, Reactions of metal carbonates and metal hydrogen carbonates with acids, Reactions of Acids and Bases with each other, Reaction of metallic oxides with acids, Reaction of Non-metallic oxide with Base, pH Scale, Importance of pH in everyday life, Bleaching powder, Baking soda, Washing soda, Plaster of paris.	8 Hrs	8 Marks	
Unit IV	**Physical and Chemical Changes** Introduction, Physical Changes, Chemical Changes, Rusting of Iron, Galvanization, Crystallization. Chemical Effects of Electric Current, Electroplating	7 Hrs	7 Marks	
References:	**1.** CHEMISTRY by Catherine E. Housecroft & Edwin C. Constabel, Pearson-Prentice Hall **2.** Basic Training in Chemistry by Steven L. Hoenig, Kluwer Academic Publishers			

	3. Encyclopedia of Chemistry by Don Rittner & Ronald A. Bailey, Facts On File, Inc. **4.** Selected Topics In Inorganic Chemistry by Wahid U. Malik, G.D. Tuli, R.D. Madan, S.Chand **5.** Principles of Physical Chemistry by Puri, Sharma, Pathania, Vishal Publishing Co. **6.** Physical Chemistry by Robert G. Mortimer, Elsevier **7.** Organic Chemistry by R.L. Madan, S.Chand **8.** Essentials of Physical Chemistry by B.S. Bahl, G.D. Tuli, Arun Bahl, S.Chand **9.** Inorganic Chemistry by Yu.V. Khodakov, D.A. Epshtein, P.A. Gloriozov. CBS Publishers & Distributors **Web resources:** **1. https://youtu.be/okolv1y6IlE** **2. https://youtu.be/cn_Vom--b4A**
Model Questions:	Short Type (At least 6) **1.** Define atomic size. **2.** What is corrosion? **3.** What is element? **4.** What is the meaning of compound? **5.** Which functional group is present in ethanol? **6.** What are allotropes? **7.** What is the meaning of galvanization? **8.** What is crystallization? **9.** What is electroplating? **10.** What is pH scale? **11.** What is the formula of washing soda? **12.** Write examples of acid and base.
	Long Type (At least 4) **1.** Draw the outline of the modern form of periodic table and indicate s,p,d and f-block in it. **2.** What is atomic size? How it vary along periods and groups in periodic table? **3.** Differentiate between metals and non-metals. **4.** Explain extraction of metals. **5.** What are allotropes? Write different allotropes of Carbon. **6.** Write any four types of organic compounds indicating functional group present in each? **7.** What different chemical properties carbon compounds shows? **8.** Explain: soaps and detergents. **9.** Explain: Rusting of Iron. **10.** Explain: Crystallization. **11.** Explain the concept electroplating. **12.** Explain the chemical effects of electric current. **13.** Differentiate between acids and bases. **14.** Explain: importance of pH in everyday life. **15.** Explain: pH scale. **16.** What is baking soda? Write its uses.
	MCQ (At least 8) 1. Modern periodic table is based on which property of elements? a) Atomic mass b) Atomic number c) Valency d) Density 2. The elements in a group of the periodic table have the same: a) Atomic number b) Number of neutrons c) Number of valence electrons d) Atomic size 3. What is the name of Group 18 elements in the periodic table? a) Alkali metals b) Alkaline earth metals c) Halogens d) **Noble gases** **4.** Which metal is liquid at room temperature? a) Iron b) Mercury c) Aluminium d) Lead **5.** Which of the following is an example of an allotrope of carbon? a) Graphite b) Diamond c) Fullerene d) **All of the above** **6. The ability of carbon to form long chains is called:**

	a) **Catenation** b) Allotropy c) Isomerism d) Hybridization **7.** Which type of bond is present in a diamond? a) Ionic bond b) **Covalent bond** c) Metallic bond d) Hydrogen bond **8. Ethanol belongs to which** homologous **series?** a) Alkanes b) Alkenes c) **Alcohols** d) Carboxylic acids 9. What is galvanization? a) **Coating of iron with zinc** b) Coating of iron with copper c) Coating of zinc with iron d) Coating of copper with aluminum 10. The primary purpose of galvanization is to: a) Make iron heavier b) Improve electrical conductivity c) **Prevent rusting of iron** d) Improve the appearance of iron 11. What is the role of cooling in crystallization? a) Increases solubility b) **Helps crystals to form** c) Prevents crystallization d) Converts solids into gases 12. Crystallization is used to purify which type of substances? a) Liquids b) Gases c) **Solids** d) Plasma 13. Which gas is produced when acids react with metals? a) Oxygen b) **Hydrogen** c) Nitrogen d) Carbon dioxide 14. What happens when an acid reacts with a base? a) **Neutralization** b) Precipitation c) Oxidation d) Reduction 15. Which base is commonly used in soap making? a) Ammonia b) **Sodium hydroxide** c) Magnesium hydroxide d) Calcium hydroxide 16. Which of the following solutions will turn red litmus blue? a) Vinegar b) Lemon juice c) **Sodium hydroxide** d) Carbonic acid

Course Category: **Vocational Skill Course VSC-2**

108218 Chemistry Lab- 8 (Preparation of Commercial products)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	III	108218	Chemistry Lab- 8 (Preparation of Commercial products)	2	60	4 Hrs	50

Course Objectives:	The intended objectives are: 1. To understand raw materials, their sources, costs, and functions in cleaning and personal care products. 2. To learn soap-making techniques and prepare hand wash, sanitizer, dish wash, and toilet cleaners. 3. To develop skills in testing product quality and understanding costing, packaging, and marketing.	
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Identify and source raw materials required for making various commercial cleaning and personal care products. 2. Explain the chemical and functional significance of different ingredients used in soap and detergent formulations. 3. Demonstrate proficiency in preparing soaps using cold process, hot process, and melt-and-pour techniques. 4. Formulate and prepare a variety of cleaning products such as hand wash, hand sanitizer, dish wash, and toilet cleaners. 5. Assess the physicochemical properties of soaps and detergents through experiments like saponification value, CMC determination, and pH analysis. 6. Calculate the production cost of selected products and understand packaging, labelling, and marketing strategies for commercial viability.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	1. **Ingredients and Their Functions** – Discuss the role of raw materials in soaps, shampoos, and cleaning agents. Compare natural vs. synthetic ingredients. 2. **Soap-Making Techniques** – Compare cold process, hot process, and melt-and-pour methods. Analyze the impact of oils and additives. 3. **Quality Control & Testing** – Explore saponification value, pH testing, and cleaning power assessment. Discuss product safety standards. 4. **Commercialization & Sustainability** – Examine cost-effectiveness, packaging, labelling, and eco-friendly alternatives in product development.	By combining hands-on experiments, discussions, and real-world applications, students will gain a comprehensive understanding of chemistry lab practices. A few suggested pedagogies are: • Students should be given suitable **pre- and post-lab** assignments and explanation revising the theoretical aspects of laboratory experiments prior to and after the conduct of each experiment. • **Hands-On Laboratory Sessions:** Provide regular hands-on laboratory sessions where students can directly apply theoretical knowledge to practical experiments. • **Demonstrations and Simulations:** Use virtual simulations for certain experiments to enhance accessibility and understanding. • **Flipped Classroom Model:** Encourage students to come to class prepared, promoting active participation. • **Interactive Workshops:** Provide opportunities for students to engage in discussions, ask questions, and seek clarification. • **Technology Integration:**
Preparation of Commercial products	Experiments: 1. List the material required for soap, shampoo, hand wash, dish wash, toilet and bathroom cleaning. Find out their sources and cost. Function of some ingredients in the soap and soap making. 2. Saponification value of oil. 3. Soap making – cold process (prepare two three types of soaps by cold process such as - awesome Bar Soap, Bay Rum Soap Bar, Big 'N' Beautiful Bubbles Soap Bar, Bubble Gum Kid-Approved Soap Bar, Bug Repellent Soap, etc). 4. Soap making – hot process (prepare two three types of soaps by cold process such as - marbled Clay Soap, Lard-Base Soap, Bastille Soap, Lemon Poppy Seed Soap, etc.). 5. Melt and Pour soap making. 6. Facial and Shaving Soap Products - almond & Tea Tree Oil Facial Wash, Almond Oil & Black Tea Facial Scrub, Aloe Vera & Tea Tree Shaving Soap, Foaming Shave Soap.	

	7. Preparation of hand wash (different types) 8. Preparation of hand sanitizer (different types) 9. Preparation of dish wash (different types) 10. Preparation of Toilet Cleaner. 11. Determination of CMC of detergent / soap. 12. Determination of cleaning power of detergent by Stalagmometer. 13. Determination pH of different detergent / soap solution by universal pH paper. 14. Calculating costing of production of at least two products, their packaging, labelling and marketing.	Incorporate digital tools for data analysis and presentation. • **Guest Lectures and Industry Connections:** Establish connections with professionals in the field to provide students with a broader perspective on chemical lab practices.
References	1. Soap Making Step-by-Step Guide to Make Homemade Soaps. Advanced and Beginner Recipes Included, Carol Varney. 2. Handbook of Detergents, Part A: Properties by Guy Broze, CRC Press 3. Modern Technology of Soaps, Detergents & Toiletries by P. K. Chattopadhyay, NIIR PROJECT CONSULTANCY SERVICES 4. Soapmaker's Companion: A Comprehensive Guide with Recipes, Techniques & Know-How by Susan Miller Cavitch, Storey Publisher **Web resources:** 1. https://5.imimg.com (Swachh herbal manufacture of cleaning and hygiene products) 2. Royal Society of Chemistry (www.rsc.org/learn-chemistry) – Learning resources on surfactants and cleaning products 3. American Cleaning Institute (www.cleaninginstitute.org) – Information on soap, detergent formulations, and safety guidelines. 4. Practical Chemistry (www.practicalchemistry.org) – Laboratory guides for pH testing, saponification, and cleaning power analysis. 5. Essential Soap – DIY soap-making techniques (https://www.soap-making-resource.com/). 6. NPTEL Chemistry – Lectures on surfactants and detergents.	
Model Questions:	**NA**	

Distribution of Marks and the scheme of (VSC) Practical Examination is as follows:

Section I: Continuous Internal Assessment

- Attendance 05 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 15 Marks
- Submission of duly certified practical record 05 Marks

Total 25 Marks

Section II: End Semester Examination (Internal only)

- Exercise 1 20 Marks
- Viva-Voce (internal) 05 Marks

Total 25 Marks

Total (Section I And II) 50 Marks

*Note: Total Performance in CAT (i.e. 50 %) shall be based on the best two out of three in CAT examinations

Course Category: **FP/CEP-I**

108219 Chemistry Lab- 9 (FP/ CEP in Chemistry - I)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	III	108219	Chemistry Lab- 9 (FP/ CEP in Chemistry - I)	2	60	--	50

Course Objectives:	The intended objectives are: • To develop an appreciation of rural culture, lifestyle and wisdom amongst students. • To learn about the status of various agricultural and development programmes. • To understand the causes of distress and poverty faced by vulnerable households and explore solutions for the same. • To apply classroom knowledge of courses to field realities and thereby improve the quality of learning.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Gain an understanding of rural life, Indian culture and ethos and social realities 2. Develop a sense of empathy and bonds of mutuality with the local community 3. Appreciate significant contributions of local communities to Indian society and Economy 4. Learn to value the local knowledge and wisdom of the community 5. Identify opportunities for contributing to community's socio-economic improvements

Guidelines/ SoP for FP/CEP

For understanding key principles of CE, forms of CE, operational guidelines and implementation strategy please refer https://www.ugc.gov.in/pdfnews/4187860_Revised-Final-Guidelines.pdf

As per NEP 2020, students of B Sc. II of Semester III and IV need to perform a Field Project (FP) for TWO (2) credits i.e. 50 Marks. The guidelines regarding the field project are as follows:

1) The total time allocation for the student to carry out field project is 60 hours.
2) Students should participate in field-based projects under the supervision of faculty.
3) Assignment of project topics to individual students or groups of students (max 4 students in one group) and one faculty member from the department will act as Guide for the student or group of students.
4) For a SURVEY based project related questionnaire (15 or more questions) should be prepared.
5) The departmental coordinator/guide should check the questions and finalize the questionnaire. The question that may create unnecessary complications should be avoided. The questions should be qualitative as well as quantitative.
6) If the project is related to work that does not involve survey work, then the questionnaire part can be replaced accordingly (e.g. Sample collection/Data collection/ Experimental base etc).
7) The student should compile all the relevant data and carry out its analysis.
8) A project report should be written individually in the standard format (2 Copies): Index, Introduction, Materials, Methods, Result, Conclusion/output, References (Numeric citation type) etc.
9) The project report should be of minimum 6 pages (excluding Title page, Certificate, Index, Acknowledgement etc.). Submit the project report with the Guide's signature to the department.
10) The oral /poster presentation for all the projects should be arranged in the department. To evaluate the project, examiner should be appointed by HoD.
11) The total project work including preparation of questionnaire to presentation should be evaluated for 2 credits (50 Marks).

Some suggested forms of FP/ CEP are:

1. **Linking learning with community service:** For example, students of chemistry can conduct water and soil testing in local areas and share the results with the local community.
2. **Linking research with community knowledge:** Community-based Participatory Research (CBPR) approaches are gaining recognition in this regard. For example, students of chemistry can undertake research in partnership with the community on solid and liquid waste disposal.
3. **Knowledge sharing and knowledge mobilization:** These can take the forms of enumerations, surveys, awareness camps and campaigns, training, learning manuals/films, maps, study reports, public hearings, policy briefs, cleanliness and hygiene teachings, legal aid clinics, etc. For example, students can undertake a 'swachhta survekshana' and/or nutrition survey for mothers and children, and educate them about hygiene and nutrition.
4. **Social innovations by students:** The students can be encouraged to initiate learning projects with a social impact and supported by HEIs. Incubation of such social innovation projects by students can also have meaningful links to existing curriculum and courses.

A few suggested (not exclusive) areas which not only provide practical applications of chemistry concepts but also foster collaboration, education, and sustainable practices within the community. are:

1. Understanding the chemical footprints of household products such as toothpaste, haircare, facecare food products etc
2. Enhance science literacy among school students through interactive chemistry demonstrations.
3. Managing organic waste to composting and improve soil health.
4. Explore the extraction and application of natural dyes as alternatives to synthetic dyes.
5. Identify and mitigate lead exposure risks in the community.
6. Implement a community-wide recycling initiative focusing on chemical waste and recyclable materials.
7. Introduce and demonstrate the principles of renewable energy sources, such as biofuels or solar energy.
8. Assess local air quality and raise awareness about pollution sources and mitigation strategies.
9. Educate community members on the safe use, storage, and disposal of household chemicals.
10. Assist local farmers in understanding soil nutrient content and composition to optimize crop production.
11. Evaluate local water sources for contaminants such as heavy metals, nitrates, and pH levels.

References	1. https://www.ugc.gov.in/pdfnews/4187860_Revised-Final-Guidelines.pdf 2. https://en.wikipedia.org/wiki/OU_Citizen_Science_Soil_Collection_Program 3. https://www.immerse.education/study-tips/100-ideas-for-research-projects-in-chemistry/ 4. https://pubs.rsc.org/en/content/articlelanding/2021/rp/d0rp00374c 5. https://www.acs.org/education/student-communities/activities.html 6. https://www.nettercenter.upenn.edu/academically-based-community-service-chemistry-outreach
Model Questions:	**NA**

Distribution of Marks and the scheme of FP/CEP Examination is as follows:

- Students' performance 20 Marks
- Submission of duly certified FP/CEP report 20 Marks
- Presentation (PPT or Poster) 10 Marks

Total **50 Marks**

Course Category: **Major (Theory)**

108220 Organic Chemistry-1

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108220	Organic Chemistry-1	2	30	2 Hrs	30+20=50

Course Objectives:	Students will familiarize about 1. classes of organic compounds and their methods of preparation, reactions and reaction mechanisms. 2. stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Compare the reactivity of halogenated hydrocarbons. 2. Write the mechanisms of SN reactions. 3. Design syntheses of organic molecules containing C-X, C-O and C=O. 4. Differentiate between enantiomers and diastereomers. 5. Assign configurations to the stereoisomers. 6. Rationalize the relative stability of different conformers

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Chemistry of Halogenated Hydrocarbons:** A) *Alkyl halides:* Methods of preparation, nucleophilic substitution reactions – SN1, SN2 and SNi mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination. B) *Aryl halides:* Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl and vinyl/aryl halides towards nucleophilic substitution reactions.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit II	**Alcohols, Phenols, Ethers and Epoxides:** *A) Alcohols:* preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement. *B) Phenols:* Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries rearrangement and Claisen rearrangement. *C) Ethers:* Preparation (Williamson synthesis and Continuous etherification), reactions with HI. *D) Epoxides:* Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$.	7 Hrs	7 Marks	
Unit III	**Carbonyl Compounds:** A) Structure, reactivity and preparation; Nucleophilic addition-elimination reactions with ammonia derivatives (NH_2OH, NH_2NH_2, $PhNHNH_2$) with mechanism; Mechanisms of Aldol and Benzoin condensation. Reactions only: Knoevenagel condensation, Claisen-Schmidt, Perkin, and Cannizzaro reaction, Wittig reaction, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, LiAlH4, NaBH4 and MPV). B) Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.	8 Hrs	8 Marks	
Unit IV	**Basic Stereochemistry:** **A) Optical isomerism:** Stereoisomerism, Optical isomerism, asymmetric carbon atom, Element of symmetry, chirality (up to two carbon atoms), enantiomers, diastereoisomers, meso compounds, configuration, relative and absolute configurations, DL and RS nomenclature (for up to 2 chiral carbon atoms), optical isomerism in allenes and biphenyls.	7 Hrs	7 Marks	

	B) Geometrical isomerism: Cis-trans & E-Z nomenclature (for up to two C=C systems) with examples and applications. **C) Conformational isomerism:** Conformational isomers, Newman & Sawhorse projection formulae, conformations of ethane, n-butane and cyclohexane, their energy level diagrams.			

References:

1. Organic Chemistry Vol. I, II and III by Mukharjee, Singh and Kapoor- Wiley Eastern.
2. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edn., Dorling Kindersley (India)
3. Pvt. Ltd. (Pearson Education).
4. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007)
5. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008).
6. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford Universitiy Press.
7. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and
8. mechanism, Kluwer Academic Publisher, (2000).
9. Organic Chemistry by S.K. Ghosh.
10. Reaction Mechanism in Organic Chemistry by S.M. Mukharjee and S.P. Singh.
11. Stereochemistry and mechanism through solved problems by P.S. Kalsi.
12. Organic Chemistry by TWG Solomons, 8th edition, John Wiley
13. Organic Chemistry by R. K. Bansal

Web resources:

1. Introductory Organic Chemistry I- https://nptel.ac.in/courses/104106119
2. https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Introductory_Chemistry_(CK-12)/25%3A_Organic_Chemistry/25.11%3A_Aldehydes_and_Ketones
3. https://archive.nptel.ac.in/content/storage2/courses/104103071/pdf/mod6.pdf
4. https://archive.nptel.ac.in/content/storage2/courses/104103071/pdf/mod8.pdf
5. https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Introduction_to_Organic_and_Biochemistry_(Malik)/03%3A_Stereochemistry/3.01%3A_Introduction_to_stereochemistry

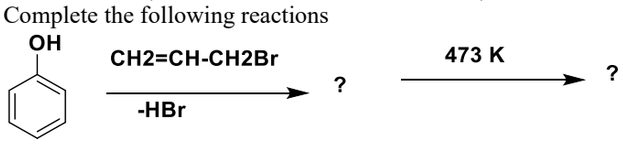
Model Questions:

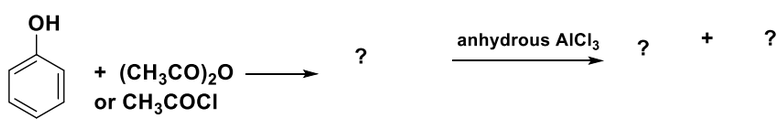
Short Type (At least 8)

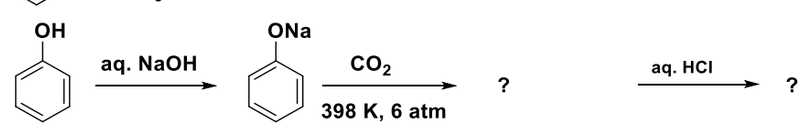
12. Name the intermediate involved in SN1 Mechanism.
13. What are ethers?
14. What is the action of the following on diethyl ether 1) cold HI and 2) hot HI
15. What is the hybridization of Cabon attached to chlorine in chlorobenzene?
16. What are reactive methylene compounds?
17. Define asymmetric carbon.
18. What is center of symmetry?
19. Place the following groups in proper priority order according to sequence rules?
    CHO, -COOH, -NH2, -H.
    -CH3, -CN, -OH, -C2H5.
    -CH3, -Cl, -H, -C2H5.
    -H, -CH2OH, -OH, -CHO
    –H, -N(CH3)2, -OCH3, -CH3

Long Type (At least 4)

1. How will you prepare: 1) vinyl chloride from acetylene 2) vinyl alcohol from vinyl chloride 3) acetylene from vinyl chloride 4) allyl chloride from propene 5) ethylene glycol from ethane 5) ethylene glycol from ethylene oxide
2. Chlorine in vinyl chloride is less reactive towards nucleophillic substitution than that in allyl chloride. Why?
3. Explain acidic nature of phenol.
4. Explain Benzyne intermediate mechanism.
5. Explain with mechanism 1) Aldol condensation 2) Benzoin condensation 3) Knoevenagel condensation 4) Claisen-Schmidt condensation 5) Perkin reaction and 6) Cannizzaro reaction
6. Complete the following reactions

1. 

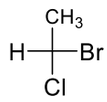
2. 

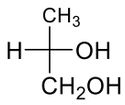
3. 

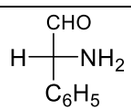
phenol

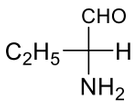
4. $C_2H_5O\text{-}Na$ + $C_2H_5\text{-}Br$ ⟶ ? + ?
sodium ethoxide ethyl bromide

7. Determine the R/S configuration of the following structures clearly indicating the steps involved-

I) 

II) 

iii) 

IV) 

8. Draw Fischer projection of R and S configuration of lactic acid?

MCQs for Internal Assessment (At least 8)

1. Chlorobenzene is an example of ____
   a) alkyl halide b) alkenyl halide c) aryl halide d) haloalkane
2. Benzyl chloride is also known as ____
   a) ∝-chlorotoluene b) benzal chloride c) chlorobenzene d) none of the above
2. Dihydric alcohols are also known as_____
   a) diols b) triols c) geraniols d) none of the above
3. Arrangements of molecules that can be obtained by rotation around C-C single bond are called ___
   a) conformations b) configurations c) enantiomers d) geometric isomers
4. The number of extreme conformation possible for ethane are
   a) 1 b) 2 c) 3 d) 4
5. The number of extreme conformation possible for n-butane are
   b) 1 b) 2 c) 3 d) 4
6. If the two groups of higher priority are on the same side of the double bond then it is assigned ___ configuration
   a) E b) Z c) R d) S
7. Ketone can be reduced to alkane using
   a) $LiAlH_4$ b) Clemenson reduction c) Zn/Acetic acid d) MPV reduction
8. Which of the following will not show iodoform reaction?
   a) Ethanol b) acetone c) acetaldehyde d) benzaldehyde

Course Category: **Major (Theory)**

108221 Physical Chemistry-1

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108221	Physical Chemistry-1	2	30	2 Hrs	30+20=50

Course Objectives:	To help the students acquire a comprehensive understanding of the principles and applications related to chemical kinetics, photochemistry, molecular structure, and electrochemistry, equipping them with the skills necessary for advanced studies and practical applications in chemistry.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Define and explain key terms such as reaction rate, order of reaction, and molecularity. 2. Distinguish between zero, first, and second-order reactions, providing examples and deriving their respective rate equations 3. Distinguish between polar and non-polar molecules, understand dipole moments, and discuss polarization, including the Clausius-Mossotti equation qualitatively. 4. Differentiate between paramagnetic and diamagnetic substances, understand the origins of various magnetic behaviors 5. Analyze factors leading to high or low quantum yields and describe methods for their experimental determination 6. Describe phenomena such as fluorescence and phosphorescence utilizing the Jablonski Diagram. 7. Explain ion migration under electric fields, determine transport numbers using Hittorf's and moving boundary methods 8. Apply Kohlrausch's law to evaluate ion migration. 9. Calculate the degree of dissociation for weak electrolytes and determine their dissociation constants

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Chemical Kinetics:** Introduction, Important terms: rate of reaction, Order of a reaction, and molecularity of reaction (explanation, unit, types and examples). Difference between order and molecularity of reaction. Derivation of rate equation for Zero, first, and second order reaction with equal initial concentration and different initial concentrations of reactants, Characteristics of zero and first order reaction (Graphical representation, half-life period) Kinetics study with modified rate equation viz. the reactions (1) hydrolysis of methyl acetate catalyzed by acid, (2) saponification of ethyl acetate by NaOH, and (3) inversion of cane sugar. Methods for determination of order reaction: Integration, Graphical, Equifractional change or half-life, Vant-Hoff's differential method, and Ostwald's isolation method. Effect of temperature on the rate of reaction, Arrhenius equation, Activation energy and its determination using Arrhenius equation. Numericals.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as**
Unit II	**Photochemistry** Introduction, Important terms: Photochemical and Thermal reactions (Explanation and Examples). Difference between Photochemical and Thermal reactions. Lambert's law (Statement and derivation). Beer's law (Statement and derivation). Reasons for deviations from Beer's law. Laws of photochemistry- (1) Grotthus-Draper law (2) Stark-Einstein law. Quantum yield of photochemical reaction. Reasons for high and low quantum yields. Experimental determination of quantum yield. Photosensitized reactions. Kinetics of photochemical decomposition of HI. Fluorescence and Phosphorescence (Explanation and Examples). Selection rule for electronic transitions. Internal conversion and Intersystem crossing. Explanation of Fluorescence and Phosphorescence based on Jablonski Diagram. Chemiluminescence and Bioluminescence (Explanation and Examples). Numericals.	7 Hrs	7 Marks	
Unit III	**Physical Properties and Molecular Structure** Introduction to Physical Properties and Molecular structure, **Electrical Properties**: Introduction, Important terms: Polar, Non-polar molecules, and Dipole moment. (Explanation and Examples).	8 Hrs	8 Marks	

	Induced polarization and orientation polarization. Clausius Mossotti equation (only qualitative treatment). Measurement of dipole moment by temperature and refractivity methods. Applications of dipole moment for determining molecular structure (Percentage ionic character of covalent bonding, molecular geometry, cis-trans isomers, ortho, meta, and para isomers of disubstituted benzene). Numericals **Magnetic Properties**: Introduction, Important terms: Magnetic Moment, Magnetic Permeability, Magnetic Susceptibility (Explanation). Types of Magnetic Susceptibility (Volume Susceptibility, Specific Susceptibility, Mass Susceptibility, and Molar Susceptibility) Relationship between Molar Susceptibility and Mass Susceptibility. Origin Of Magnetism, Paramagnetism, Diamagnetism, Ferromagnetism, and Antiferromagnetism (Properties, Explanation, and Examples). Effect of temperature on magnetics Susceptibility, Relationship between Magnetic Moment and Number of unpaired electrons. Gouy's balance method for Determination of Magnetic Susceptibility. Application of magnetic moment in the determination of molecular structure. Numericals.			**applicable.**
Unit IV	**Electrochemistry -I** Introduction, Important terms: Conductor and Types of Conductors, Resistance, Specific Resistance, Conductance, Specific Conductance, and their units (Explanation), Conductance of Electrolytes, Types of Conductance (Specific, Equivalent, and Molar Conductance). Determination of conductance of electrolyte solution, Variation of Specific and Equivalent Conductance with dilution. Conductometric Titrations, Applications of Conductometric Titration. Migration of ions under the influence of electric field. The transport number of ions. Hittorf's theoretical Device. Kohlrausch's law of independent migration of ions. Determination of association and degree of dissociation of a weak electrolyte. Numericals.	7 Hrs	7 Marks	
References:	1. Physical Chemistry: Walter, J. Moore, 5th edn., New Delhi. 2. Physical Chemistry: G.M. Barrow, McGraw Hill, Indian Edn. 3. Principles of Physical Chemistry: Maron and Prutton. 4. Principles of Physical Chemistry: Puri, Sharma, and Pathania. 5. Physical Chemistry: P.W. Atkins, 6th Edn. 6. Physical Chemistry: Levine 7. Essential of Physical Chemistry: Bahl and Tuli 8. A Textbook of Physical Chemistry: K.L. Kapoor **Web resources:** 1. https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Chemistry_-_The_Central_Science_(Brown_et_al.) 2. https://faculty.gvsu.edu/mcbaneg/notes-358.pdf			
Model Questions:	**Short Type (At least 8)** 1. Define the order of a reaction. How is it different from molecularity? 2. Write the integrated rate equation for a first-order reaction and explain the terms. 3. What is the effect of temperature on the rate of a chemical reaction? 4. How can we determine the order of a reaction using the graphical method? 5. Differentiate between photochemical and thermal reactions 6. State Stark-Einstein Law 7. What is the Jablonski diagram? 8. Why do some photochemical reactions have high quantum yield? 9. Differentiate between polar and non-polar molecules with examples. 10. What is orientation polarization? 11. State the relationship between magnetic moment and unpaired electrons. 12. What is the significance of dipole moment in determining molecular structure? 13. Define resistance, specific resistance, and conductance. 14. Define conductometric titration 15. Define the transport number of an ion 16. State Kohlrausch's Law			
	Long Type (At least 4) 1. Derive the rate equation for a first-order reaction. Show how half-life is related to the rate constant.			

	2. Describe the characteristics of first and second-order reactions with suitable examples. 3. Explain how Ostwald isolation method and integration are used to determine order of reaction 4. Discuss the Arrhenius equation and describe how activation energy is determined graphically. 5. State and derive Lambert's Law 6. State and derive Beer's Law. 7. Define the quantum yield of a photochemical reaction and explain its experimental determination. 8. Explain the Jablonski Diagram. 9. Explain the concept of dipole moment and its applications in determining molecular structure. 10. Derive the relationship between magnetic moment and unpaired electrons 11. Describe Gouy's method for determining magnetic susceptibility. 12. Explain the measurement of dipole moment by temperature method. 13. Explain the effect of dilution Specific equivalent and molar conductivities. 14. Describe Hittorf's method for determining the transport number.
	MCQs for Internal Assessment (At least 8) The unit of rate constant for a first-order reaction is: a) L mol^{-1} s^{-1} **b) s^{-1}** c) mol L^{-1} s^{-1} d) L^2 mol^{-2} s^{-1} 2. Which of the following statements is true about molecularity of a reaction? a) It can be a fraction. b) It is determined experimentally. **c) It is always a whole number**. d) It depends on temperature. 3. The half-life of a first-order reaction depends on: a) Initial concentration b) Final concentration **c) Rate constant** d) Both (a) and (c) 4. The Arrhenius equation is used to determine: a) Molecularity of reaction **b) Activation energy** c) Order of reaction d) Rate of diffusion 5. Which of the following is a photochemical reaction? a) Rusting of iron **b) Photosynthesis** c) Burning of wood d) Evaporation of water 6. Beer's Law states that the absorption of light is proportional to the: a) Thickness of the solution b) Concentration of the solution c) Wavelength of light **d) Both (a) and (b)** 7. The Grotthus-Draper law states that: **a) Light must be absorbed for a reaction to occur** b) Every absorbed photon causes a reaction c) Light intensity does not affect reaction rate d) Energy is conserved in photochemical reactions 8. Which of the following is an example of chemiluminescence? **a) Fireflies glowing** b) Burning of coal c) Reflection of sunlight d) Formation of rust 9.Which of the following molecules is polar? a) CO_2 b) CH_4 **c) H_2O** d) BF_3 10. Which of the following is a paramagnetic substance? a) NaCl **b) O_2** c) N_2 d) H_2O 11. Clausius-Mossotti equation relates: a) Dipole moment and temperature b) Polarizability and refractivity **c) Dielectric constant and polarizability** d) Molar mass and dipole moment 12.Gouy's balance is used to determine: a) Refractive index **b) Magnetic susceptibility** c) Dipole moment d) Ionic character 13.Which of the following has the unit S cm^{-1}?

	a) Resistance b) Conductance **c) Specific conductance** d) Transport number 14. The conductance of an electrolyte solution generally _____ with dilution. a) **Increases** b) Decreases c) Remains constant d) First decreases, then increases 15. Kohlrausch's law states that at infinite dilution, the conductivity of an electrolyte is due to: a) **Independent migration of ions** b) Movement of cations only c) Movement of anions only d) Ion-pair formation 16.Which method is NOT used to determine the transport number of an ion? a) Hittorf's method b) Moving boundary method c**) Conductometric titration** d) Kohlrausch's method

Course Category: **Major (Theory)**

108229 Analytical Chemistry

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.	IV	108229	**Analytical Chemistry**	2	30	2 Hrs.	30+20=50

Course Objectives:	To introduce the fundamental concepts and techniques of Analytical Chemistry used in qualitative and quantitative chemical analysis. The course aims to develop understanding of sampling, error analysis, gravimetric methods, separation techniques, and basic chromatographic methods used in chemical laboratories.
Course Outcomes:	Upon completion of this course, students will be able to: 1. Explain the basic principles of qualitative and quantitative analysis, sampling methods, and sources of analytical errors. 2. Apply the principles of gravimetric analysis for quantitative estimation of chemical substances. 3. Describe the fundamentals of solvent extraction and its applications in separation techniques. 4. Calculate amount of the solute left after n^{th} extraction during batch extraction. 5. Analyze and interpret separations using paper chromatography and thin layer chromatography (TLC).

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Introduction to Analytical Chemistry** • Scope and importance of analytical chemistry • Qualitative and quantitative analysis • Steps involved in chemical analysis • Sampling methods and sample handling • Types of errors: systematic, random, and gross errors • Accuracy, precision, sensitivity, and significant figures	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research.
Unit II	**Gravimetric Analysis** • Definition. and principles of gravimetry. • Theoretical principles underlying various steps involved in gravimetric analysis with reference to estimation of barium as barium sulphate. • Coprecipitation and post precipitation. (Definition, types and factors affecting).	7 Hrs	7 Marks	
Unit III	**Separation Techniques – Solvent Extraction** • Principle of solvent extraction (Nerst distribution law) • Application of Nernst Distribution Law • to association and dissociation of solute in one of the solvent. • Batch and continuous extraction. Derivation of formula for the amount of solute left unextracted after n^{th} extraction. • Applications of solvent extraction in chemical analysis	8 Hrs	8 Marks	
Unit IV	A) **Paper Chromatography**: • Definition and classification of chromatographic techniques. • Principle of differential migration. • Principle and technique of paper	7 Hrs	7 Marks	

	chromatography -ascending, descending and circular. • Rf value and factors affecting Rf value **B) Thin Layer Chromatography (TLC)** • Principle and technique • Selection of stationary and mobile phases • Rf value determination • Applications of TLC in separation and identification of compounds			**Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
References:	1. Analytical Chemistry: Problems and Solutions" by S. M. Khopkar (New Age International Publication) 2. Basic Concepts in Analytical Chemistry" by S. M. Khopkar (New Age International Publication) 3. Quantitative Analysis" by Day and Underwood (Prentice-Hall of India) 4. Vogel's Textbook of Quantitative Inorganic Analysis" by Bassett, Denney, Jeffery, and Mendham (ELBS) 5. Analytical Chemistry" by Gary D. Christian (Wiley, India) 6. Instrumental Methods of Analysis" by Willard, Merrit, Dean, Settle (CBS Publishers, Delhi, 1986) 7. Instrumental Methods of Chemical Analysis" by Braun (Tata McGraw-Hill) 8. Advanced Analytical Chemistry" by Meites and Thomas (McGraw-Hill) 9. Instrumental Methods of Analysis" by G. Chatwal and S. Anand (Himalaya Publishing House) 10. Fundamentals of Analytical Chemistry" by S. A. Skoog and D. W. West (Saunders College Publishing) **Web resources:** https://chem.libretexts.org/Bookshelves/Analytical_Chemistry https://mpbou.edu.in/uploads/files/PAPER-07_ANALYTICAL_CHEMISTRY.pdf https://ebooks.inflibnet.ac.in/esp02/chapter/chromatographic-methods-paper-tlc-and-column-chromatography/			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1. Define systematic error. 2. What is random error? 3. Define gross error in analysis. 4. Define accuracy and precision 5. Define coprecipitation. 6. What is post precipitation? 7. State Nernst distribution law. 8. Define distribution coefficient. 9. Define chromatography. 10. State one application of TLC. 11. What is the stationary phase in TLC? 12. What is the mobile phase in TLC?			
	Answer in brief (At least 6) (3 Marks each) 1) Differentiate between qualitative and quantitative analysis with suitable examples 2) Explain the importance of sampling in analytical chemistry. 3) Differentiate between accuracy and precision 4) Write a short note on coprecipitation 5) Explain post precipitation with suitable examples. 6) Derive the expression for the amount of solute left unextracted after multiple extractions. 7) Define chromatography and classify chromatographic techniques. 8) Describe the technique of ascending paper chromatography 9) Explain the principle and technique of thin layer chromatography (TLC).			
	Answer in Detail (At least 4) (6 Marks each) 1) Describe the estimation of barium as barium sulphate by gravimetric method. 2) Discuss the selection of stationary and mobile phases in TLC. 3) Explain the determination and significance of Rf value in TLC. 4) Define Rf value and discuss factors affecting it.			
	MCQs for Internal Assessment (At least 4) 1. Which type of error arises due to faulty instrument calibration? A) Random error B) Gross error C) Systematic error D) Personal error			

	2. The principle of solvent extraction is based on: A) Raoult's law B) Beer-Lambert law C) Nernst distribution law D) Hess's law 3. In thin layer chromatography, the stationary phase is usually: A) Water B) Alcohol C) Silica gel D) Acetone 4. Which type of paper chromatography involves movement of solvent upward due to capillary action? A) Descending chromatography B) Circular chromatography C) Ascending chromatography D) Column chromatography

Course Category: **Major Lab**

108222 Chemistry Lab 10

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108222	Chemistry Lab 10	2	60	4 h	25+25= 50

Course Objectives:	To develop necessary skills in qualitative analysis of organic compounds, chemical kinetics and conductometric measurements through hands-on laboratory experiments, fostering a comprehensive understanding of key techniques in organic and physical chemistry.	
Course Outcomes:	At the end of this course students will be able to: 1. Identify extra elements through qualitative analysis techniques 2. Identify simple unknown organic compounds containing 1 or 2 functional groups. 3. Determine the rate constant of various reactions 4. To determine the molar refractivity and calculate the refraction equivalence of elements. 5. To perform various conductometric titrations 6. Apply conductometric measurement for determination of dissociation constant of weak acids and solubility products of sparingly soluble salts. 7. Develop precision in measuring and recording physical properties. 8. Develop skills in recording and reporting experimental procedures and results.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	1. Introduction to qualitative analysis of organic compounds 2. Importance of Chemical Kinetics and Conductometry	• By combining hands-on experiments, discussions, and real-world applications, students will gain a comprehensive understanding of chemistry lab practices. A few suggested pedagogies are: • Students should be given suitable **pre- and post-lab** assignments and explanation revising the theoretical aspects of laboratory experiments prior to and after the conduct of each experiment. • **Hands-On Laboratory Sessions:** Provide regular hands-on laboratory sessions where students can directly apply theoretical knowledge to practical experiments. • **Demonstrations and Simulations:** Use virtual simulations for certain experiments to enhance accessibility and understanding. • **Flipped Classroom Model:** Encourage students to come to class prepared, promoting active participation. • **Interactive Workshops:** Provide opportunities for students to engage in discussions, ask questions, and seek clarification. • **Technology Integration:** Incorporate digital tools for data analysis and presentation. • **Guest Lectures and Industry Connections:** Establish connections with professionals in the field to provide students with a broader perspective on chemical lab practices. • **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. • **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge
Organic Chemistry practical	1. Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid, amide and amine group of compounds. **(at least 6**) 2. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc. **(at least 8)**	
Physical Chemistry Practical	**(At least 8 experiments)** **Chemical Kinetics** 1. To determine the rate constant of the hydrolysis of ethyl acetate catalyzed by an acid 2. To determine the order of saponification reaction of ethyl acetate with NaOH 3. To study the kinetics of the iodination of acetone in the presence of an acid 4. To Study the kinetics of iodine clock reaction **Physical properties and Molecular structure** 5. To determine refractive index of liquid by using Abbe's refractometer 6. To determine the molar refractivity of methyl acetate, ethyl acetate, n-hexane and carbon tetrachloride and calculate the refraction equivalence of C, H and Cl atom by using Abbe's refractometer 7. To study the variation of refractive index with composition of mixture of carbon tetrachloride and ethyl acetate. **Conductometry** 8. To determine the cell constant of a conductivity cell. 9. To find out the strength of HCl solution by titrating against standard NaOH solution conductometrically. 10. To find out the strength of acetic acid solution by titrating against standard NaOH solution conductometrically.	

	11. To find out the strength of HCl and acetic acid in mixture of both by titrating against standard NaOH solution conductometrically. 12. To determine the dissociation constant of weak acid (acetic acid) conductometrically. 13. To determine the solubility and solubility product of a sparingly soluble salt conductometrically. 14. To find out strength of acetic acid in commercial vinegar sample by conductometric titration.	
References	1. Practical Chemistry (for B.Sc. I, II and III year students) – O P Pandey, D. N. Bajpaiand S. Giri (S Chand and company Ltd) 2. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press. 3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R.(2012),Vogel's Textbook of Practical Organic Chemistry, Pearson. 4. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press. 5. Advanced practical Organic Chemistry: O P Agrawal 6. Advanced Physical Chemistry Experiments: J N Gurtu and Amit Gurtu (Pragati Prakashan) 7. Experimental Physical Chemistry: V D Athawale and Parul Mathur (New Age Int. Pub.) 8. Advanced Practical Physical Chemistry: J B Yadav 9. Experiments in Physical Chemistry: D V Jahagirdar **Web resources:** 1. https://vlab.amrita.edu/?sub=2 2. https://chemcollective.org/vlabs 3. https://chem.libretexts.org/ 4. MIT OpenCourseWare: https://ocw.mit.edu 5. Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry	
Model Questions:	**NA**	

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Organic Chem Practical) 10 Marks
- Exercise 2 (Physical Chem Practical) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category**: Minor (Theory)**

108223 Minor Chemistry-2

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5	IV	108223	Minor Chemistry-2	2	30	2 Hrs	30+20=50

Course Objectives:	1. To develop a comprehensive understanding of bonding theories and are able to apply theoretical principles to analyze and predict molecular structures. 2. To develop the fundamental theoretical understanding of quantitative chemistry 3. To develop an understanding about C-X and C-O bond chemistry along with basic stereochemistry of organic molecules.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Describe Born-Haber's cycle. 2. Predict molecular geometries using hybridization 3. Define the mole in terms of mass, volume, and number of particles. 4. Solve problems on concentrations (molarity, normality, molality, mole fraction). 5. Explain the requirements for standard solutions and primary standard substances. 6. Compare the reactivity of halogenated hydrocarbons. 7. Write the mechanisms of SN reactions. 8. Design syntheses of organic molecules containing C-X, and C-O bonds. 9. Differentiate between enantiomers and diastereomers. 10. Assign configurations to the stereoisomers.

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Ionic bonding:** Definition of ionic bond, Factors affecting ionic bond formation (energetic of ionic bond formation ionization energy, electron affinity and lattice energy). Born-Haber's cycle to determine lattice energy. **Covalent bonding:** Directional nature of covalent bond. Valance Bond Theory (VBT), Limitations of VBT, Hybridization, Need of Hybridization, Types of hybridization to explain geometries of $BeCl_2$, BF_3, CH_4, $PC1_5$, SF_6 and IF_7.	8 Hrs	8 Marks	To enhance conceptual understanding and practical skills, a **blended teaching methodology** is employed, integrating the following strategies: **1. Conceptual & Visual Learning** • **Concept Mapping & Digital Simulations** (PhET, ChemSketch) for bonding, reaction mechanisms, and isomerism. • **3D Molecular Models & Interactive Discussions** for stereochemistry and hybridization. **2. Inquiry-Based & Experimental Learning** • **Hands-on Lab Work & Virtual Labs** for volumetric analysis, calorimetry, and synthesis. • **Problem-Solving & Data Analysis** for numerical applications (molarity, bond order, thermodynamics). **3. Digital & Flipped Learning** • **Pre-Class Video Lectures & Online Quizzes** for self-
Unit II	**A) The mole concept** Definition of mole in terms of mass, volume and number of particles. Avogadro's law, Atomic mass, average atomic mass and Molar Mass, Terms to express concentrations of solutions namely- molarity, normality, molality, mole fraction (Simple numerical expected). **B] Volumetric Analysis:** Important terms: titrant, titrate, end point, equivalence point, indicator, etc. Requirements and advantages of volumetric analysis. Definition of standard solution, Primary standard substance and its requirements.	7 Hrs	7 Marks	
Unit III	*A) Alkyl halides:* Methods of preparation, nucleophilic substitution reactions of ethyl bromide. *B) Aryl halides:* Preparation from diazonium salts. nucleophilic aromatic substitution; Benzyne mechanism. *C) Alcohols:* Preparation and reactions of ethyl alcohol.	8 Hrs	8 Marks	

	D) Phenols: Preparation and properties; Acidity of phenol, Reactions only: Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries rearrangement and Claisen rearrangement. *E) Ethers:* Classification. Preparation (Williamson synthesis and Continuous etherification), reactions of diethyl ether with hot and cold HI.			paced learning. • **Gamification & Case Studies** to relate theory to real-world applications. **4. Application & Research-Based Learning** • **Case-Based & Interdisciplinary Approach** connecting chemistry with industrial and environmental applications. • **Mini-Projects & Literature Reviews** to encourage analytical thinking. This **integrated approach** fosters **engagement, critical thinking, and practical competence**, ensuring a **dynamic and research-oriented** chemistry learning experience.
Unit IV	**Stereochemistry:** **A) Optical isomerism:** Stereoisomerism, Optical isomerism, asymmetric carbon atom, Element of symmetry, chirality (up to two carbon atoms), enantiomers, diastereoisomers, meso compounds, configuration, DL and RS nomenclature (for up to 2 chiral carbon atoms). **B) Geometrical isomerism:** Cis-trans & E-Z nomenclature (for up to two C=C systems) with examples and applications. **C) Conformational isomerism:** Conformational isomers, Newman & Sawhorse projection formulae, conformations of ethane, n-butane.	7 Hrs	7 Marks	

References:

1. Principles of Inorganic Chemistry by Puri, Sharma and Kalia- S. Naginchand & Co., Delhi.
2. Inorganic Chemistry by A.K. De, Wiley East Ltd.
3. Selected Topics in Inorganic Chemistry by Malik, Tuli and Madan, S. Chand & Co.
4. Concise Inorganic Chemistry by J.D. Lee, ELBS.
5. Inorganic Chemistry by J.E. Huheey- and Kettle, Harper & Row.
6. Advanced Inorganic Chemistry, Vol-I, Satya Prakash, Madan, Tuli, Basu.
7. Advanced Practical Inorganic Chemistry by Gurdeep Raj, Goel Pulishing House, Meerut.
8. Organic Chemistry Vol. I, II and III by Mukharjee, Singh and Kapoor- Wiley Eastern.
9. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
10. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007)
11. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008).
12. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford Universitiy Press.
13. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher, (2000).
14. Organic Chemistry by S.K. Ghosh.
15. Reaction Mechanism in Organic Chemistry by S.M. Mukharjee and S.P. Singh.
16. Stereochemistry and mechanism through solved problems by P.S. Kalsi.
17. Organic Chemistry by TWG Solomons, 8th edition, John Wiley
18. Organic Chemistry by R. K. Bansal

Web resources:

1. https://wou.edu/chemistry/courses/online-chemistry-textbooks/ch105-consumer-chemistry/chapter-3-ionic-covelent-bonding/
2. https://gchem.cm.utexas.edu/bonding/index.php
3. https://chem.libretexts.org/Courses/East_Tennessee_State_University/CHEM_3110%3A_Descriptive_Inorganic_Chemistry/03%3A_Bonding_Theories?
4. https://courses.lumenlearning.com/suny-mcc-introductorychemistry/chapter/formula-mass-and-mole-concept-from-che100/
5. Introductory Organic Chemistry I- https://nptel.ac.in/courses/104106119
6. https://archive.nptel.ac.in/content/storage2/courses/104103071/pdf/mod8.pdf
7. https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Introduction_to_Organic_and_Biochemistry_(Malik)/03%3A_Stereochemistry/3.01%3A_Introduction_to_stereochemistry

Model Questions:

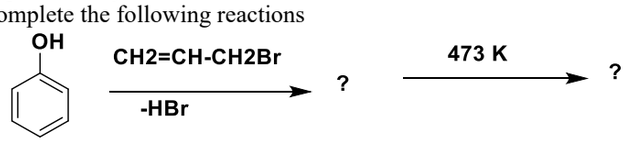
Short Type (At least 8)

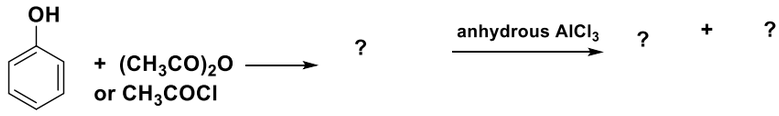
1. Define ionic bond
2. What is lattice energy?
3. Identify the hybridization of central atom in the following: $BeCl_2$, BF_3, CH_4, $PC1_5$, SF_6 and IF_7
4. Sate Avogadro's law
5. What is standard solution?
6. Name any two primary standard acids
7. Name the intermediate involved in SN1 Mechanism.

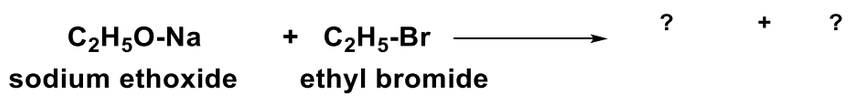
8. What are ethers?
9. What is the action of the following on diethyl ether 1) cold HI and 2) hot HI
10. What is the hybridization of Cabon attached to chlorine in chlorobenzene?
11. What are reactive methylene compounds?
12. Define asymmetric carbon.
13. What is center of symmetry?
14. Place the following groups in proper priority order according to sequence rules?
    CHO, -COOH, -NH2, -H. -CH3, -CN, -OH, -C2H5

Long Type (At least 4)

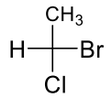
1. Describe Born-Haber's cycle to determine lattice energy
2. Explain geometries of (any one) $BeCl_2$, BF_3, CH_4, $PC1_5$, SF_6 and IF_7 using concept of hybridization.
3. Calculate the normality of 0.1 M H_2SO_4
4. Calculate the mole fractions of H_3PO_4 and water in a solution of 14.5 g of H_3PO_4 in 125 g of water?
5. Explain acidic nature of phenol.
6. Explain Benzyne intermediate mechanism.
7. Complete the following reactions

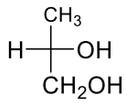
1. 

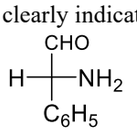
2. 

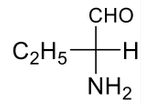
3. 

8. Determine the R/S configuration of the following structures clearly indicating the steps involved-

I) 

II) 

iii) 

IV) 

9. Draw Fischer projection of R and S configuration of lactic acid?

MCQs for Internal Assessment (At least 8)

1. The hybridization of P in $PC1_5$__
   a) sp3 b) sp3d c) sp3d2 d) sp2
2. The hybridization of S in SF_6 is___
   a) sp3 b) sp3d c) sp3d2 d) sp2
3. The hybridization of I in IF_7 is —
   a) sp3 b) sp3d3 c) sp3d2 d) sp2
4. According to VSEPR theory, the shape of NH_3 is__
   a) Tetrahedral b) pyramidal c) trigonal bipyramidal d) trigonal planar
5. According to VSEPR theory, the shape of SF_4 is _
   a) Tetrahedral b) pyramidal c) 'see-saw' shaped d) trigonal planar
6. According to VSEPR theory, the shape of SO_2, is__
   a) 'V' shaped b) pyramidal c) 'see-saw' shaped d) trigonal planar
7. According to VSEPR theory, the shape of XeF_4 is_
   a) Tetrahedral b) square planar c) 'see-saw' shaped d) trigonal planar
8. The mole is used in chemistry to represent ____of something
   a) 6.022×10^{23} b) 6.23×10^{23} c) 8.022×10^{23} d) 6.022×10^{32}
9. Arrangements of molecules that can be obtained by rotation around C-C single bond are called ___
   a) conformations b) configurations c) enantiomers d) geometric isomers
10. The number of extreme conformation possible for ethane are
    a) 1 b) 2 c) 3 d) 4
11. The number of extreme conformation possible for n-butane are
    a) 1 b) 2 c) 3 d) 4
12. If the two groups of higher priority are on the same side of the double bond then it is assigned ___ configuration
    a) E b) Z c) R d) S

Course Category**: Minor Lab**

108224 Minor Chemistry Lab- 11

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108224	Minor Chemistry Lab- 11	2	60	4 h	25+25= 50

Course Objectives:	The intended objectives are: 1. To develop practical skills in the preparation, dilution, and standardization of solutions essential for quantitative chemical analysis. 2. To apply qualitative and quantitative techniques for the identification of organic compounds based on their functional groups.	
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Prepare and standardize various solutions with precise concentration for laboratory applications. 2. Understand dilution principles and concentration calculations (molarity, normality, molality, and strength). 3. Apply volumetric techniques to determine unknown solution concentrations. 4. Perform qualitative analysis of organic compounds containing mono- and bifunctional groups. 5. Interpret chemical reactions to identify characteristic functional groups in organic compounds. 6. Demonstrate proficiency in handling laboratory glassware, chemicals, and instruments. 7. Enhance analytical problem-solving skills through accurate solution preparation and titration. 8. Apply theoretical concepts to experimental work, reinforcing the principles of chemical analysis. 9. Develop essential laboratory safety practices and documentation skills.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	• Theoretical Background: Explanation of concentration terms, dilution methods, and principles of solution preparation. • Numerical Applications: Practice problems on molarity, normality, and dilution calculations. • Experimental Techniques: Stepwise procedures for standardization, titration, and qualitative organic analysis. • Case-Based Learning: Interpretation of experimental results and discussion on error minimization in quantitative analysis.	• **Hands-on Experimental Learning** – Practical laboratory sessions for solution preparation, titration, and organic compound identification. • **Inquiry-Based Learning** – Encouraging students to analyze unknown solutions and predict concentrations based on calculations. • **Conceptual Visualization** – Demonstrations, charts, and digital simulations for understanding solution chemistry and functional group identification. • **Collaborative Learning** – Group discussions and peer review of experimental procedures and results. • **Problem-Based Learning (PBL)** – Application of theoretical concepts to real-world scenarios, such as industrial and pharmaceutical solution preparations.
Inorganic Experiments	**Preparation and standardization of solution** 1. Preparation of 1% and 2% w/v solutions of NaCl and glucose. 2. Preparation of 1 and 2% v/v solutions of acetic acid, HCl, HNO_3 or H_2SO_4. 3. Preparation of 0.1 M solutions of ammonia. 4. Preparation of 0.1 M and 0.01 M solutions of HCl. 5. Preparation of 10 ppm and 1 ppm solutions $KMnO_4$ from its 100 ppm stock solution 6. Preparation of 0.5 M, 0.1 M, 0.01 M, and 0.05 M NaOH solution by dilution method from its 1 M stock solution. 7. Preparation of 0.1 N solution of oxalic acid and calculate its molarity. 8. Preparation of 0.1 N solutions of sulfuric acid and calculate its molarity. 9. Determination of concentrations of given oxalic acid solution (0.6 g in 100 mL) in terms of normality, molarity, molality and strength. 10. Determination of concentrations of given sodium carbonate solution (0.5 g in 100 mL) in terms of normality, molarity, molality and strength. 11. Preparation of 1% NaOH solution and determine its normality and molarity by using standard 0.1 N Oxalic acid solution.	

	12. Preparation of 0.1 N H_2SO_4 solution and find out its exact normality using NaOH as an intermediate solution and 0.1 N Oxalic acid as standard solution. 13. Determination of molarity and strength of unknown hydrochloric acid solution with the help of standard 0.05M sodium carbonate solution. 14. Standardization of given NaOH solutions using standard 0.02 N Na_2CO_3.	• **Digital & Flipped Learning** – Pre-lab instructional videos, online quizzes, and virtual lab simulations for self-paced understanding. This integrated approach ensures students develop technical competence, analytical skills, and a deeper understanding of solution chemistry and organic qualitative analysis.
Organic Experiments	1. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc. **(At least 6)**	
References	1. Vogel's Textbook of Practical Organic Chemistry, 5th Edition by B. S. Furniss, A. J. Hannaford, Peter W. G. Smith, A. R. Tatchell; Pearson. 2. Organic Chemistry: Laboratory Manual by R. K. Bansal, New Age International Publisher 3. Advanced Practical Organic Chemistry by N. K. Vishnoi, Vikas Publishing House 4. Practical Organic Chemistry by Mann & Saunders, Pearson 5. Practical Chemistry (for B.Sc. I, II and III year students) – O P Pandey, D. N. Bajpai and S. Giri (S Chand and company Ltd 6. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press. 7. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press. 8. Advanced practical Organic Chemistry: O P Agrawal **Web resources:** 1. **Royal Society of Chemistry (www.rsc.org/learn-chemistry)** – Free chemistry resources and lab techniques. 2. Organic Syntheses (www.orgsyn.org) – Peer-reviewed procedures for organic compound synthesis. 3. MIT OpenCourseWare: https://ocw.mit.edu 4. https://vlab.amrita.edu/?sub=2 5. https://chemcollective.org/vlabs	
Model Questions:	**NA**	

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Inorganic Chem Practical) 10 Marks
- Exercise 2 (Organic Chem Practical) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category**: GE/OE -4**

108225 Chemistry for Sustainable Agriculture

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108225	Chemistry for Sustainable Agriculture	2	30	2 Hrs	30+20=50

Course Objectives:	This course aims to provide a fundamental understanding of the role of chemistry in sustainable agriculture, with a special focus on chemical and biopesticides. Students will learn how to apply this knowledge to improve crop yield while ensuring environmental safety.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Define the principles of sustainable agriculture and explain the role of chemistry in it. 2. Explain the chemical composition and properties of chemical and biopesticides. 3. Analyze how chemical and biopesticides affect crop yield and pest control. 4. Evaluate the environmental impact of chemical and biopesticides, including their degradation, persistence, and potential hazards. 5. Apply chemical principles to optimize agricultural practices and promote sustainable farming methods.

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Introduction to Sustainable Agricultural and the role of Chemistry:** **Overview of Sustainable Agricultural Chemistry**: Definition, scope, and importance in modern agriculture. **Basic Chemical Principles in Agriculture**: Atoms, molecules, chemical bonds, and reactions relevant to pest control. **Role of chemistry in pest management and crop nutrition.**	7 Hrs	7 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-on Activity: Identification of various pests in mono and dicotyledon plants samples;** to improve practical understanding **Case Study: Pesticide Overuse and Its Environmental Consequences**. Read the daily news papers and make a report. **Field Study: Common Pesticides Used in Local Farming Practices**. To correlation relevance of theoretical knowledge with real world. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research.
Unit II	**Pesticides Their Environmental Impact** **Classification of Pesticides**: Insecticides, herbicides, fungicides, and their chemical nature. **Mode of action and environmental impact:** How pesticides affect target organisms, soil, and water bodies. **Degradation, persistence, and bioaccumulation:** Chemical breakdown, residual toxicity, and effects on non-target species. **Safe handling, application, and government regulations** (e.g., **EPA, BIS standards**).	8 Hrs	8 Marks	
Unit III	**Chemical Pesticides – Uses, Benefits, and Risks** **Definition and classification** of **chemical pesticides** (synthetic vs. semi-synthetic). **Types of chemical pesticides**: Organophosphates, carbamates, pyrethroids, neonicotinoids, etc. **Mode of Action:** How **chemical pesticides** interact with **pests and crops**. **Advantages of chemical pesticides**: Cost-effectiveness, rapid action, and crop yield improvement. **Impact on human health and ecosystems**: Toxicity, bioaccumulation, and resistance development. Specify **examples of commonly used pesticides** (e.g., **DDT, Malathion, Glyphosate**)	7 Hrs	7 Marks	

	Alternatives to chemical pesticides: Integrated Pest Management (IPM) and reduced-chemical approaches.			**Practical-Based Learning: Making Neem-Based Biopesticide Solution"**. Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit IV	**Biopesticides: A Sustainable Alternative to Chemical Pesticides** **Definition and classification** of **biopesticides**: Microbial, botanical, and biochemical biopesticides. **Types of biopesticides**: Bacteria (*Bacillus thuringiensis*), fungi (*Beauveria bassiana*), and plant-based pesticides (neem extract, pyrethrin). **Mechanism of action**: How **biopesticides** target pests and diseases. **Global and local perspectives:** Trends, regulatory framework, and adoption barriers. **Challenges in commercializing biopesticides:** Cost, shelf-life and efficacy. **Environmental impact**: Biodegradability, effects on beneficial insects, and sustainability strategies.	8 Hrs	8 Marks	

References:

1. Introductory Agricultural Chemistry: Dr. D. P. Ray
2. Elements of Agricultural Chemistry: Thomas Andrson
3. Agricultural Chemistry: Ajay Singh
4. Neem: A Tree for Solving Global Problems by National Research Council
5. Biopesticides Handbook by L.G. Copping Eggshells: Waste to Wealth by Dr. S. Sharma
6. Biopesticides and Pest Management" by Dr. R.K. Upadhyay.
7. Soil Fertility and Fertilizers by J.L. Havlin
8. Chemistry and Technology of Agrochemical Formulations by A. Knowles
9. Organic Farming: Principles & Practices by K.P. Prabhakaran Nair

To further refine your syllabus and align it with established agricultural university curricula, consider the following insights drawn from various institutions:

1. **Biopesticides and Biofertilizers:**
Amrita Vishwa Vidyapeetham offers a course titled "Biopesticides & Biofertilizers" as part of their B.Sc. (Hons.) Agriculture program.

2. Practical Applications in Soil and Plant Analysis:
The College of Agriculture at CSK Himachal Pradesh Agricultural University emphasizes hands-on experience in their curriculum.

3. Integrated Pest Management and Entomology:
Vasantrao Naik Marathwada Krishi Vidyapeeth's College of Agriculture offers comprehensive courses in entomology and pest management.

TED and TEDx Talks:

1. **The Other Inconvenient Truth" by Jonathan Foley**
2. **Biopesticides: The Natural Solution to Pest Control" by Agnès Ricroch**
3. **MIT Open Course Ware :** Land, Water, Food, and Climate (Course 1.74)

Web resources:
https://chem.libretexts.org/Courses/Anoka-Ramsey_Community_College/Introduction_to_Chemistry/01%3A_What_is_Chemistry/1.02%3A_Chemistry_in_Agriculture

Model Questions:

Short Type (At least 6)

1. Define sustainable agriculture and explain its importance.
2. How does chemistry contribute to modern agricultural practices?
3. What is the role of soil pH in crop production?
4. Explain the difference between organic and inorganic compounds in agricultural chemistry.
5. What are the main types of pesticides used in agriculture? Give one example of each.
6. Explain the mode of action of herbicides in weed control.
7. How do pesticides persist in the environment, and what are the risks associated with their overuse?
8. Define chemical pesticides and classify them based on their chemical nature.
9. What are the advantages and disadvantages of using chemical pesticides?
10. Define biopesticides and list their different types.
11. Explain how neem-based biopesticides work against pests.
12. What is pesticide resistance**,** and how does it develop in insect populations?

Long Type (At least 4)

1. Define sustainable agriculture. Discuss its significance and challenges in modern farming.
2. Explain the role of chemistry in agriculture, highlighting its application in soil health, plant growth, and pest control.
3. Discuss the chemical composition of soil and explain how soil pH affects nutrient availability.
4. Describe the different types of chemical bonds and their importance in agricultural chemistry.
5. Explain the classification of pesticides with examples. Describe their chemical nature and mode of action.
6. What is pesticide degradation? Discuss the environmental impact of pesticide persistence and bioaccumulation.
7. Discuss the safe handling, application, and government regulations associated with pesticide use.
8. Compare synthetic fertilizers and organic fertilizers in terms of their composition, benefits, and drawbacks.
9. Define chemical pesticides and explain their types, advantages, and disadvantages.
10. Describe the mechanism of action of insecticides, herbicides, and fungicides in agricultural applications.
11. Explain the concept of pesticide resistance. How does excessive pesticide use lead to resistance development in pests?
12. Discuss alternative pest management strategies, including Integrated Pest Management (IPM) and chemical-free approaches.
13. Define biopesticides and describe their classification, advantages, and limitations.
14. Compare biopesticides and chemical pesticides in terms of mode of action, environmental impact, and effectiveness.
15. Explain the mechanism of action of microbial biopesticides with examples such as Bacillus thuringiensis (Bt) and Trichoderma.
16. Discuss the challenges and future prospects of biopesticides in sustainable agriculture.

MCQ (At least 8)

1. **What is the primary goal of sustainable agriculture?**
   a) Maximizing pesticide use
   b) Increasing chemical fertilizer dependency
   c) Ensuring long-term soil fertility and environmental balance ✅
   d) Encouraging monoculture farming

2. **Which chemical property of soil affects nutrient availability the most?**
   a) Soil texture
   b) Soil pH ✅
   c) Soil color
   d) Soil depth
3. **Which of the following is NOT a macronutrient required by plants?**
   a) Nitrogen
   b) Phosphorus
   c) Potassium
   d) Iron ✅
4. **Which branch of chemistry is most relevant to agriculture?**
   a) Organic chemistry
   b) Analytical chemistry
   c) Agricultural chemistry ✅
   d) Physical chemistry

5. **Which type of pesticide is used to control fungal diseases in crops?**
   a) Herbicide
   b) Insecticide
   c) Fungicide ✅
   d) Rodenticide
6. **What is the main environmental concern of synthetic pesticide overuse?**
   a) Increased crop yield
   b) Development of pesticide-resistant pests ✅
   c) Faster plant growth
   d) Improved soil fertility
7. **Which of the following is a characteristic of persistent pesticides?**
   a) They break down quickly in the environment
   b) They accumulate in soil and water ✅
   c) They do not affect non-target organisms
   d) They have no effect on biodiversity
8. **Which regulatory body in India oversees pesticide safety?**
   a) Food and Drug Administration (FDA)
   b) Bureau of Indian Standards (BIS)

c) Central Insecticides Board and Registration Committee (CIBRC) ✅
d) Indian Council of Agricultural Research (ICAR)

9. **Which of the following is a synthetic insecticide?**
a) Neem extract
b) Bacillus thuringiensis
c) DDT ✅
d) Trichoderma
10. **What is the main advantage of chemical pesticides over biopesticides?**
a) They degrade faster in the environment
b) They provide immediate pest control ✅
c) They have no environmental impact
d) They improve soil microbial diversity
11. **Which pesticide component is responsible for harming pollinators like bees?**
a) Organophosphates ✅
b) Nitrogen fertilizers
c) Phosphate solubilizers
d) Biofertilizers
12. **Which of the following is a major disadvantage of chemical pesticides?**
a) They are cost-effective
b) They degrade soil health over time ✅
c) They increase biodiversity
d) They are non-toxic to humans

13. **Which of the following is an example of a microbial biopesticide?**
a) Neem oil
b) Bacillus thuringiensis (Bt) ✅
c) Glyphosate
d) DDT
14. **Why are biopesticides considered more sustainable than chemical pesticides?**
a) They require high doses for effectiveness
b) They degrade quickly without harming the environment ✅
c) They persist in the environment for a long time
d) They promote chemical dependency in farming
15. **Which plant-derived compound is commonly used in biopesticides?**
a) Glyphosate
b) Pyrethrin ✅
c) Malathion
d) DDT
16. **Which of the following is a limitation of biopesticides?**
a) They are highly toxic to humans
b) They have a shorter shelf-life than chemical pesticides ✅
c) They persist in the environment for decades
d) They kill beneficial insects along with pests

Course Category: **Vocational Skill Course VSC-3**

108226 Chemistry Lab- 12 (Synthesis and extraction of industrial products)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108226	Chemistry Lab- 12 (Synthesis and extraction of industrial products)	2	60	4 Hrs	50

Course Objectives:	The intended objectives are: 1. To learn the synthesis and extraction of important organic compounds. 2. To develop practical skills in reaction setup, purification, and product analysis. 3. To understand green chemistry and the isolation of bioactive compounds from natural sources.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Synthesize key industrial organic compounds such as aspirin, paracetamol, and benzocaine using established chemical methods. 2. Perform extraction and isolation of natural products like caffeine, lycopene, and limonene from plant sources. 3. Apply green chemistry principles in organic synthesis to minimize environmental impact. 4. Utilize purification techniques such as recrystallization, melting point analysis, and thin-layer chromatography (TLC) for product characterization. 5. Understand the industrial relevance and applications of synthesized and extracted compounds in pharmaceuticals, cosmetics, and food industries.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	**A. Preparation of Organic Compounds** 1. **Reaction Mechanisms** – Understand key reactions like esterification, nitration, and condensation. 2. **Purification & Testing** – Learn recrystallization, melting point checks, and TLC analysis. 3. **Green Chemistry** – Compare traditional vs. eco-friendly synthesis methods. 4. **Real-World Applications** – Discuss industrial and pharmaceutical uses of synthesized compounds. **B. Extraction and Isolation** 5. **Extraction Methods** – Explore techniques like solvent extraction and steam distillation. 6. **Yield & Purity Factors** – Learn how solvent choice and conditions affect extraction. 7. **Analysis Techniques** – Use TLC, UV-Vis, and melting point to test extracted compounds. 8. **Uses of Natural Extracts** – Discuss their applications in medicine, cosmetics, and food.	To enhance student engagement and learning outcomes, the following pedagogical approaches will be incorporated: • **Experiential Learning (Hands-on Laboratory Work)** a. Conduct guided experiments on the synthesis of industrially relevant organic compounds. b. Perform extractions and isolations of natural products to develop technical proficiency. • **Inquiry-Based Learning** a. Encourage students to analyze reaction mechanisms and predict product yields. b. Promote critical thinking by comparing conventional and green synthesis approaches. • **Collaborative Learning** a. Facilitate group-based experimental work to enhance teamwork and problem-solving skills. b. Conduct peer discussions on challenges and improvements in experimental procedures. • **Technology-Enhanced Learning** a. Use digital tools (e.g., molecular modeling software, virtual labs) to visualize reaction pathways.
Preparations	**(Collected solid samples may be used for recrystallization, melting point and TLC) (At least 8)** 1. Aspirin from Salicylic acid. 2. Methyl Salicylate from Salicylic Acid 3. Paracetamol from p-amino phenol 4. Benzocaine from p-nitro benzoic acid 5. Acetanilide from aniline 6. Diphenylhydantoin from Benzoin. 7. Diclofenac sodium from aniline. 8. Nitration of Salicylic acid by green approach (using ceric ammonium nitrate). 9. Reduction of *p*-nitrobenzaldehyde by sodium borohydride. 10. Hydrolysis of amides and esters. 11. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.	

	12. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid). 13. Aldol condensation with either conventional or green method. 14. Synthesis of Indigo (using aldol condensation reaction of 2-nitrobenzaldehyde with acetone in basic condition).	b. Integrate spectroscopy and chromatography techniques for product characterization. • **Case-Based and Problem-Solving Approach** a. Analyze industrial case studies related to pharmaceutical synthesis and natural product extraction. b. Discuss challenges in large-scale production and sustainability in chemical industries. • **Assessment through Reflective Learning** a. Encourage students to maintain lab journals for recording observations and interpretations. b. Conduct oral presentations and report writing to develop scientific communication skills.
Extraction and Isolation	**(At least 4)** 1. Isolation of casein rom milk. 2. Isolation of lactose rom milk. 3. Isolation of caffeine from tea leaves. 4. Isolation of lycopene from tomato. 5. Extraction of limonene from orange peels. 6. Extraction of piperine from black pepper. 7. Extraction of Nimbin from Neem Seeds. 8. Extraction of Nicotine from Tobaco leaves. 9. Extraction of Citronella from lemon grass. 10. Extraction of Rose oil and rose hydrosol from rose petals. 11. Extraction of Anthocyanin from rose petals.	
References	1. Vogel's Textbook of Practical Organic Chemistry, 5th Edition by B. S. Furniss, A. J. Hannaford, Peter W. G. Smith, A. R. Tatchell; Pearson. 2. Organic Chemistry: Laboratory Manual by R. K. Bansal, New Age International Publisher 3. Advanced Practical Organic Chemistry by N. K. Vishnoi, Vikas Publishing House 4. Practical Organic Chemistry by Mann & Saunders, Pearson 5. Green Chemistry: Theory and Practice by Paul T. Anastas and John C. Warner, OUP UK 6. Essential Oils: Extraction Methods and Applications by by Inamuddin, Tariq Altalhi, Jorddy Neves Cruz, Wiley-Scrivener **Web resources:** 1. **Royal Society of Chemistry (www.rsc.org/learn-chemistry)** – Free chemistry resources and lab techniques. 2. Organic Syntheses (www.orgsyn.org) – Peer-reviewed procedures for organic compound synthesis. 3. https://www.youtube.com/watch?v=bMFt1lOmlQ4; 4. MIT OpenCourseWare – Organic Chemistry" for lab demonstrations.	
Model Questions:	**NA**	

Distribution of Marks and the scheme of (VSC) Practical Examination is as follows:

Section I: Continuous Internal Assessment

- Continuous Assessment Tests (CAT) (At least three tests) * 15 Marks
- Submission of duly certified practical record 10 Marks

Total 25 Marks

Section II: End Semester Examination (Internal only)

- Exercise 1 20 Marks
- Viva-Voce (internal) 05 Marks

Total 25 Marks

Total (Section I And II) 50 Marks

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Course Category: **Skill Enhancement Course SEC-3**

108227 Chemistry Lab- 13 (Basic Cheminformatics)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108227	Chemistry Lab- 13 **(Basic Cheminformatics)**	2	60	4 Hrs	50

Course Objectives:	The intended objectives are: 1. To introduce students to the fundamental concepts and applications of cheminformatics, including molecular modeling and structure elucidation. 2. To develop computational skills for molecular representation, database searching, and cheminformatics software utilization. 3. To enhance proficiency in scientific documentation, digital tools, and science communication through internet platforms
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Demonstrate a comprehensive understanding of cheminformatics principles, including molecular representation, structure elucidation, and computational methods. 2. Apply cheminformatics techniques to encode molecular structures using various formats such as SMILES, InChI, and MOL files. 3. Efficiently retrieve and analyze chemical information through database searches using PubChem, ChemSpider, and SciFinder. 4. Utilize molecular modeling and visualization tools for structure optimization, conformational analysis, and property prediction. 5. Develop scientific documentation and presentations using MS Office, Open Office, and other digital tools for effective communication of cheminformatics concepts. 6. Integrate cheminformatics knowledge with practical applications in molecular design, structural analysis, and chemical data interpretation.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	1. **Introduction to Cheminformatics**: History, Prospects of cheminformatics, Molecular Modelling and Structure elucidation 2. **Representation of molecules and chemical reactions:** Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits. 3. **Searching chemical structures:** Full structure search, sub-structure search, basic ideas, similarity search, three-dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization 4. Introduction to advanced functions of MS Word and its Open Office substitutes including tracking changes, inserting page numbers and automatic table of contents, Google Docs and Forms, MS Power point 5. Science outreach through internet: social media, Websites, Blogs, YouTube, Podcast etc.	To enhance student engagement and learning outcomes, the following pedagogical approaches will be incorporated: • **Experiential Learning (Hands-on Laboratory Work)** a. Conduct guided experiments on the synthesis of industrially relevant organic compounds. b. Perform extractions and isolations of natural products to develop technical proficiency. • **Inquiry-Based Learning** a. Encourage students to analyze reaction mechanisms and predict product yields. b. Promote critical thinking by comparing conventional and green synthesis approaches. • **Collaborative Learning** a. Facilitate group-based experimental work to enhance teamwork and problem-solving skills. b. Conduct peer discussions on challenges and improvements in experimental procedures.
Exercise/ Experiments	**(At least 8) (Any suitable software other than the software mentioned can be used)** 1. Drawing well labelled diagram of simple acid-base titration assembly using ChemSketch. 2. To visualize structural, isomers using MolView/ Kingsdraw. Example Butane (C_4H_{10}) - n-butane & isobutane 3. To visualize geometrical isomers using MolView/ Kingsdraw. Example: 2-Butene (C_4H_8) 4. To visualize optical isomers using MolView/ Kingsdraw. Example: Lactic Acid ($C_3H_6O_3$) - D & L isomers (optical isomers) 5. To study the 3D structure and molecular properties of paracetamol using PubChem's molecular visualization tools. 6. SMILES & InChI Encoding: Convert molecular structures into SMILES notation using software like ChemDraw, Open Babel, or Online SMILES generators. 7. To Perform Full and Sub-Structure Searching of Chemical Compounds Using PubChem, ChemSpider, and SciFinder. 8. To Read, Write, and Edit Molfile & SDF Formats Using	

	RDKit or Open Babel or ChemAxon's Marvin. 9. Drawing the 2D-structures of different conformers of ethane, n-butane, and cyclohexane and their conversion to 3D- optimized structures using MMFF94 forcefield using Avogadro. 10. Drawing the 2D-structures of different conformers of mono- and di-substituted cyclohexane and their conversion to 3D- optimized structures using MMFF94 forcefield using Avogadro. 11. To measure and compare bond lengths and angles in different molecules using Jmol. (Example: Methane, Ammonia, Water, Carbon Dioxide). 12. To analyze the polarity and dipole moment direction, polarizability, surface tension, density in molecules using ChemSketch.	• **Technology-Enhanced Learning:**Use digital tools (e.g., molecular modeling software, virtual labs) to visualize reaction pathways. • **Case-Based and Problem-Solving Approach** a. Analyze industrial case studies related to pharmaceutical synthesis and natural product extraction. b. Discuss challenges in large-scale production and sustainability in chemical industries. • **Assessment through Reflective Learning** a. Encourage students to maintain lab journals for recording observations and interpretations. b. Conduct oral presentations and report writing to develop scientific communication skills.
Activities	To prepare a PowerPoint presentation using structure drawing software(s) and submit soft copy to the instructor. A few students may be asked to present a seminar on the topics: Suggested list of activities (may be extended according to the wisdom of the instructor): 1. Organic reaction with suitable mechanism. 2. Derivation of a equation in physical chemistry 3. Jablonskii Diagram to explain radiative and nonradiative processes 4. Conformational analysis ethane/ butane/ cyclohexane	
References	References: 1. Svehla, G., & Vogel, A. I. (1989). *Vogel's textbook of practical inorganic chemistry* (5th ed.). Pearson Education. 2. Vogel, A. I. (1996). *Qualitative inorganic analysis* (7th ed.). Prentice Hall. 3. Malik, W. U., Tuli, G. D., & Madan, R. D. (2009). *Laboratory manual of inorganic chemistry*. S. Chand Publishing. 4. Pandey, O. P., Bajpai, D. N., & Giri, S. (2010). *Practical chemistry*. S. Chand Publishing. 5. Agarwal, O. P. (2014). *Advanced practical inorganic chemistry*. Krishna Prakashan Media. Web source: 1. https://sourceforge.net/projects/openbabel 2. https://jmol.sourceforge.net/ 3. Jmol Application - 3D chemical structure viewer By Prof Kannan Moudgalya, https://onlinecourses.swayam2.ac.in/aic20_sp63/preview 4. https://edu.rsc.org/resources/practical-chemistry 5. https://nptel.ac.in/courses/104/103/104103112/ 6. http://chemcollective.org/vlabs	
Model questions	NA	

Distribution of Marks and the scheme of (SEC) Practical Examination is as follows:

Section I: Continuous Internal Assessment

- Continuous Assessment Tests (CAT) (At least three tests) * 15 Marks
- Submission of duly certified practical record 10 Marks

Total 25 Marks

Section II: End Semester Examination (Internal only)

- Exercise 1 20 Marks
- Viva-Voce (internal) 05 Marks

Total 25 Marks

Total (Section I And II) 50 Marks

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Course Category: **FP/CEP-II**

108228 Chemistry Lab- 14 (FP/ CEP in Chemistry - II)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108228	Chemistry Lab- 14 (FP/ CEP in Chemistry - II)	2	60	--	50

Course Objectives:	The intended objectives are: • To develop an appreciation of rural culture, lifestyle and wisdom amongst students. • To learn about the status of various agricultural and development programmes. • To understand the causes of distress and poverty faced by vulnerable households and explore solutions for the same. • To apply classroom knowledge of courses to field realities and thereby improve the quality of learning.
Course Outcomes:	Upon successful completion of this course, students will be able to: 10. Gain an understanding of rural life, Indian culture and ethos and social realities 11. Develop a sense of empathy and bonds of mutuality with the local community 12. Appreciate significant contributions of local communities to Indian society and Economy 13. Learn to value the local knowledge and wisdom of the community 14. Identify opportunities for contributing to community's socio-economic improvements

Guidelines/ SoP for FP/CEP

For understanding key principles of CE, forms of CE, operational guidelines and implementation strategy please refer https://www.ugc.gov.in/pdfnews/4187860_Revised-Final-Guidelines.pdf

As per NEP 2020, students of B Sc. II of Semester III and IV need to perform a Field Project (FP) for TWO (2) credits i.e. 50 Marks. The guidelines regarding the FP/CEP are as follows:

1) The total time allocation for the student to carry out field project is 60 hours.
2) Students should participate in field-based projects under the supervision of faculty.
3) Assignment of project topics to individual students or groups of students (max 4 students in one group) and one faculty member from the department will act as Guide for the student or group of students.
4) For a SURVEY based project related questionnaire (15 or more questions) should be prepared.
5) The departmental coordinator/guide should check the questions and finalize the questionnaire. The question that may create unnecessary complications should be avoided. The questions should be qualitative as well as quantitative.
6) If the project is related to work that does not involve survey work, then the questionnaire part can be replaced accordingly (e.g. Sample collection/Data collection/ Experimental base etc).
7) The student should compile all the relevant data and carry out its analysis.
8) A project report should be written individually in the standard format (2 Copies): Index, Introduction, Materials, Methods, Result, Conclusion/output, References (Numeric citation type) etc.
9) The project report should be of minimum 6 pages (excluding Title page, Certificate, Index, Acknowledgement etc.). Submit the project report with the Guide's signature to the department.
10) The oral /poster presentation for all the projects should be arranged in the department. To evaluate the project, examiner should be appointed by HoD.
11) The total project work including preparation of questionnaire to presentation should be evaluated for 2 credits (50 Marks).

Some suggested forms of FP/ CEP are:

1. **Linking learning with community service:** For example, students of chemistry can conduct water and soil testing in local areas and share the results with the local community.
2. **Linking research with community knowledge:** Community-based Participatory Research (CBPR) approaches are gaining recognition in this regard. For example, students of chemistry can undertake research in partnership with the community on solid and liquid waste disposal.
3. **Knowledge sharing and knowledge mobilization:** These can take the forms of enumerations, surveys, awareness camps and campaigns, training, learning manuals/films, maps, study reports, public hearings, policy briefs, cleanliness and hygiene teachings, legal aid clinics, etc. For example, students can undertake a 'swachhta survekshana' and/or nutrition survey for mothers and children, and educate them about hygiene and nutrition.
4. **Social innovations by students:** The students can be encouraged to initiate learning projects with a social impact and supported by HEIs. Incubation of such social innovation projects by students can also have meaningful links to existing curriculum and courses.

A few suggested (not exclusive) areas which not only provide practical applications of chemistry concepts but also foster collaboration, education, and sustainable practices within the community. are:

1. Understanding the chemical footprints of household products such as toothpaste, haircare, facecare food products etc
2. Enhance science literacy among school students through interactive chemistry demonstrations.
3. Managing organic waste to composting and improve soil health.
4. Explore the extraction and application of natural dyes as alternatives to synthetic dyes.
5. Identify and mitigate lead exposure risks in the community.
6. Implement a community-wide recycling initiative focusing on chemical waste and recyclable materials.
7. Introduce and demonstrate the principles of renewable energy sources, such as biofuels or solar energy.
8. Assess local air quality and raise awareness about pollution sources and mitigation strategies.
9. Educate community members on the safe use, storage, and disposal of household chemicals.
10. Assist local farmers in understanding soil nutrient content and composition to optimize crop production.
11. Evaluate local water sources for contaminants such as heavy metals, nitrates, and pH levels.

References	1. https://www.ugc.gov.in/pdfnews/4187860_Revised-Final-Guidelines.pdf 2. https://en.wikipedia.org/wiki/OU_Citizen_Science_Soil_Collection_Program 3. https://www.immerse.education/study-tips/100-ideas-for-research-projects-in-chemistry/ 4. https://pubs.rsc.org/en/content/articlelanding/2021/rp/d0rp00374c 5. https://www.acs.org/education/student-communities/activities.html 6. https://www.nettercenter.upenn.edu/academically-based-community-service-chemistry-outreach
Model Questions:	**NA**

Distribution of Marks and the scheme of FP/CEP Examination is as follows:

- Students' performance 20 Marks
- Submission of duly certified FP/CEP report 20 Marks
- Presentation (PPT or Poster) 10 Marks

Total **50 Marks**

SANT GADGE BABA AMRAVATI UNIVERSITY, AMRAVATI

Degree of Bachelor of Science

Chemistry

Semester V and VI

FACULTY: SCIENCE AND TECHNOLOGY

(Courses effective from Academic Year 2026-27)
Under NEP 2020 (As per Uniform NEP Scheme)

SYLLABUS

Contents

TLE Scheme for THIRD YEAR: SEMESTER – V (Level 5.5)

Level	The Vertical	Course Code	Course Title	Credits	Workload	Theory/Practical Marks				Theory/Pract (Total) Marks	
						External		Internal			
						Max.	Min.	Max.	Min.	Max.	Min.
5.5	Major-T	108230	InorganicChemistry-2	2	2	30	9	20	6	50	20
5.5	Major-T	108231	Organic Chemistry-2	2	2	30	9	20	6	50	20
5.5	Major-T	108232	Physical chemistry 2	2	2	30	9	20	6	50	20
5.5	Major-P	108233	Chemistry Lab 15	2	4	25	10	25	10	50	20
5.5	Major-Elective T1	108234	Elective Chemistry-1 (Spectroscopy I)	2	2	30	9	20	6	50	20
5.5	Major-Elective P1	108235	Chemistry Lab 16 A (Elective Chemistry-1)	2	4	25	10	25	10	50	20
OR											
5.5	Major-Elective T2	108236	Elective Chemistry-2 (Spectroscopy II)	2	2	30	9	20	6	50	20
5.5	Major-Elective P2	108237	Chemistry Lab 16 B (Elective Chemistry-2)	2	4	25	10	25	10	50	20
OR											
5.5	Major-Elective T3	108238	Elective Chemistry-3 (Biomolecules)	2	2	30	9	20	6	50	20
5.5	Major-Elective P3	108239	Chemistry Lab 16 C (Elective Chemistry-3)	2	4	25	10	25	10	50	20
5.5	Minor-T	108240	Minor Chemistry-3	2	2	30	9	20	6	50	20
5.5	Minor-P	108241	Minor Chemistry Lab 17	2	4	25	10	25	10	50	20
5.5	VSC-P	108242	Chemistry Lab -18 (Oil and Milk Analysis)	2	4	-	-	50	20	50	20
5.5	SEC-P1	107243	Chemistry Lab 19 (ICT Tools in Chemistry)	2	4	-	-	50	20	50	20
5.5	FP/CEP	108244	Chemistry Lab 20 (FP/ CES in Chemistry - III)	2	4	-	-	50	20	50	20
5.5	Non Credit		Foundation of Artificial Intelligence	NC	2			30+20	9+6	50	20

Important:

- **VSC Should be Complementary to Major**
- **SEC must be selected from the Basket Provided by University, from the same Faculty/Discipline of the Major/Minor**
- As per Sant Gadge Baba Amravati University, Amravati Extra-Ordinary Notification No. No. 241/2025 Dated 24/12/2025 “Foundation of Artificial Intelligence” is the mandatory **Non Credit Course** compulsory course for all the UG students in fifth semester of all undergraduate programs of all faculties in Sant Gadge Baba Amravati University, Amravati to earn their degree
- NC is Non Credit Course
- Students must select **Any One** of the Major-Elective Courses (T1 to T3) with respective Practical Course in Semester V**.**

TLE Scheme for THIRD YEAR: SEMESTER – VI (Level 5.5)

Level	The Vertical	Course Code	Course Title	Credits	Workload	Theory/Practical Marks				Theory/Pract (Total) Marks	
						External		Internal			
						Max.	Min.	Max.	Min.	Max.	Min.
5.5	Major-T	108245	Inorganic Chemistry 3	2	2	30	9	20	6	50	20
5.5	Major-T	108246	Organic Chemistry 3	2	2	30	9	20	6	50	20
5.5	Major-T	108247	Physical Chemistry 3	2	2	30	9	20	6	50	20
5.5	Major-P	108248	Chemistry Lab 21	2	4	25	10	25	10	50	20
5.5	Major-Elective T1	108249	Elective Chemistry 4 (Organic Spectroscopy)	2	2	30	9	20	6	50	20
5.5	Major-Elective P1	108250	Chemistry Lab 22 A (Elective Chemistry 4)	2	4	25	10	25	10	50	20
OR											
5.5	Major-Elective T2	108251	Elective Chemistry 5 (Green Chemistry and Nanochemistry)	2	2	30	9	20	6	50	20
5.5	Major-Elective P2	108252	Chemistry Lab 22 B (Elective Chemistry 5)	2	4	25	10	25	10	50	20
OR											
5.5	Major-Elective T3	108253	Elective Chemistry 6 (Chemistry of Consumer and Industrial Products)	2	2	30	9	20	6	50	20
5.5	Major-Elective P3	108254	Chemistry Lab 22 C (Elective Chemistry 6)	2	4	25	10	25	10	50	20
5.5	Minor-T	108255	Minor Chemistry 4	2	2	30	9	20	6	50	20
5.5	Minor-P	108256	Minor Chemistry Lab 23	2	4	25	10	25	10	50	20
5.5	VSC-P	108257	Chemistry Lab 24 (Water and Soil Analysis)	2	4	-	-	50	20	50	20
5.5	Intern/Apprenticeship	108258	Chemistry Lab 25 (Internship / Apprenticeship)	4	8	-	-	50	20	50	20

Important:

- VSC Should be Complementary to Major has to be selected from the Basket Provided by University, from the same Faculty/Discipline of the Major/Minor
- **Students** must select **Any One** of the Major-Elective Courses (T1 to T3) with respective Practical Course in Semester VI**.**

Examination and Assessment Process:

i. The basic principle of the Credit framework is that Credits are a function of the successful completion of a program of study/ vocational education/ training and assessment. No Credit can be earned by the student unless the student is assessed for the achievement of the desired competencies and outcome of a program.

ii. Exit options are provided with Certificate, Diploma and Basic Bachelor's degrees to the students at the end of the second, fourth and sixth semesters of a Four Years Multidisciplinary Degree Programme. Students will receive a Bachelor's degree with Honors/ Research on successfully completing of all eight semesters of the UG Program either at a stretch or with opted exits and re-entries.

iii. For the smooth success of four-year degree programme with multiple entry and exit systems, the examination mode should be based on the combination of innovative trends in formative (informal and formal tests administered during the learning process) and summative (evaluation of students learning at the end of an instructional unit) examination modes in line with the UGC Report on 'Evaluation Reforms in Higher Educational Institutions (2019).

Examination, Evaluation and Assessment Scheme

The total marks for each Course shall be based on Continuous Assessment and Semester End Examination. Each theory course of Major, Minor, GE/OE, AEC, IKS, VEC as mentioned in **Teaching Learning Scheme** prepared by the Board of Studies shall be evaluated as per the scheme as mentioned in the following table

Examination, Evaluation and Assessment Scheme

Vertical No.	The Vertical	Mode of Examination, Evaluation & Assessment	Theory				Theory (Total)		Practical				Practical (Total)	
			External		Internal				External		Internal			
			Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks
A	Major	External & Internal	30/60	9/18	20/40	6/12	50/100	20/40	25/50	10/20	25/50	10/20	25/50	10/20
B	Minor		30/60	9/18	20/40	6/12	50/100	20/40	25/50	10/20	25/50	10/20	25/50	10/20
C	Generic/ Open Elective	Internal			50	20	50	20	--	--	50	20	50	20
D	VSC	Internal			50	20	50	20			50	20	50	20
	SEC	Internal	--	--	50	20	50	20			50	20	50	20
e	AEC (Eng. & One MIL Composite)	Internal			50	20	50	20						
	IKS (Generic)	Internal			50	20	50	20						
	VEC	Internal			50	20	50	20						
F	Internship/ Apprenticeship	Internal	Assessment of these verticals shall be based on various activities/practices. The evaluation/assessment shall be done by appointing external examiner by principal from Industry/Organisation/Academia. The mentor faculty shall be the internal examiner. It shall be evaluated by giving maximum 50 marks per 2 Credit Course with separate activity weightages/levels. A detailed SOP for this assessment process shall be prescribed separately.											
	FP/CEP													
	CC													

Continuous Assessment Tests (CAT)

For internal assessment, the Continuous Assessment Tests (CAT) shall be conducted as under-

i. Three CAT each of 8 / 10 Marks (Theory) as applicable and 10 Marks (Practical).

- First on completion of 25% Syllabus of the course or on completion of 25 teaching days,
- Second on completion of 50% Syllabus of the course or on completion of 50 teaching days,
- Third on completion of 75% Syllabus of the course or on completion of 75 teaching days.

ii. Each concurrent assessment (CAT-I, II & III) will be mapped to relevant Course

Learning Outcome.

iii. Total Performance in CAT (i.e.40 %) shall be based on the **best two out of three** in CAT examinations

iv. Internal assessment (CAT) shall be carried out by the respective course teacher by choosing variety of assessment tools/methods such as class test, record book, seminar, case study, field work, mini project work, quiz or any innovative method, which may be deemed to be appropriate for assessing the relevant course outcome.

Conduction of the Examination:

As per the scheme of teaching, learning, examination and evaluation, theory/practical examinations of Semester-I, II, III, IV, V, VI, VII and VIII shall be conducted by the University (except for Internal Examinations as applicable) at the end of each semester.

The theory/practical examinations of all the Semesters shall be held as per the following Schedule

Sr.No.	Name of the Examination	End Sem Examination	Supplementary Examination*
1	Semester-I, III, V and VII	Winter	Summer
2	Semester-II, IV, VI and VIII	Summer	Winter

*****The University may evolve mechanism for conducting repeat end semester examination. Such repeat examinations shall have to be conducted within one month of the regular even semester examination and on demand examination.

1. The practical examination of all semesters shall be conducted by the University at the end of each semester. The HEI shall conduct the Practical examination of odd semesters as per the schedule announced by the University. **However, the appointment of the External and Internal Examiners shall be done by the Head or Principal of respective HEI to conduct external examination of the odd semester and the same should be communicated to the University before commencement of the practical examination.** The University shall conduct the external practical examination of all even semester by appointing external and internal examiners.
2. The examinations specified above shall be held twice in a year at such places and on such dates as may be prescribed by the University.
3. An applicant to an examination specified above, shall pursue a regular course of study in courses prescribed for the examination concerned for not less than one semester in a particular semester in a College/Institute/University department.
4. Provided that the student shall be eligible to appear for examination if -
   a. He/she complies with the provisions of the Ordinance pertaining to the Examination in general from time to time.
   b. He/she has prosecuted a regular course of study in a university department/college affiliated to the University.

c. He/she has in the opinion of the Principal shown satisfactory progress in his/her studies.

5. The provisions of Ordinance No. 6 and Ordinance No. 9 shall be *mutatis-mutandis* applicable to every collegiate/non-collegiate student.
6. The fees for each theory examination and practical examination conducted by the university shall be as prescribed by the University, from time to time.

Course Category: **Major (Theory)**

108230 Inorganic Chemistry-2

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108230**	**Inorganic Chemistry-2**	2	30	2 Hrs	30+20=50

Course Objectives:	1. To develop a comprehensive understanding of occurrence of elements in nature and their extractions, transition elements and their characteristics and coordination compounds 2. To develop fundamental understanding of formation of coordination compounds on the basis of different theories.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Learn the transition elements, their electronic configuration. 2. Write the general characteristics of transition elements 3. Appreciate the postulates of Werner's theory. 4. Classify double salt and coordination compounds 5. Know the meaning of the terms in coordination compounds 6. Learn the rules of IUPAC nomenclature of coordination compounds 7. Calculate EAN and to predict the magnetic properties of complexes. 8. Corelate the nature of metal-ligand bonding in coordination compound by VBT and predict their geometries. 9. Define different types of isomerism in coordination compounds. 10. Explain the terms minerals, ores, concentration of ores, roasting, calcinations, refining, etc. 11. Apply the basic principle of extraction of different metals on the basis of their occurrence and reactivity

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Chemistry of Elements of Transition Series**: Definition and general characteristics of transition elements; Comparative study of first transition series elements (3d) with reference to following properties: (i) Electronic configuration (ii) Atomic and ionic size (iii) Ionization energy (iv) Metallic nature (v) Oxidation states (vi) Magnetic properties (vii) Color of salts (viii) Catalytic properties and (ix) Complex formation behavior; Electronic configuration of 4d and 5d series elements; Comparison of 3d series elements with 4d and 5d series elements with respect to atomic size and oxidation states.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss
Unit II	**Coordination Chemistry-1** Addition compounds: double salts & complex salts; Important terms in coordination compounds: central metal ion, ligands, complex ion, coordination sphere, coordination number; Classification of ligands; Homoleptic and heteroleptic complexes; IUPAC nomenclature of coordination compounds; Werner's theory of coordination complexes with reference to cobaltammines and its experimental verification on the basis of molar conductance and precipitation; Sidgwick's electronic interpretation: EAN rule.	7 Hrs	7 Marks	
Unit III	**Coordination Chemistry-2 (VBT and Isomerism)** **A) Valence bond theory (VBT):** Steps involved in describing metal-ligand bonding	8 Hrs	8 Marks	

	in coordination compounds using VBT; Types of hybridization, geometries and magnetic properties to understand formation of complexes of 3d elements with coordination number 6 (Inner and outer orbital complexes) and 4 (Tetrahedral and square planar). Limitations of VBT. **B) Isomerism in coordination Compounds:** Structural or constitutional isomerism: ionization, linkage, coordination and hydrate; Stereoisomerism: Geometrical isomerism in square planar {type: Ma_2b_2, Ma_2bc &Mabcd} and in octahedral complexes {type: Ma_4b_2, $Ma_2b_2c_2$, Ma_3b_3 & Mabcdef}, Optical isomerism in octahedral complexes (type: cis-$Ma_2b_2c_2$, $M(AA)_3$ & $Ma_2(AA)_2$) and in tetrahedral complexes {type: Mabcd}			real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit IV	**Extraction of elements and General Principles of Metallurgy** Occurrence of metals; Principles involved in extraction of metals: Major methods of separating and extracting elements (mechanical separation, thermal decomposition, displacement of one metal by another, high temperature chemical reduction, reduction by another metal, electrolytic reduction); Factors influencing the choice of extraction process; Definitions of metallurgy, minerals, ores, gangue; examples of principal ores of Al, Fe, Cu and Zn; Meaning of terms hydrometallurgy, pyrometallurgy and electrometallurgy; General Principles or Steps in metallurgy: i) Processing of ore ii) Ore dressing: Physical methods (gravity separation, froth floatation & electromagnetic separation, Chemical method (leaching) iii) roasting & calcination iv) smelting v) refining of crude metals: Liquation, distillation, cupellation, Van-Arkel method & electrolytic refining)	7 Hrs	7 Marks	
References:	1. Principles of Inorganic Chemistry by Puri, Sharma and Kalia- S. Naginchand& Co., Delhi. 2. Inorganic Chemistry by A.K. De, Wiley East Ltd. 3. Selected Topics in Inorganic Chemistry by Malik, Tuli and Madan, S. Chand & Co. 4. Concise Inorganic Chemistry by J.D. Lee, ELBS. 5. Inorganic Chemistry by J.E. Huheey- and Kettle, Harper & Row. 6. Advanced Inorganic Chemistry, Vol-I, Satya Prakash, Madan, Tuli, Basu. 7. Advanced Practical Inorganic Chemistry by Gurdeep Raj, GoelPulishing House, Meerut. **Web resources:** 1. https://www.chemguide.co.uk/inorganic/transitionmenu.html 2. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Supplemental_Modules_and_Websites_(Inorganic_Chemistry)			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) What are transition elements? 2) Write the general electronic configuration of first transition series elements. 3) Define coordination compounds 4) Write IUPAC name of $[Co(NH_3)_4Cl_2]Cl$. 5) Write an example of ionization isomers in complexes. 6) Predict the geometry of $[Fe(H_2O)_6]^{2+}$ ion on the basis of VBT 7) Define Metallurgy			
	Answer in brief (At least 6) (3 Marks each) 1) Write the electronic configuration of first transition series elements 2) Discuss the variation of atomic radii in 3d elements. 3) What is EAN? Calculate the EAN of central metal ion in i) $[Cu(NH_3)_4]SO_4$ i) $K_4[Fe(CN)_6]$			

	4) Define i) Complex ion ii) Ligands iii) Homoleptic complexes 5) Distinguish between double salt and complex. 6) Explain the geometry of $[Co(NH_3)_6]^{3+}$ and $[CoF_6]^{3-}$ complex ions on the basis of VBT. 7) Define i) Hydrometallurgy ii) Pyrometallugy iii) Electrometallurgy
	Answer in Detail (At least 4) (6 Marks each) 1) Discuss the following properties of first transition series elements i) Oxidationa states ii) catalytic properties 2) Write the postulates of Werner's theory of coordination complexes. Give the experimental verification on the basis of molar conductance and precipitation 3) Write i) hybridization state of central metal ion, ii) geometry and iii) magnetic properties of each of the following a) $[Fe(H_2O)_6]^{3+}$ b) $[NiCl_4]^{2-}$ c) $[Co(en)_3]^{3+}$ and d) $[Ni(NH_3)_6]^{2+}$ 4) Explain the steps involved in metallurgical process
	MCQs for Internal Assessment (At least 4) 1) Which of the following elements shows maximum number of different oxidation states in its compounds? a) Ti b) V c) Cr d) Mn 2) Which of the following ions does not form coloured compounds? a) Fe^{2+} b) Ti^{3+} c) Zn^{2+} d) Cu^{2+} 3) The catalytic properties of transition metal ions are due to a) variable oxidation states b) surface area c) presence of one or more unpaired electrons d) all of these 4) The number of moles of AgCl formed, when 1 mole of $[Co(NH_3)_4Cl_2]Cl$ is treated with excess of $AgNO_3$ solution is a) 1 mole b) 1.5 moles c) 2 moles d) 3 mole 5) Coordination number and oxidation number of Cr in $K_3[Cr(C_2O_4)_3]$ are respectively a) 4 and +2 b) 6 and +3 c) 3 and +3 d) 3 and 0 6) $K_3[Al(C_2O_4)_3]$ is called .. a) Potassium alumino oxalate b) Potassiumtrioxalatoaluminate (III) c) Potassium aluminium (III) oxalate d) Potassium trioxalato aluminate (VI) 7) In which there is outer orbital hybridization? a) $[Zn(NH_3)_6]^{2+}$ b) $[Co(NH_3)_6]^{3+}$ c) $[Cr(NH_3)_6]^{3+}$ d) $[V(NH_3)_6]^{3+}$ 8) $[Co(NH_3)_4Cl_2]NO_2$ and $[Co(NH_3)_4ClNO_2]Cl$ exhibit which type of isomerism? [MP PMT 1993] a) Geometrical b) Optical c) Linkage d) Ionization 9) The sulphide ore of ZINC is concentrated by.. a) chemical method b) froth flotation method c) magnetic method d) gravity separation 10) Heating of ore in presence of excess of oxygen before its melting point is called.. a) roasting b) calcination c) smelting d) leaching

Course Category: **Major (Theory)**

108231 Organic Chemistry-2

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108231**	**Organic Chemistry-2**	2	30	2 Hrs	30+20=50

Course Objectives:	1. To provide fundamental understanding of the structure, preparation, properties, and reactions of carboxylic acids, esters, and nitrogen-containing organic compounds. 2. To introduce the chemistry of amino acids, peptides, and carbohydrates with emphasis on their structure, biological significance, and chemical behavior.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Explain the structure, preparation, properties, and reactions of carboxylic acids and esters, including mechanisms of esterification and hydrolysis. 2. Analyze the synthesis, reactivity, and applications of nitrogen-containing organic compounds such as nitro compounds, amines, and diazonium salts. 3. Describe the structure, stereochemistry, synthesis, and reactions of amino acids and peptides, and explain their biological and pharmaceutical importance. 4. Interpret the classification, structure, stereochemistry, and chemical behavior of carbohydrates including monosaccharides, disaccharides, and polysaccharides. 5. Apply mechanistic and structural concepts to predict the reactivity and interconversion of important organic compounds. 6. Correlate the chemical properties of biomolecules with their biological functions and industrial applications.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Carboxylic acids and Esters** A) **Carboxylic acids:** Structure and reactivity of carboxylic groups. Acidity of carboxylic acids, effects of substituents on acidic strength. **Oxalic acid:** Preparation from ethylene glycol and cyanogens, reactions with ethanol, ammonia, glycerol and action of heat. **Lactic acid:** Preparation from acetaldehyde and pyruvic acid, reaction with ethanol, PCl_5, action of heat, oxidation and reduction. **Benzoic acid**: Preparation from toluene, benzyl alcohol and benzamide, reactions with ethanol, PCl_5 and ammonia. **Salicylic acid:** Preparation by Reimer-Tiemann reaction. Reactions with CH_3COCl, CH_3OH and C_6H_5OH. **B) Ester**: Structure and nomenclature of esters, Preparation of ester by reaction of acetic acid, benzoyl chloride with ethanol; acetic anhydride with ethanol and salicylic acid; propanoic acid with diazomethane; silver acetate with methyl bromide. Reaction of methyl acetate with ammonia, PCl5, hydrolysis. Mechanism of esterification and hydrolysis (acidic and basic).	8 Hrs	8 Marks	**1. Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. 2. **Hands-On Models**: use of model 3. **Problem-Solving Sessions**: Organize regular problem-solving sessions. 4. Explore virtual labs and simulations to enhance understanding of the topic. 5. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. 6. Ask students to create concept maps that illustrate the relationships between different concepts. 7. **Inquiry-Based Learning:** Explore topics
Unit II	**Nitrogen containing compounds** **A) Aromatic nitro compounds:** Nitrobenzene: Resonance structure, synthesis from benzene, Reductions : i)	7 Hrs	7 Marks	

	in acidic medium, ii) In neutral medium, iii) In alkaline medium. **B) Amino Compounds:** Aniline: Basicity and effect of substituents. Preparation of aniline from nitrobenzene, reactions with acetyl chloride and benzoyl chloride, Br_2 (aq) and $Br_2(CS_2)$, carbylamine reaction, alkylation, Hoffmann's exhaustive methylation and its mechanism. C) **Diazo Compounds:** Preparation benzene diazonium chloride, Synthetic applications- Preparation of benzene, phenol, halobenzene, nitrobenzene, benzonitrile, coupling with phenol and aniline.			through questioning, investigation, and research. 8. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. 9. **Any other innovative pedagogy as applicable.**
Unit III	**Amino acids and Peptides :** **A) Amino Acids:** Structure & Classification, Chirality, D, L configuration. synthesis by Strecker and Gabriel phthalimide method, Zwitterion structure, Isoelectric point, reactions of amino acids with Ninhydrin, Sanger's Edman's reagent. **B) Peptides**: Classification and nomenclature, synthesis of peptides, structure determination of polypeptides by end group analysis, biological and pharmaceutical importance	8 Hrs	8 Marks	
Unit IV	**Carbohyadrates** Occurrence, classification and their biological importance. **Monosaccharides**: Constitution and absolute configuration of Glucose and Fructose, cyclic structure, Epimerization, conversion of glucose to fructose and vice-versa, Haworth projections and conformational structures. Structure of Ribose, 2-deoxyribose, Pyranose and Furanose, **Disaccharides** – Structure of Sucrose, maltose & Lactose. **Polysaccharides** – Structure and properties of starch & cellulose.	7 Hrs	7 Marks	
References:	1. Organic Chemistry Vol. I, II and III by Mukharjee, Singh and Kapoor- Wiley Eastern. 2. Organic Chemistry, Morrison, R. N. & Boyd, R. N. 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 3. Organic Chemistry Pine S. H., Fifth Edition, McGraw Hill, (2007) 4. Organic Chemistry F. A. Carey, Seventh Edition, Tata McGraw Hill (2008). 5. Organic Chemistry J. Clayden, N. Greeves, S. Warren, , 2nd Ed., (2012), Oxford Universitiy Press. 6. Advanced Organic Chemistry Part A: Structure and mechanism, F. A. Carey, R. J. Sundberg, Kluwer Academic Publisher, (2000). 7. Organic Chemistry by S.K. Ghosh. 8. Reaction Mechanism in Organic Chemistry by S.M. Mukharjee and S.P. Singh. 9. Stereochemistry and mechanism through solved problems by P.S. Kalsi. 10. Organic Chemistry by Solomons, 8th edition, John Wiley 11. Organic Chemistry by R. K. Bansal 12. Organic Chemistry by L.G. Wade. Prentice Hall. 13. Synthetic Organic Chemistry, by: G. R. Chatwal. 14. Modern Organic Chemistry by M. K. Jain and S. C. Sharma. 15. Organic Chemistry, Reactions, Rearrangements and Reagents, by: O. P. Agarwal. 16. A Text book of organic chemistry by Bahl and Bahl.			

	17. A Text book of organic chemistry by P. L. Soni **Web resources:** 1. https://www.masterorganicchemistry.com/reaction-guide/ 2. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Carboxylic_Acids 3. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Esters 4. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Amines 5. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Organic_Chemistry_(OpenStax)/24%3A_Amines_and_Heterocycles 6. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Organic_Chemistry_(OpenStax)/26%3A_Biomolecules-_Amino_Acids_Peptides_and_Proteins 7. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Carbohydrates
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) Give the IUPAC name for the ester formed from acetic acid and ethanol. 2) Define the term 'Esterification'. 3) What is the action of heat on Lactic acid 4) What is the IUPAC name of the product obtained from the acetylation of aniline? 5) Why does the nitro group in nitrobenzene decrease the electron density of the benzene ring? 6) Identify the product formed when nitrobenzene is reduced in a strongly acidic medium. 7) Define the term 'Zwitterion'. 8) State the definition of the Isoelectric Point. 9) What is a 'Tripeptide'? 10) What are "Epimers"? Give one example. 11) What is "Mutarotation"? 12) What is a "Furanose" ring?
	Answer in brief (At least 6) (3 Marks each) 1) How is Lactic acid prepared from Pyruvic acid? 2) Explain the reaction of benzoic acid with ethanol and PCl5. 3) Write the Reimer-Tiemen reaction. 4) Explain the mechanism of the nitration of nitrobenzene. 5) Define Hoffmann's exhaustive methylation. What is the end product of this process? 6) What happens when aniline reacts with bromine in the presence of carbon disulphide. 7) Describe the Strecker synthesis of amino acids with the help of chemical equations. 8) Explain the classification of amino acids based on the nature of their side chains (Acidic, Basic, and Neutral) with one example each. 9) Explain the formation of a Zwitterion structure and how it affects the physical properties of amino acids 10) Differentiate between Pyranose and Furanose structures with suitable diagrams. 11) Explain the steps to convert D-Glucose into D-Fructose. 12) Draw and compare the structures of D-Ribose and 2-Deoxy-D-ribose. Mention their biological significance.
	Answer in Detail (At least 4) (6 Marks each) 1) Explain the reaction of oxalic acid with ethyl alcohol, ammonia and glycerol. 2) Explain acidic and basic hydrolysis of ester. 3) Discuss the reduction of nitrobenzene in detail under acidic, neutral, and alkaline conditions. 4) Explain the mechanism of Hoffmann's exhaustive methylation followed by Hoffmann elimination. 5) Discuss the complete mechanism of the Strecker synthesis and the Gabriel Phthalimide synthesis. 6) Describe in detail the Sanger Method (using DNFB) and the Edman Degradation method for N-terminal analysis of polypeptides. 7) Explain the detailed mechanism for the inter conversion of Glucose to Fructose and vice-versa. 8) Explain the Structure and properties of starch & cellulose.
	MCQs for Internal Assessment (At least 4) 1) Lactic acid contains which of the following functional groups? A) Only Carboxylic acid B) Carboxylic acid and Ketone C) Carboxylic acid and Hydroxyl D) Carboxylic acid and Aldehyde 2) Saponification is the:

A) Acidic hydrolysis of an ester B) Basic hydrolysis of an ester

C) Oxidation of an alcohol D) Dehydration of an acid

3) The reaction of Aniline with Benzoyl chloride is known as:

A) Friedel-Crafts reaction B) Schotten-Baumann reaction

C) Hoffmann reaction D) Perkin reaction

4) The Carbylamine reaction is performed by heating a primary amine with:

A) $CHCl_3$ and alcoholic KOH B) CCl_4 and alcoholic KOH

C) CHCl and alcoholic OH D) $CHCl_3$ and HCl

5) Which of the following amino acids is achiral?

A) Alanine B) Valine

C) Glycine D) Leucine

6) Which of the following is a basic amino acid?

A) Aspartic acid B) Lysine

C) Serine D) Phenylalanine

7) D-Glucose and D-Galactose are:

A) Anomers B) C-2 Epimers

C) C-4 Epimers D) Enantiomers

8) The number of chiral centers in the cyclic form of Glucose is:

A) 4 B) 5

C) 6 D) 3

9) Preparation of Benzoic acid from Benzamide involves:

A) Reduction B) Oxidation

C) Hydrolysis D) Hydrogenation

10) Nitrobenzene is also known as:

A) Oil of Wintergreen B) Oil of Mirbane

C) Oil of Vitriol D) Mustard Oil

11) A peptide bond is chemically an:

A) Ester linkage B) Ether linkage

C) Amide linkage D) Glycosidic linkage

12) Sucrose is composed of:

A) Glucose + Glucose B) Glucose + Galactose

C) Glucose + Fructose D) Fructose + Fructose

Course Category: **Major (Theory)**

108232 Physical chemistry 2

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108232**	**Physical chemistry 2**	2	30	2 Hrs	30+20=50

Course Objectives:	1. To understand the fundamental principles of quantum chemistry, chemical equilibrium, and phase equilibria. 2. To apply quantum mechanical and thermodynamic concepts to explain chemical systems and processes. 3. To develop analytical and numerical problem-solving skills in physical chemistry.
Course Outcomes:	After successful completion of the course, a student will be able to-. 1. Explain the limitations of classical mechanics and the development of quantum theory. 2. Describe photoelectric effect, Compton effect, and de Broglie matter waves. 3. Apply de Broglie equation and Heisenberg uncertainty principle to quantum systems. 4. Derive and interpret Schrödinger wave equation in one and three dimensions. 5. Explain the significance of wave functions and atomic orbitals. 6. Apply Schrödinger wave equation to simple systems such as particle in one-dimensional and three-dimensional boxes and interpret the physical significance of wave functions and atomic orbitals. 7. Analyze chemical equilibrium using the law of mass action, equilibrium constants, thermodynamic relationships, and Le-Chatelier's principle. 8. Explain phase equilibria using Gibbs phase rule and interpret phase diagrams of one-component and partially miscible liquid systems. 9. Solve numerical problems related to quantum chemistry, chemical equilibrium, and phase equilibria.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Quantum chemistry I** Limitations of classical mechanics. Planck's quantum theory (postulates only). Photoelectric effect - Experiments, observation and Einstein's explanation. Compton effect and its explanation. de Broglie hypothesis of matter waves. de Broglie's equation. Heisenberg's uncertainty principle. Numericals.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Any other innovative pedagogy as applicable.**
Unit II	**Quantum chemistry II** Classical wave equation, derivation of time independent Schrodinger's wave equation in one-dimension and its extension to a three-dimensional space. Well behaved wave function, physical significance of wave function (Born interpretation). Application of Schrodinger wave equation to a particle in one-dimensional box and its extension to a three-dimensional box. Concept of atomic orbital. Numericals.	7 Hrs	7 Marks	
Unit III	**Chemical equilibrium** Introduction. Characteristics of chemical equilibrium. Law of Mass Action, Law of Chemical equilibrium. Types of equilibrium constants and their units- Kc, Kp and Kx. Relation between Kp, Kc and Kx. Chemical potential or partial molar free energy, Derivation of Gibb's-Duhem equation, Thermodynamic derivation of law of chemical equilibrium. Derivation of Vant Hoff's reaction isotherm. Le-Chatelier's principle- Statement and effect of change of concentration, temperature and pressure on equilibrium.	8 Hrs	8 Marks	

	Clausius-Clapeyron equation (only qualitative statement).			
Unit IV	**Phase equilibria:** The Phase rule. Explanation of the terms: phase, component, degree of freedom. Calculation of number of components, phases and degrees of freedom in equilibrium systems. Phase diagram of one-component system- Water system and Sulphur system. Phase transition Partially miscible liquids - Phase diagram of phenol-water, triethyl amine - water and nicotine-water systems. Numericals.	7 Hrs	7 Marks	
References:	1) Principles of Physical Chemistry by B. R. Puri, L. R. Sharma & M. S. Pathania 2) Atkins' Physical Chemistry by Peter Atkins & Julio de Paula 3) Physical Chemistry by R. L. Madan 4) Physical Chemistry: A Molecular Approach by Donald A. McQuarrie & John D. Simon 5) Essentials of Physical Chemistry by B. S. Bahl, G. D. Tuli & Arun Bahl 6) Physical Chemistry: Quantum Chemistry And Spectroscopy by Peter W. Atkins and Julio de Paula **Web resources:** 3. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps?utm_source=chatgpt.com 4. https://ocw.mit.edu/search/?q=physical+chemistry&utm_source 5. hemcontent.com/2021/11/quantum-chemistry-handwritten-notes-pdf.html 6. https://www.physchem.info/en/lecture-notes/?utm_source 7. https://vergil.chemistry.gatech.edu/resources?utm_source 8. https://qchem1.qcdevs.org/?utm_source 9. https://mariovelo.com/physical-chemistry-quantum-mechanics?utm_			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1. State Planck's quantum theory. 2. What is photoelectric effect? 3. Define threshold frequency. 4. State Einstein's photoelectric equation. 5. What is Compton effect? 6. State de Broglie hypothesis. 7. State Heisenberg's uncertainty principle. 8. What is wave function? 9. Define well-behaved wave function. 10. What is a particle in a box? 11. Define chemical equilibrium. 12. State the law of mass action. 13. Define equilibrium constant. 14. Define phase. 15. What is a component in phase rule? 16. Define degree of freedom. 17. State Gibbs phase rule. 18. What is triple point? 19. Define eutectic point. 20. Define partially miscible liquids. 21. Give one example of a one-component system. 22. Name one system showing upper critical solution temperature (UCST).			

	Answer in brief (At least 6) (3 Marks each) 1. Explain the limitations of classical mechanics. 2. Explain Einstein's explanation of photoelectric effect. 3. Explain Compton effect with suitable illustration. 4. Derive de Broglie equation for matter waves. 5. Discuss the physical significance of wave function. 6. Write a short note on atomic orbitals. 7. State and explain the law of mass action. 8. Differentiate between Kc, Kp and Kx. 9. Derive the relation between Kp and Kc. 10. Derive Van't Hoff reaction isotherm. 11. Explain Le-Chatelier's principle with examples. 12. Discuss the effect of temperature on chemical equilibrium. 13. Discuss the effect of pressure on equilibrium. 14. Define phase, component and degree of freedom with examples. 15. Explain Gibbs phase rule. 16. Describe the phase diagram of water system.
	Answer in Detail (At least 4) (6 Marks each) 1. Explain the photoelectric effect and discuss Einstein's interpretation with experimental observations. 2. Explain de Broglie hypothesis of matter waves and derive de Broglie equation. 3. Derive the time-independent Schrödinger wave equation in one dimension and extend it to three dimensions. 4. Discuss the application of Schrödinger wave equation to a particle in one-dimensional box and derive the energy expression. 5. Explain different equilibrium constants (Kc, Kp and Kx) and derive the relationship among them. 6. Explain the concept of chemical potential and derive Gibbs–Duhem equation 7. State and explain Le-Chatelier's principle with suitable examples involving concentration, pressure and temperature changes. 8. Discuss the phase diagram of water system and explain its important features. 9. Explain the phase diagram of sulphur system and discuss the allotropy of sulphur. 10. Discuss the phase diagrams of partially miscible liquid systems such as phenol–water, triethylamine–water and nicotine–water systems.
	MCQs for Internal Assessment (At least 4) 1. According to de Broglie hypothesis, particles possess: A) Charge only B) Spin only C) Wave nature D) Magnetic nature **2.** The uncertainty principle was proposed by: A) Planck B) Einstein C) Schrödinger D) Heisenberg 3. The equilibrium constant Kp is related to: A) Concentration of reactants B) Partial pressures of gases C) Volume of reaction vessel D) Rate of reaction 4. The degree of freedom for water system at triple point is: A) 0 B) 1 C) 2 D) 3 5. The phenol–water system shows: A) Lower critical solution temperature only B) Upper critical solution temperature only C) Both upper and lower critical solution temperatures D) No critical solution temperature

Course Category: **Major Lab**

108233 Chemistry Lab 15

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108233**	**Chemistry Lab 15**	2	60	4 h	25+25= 50

Course Objectives:	1. To develop practical skills in the synthesis, purification, and characterization of coordination compounds and inorganic complexes in Inorganic Chemistry. 2. To provide hands-on training in qualitative organic analysis, separation techniques, and identification of components of binary organic mixtures.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1) Prepare and characterize various inorganic and coordination complexes using standard laboratory techniques. 2) Interpret the valence bond structure, magnetic behavior, and color of coordination compounds. 3) Perform spot tests and identify metal ions present in inorganic complexes. 4) Separate and identify components of binary organic mixtures using systematic qualitative analysis methods. 5) Apply recrystallization, filtration, extraction, and derivative preparation techniques for purification and identification of organic compounds. 6) Demonstrate safe laboratory practices, analytical skills, and accurate reporting of experimental observations and results.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	1. Writing balanced chemical equations for synthesis of coordination compounds. 2. Determination of oxidation state, coordination number, and geometry of complexes. 3. Prediction of magnetic properties and VB structures of coordination compounds. 4. Interpretation of color in transition metal complexes based on crystal field concepts. 5. Principles of separation techniques used in binary organic mixture analysis. 6. Selection of fixing reagents for separation of acidic, basic, and neutral organic compounds. 7. Flow chart preparation for systematic qualitative organic analysis.	• **Experiential Learning** Hands-on laboratory experiments for synthesis, separation, purification, and analysis of inorganic and organic compounds. • **Demonstration Method** Demonstration of complex preparation, spot tests, recrystallization, TLC, and melting point determination by instructor before student performance. • **Problem-Based Learning (PBL)** Students solve unknown mixture analysis and identification problems using systematic qualitative methods. • **Inquiry-Based Learning** Students select suitable fixing reagents, predict reaction outcomes, and interpret observations independently. • **Collaborative Learning** Group-based synthesis, analysis, and discussion activities to encourage teamwork and peer learning. • **Project-Based Learning** Mini-projects on coordination compounds, green synthesis, qualitative analysis schemes, or industrial applications of complexes. • **ICT-Enabled Teaching** Use of molecular visualization software, virtual laboratories, videos, and digital flowcharts for coordination chemistry and organic analysis. • **Flipped Classroom Approach** Students study theory, reaction
Inorganic Chemistry practical	**Inorganic Complex Preparations: (At least 5)** 1. Preparation of tetraamminecopper(II)sulphate. 2. Preparation of hexaamminenickel(II)chloride. 3. Preparation of Prussian blue 4. Preparation of potassiumtrisoxalato-aluminate(III). 5. Preparation of chrome alum. 6. Preparation of sodium thiosulphate and dithionite. 7. Preparation of cis and trans-bisoxalato diaqua chromate (III) ion. (Comment on VB structure, magnetic properties and color of 1, 2 and 3 complexes) **Preparation of following inorganic complexes and spot tests for metal ion: (At least 4)** 1. Preparation of Tris(acetylacetonato)iron(III): $[Fe(acac)_3]$ 2. Preparation of Hexaminecobalt(III) chloride: $[Co(NH_3)_6]Cl_3$ 3. Preparation of Sodium Hexanitritocobaltate(III): $Na_3[Co(NO_2)_6]$ 4. Preparation of Potassium trisoxalatoferrate(III): $K_3[Fe(C_2O_4)_3]$ 5. Preparation of Trsi(acetylacetonato)-manganese(III): $[Mn(acac)_3]$	

	6. Preparation of Tris(glycinato)nickelate(II): $[Ni(gly)_3]^-$ 7. Preparation of Potassium dioxalatocuprate (II): $[Cu(C_2O4)_2]^{2-}$	mechanisms, and analysis schemes before laboratory sessions for better practical engagement. • **Peer Teaching and Seminar Method** Student presentations on coordination compounds, spot tests, and qualitative analysis techniques. • **Reflective Learning** Maintenance of laboratory journals, error analysis, self-assessment, and interpretation of experimental results. • **Skill-Based Training** Emphasis on laboratory techniques, safe chemical handling, analytical calculations, and scientific report writing. **Any other innovative pedagogy as applicable.**
Organic Chemistry Practical	**Qualitative Organic Analysis (At least 6 mixture)** **Separation and Identification of One of the Components of a Binary Organic Mixture** (1.0 g mixture given) 1. Minimum Six mixtures to be completed by the students. 2. Components of the mixture should include water soluble and water insoluble acids (carboxylic acid), water insoluble phenols (2-naphthol, 1- naphthol), water insoluble bases (nitroanilines), water soluble (urea, thiourea) and water insoluble neutral compounds (anilides, amides, mDNB, hydrocarbons). 3. A sample of the mixture to be given to the student for detection of the chemical type of the mixture. 4. After correct determination of chemical type, the fixing reagent should be decided by the student for separation. 5. After separation into component A and component B, One component (decided by the mentor/examiner) is to be analyzed and identified.	
Suggested Group activity	**1. Coordination Complex Exhibition** Student groups prepare different inorganic complexes and present their: Structure, Color, Geometry, Magnetic properties, Applications **2. Binary Mixture Analysis Competition** **3. Flowchart Preparation Activity** **4. Model and Chart Presentation** **5. Mini Research Project** **6. Case Study Discussion**	
References	1. *Advanced Practical Inorganic Chemistry* – Gurdeep Raj, Goel Publishing. 2. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Inorganic Chemistry: Qualitative Analysis, University Press. 3. Vogel's Textbook of Quantitative Chemical Analysis – J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, Pearson. 4. Practical Chemistry (For B.Sc. I, II and III Year Students). By Pandey O.P. & Bajpai D.N. & Giri S., S.Chand 5. Morgan, E. D. "Vogel's textbook of practical organic chemistry. 5th edn.: By BS Furniss, AJ Hannaford, PWG Smith and AR Tatchell. Pp. 1514. Longman, Harlow. (1990): 148. 6. *Handbook of Organic Analysis: Qualitative and Quantitative* – H. T. Clarke, CBS Publishers. 7. Ahluwalia, V. K., and Renu Aggarwal. Comprehensive practical organic chemistry: preparation and quantitative analysis. Universities Press, 2001. 8. Sethi, Arun. *Systematic lab experiments in organic chemistry*. New Age International, 2006 9. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press. 10. Advanced practical Organic Chemistry: O P Agrawa **Web resources:** 1. MIT OpenCourseWare: https://ocw.mit.edu 2. Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry 3. ChemCollective Virtual Labs: http://chemcollective.org	
Model Questions:	**NA**	

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Inorganic Chem Practical) 10 Marks
- Exercise 2 (Organic Chem Practical) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **Major- Elective (Theory)**

108234 Elective Chemistry-1 (Spectroscopy-I)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108234**	**Elective Chemistry-1 (Spectroscopy-I)**	2	30	2 Hrs	30+20=50

Course Objectives:	To provide detailed understanding of the origin of electromagnetic radiation terms associated with it. The course aims to develop the ability to understand and apply the basic principles of spectroscopy, rotational spectroscopy, UV and IR spectroscopy for structure determination.
Course Outcomes:	After successful completion of the course, a student will be able to-. 1. Explain the origin and regions of electromagnetic radiation 2. Appreciate the factors governing the intensity of bands 3. Classify molecules as Microwave active/ inactive and IR active/inactive 4. State and apply Beer- Lambert law. 5. Predict and explain the type of transition in the molecule. 6. Predict approximate wavelength regions for different types of transitions. 7. Recognize the factors that complicate the interpretation of infrared spectra 8. Justify the peaks in ultra-violet spectrum. 9. Apply Woodward-Fieser rules for various compounds for calculating λ max

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Introduction to Spectroscopy:** Electromagnetic radiation, characteristics of electromagnetic radiation in terms of wavelength, wave number, frequency and energy of photon. Spectrum of electromagnetic radiation. Types of spectra - Emission and absorption spectra, atomic and molecular spectra, line and band spectra. Translational, vibrational, rotational and electronic motion. The degree of freedom in each motion. Energy level diagram of a molecule indicating electronic, vibrational and rotational transitions Franck-Condon principle, Stark effect, Zeeman effect.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge.
Unit II	**Rotational spectroscopy** Introduction, Condition for pure rotational spectrum (i.e. microwave active molecules), Derivation of expression for moment of inertia of a diatomic rigid rotor. Rotational energy levels of Diatomic Molecules, Selection rule for Microwave spectra. Derivation showing that Rotational Spectral Lines for diatomic molecules are equally spaced Isotope effect. Applications of microwave spectroscopy for the determination of moment of inertia and bond length in diatomic molecules. Problems.	7 Hrs	7 Marks	
Unit III	**UV-visible spectroscopy** Introduction, Instrumentation, Theory or Principle of Electronic Spectroscopy, Absorption Laws, Electronic Transitions, Important terms used in UV Spectroscopy- chromophore, auxochrome, bathochromic shift,	8 Hrs	8 Marks	

	hypsochromic shift, hyperchromic effect and hypochromic effect. Applications in the structure determination of dienes, Ultra-violet Absorption in unsaturated Carbonyl Compounds (aldehyde and Ketones), Ultraviolet visible Spectra of Aromatic Compounds. Problems			**Any other innovative pedagogy as applicable.**
Unit IV	**IR spectroscopy** Basic principles of IR spectroscopy. IR active and inactive molecules. Degree of Freedom. Calculation of vibrational degrees of freedom. Types of molecular vibrations- stretching and bending Hooke's law and factors affecting vibrational frequency. Functional group region (H-stretching, triple bond, double bond) and fingerprint region. IR spectra of simple organic molecules (alkanes, alkenes, alkynes, aromatic compounds, alcohols, amines and carbonyl compounds). Identification of simple organic compounds using IR spectral data. Distinction between the pair of compounds using IR spectra.	7 Hrs	7 Marks	
References:	1. Advanced Organic Chemistry Part-A &B by Carey, Francis A, Sundberg, Richard J 2. Advanced Organic Chemistry by Michael B. Smith, Jerry March. 3. Banwell.,(2017). Fundamentals of Molecular; Spectroscopy (IV Edition), McGraw-Hill Education (India) Pvt. Limited. 4. Sharma, Y. R. (2013). Elementary Organic Spectroscopy: Principles and Chemical. 5. Organic Structure From Spectra by L D Field, S Sternhell 6. P S Kalsi,(2016). Spectroscopy of Organic Compounds, 7th edition. Delhi: New age international publisher. 7. Robert M. Silverstein, Francis X. Webster, (1996).Spectrometric Identification of Organic Compounds, 6th Edition. New York: John Wiley & Sons. **Web resources:** https://onlinecourses.nptel.ac.in/noc21_cy09/unit?unit=24&lesson=30 https://onlinecourses.nptel.ac.in/noc21_cy09/unit?unit=100&lesson=102 https://onlinecourses.swayam2.ac.in/5231-online-refresher-course-in-chemistry-for-higher-education-faculty/unit?unit=75&lesson=77 https://onlinecourses.nptel.ac.in/noc21_cy09/unit?unit=41&lesson=46 https://onlinecourses.nptel.ac.in/noc21_cy09/unit?unit=57&lesson=60 https://onlinecourses.swayam2.ac.in/arp20_ap02/unit?unit=40&lesson=43 https://onlinecourses.swayam2.ac.in/arp20_ap02/unit?unit=40&lesson=44			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) Define Chromophores and auxochromes 2) Define Fluorescence and phosphorescence 3) What is selection rule for Rayleigh line In rotational Raman ? 4) What is the condition for a molecule to be microwave active? 5) Define Natural line width and Broadening-of spectral line 6) What is electronic spectroscopy?			
	Answer in brief (At least 6) (3 Marks each) 1) Discuss various types of electronic transitions giving one example of each 2) Discuss the Woodward-Fieser rules for calculating λmax in dienes. 3) Discuss Fluorescence and phosphorescence with diagram 4) Discuss the modes of vibration in IR 5) Derive the equation for Beer-Lambert Law 6) Discuss double bond region in IR			
	Answer in Detail (At least 4) (6 Marks each) 1. Explain why ethylene shows π→π* transitions at 180 nm while butadiene at 217 nm? 2. Calculate the energy associated with an ultraviolet radiation having wavelength 250 nm. Give the answer in kcal/rnole and also in kJ/mole. 3. Explain the Bathochromic and hypsochromic shifts with diagram 4. Explain the Franck-Condon principle			
	MCQs for Internal Assessment (At least 4)			

	1. The electron which do not involve in bonding between the atoms in molecule belongs to a) σ (b) π (c) n (d) π* 2.What is the number of vibrational degrees of freedom in $C_6H_5CH_3$? a) 39 b) 15 c)18 d) 4 3. Which of the following molecules will not show infrared spectrum? (a)HCl (b) H_2 (c) CH_4 (d) CO_2 4. Which of the following molecules show microwave activity? (a)SF6 (b) CH_3Cl (c) H_2 (d) CO_2

Course Category: **Major Elective Practical**

108235 Chemistry Lab 16 A (Elective Chemistry-1)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108235**	**Chemistry Lab 16 A (Elective Chemistry-1)**	2	60	4 h	25+25= 50

Course Objectives:	1. To develop practical skills in quantitative estimation of commercially important organic compounds using standard analytical methods. 2. To provide hands-on training in UV–Visible Spectroscopy and Infrared Spectroscopy for qualitative and quantitative analysis of organic compounds.	
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Perform quantitative estimation of organic compounds such as glucose, phenol, esters, vitamin C, aspirin, paracetamol, acetamide, and nitrogen using standard laboratory methods. 2. Apply Beer–Lambert law and UV–Visible spectroscopic techniques for concentration determination and spectral analysis of organic and inorganic compounds. 3. Interpret IR spectra for identification of functional groups, hydrogen bonding, aromatic/aliphatic compounds, and structural distinctions between organic molecules. 4. Analyze and compare spectral data to identify unknown compounds and correlate spectral features with molecular structure. 5. Demonstrate laboratory analytical skills, safe handling of instruments, data interpretation, and scientific reporting in spectroscopic and organic analytical experiments.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	1. Calculations involved in organic estimations. 2. Numerical problems based on wavelength, frequency, wave number, and photon energy calculations. 3. Problems based on Beer–Lambert law and determination of concentration using UV–Visible spectroscopy. 4. Identification of chromophores and auxochromes in organic compounds. 5. Calculation of vibrational degrees of freedom for linear and non-linear molecules. 6. Interpretation of IR spectra for identification of functional groups. 7. Distinction between aldehydes, ketones, alcohols, amines, and acids using IR spectra.	• **Experiential Learning** Hands-on laboratory training in organic estimations, UV–Visible spectroscopy, and IR spectral interpretation. • **Demonstration Method** Demonstration of spectrophotometer handling, sample preparation, calibration, and spectral recording before student experimentation. • **Problem-Based Learning (PBL)** Students solve unknown concentration and spectral interpretation problems using analytical and spectroscopic techniques. • **Inquiry-Based Learning**
Organic Estimations	**Organic Estimations (At least 4)** 1. Estimation of glucose by Fehling's method 2. Estimation of phenol by bromination method 3. Estimation of ester by hydrolysis method 4. Estimation of vitamin C in fruit juice/tablets 5. Estimation of aspirin/paracetamol in formulations 6. Estimation of acetamide. 7. Determination of equivalent weight of an organic acid 8. Estimation of Nitrogen by Kjeldahl's method	

Spectral interpretation	**UV-Visible spectroscopy** (Reference spectra may be obtained from literature) 1. Verification of Beer–Lambert law using potassium permanganate or potassium dichromate solution. 2. To determine the indicator constant of methyl red/ any suitable indicator 3. To estimate the Fe^{3+} ions by the thiocyanate method. 4. Estimation of copper using colorimetric/UV-visible method. 5. Determination of λmax of organic compounds such as benzaldehyde and anisole. 6. Determination of concentration of unknown solution using UV–Visible spectrophotometer. 7. Comparative UV spectra of 1,3-butadiene and 1,3,5-hexatriene. **IR Spectroscopy** (Reference spectra may be obtained from literature) 1. Identification of functional groups in alcohols, aldehydes, ketones, acids, esters, and amines using IR spectra. 2. Identification of hydrogen bonding using IR spectral shifts. 3. Determination of vibrational degrees of freedom for simple molecules. 4. Distinction between aldehydes and ketones (Benzaldehyde and Acetophenone) using IR spectra. 5. Identification of aromatic and aliphatic compounds using IR data. 6. Identification of hydrogen bonding in: Salicylic acid, o-Nitrophenol and p-Nitrophenol 7. Comparative study of IR spectra of primary, secondary and tertiary amines.	Students predict spectral behavior, identify functional groups, and interpret structural features from experimental data. • **Collaborative Learning** Group-based experimental work, spectral analysis, and comparative interpretation of compounds. • **ICT-Enabled Teaching** Use of online spectral databases, virtual spectroscopy tools, simulation software, and digital spectral libraries. • **Project-Based Learning** Mini-projects on pharmaceutical estimations, food analysis. • **Flipped Classroom Approach** Students study theory, spectra, and experimental procedures before laboratory sessions to improve practical engagement. • **Peer Learning and Seminar Method** Student presentations on UV, IR spectroscopy, and applications in pharmaceutical and industrial chemistry. • **Any other innovative pedagogy as applicable.**
Suggested Student Activities	1. Comparative Spectra Study 2. **Mini Project on Pharmaceutical Analysis** Estimation of vitamin C, aspirin, or paracetamol in commercial formulations and preparation of analytical reports. 3. **Preparation of Functional Group Charts** Students prepare charts correlating IR absorption frequencies with functional groups 4. **ICT-Based Spectral Analysis** Use of online spectral databases and software tools for interpretation of UV and IR spectra. 5. **Poster Presentation**	
References	1. Morgan, E. D. "Vogel's textbook of practical organic chemistry. 5th edn.: By BS Furniss, AJ Hannaford, PWG Smith and AR Tatchell. Pp. 1514. Longman, Harlow. (1990): 148. 2. *Handbook of Organic Analysis: Qualitative and Quantitative* – H. T. Clarke, CBS Publishers. 3. Practical Chemistry (For B.Sc. I, II and III Year Students). By Pandey O.P. & Bajpai D.N. & Giri S., S.Chand. 4. Ahluwalia, V. K., and Renu Aggarwal. Comprehensive practical organic chemistry: preparation and quantitative analysis. Universities Press, 2001. 5. Sethi, Arun. *Systematic lab experiments in organic chemistry*. New Age International, 2006 6. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC	

	Press. 7. Advanced practical Organic Chemistry: O P Agrawal 8. Sharma, Y. R. (2013). Elementary Organic Spectroscopy: Principles and Chemical. 9. Organic Structure From Spectra by L D Field, S Sternhell 10. P S Kalsi,(2016). Spectroscopy of Organic Compounds, 7th edition. Delhi: New age international publisher. 11. Robert M. Silverstein, Francis X. Webster, (1996).Spectrometric Identification of Organic Compounds, 6th Edition. New York: John Wiley & Sons. **Web resources:** https://nanohub.org/modelsimulate https://sdbs.db.aist.go.jp/SearchInformation.aspx https://avogadro.cc/ https://molview.org/
Model Questions:	**NA**

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Organic Estimation) 10 Marks
- Exercise 2 (Spectral interpretation) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **Major- Elective (Theory)**

108236 Elective Chemistry-2 (Spectroscopy-II)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108236**	**Elective Chemistry-2 (Spectroscopy-II)**	2	30	2 Hrs	30+20=50

Course Objectives:	The course aims to develop the ability to understand and apply the rotational, vibrational, Raman spectroscopy and X-ray diffraction for structural analysis
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Explain the origin and regions of electromagnetic radiation 2. Classify molecules as Microwave active/ inactive and IR active/inactive 3. Predict and explain the type of transition in the molecule 4. Determine the frequency, wavelength, wavenumber and energy change associated with an infrared transition. 5. Explain rotational, vibrational and Raman spectroscopy 6. Corelate the relationship between wavelength, interplanar spacing (d), and the diffraction angle. 7. Explain the principle and methods of X-ray diffraction for structural analysis

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Introduction to Spectroscopy:** Electromagnetic radiation, characteristics of electromagnetic radiation in terms of wavelength, wave number, frequency and energy of photon. Spectrum of electromagnetic radiation. Types of spectra - Emission and absorption spectra, atomic and molecular spectra, line and band spectra. Translational, vibrational, rotational and electronic motion. The degree of freedom in each motion. Energy level diagram of a molecule indicating electronic, vibrational and rotational transitions Franck-Condon principle, Stark effect, Zeeman effect.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit II	**Rotational spectroscopy** Introduction, Condition for pure rotational spectrum (i.e. microwave active molecules), Derivation of expression for moment of inertia of a diatomic rigid rotor. Rotational energy levels of Diatomic Molecules, Selection rule for Microwave spectra. Derivation showing that Rotational Spectral Lines for diatomic molecules are equally spaced Isotope effect. Applications of microwave spectroscopy for the determination of moment of inertia and bond length in diatomic molecules. Problems.	7 Hrs	7 Marks	
Unit III	**A) Vibrational or Infrared Spectroscopy:** Condition for molecule to be IR active, Vibrational energy levels of a simple harmonic oscillator, zero point energy. Selection rule for vibrational transitions, Relation between vibrational frequency and force constant. Problems. **Raman Spectroscopy:** Rayleigh scattering and Raman scattering.	8 Hrs	8 Marks	

	Discovery and significance of Raman effect. Stokes and anti-Stokes lines. Classical and quantum theories of Raman effects, Condition for exhibiting Raman spectrum (i.e. Raman active molecule), Pure rotational spectrum of diatomic molecule, vibrational Raman spectrum of a diatomic molecule. Pure vibrational and vibrational rotational Raman spectra, selection rules.			
Unit IV	• **X-ray diffraction :** X-ray diffraction: Interaction of x-ray with matter, scattering and diffraction. Brags method Debye-Sherrer method of X-ray structural analysis of crystals, index reflection, identification of unit cell from systematic absence in diffraction pattern structure of simple lattice and x-ray intensities structure factor, its relation to intensity of electron density procedure for x-ray structure analysis, Problems	7 Hrs	7 Marks	
References:	1. Banwell.,(2017). Fundamentals of Molecular Spectroscopy (IV Edition), McGraw-Hill Education (India) Pvt. Limited. 2. Sharma, Y. R. (2013). Elementary Organic Spectroscopy: Principles and Chemical. 3. Applications (Revised V Edition). New Delhi: S. Chand & Company Limited. 4. Principles of Physical Chemistry: Puri, Sharma, and Pathania. 5. Physical Chemistry: P.W. Atkins, 6th Edn. 6. Physical Chemistry: Levine 7. A Textbook of Physical Chemistry, Kapoor, K.L. (2019), Vol.7, 1st Edition, McGraw Hill Education **Web resources:** https://youtu.be/BU0DO7xaT0M https://onlinecourses.nptel.ac.in/noc21_cy09/unit?unit=100&lesson=102 https://onlinecourses.swayam2.ac.in/5231-online-refresher-course-in-chemistry-for-higher-education-faculty/unit?unit=75&lesson=77			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) What is Raman Effect? 2) What is rigid rotor? 3) What are microwave active molecules? 4) What is the selection rule for vibrational transitions? 5) Define the terms: unit cell and Bragg's law 6) What are Miller indices?			
	Answer in brief (At least 6) (3 Marks each) 1) What is the selection rule for Rotational spectra? 2) Discuss the conditions for molecule to be IR active 3) Differentiate between Coherent and incoherent scattering 4) Discuss the fundamental principle of X-ray diffraction 5) Differentiate between Absorption and Emission Spectra 6) What is the condition for a molecule to be microwave active? Explain with examples			
	Answer in Detail (At least 4) (6 Marks each) 1) Derive the relation between vibrational frequency and force constant 2) Outline the fundamental modes of Vibration of CO_2 and predict which of these modes will be IR active and which will be Raman active. 3) Derive the relation betweenmoment inertia and bondlength of a diatomic rigid rotator 4) Derive Bragg's equation.			
	MCQs for Internal Assessment (At least 4) 1. Which of the following molecules show microwave activity? (a) SF_6 (b) CH_3Cl (c) H_2 (d) CO_2 The radiant source of visible light is (a) Tungsten Filament lamp (b) Mercury lamp (c) Deuterium lamp (d) Hydrogen Discharge lamp 3. The best monochromtion is provided by (a) Grating (b) Filter (c) Prism (d) Human eye 4..Real deviation from Beer's law may arise from changes in a) Refraction index of analytical system b) Band pass of filters c) Shift in the position of chemical equilibrium d) Shift in the position of physical equilibrium			

Course Category: **Major Elective Lab**

108237 Chemistry Lab 16B (Elective Chemistry-2)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108237**	**Chemistry Lab 16B (Elective Chemistry-2)**	2	60	4 h	25+25= 50

Course Objectives:	1. To develop practical skills in quantitative estimation of commercially important organic compounds using standard analytical methods. 2. To provide hands-on training in interpretation and analysis of rotational, vibrational, Raman, and X-ray diffraction spectra in Spectroscopy. 3. To familiarize students with modern simulation software, spectral databases, and virtual laboratory platforms used in chemical analysis and structure determination.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Perform quantitative estimation of organic compounds such as glucose, phenol, esters, vitamin C, aspirin, acetamide, and nitrogen using standard laboratory procedures. 2. Analyze rotational, vibrational, Raman, and X-ray diffraction spectral data for determination of molecular and crystal structure parameters. 3. Calculate bond length, moment of inertia, force constant, lattice parameters, crystal density, and related spectroscopic quantities from spectral data. 4. Distinguish IR active and Raman active molecules and interpret molecular vibrations and electronic transitions. 5. Apply ICT-based tools, simulations, and spectral databases for visualization, analysis, and interpretation of spectroscopic data. 6. Demonstrate analytical thinking, problem-solving ability, and scientific reporting skills in spectroscopy and organic analytical experiments.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	• Numerical problems based on Planck's equation and photon energy. • Calculation of moment of inertia and bond length of diatomic molecules. • Problems based on rotational spectra and isotope effect. • Calculation of force constant from IR vibrational frequency. • Problems based on Raman shifts and selection rules. • Calculation of interplanar distance using Miller indices. • Numerical problems based on Bragg's equation and X-ray diffraction. • Indexing of diffraction peaks in cubic crystal systems**.**	• Experiential and hands-on laboratory learning • ICT-enabled teaching using virtual labs, PhET, and NanoHUB simulations • Problem-based and inquiry-based learning through spectral interpretation • Collaborative learning through group activities and discussions • Project-based learning using case studies and spectral analysis • Demonstration and peer-learning methods for instrument handling and data analysis • Outcome-based continuous assessment through practical performance, assignments, and viva voce Any other innovative pedagogy as applicable.
Organic Estimations	**Organic Estimations (At least 4)** 1. Estimation of glucose by Fehling's method 2. Estimation of phenol by bromination method 3. Estimation of ester by hydrolysis method 4. Estimation of vitamin C in fruit juice/tablets 5. Estimation of aspirin/paracetamol in formulations 6. Estimation of acetamide. 7. Determination of equivalent weight of an organic acid 8. Estimation of Nitrogen by Kjeldahl's method	
Spectral analysis	**Spectral analysis:** (Reference spectra may be obtained from literature) (at least 8) 1. Verification of relationship between wavelength, frequency, and wave number	

	2. Study of emission spectrum of hydrogen/mercury lamp 3. Identification of atomic and molecular spectra from spectral charts 4. Analysis of the given rotational spectrum of HCl(g) 5. Calculation of moment of inertia of diatomic molecules from microwave spectral data 6. Determination of bond length of diatomic molecules using rotational constants 7. Verification of equal spacing of rotational spectral lines 8. Study of isotope effect in rotational spectra using simulated data 9. Determination of force constant from vibrational frequency 10. Comparison of IR active and IR inactive molecules 11. Analysis of the given vibrational spectrum of CO2 12. Analysis of the given vibrational spectrum of H2O 13. Identification of Stokes and anti-Stokes lines from Raman spectra 14. Comparison of IR and Raman active molecules 15. Determination of lattice parameter from XRD data 16. Identification of simple cubic, BCC, and FCC structures from diffraction patterns 17. Analysis of crystal structure from X-ray diffraction spectra of any two compounds (Calculation d, lattice constant, crystal volume and density, and assigning planes to peaks using JCPDS data) **Simulation / ICT-Based Activities using PhET simulations/ NanoHUB Spectroscopy Tools/ Virtual Labs by IITs** 1. Simulation of rotational and vibrational spectra using online software 2. Molecular vibration visualization using virtual spectroscopy tools 3. Simulation of Raman scattering and IR absorption 4. Virtual XRD pattern analysis and indexing 5. Use of spectral databases for interpretation of IR and Raman spectra	
Suggested Skill-Based Activities	1. Spectral interpretation assignments 2. Group seminar on modern spectroscopic techniques 3. Comparison of IR and Raman spectroscopy applications 4. Mini-project on spectroscopy in pharmaceuticals/material science 5. Data analysis from published spectral data	
References	1. Morgan, E. D. "Vogel's textbook of practical organic chemistry. 5th edn.: By BS Furniss, AJ Hannaford, PWG Smith and AR Tatchell. Pp. 1514. Longman, Harlow. (1990): 148. 2. *Handbook of Organic Analysis: Qualitative and Quantitative* – H. T. Clarke, CBS Publishers. 3. Practical Chemistry (For B.Sc. I, II and III Year Students). By Pandey O.P. & Bajpai D.N. & Giri S., S.Chand.	

	4. Ahluwalia, V. K., and Renu Aggarwal. Comprehensive practical organic chemistry: preparation and quantitative analysis. Universities Press, 2001. 5. Sethi, Arun. *Systematic lab experiments in organic chemistry*. New Age International, 2006 6. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press. 7. Advanced practical Organic Chemistry: O P Agrawal 8. Sharma, Y. R. (2013). Elementary Organic Spectroscopy: Principles and Chemical. 9. Organic Structure From Spectra by L D Field, S Sternhell 10. P S Kalsi,(2016). Spectroscopy of Organic Compounds, 7th edition. Delhi: New age international publisher. 11. Robert M. Silverstein, Francis X. Webster, (1996).Spectrometric Identification of Organic Compounds, 6th Edition. New York: John Wiley & Sons. **Web resources:** https://nanohub.org/modelsimulate https://sdbs.db.aist.go.jp/SearchInformation.aspx https://avogadro.cc/ https://molview.org/ Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry ChemCollective Virtual Labs: http://chemcollective.org PhET Interactive Simulations (University of Colorado Boulder): https://phet.colorado.edu
Model Questions:	**NA**

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Organic Estimation) 10 Marks
- Exercise 2 (Spectral analysis) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Cat Course Category: **Major- Elective (Theory)**

108238 Elective Chemistry-3 (Biomolecules)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108238**	**Elective Chemistry-3 (Biomolecules)**	2	30	2 Hrs	30+20=50

Course Objectives:	To provide a comprehensive understanding of the structure, properties, biological functions, and significance of carbohydrates, lipids, vitamins, and nucleic acids in living systems.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Classify carbohydrates and lipids and explain their occurrence, structure, and biological importance. 2. Describe the constitution, stereochemistry, cyclic structures, Haworth projections, and conformations of important monosaccharides such as glucose and fructose. 3. Explain the structures and properties of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose). 4. Discuss the classification, structure, properties, and biological functions of fatty acids, triacylglycerols, and other lipids. 5. Explain the concepts of saponification, rancidity, iodine number, acid number, and saponification number and their significance in the analysis of fats and oils. 6. Relate the physicochemical properties of carbohydrates and lipids to their nutritional and biological functions in living organisms.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Carbohyadrates:** Occurrence, classification and their biological importance. **Monosaccharides**: Constitution and absolute configuration of Glucose and Fructose, cyclic structure, Epimerization, conversion of glucose to fructose and vice-versa, Haworth projections and conformational structures. Structure of Ribose, 2- deoxyribose, Pyranose and Furanose, **Disaccharides** – Structure of Sucrose, maltose & Lactose. **Polysaccharides** – Structure and properties of starch & cellulose.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:**
Unit II	**Lipids:** Classification and biological significance of lipids. Fatty acids, Triacylglycerols, Properties of Triacylglycerols (Saponification, Rancidity), Tests to check purity of fats and oils (Iodine number, Saponification number, , Acid number), Lipoproteins, steroids (Cholesterol, Ergosterol).	7 Hrs	7 Marks	
Unit III	**Vitamins:** Definition, Classification of Vitamins-Fat-soluble and Water-soluble.Individual Vitamin: Vitamin A, D, E, K, C, B1, B2, B6, B12, Biotin, Niacin, Folic acid, Pantothenic acid, (Chemistry, Functions, Sources, Deficiency symptoms)	8 Hrs	8 Marks	

<table>
<tr><td>Unit IV</td><td>Nucleotides and Nucleic Acids:
Introduction to Nucleic Acids, Functions of nucleic acids, Chemistry of Nitrogenous Bases: Purines and pyrimidines, General Composition of Nucleic Acids: Nucleosides and nucleotides, Structure of DNA: Watson–Crick model, Chargaff’s rule of DNA composition, RNA: Structure and function of major RNA species.</td><td>7 Hrs</td><td>7 Marks</td><td>Analyze and discuss real cases to apply theoretical knowledge.
Any other innovative pedagogy as applicable.</td></tr>
<tr><td>References:</td><td colspan="4">1. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox, Macmillan Publishers, 4th Edition, 2005
2. Biochemistry, U. Satyanarayana, U. Chakrapani, Books and Allied (P) Ltd., 5th Edition, 2020.
3. Principles of Biochemistry, Donald Voet, Judith G. Voet, Charlotte W. Pratt, John Wiley & Sons, 3rd Edition, 2008.
4. Harper’s Illustrated Biochemistry, Robert K. Murray et al., McGraw-Hill, 27th Edition, 2006.
5. Biochemistry, Jeremy M. Berg, John L. Tymoczko, Lubert Stryer, W. H. Freeman & Company, 7th Edition, 2012.
6. Fundamentals of Biochemistry, J. L. Jain, S. Jain, Nitin Jain, S. Chand Publishing, 7th Edition, 2016.
7. Organic Chemistry, R. T. Morrison, R. N. Boyd, Pearson Education, 7th Edition, 2010
Web resources:
https://bio.libretexts.org/Bookshelves/Biochemistry
https://med.libretexts.org/Bookshelves/Nutrition
https://www.nature.com/scitable
https://ocw.mit.edu</td></tr>
<tr><td>Model Questions:</td><td colspan="4">Short Type (At least 6) (1 Marks each)
1. What is an epimer?
2. Name the sugar present in DNA.
3. Which polysaccharide is the main structural component of plant cell walls?
4. What is rancidity of fats and oils?
5. What does the iodine number of an oil indicate?
6. Deficiency of which vitamin causes scurvy?
7. What is a nucleotide?
8. State Chargaff's rule of DNA composition.</td></tr>
<tr><td></td><td colspan="4">Answer in brief (At least 6) (3 Marks each)
1. Explain the classification of carbohydrates with suitable examples.
2. Describe the cyclic structure of glucose and its Haworth projection.
3. Differentiate between starch and cellulose.
4. Explain the process of saponification of fats and oils.
5. Discuss the biological functions of cholesterol.
6. Classify vitamins into fat-soluble and water-soluble vitamins with examples.
7. Describe the structure and biological functions of Vitamin C.
8. Explain the Watson–Crick model of DNA and discuss its salient features.</td></tr>
<tr><td></td><td colspan="4">Answer in Detail (At least 4) (6 Marks each)
1. Explain the constitution, absolute configuration, cyclic structure, Haworth projection, and conformational structure of glucose.
2. Describe the structure, properties, and biological significance of the following polysaccharides:
i) Starch ii) Cellulose
3. Classify lipids and discuss the structure, properties, and biological importance of triacylglycerols, lipoproteins, and steroids.
4. Explain the concepts of saponification, rancidity, iodine number, saponification number, and acid number of fats and oils.
5. Classify vitamins and discuss the chemistry, functions, sources, and deficiency symptoms of Vitamins A, D, E, K, and C.
6. Describe the chemistry, biological functions, dietary sources, and deficiency diseases of the B-complex vitamins (B_1, B_2, B_6, B_{12}, biotin, niacin, folic acid, and pantothenic acid).
7. Discuss the structure and functions of nucleic acids. Explain the Watson–Crick model of DNA, Chargaff’s rules, and the structure and functions of the major types of RNA..</td></tr>
</table>

	MCQs for Internal Assessment (At least 4) 1. **Which of the following is a ketose sugar?** A) Glucose B) Ribose C) Fructose D) Galactose 2. **Which sugar is present in DNA?** A) Ribose B) Fructose C) Glucose D) 2-Deoxyribose 3. **Deficiency of Vitamin C causes:** A) Rickets B) Beriberi C) Scurvy D) Night blindness 4. **According to Chargaff's rule in DNA:** A) A = G and T = C B) A = T and G = C C) A = C and G = T D) A + G = T 5. **Which of the following is a purine base?** A) Cytosine B) Thymine C) Uracil D) Adenine

Course Category: **Major Elective Lab**

108239 Chemistry Lab 16C (Elective Chemistry-3)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108239**	**Chemistry Lab 16C (Elective Chemistry-3)**	2	60	4 h	25+25= 50

Course Objectives:	1. To develop practical skills in the identification, estimation, and analysis of biologically important molecules such as carbohydrates, lipids, proteins, vitamins, and nucleic acids. 2. To familiarize students with basic biochemical techniques and analytical methods used in food, pharmaceutical, and biological laboratories		
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Perform qualitative and quantitative analysis of carbohydrates, lipids, vitamins, proteins, and nucleic acids. 2. Apply biochemical tests for identification and characterization of biomolecules. 3. Determine important physicochemical properties of oils and biologically relevant compounds. 4. Demonstrate laboratory skills relevant to food, pharmaceutical, clinical, and biochemical industries. 5. Interpret experimental observations and prepare scientific laboratory reports.		
Unit System	**Contents**		**Incorporation of Pedagogies**
Tutorial and Discussion	● Classification of carbohydrates and lipids. ● Haworth structures of glucose and fructose. ● Starch, cellulose, and glycogen. ● Iodine number, saponification number, and acid number. ● Classification and functions of vitamins. ● Structure of nucleosides and nucleotides. ● Watson–Crick model of DNA. ● Differences between DNA and RNA.		● Experiential and hands-on laboratory learning ● ICT-enabled teaching using virtual labs, PhET, and NanoHUB simulations ● Problem-based and inquiry-based learning through spectral interpretation ● Collaborative learning through group activities and discussions ● Project-based learning using case studies and spectral analysis ● Demonstration and peer-learning methods for instrument handling and data analysis ● Outcome-based continuous assessment through practical performance, assignments, and viva voce Any other innovative pedagogy as applicable.
Organic Estimations	**Organic Estimations (At least 4)** 1. Estimation of glucose by Fehling's method 2. Estimation of phenol by bromination method 3. Estimation of ester by hydrolysis method 4. Estimation of vitamin C in fruit juice/tablets 5. Estimation of aspirin/paracetamol in formulations 6. Estimation of acetamide. 7. Determination of equivalent weight of an organic acid 8. Estimation of Nitrogen by Kjeldahl's method		
Biomolecules	**. Qualitative Analysis of Carbohydrates** . Molisch test . Benedict's test . Fehling's test . Iodine test . Seliwanoff's test Distinction between reducing/non-reducing sugars **. Detection of Rancidity and Adulteration in Oils** . Rancidity test		

	. Comparative study of commercial edible oils . **Qualitative Analysis of Proteins and Amino Acids** . Biuret test . Xanthoproteic test . Ninhydrin test . **Isolation of DNA from Plant Material** . DNA isolation from onion/banana . Observation of DNA precipitation . **Identification of Biomolecules in Unknown Samples** Systematic identification of carbohydrate, protein, lipid, or vitamin-containing samples	
Suggested Skill-Based Activities	1. Comparative analysis of Vitamin C in local fruits. 2. Nutritional analysis of edible oils. 3. DNA isolation competition/project. 4. Survey and testing of commercial food products. 5. Preparation of biomolecule identification flowcharts.	
References	1. Sattanathan, Dr G., S. S. Padmapriya, and Balasubramanian Balamuralikrishnan. *Practical Manual of Biochemistry*. Skyfox Publishing Group, 2020. 2. Hassall, H. An introduction to practical biochemistry: By David T. Plummer. McGraw-Hill. (1972): 14-15. 3. Shanmugam, S., T. Sathish Kumar, and K. Panneer Selvam. *Laboratory handbook on biochemistry*. PHI Learning Pvt. Ltd., 2019. 4. Sadasivam, S. *Biochemical methods*. New age international, 1996. **Web resources:** https://bio.libretexts.org Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry ChemCollective Virtual Labs: http://chemcollective.org PhET Interactive Simulations (University of Colorado Boulder): https://phet.colorado.edu	
Model Questions:	**NA**	

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Organic Estimation) 10 Marks
- Exercise 2 (Biomolecules) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Category: **Minor (Theory)**

108240 Minor Chemistry-3

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108240**	**Minor Chemistry-3**	2	30	2 Hrs	30+20=50

Course Objectives:	1. To develop a comprehensive understanding of transition elements and their characteristics and to develop fundamental understanding of formation of coordination compounds. 2. To develop understanding of crystal structure, symmetry, solid-state properties, X-ray diffraction, and phase equilibria of one-component and partially miscible liquid systems.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Write the general characteristics of transition elements 2. Classify double salt and coordination compounds 3. Name the coordination compounds according to IUPAC. 4. Calculate EAN and to predict the magnetic properties of complexes 5. Analyze chemical equilibrium using the law of mass action, equilibrium constants, thermodynamic relationships, and Le-Chatelier's principle. 6. Explain phase equilibria using Gibbs phase rule and interpret phase diagrams of one-component and partially miscible liquid systems. 7. Explain symmetry elements and laws of crystallography. 8. Calculate Miller indices and interplanar distances in cubic systems. 9. Differentiate between S.C.C., B.C.C., and F.C.C. crystal structures. 10. Derive and apply Bragg's equation for X-ray diffraction

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit-I	**Chemistry of Elements of Transition Series**: Definition and general characteristics of transition elements; Comparative study of first transition series elements (3d) with reference to following properties: (i) Electronic configuration (ii) Atomic and ionic size (iii) Ionization energy (iv) Metallic nature (v) Oxidation states (vi) Magnetic properties (vii) Color of salts (viii) Catalytic properties and (ix) Complex formation behavior; Electronic configuration of 4d and 5d series elements; Comparison of 3d series elements with 4d and 5d series elements with respect to atomic size and oxidation states.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through
Unit-II	**Coordination Chemistry-1** Addition compounds: double salts & complex salts; Important terms in coordination compounds: central metal ion, ligands, complex ion, coordination sphere, coordination number; Classification of ligands; Homoleptic and heteroleptic complexes; IUPAC nomenclature of coordination compounds; Werner's theory of coordination complexes with reference to cobaltammines and its experimental verification on the basis of molar conductance and precipitation; Sidgwick's electronic interpretation: EAN rule.	7 Hrs	7 Marks	
Unit-III	• , **Crystaline/Solid state** Introduction, Symmetry in crystal, plane of symmetry, axis of symmetry and point of symmetry. Law of constancy of interfacial angles. Elements of symmetry in cubic crystals. Laws of symmetry. Law of rational indices, Weiss and Miller indices of a lattice planes, calculation of interplanar distance d(h,k,l) from Miller indices in a cubic system. Seven crystal systems and fourteen Bravais lattices, Bravais lattices of cubic system. Simple cubic system	8 Hrs	8 Marks	

	(S.C.C.), body centered cubic system (B.C.C.) and face centered cubic system (F.C.C.). Calculation of number of constituent units in S.C.C., B.C.C. and F.C.C. Derivation of Bragg's equation for X-ray diffraction, Numericals.			questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit-IV	**Phase equilibria:** The Phase rule. Explanation of the terms: phase, component, degree of freedom. Calculation of number of components, phases and degrees of freedom in equilibrium systems. Phase diagram of one-component system- Water system and Sulphur system. Phase transition Partially miscible liquids - Phase diagram of phenol-water, triethyl amine - water and nicotine-water systems. Numericals.	7 Hrs	7 Marks	

References

1. Principles of Inorganic Chemistry by Puri, Sharma and Kalia- S. Naginchand& Co., Delhi.
2. Inorganic Chemistry by A.K. De, Wiley East Ltd.
3. Selected Topics in Inorganic Chemistry by Malik, Tuli and Madan, S. Chand & Co.
4. Concise Inorganic Chemistry by J.D. Lee, ELBS.
5. Physical Chemistry: Walter, J. Moore, 5th edn., New Delhi.
6. Physical Chemistry: G.M. Barrow, McGraw Hill, Indian Edn.
7. Principles of Physical Chemistry: Maron and Prutton.
8. Principles of Physical Chemistry: Puri, Sharma, and Pathania.
9. Physical Chemistry: P.W. Atkins, 6th Edn.
10. Physical Chemistry: Levine

Web resource:

1. https://nptel.ac.in/courses/104106094?utm_source
2. https://www.physchem.info/en/lecture-notes/?utm_source
3. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Online_Dictionary_of_Crystallography_(IUCr_Commission)/01%3A_Fundamental
4. https://serc.carleton.edu/research_education/geochemsheets/BraggsLaw.html

Model Questions:

Short Type (At least 6) (1 Marks each)

1) What are transition elements?
2) Write the general electronic configuration of first transition series elements.
3) Define coordination compounds.
4) Write IUPAC name of $[Co(NH_3)_4Cl_2]Cl$
5) Define plane of symmetry in crystals.
6) State Bragg's equation for X-ray diffraction.
7) What is meant by degree of freedom in phase rule?
8) Define partially miscible liquids.

Answer in brief (At least 6) (3 Marks each)

1. Write the electronic configuration of first transition series elements
2. Discuss the variation of atomic radii in 3d elements.
3. What is EAN? Calculate the EAN of central metal ion in i) $[Cu(NH_3)_4]SO_4$ i) $K_4[Fe(CN)_6]$
4. Define i) Complex ion ii) Ligands iii) Homoleptic complexes
5. Distinguish between double salts and complex compounds.
6. Explain the law of rational indices with suitable examples.
7. Explain Gibbs phase rule and define phase, component, and degree of freedom.
8. Discuss the phase diagram of phenol–water system.

Answer in Detail (At least 4) (6 Marks each)

1. Discuss the following properties of first transition series elements i) Oxidationa states ii) catalytic properties
2. Write the postulates of Werner's theory of coordination complexes. Give the experimental verification on the basis of molar conductance and precipitation
3. Explain the symmetry elements in crystals and discuss the seven crystal systems and fourteen Bravais lattices.
4. Derive Bragg's equation for X-ray diffraction and discuss its applications in crystal structure determination.
5. Explain the phase diagram of water system and discuss its important features and phase transitions.
6. Discuss the phase diagrams of partially miscible liquid systems such as phenol–water, triethylamine–water, and nicotine–water systems.

	MCQs for Internal Assessment (At least 4) 1. The number of Bravais lattices is: A) 7 B) 14 C) 21 D) 32 2. In a face-centered cubic (FCC) lattice, the number of constituent particles per unit cell is: A) 1 B) 2 C) 4 D) 6 3. Bragg's equation is represented as: A) PV = nRT B) nλ = 2d sinθ C) E = hν D) λ = h/mv 4. The degree of freedom at the triple point of water system is: A) 0 B) 1 C) 2 D) 3 5. Phenol–water system exhibits: A) Lower critical solution temperature only B) Upper critical solution temperature only C) Both UCST and LCST D) No critical solution temperature

Course Category: **Minor Lab**

108241 Minor Chemistry Lab 17

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108241**	**Minor Chemistry Lab 17**	2	60	4 h	25+25= 50

Course Objectives:	1. To develop practical skills in volumetric analysis, inorganic complex preparation, and physicochemical measurements using standard laboratory techniques. 2. To provide hands-on training in redox titrations, coordination compound synthesis, conductometric analysis, phase equilibria, and partition studies in Physical Chemistry and Inorganic Chemistry.	
Course Outcomes:	At the end of this course students will be able to: 1. Perform redox volumetric estimations using potassium permanganate and potassium dichromate with suitable indicators. 2. Prepare and characterize inorganic coordination compounds and interpret their valence bond structure, magnetic properties, and color. 3. Determine molecular weight, partition coefficient, solubility, heat of solution, and consolute temperature using physicochemical methods. 4. Apply conductometric techniques for acid-base titrations, determination of dissociation constants, and solubility product measurements. 5. Analyze experimental data, perform calculations accurately, and interpret physicochemical and analytical results scientifically. 6. Demonstrate laboratory skills, safe handling of chemicals and instruments, and proper scientific reporting practices.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	• Balancing redox equations using ion–electron method and Calculation of equivalent weight of $KMnO_4$ and $K_2Cr_2O_7$. • Principles and applications of internal and external indicators in redox titrations. • Determination of oxidation state, coordination number, and geometry of coordination compounds. • Prediction of magnetic properties and VB structures of inorganic complexes. • Construction and interpretation of phase diagrams of partially miscible liquids. • Calculation of partition coefficient using Nernst distribution law. • Graph plotting and interpretation in conductometric titrations.	1. Experiential and hands-on laboratory learning 2. Demonstration-based teaching for titrations, conductometry, and complex preparation 3. Problem-based learning through analytical calculations and data interpretation 4. Inquiry-based learning for experimental observations and result analysis 5. Collaborative learning through group experiments and discussions 6. ICT-enabled teaching using
Inorganic Chemistry practical	**Volumetric estimations: (At least 2)** 1. Estimation of oxalic acid using standardized KMnO4 as an intermediate solution. 2. Estimation of Fe(II) (FAS) using standardized KMnO4 as an intermediate solution. 3. Estimation of Fe(II) (FAS) with K2Cr2O7 using internal (diphenylamine, anthranilic acid) or external indicator potassium ferricyanide.	

	4. Determination of equivalent weight of oxidizing agent $KMnO_4$ or $K_2Cr_2O_7$ by titration with standard Fe(II) (FAS) solution **Inorganic Complex Preparations: (At least 4)** 1. Preparation of tetraamminecopper(II)sulphate. 2. Preparation of hexaamminenickel(II)chloride. 3. Preparation of Prussian blue 4. Preparation of potassiumtrioxalate aluminate(III). 5. Preparation of chrome alum. 6. Preparation of sodium thiosulphate and dithionite. 7. Preparation of cis and trnas-bisoxalato diaqua chromate (III) ion. • (Comment on VB structure, magnetic properties and color of 1, 2 and 3 complexes)	virtual labs and simulation tools 7. Project-based learning through mini-projects and case studies 8. Peer learning and seminar presentations on coordination chemistry and physicochemical analysis 9. Outcome-based continuous assessment through laboratory performance, assignments, viva voce, and reports
Physical Chemistry Practical	**(At least 6 experiments)** 1. To determine the molecular weight of nonvolatile solute by Rast's method 2. To construct phase diagram of phenol-water system and to determine consolute temperature for the system 3. To determine partition coefficient of benzoic acid between toluene and water 4. To determine partition coefficient of iodine between CCl4/Kerosene and water. 5. To determine solubility of benzoic acid at different temperature and heat of solution 6. To determine the cell constant of a conductivity cell. 7. To find out the strength of HCl solution by titrating against standard NaOH solution conductometrically. 8. To find out the strength of acetic acid solution by titrating against standard NaOH solution conductometrically. 9. To find out the strength of HCl and acetic acid in mixture of both by titrating against standard NaOH solution conductometrically. 10. To determine the dissociation constant of weak acid (acetic acid) conductometrically. 11. To determine the solubility and solubility product of a sparingly soluble salt conductometrically.	
Suggested Student Activities	• Coordination Compound Exhibition • Phase Diagram Plotting Activity • Conductometric Data Analysis • Mini Project on Coordination Chemistry • ICT-Based Simulation Activities	
References	Advanced Practical Inorganic Chemistry – Gurdeep Raj, Goel Publishing. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Inorganic Chemistry: Qualitative Analysis, University Press. Vogel's Textbook of Quantitative Chemical Analysis – J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, Pearson. Practical Chemistry (For B.Sc. I, II and III Year Students). By Pandey O.P. & Bajpai D.N. & Giri S., S.Chand. Vogel, Arthur Israel, and John Bassett. "Vogel's textbook of quantitative inorganic analysis: including elementary instrumental analysis." (1978). Advanced Physical Chemistry Experiments: J N Gurtu and Amit Gurtu (Pragati Prakashan) Experimental Physical Chemistry: V D Athawale and Parul Mathur (New Age Int. Publishers) Advanced Practical Physical Chemistry: J B Yadav Experiments in Chemistry: D V Jahagirdar). Advanced Physical Chemistry Experiments: J N Gurtu and Amit Gurtu (Pragati Prakashan) . **Web resources:** https://vlab.amrita.edu/?sub=2 https://chemcollective.org/vlabs https://chem.libretexts.org/ Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry	
Model Questions:	**NA**	

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Inorganic Chem Practical) 10 Marks
- Exercise 2 (Physical Chem Practical) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **Vocational Skill Course VSC**

108242 Chemistry Lab- 18 (Oil and Milk Analysis)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108242**	**Chemistry Lab- 18 (Oil and Milk Analysis)**	2	60	4 Hrs	50

Course Objectives:	To develop practical skills in estimation and quality analysis of edible oils, oil seeds, and milk using standard analytical techniques relevant to food, pharmaceutical, and chemical industries.	
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Perform physicochemical analysis of oil seeds and edible oils using standard analytical methods. 2. Determine important quality parameters of oils such as acid value, iodine value, peroxide value, saponification value, and ester value. 3. Analyze milk samples for physicochemical properties including pH, acidity, fat content, total solids, and SNF. 4. Detect adulteration and assess quality and purity of edible oils and milk samples. 5. Apply laboratory analytical and quality control techniques relevant to food, dairy, and edible oil industries.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	1. Calculations involved in volumetric and gravimetric estimations. 2. Interpretation of analytical data and report writing. 3. Calculation of acid value, iodine value, peroxide value, and saponification value of oils. 4. Error analysis and precautions in analytical experiments.	By combining hands-on experiments, discussions, and real-world applications, students will gain a comprehensive understanding of chemistry lab practices. A few suggested pedagogies are: • Students should be given suitable **pre- and post-lab** assignments and explanation revising the theoretical aspects of laboratory experiments prior to and after the conduct of each experiment. • **Hands-On Laboratory Sessions:** Provide regular hands-on laboratory sessions where students can directly apply theoretical knowledge to practical experiments. • **Demonstrations and Simulations:** Use virtual
Analysis of Oil and Milk	**Analysis of Oil Seeds and Oil** 1. Determination of moisture content in oil seed 2. Estimation of oil content from oil seed by solvent extraction 3. Determination of ash contents in oil seed 4. Determination of acid value of an oil sample 5. Determination of saponification value of an oil sample 6. Determination of iodine value of an oil sample 7. Determination of peroxide value of an oil sample 8. Determination of ester value of an oil sample 9. Determination of specific gravity and refractive index of an oil sample 10. Detection of rancidity of an oil sample **Analysis of milk:** 1. Determination of pH and acidity of milk 2. Determination of specific gravity using lactometer 3. Estimation of fat content in milk	

	4. Determination of total solids and solids-not-fat (SNF) Detection of adulterants in milk: Water, Starch, Urea, Detergent, Formalin	simulations for certain experiments to enhance accessibility and understanding
Suggested Group Activities	1. Comparative analysis of commercial oil and milk samples 2. Detection of food adulteration survey 3. Preparation of analytical reports and presentations **4.** Industrial visit to dairy/oil processing laboratory	
Group Discussion or Seminar	• Career opportunities in food, dairy, and analytical laboratories. • Food adulteration and public health issues. • Nutritional importance of edible oils and milk products. • Detection and prevention of adulteration in commercial products. • Quality standards of edible oils and dairy products (FSSAI/BIS). • Consumer awareness regarding food quality and safety.	
References	1. Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3rdEd. ELBS (1964) 2. Vogel's textbook of quantitative chemical analysis, Sixth Ed. Mendham, Denny, Barnes 3. Nielsen, S. Suzanne, ed. "Food analysis." (2010). 4. Nielsen, S. Suzanne. "Introduction to food analysis." In *Nielsen's food analysis*, pp. 3-14. Cham: Springer International Publishing, 2024. **Web resources:** 1. http://elibrary.mukuba.edu.zm:8080/jspui/bitstream/123456789/144/1/Food%20Analysis%20Laboratory%20Manual.pdf 2. https://www.academia.edu/download/54933601/S._Suzanne_Nielsen_auth.__S._Suzanne_Nielsen_eds._Food_Analysis.pdf#page=15	
Model Questions:	**NA**	

Distribution of Marks and the scheme of (VSC) Practical Examination is as follows:

Section I: Continuous Internal Assessment

- Continuous Assessment Tests (CAT) (At least three tests) * 15 Marks
- Submission of duly certified practical record 10 Marks

Total 25 Marks

Section II: End Semester Examination (Internal only)

- Exercise 1 20 Marks
- Viva-Voce (internal) 05 Marks

Total 25 Marks

Total (Section I And II) 50 Marks

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Course Category: **Skill Enhancement Course SEC**

108243 Chemistry Lab- 19 (ICT Tools in Chemistry))

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108243**	**Chemistry Lab- 19 (ICT Tools in Chemistry)**	2	60	4 Hrs	50

Course Objectives:	1. To introduce Information and Communication Technology (ICT) tools used in teaching, learning, research, and data analysis in Chemistry. 2. To develop practical skills in chemical structure drawing, molecular visualization, spectral interpretation, data handling, and virtual laboratory applications. 3. To familiarize students with digital resources, simulation tools, and online databases used in modern chemical sciences.	
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Use ICT tools for chemical structure drawing, molecular visualization, and scientific communication. 2. Retrieve and interpret chemical and spectral data using online databases and software tools. 3. Apply virtual laboratory simulations and digital platforms for understanding chemical concepts and experiments. 4. Perform basic chemical data analysis, graph plotting, and preparation of scientific reports and presentations. 5. Utilize chemoinformatics resources and ICT-enabled platforms in chemistry learning and research.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	**A. Scientific Documentation** Introduction to scientific documentation, digital report preparation, spreadsheet applications, data handling, graph plotting, and scientific presentations using MS Office and Google Workspace tools. **B. Data Visualization and Reporting** Introduction to scientific data visualization, graph preparation, interpretation of experimental data, and preparation of reports on chemistry e-resources and digital platforms. **C. Chemical Databases and Scientific Literature** Introduction to chemical databases, scientific journals, publishers, online literature searching, research and review articles, citation methods, and scientific summarization techniques. **D. Academic and Professional Networking** Introduction to academic networking platforms such as Google Scholar, ResearchGate, and LinkedIn for literature searching, citation tracking, scientific communication, and professional development. **E. Basic Chemoinformatics and Molecular Visualization** Introduction to chemoinformatics, molecular representation, resonance effects, stereochemistry, molecular visualization, conformational analysis, geometry optimization, and physicochemical property analysis using computational chemistry tools and online databases.	To enhance conceptual understanding and digital competency in chemistry, the following pedagogical approaches will be incorporated: • **Experiential Learning:** Hands-on training in scientific documentation, molecular visualization, chemical structure drawing, and computational chemistry tools. • **Inquiry-Based Learning:** Activities involving interpretation of molecular structures, resonance effects, conformational analysis, and physicochemical properties. • **Collaborative Learning:** Group-based assignments, presentations, database searching, and scientific discussions to promote teamwork and communication skills. • **Technology-Enhanced Learning:** Use of
Exercise/ Experiments	**(At least 12) (Any suitable software other than the software mentioned can be used)** **A. Scientific Documentation** 1. Preparation of a scientific document (2–3 pages) containing: Text, Images, Hyperlinks using MS Word or Google Docs. 2. Preparation of a spreadsheet containing: Experimental data, Calculations, Tables, Graphs, Hyperlinks using MS Excel or Google Sheets. 3. Preparation of a scientific presentation (8–10 slides) containing: Text, Images, Graphs, Video embedding, Hyperlinks using MS PowerPoint or Google Slides. **B. Data Visualization and Reporting** 1. Preparation and interpretation of scientific graphs using software tools. a) Plot graphs using experimental data. b) Prepare a report containing: Graph title, Axis labels,	

	Captions, Interpretation 2. Preparation of a report on chemistry e-resources. The report should contain: Name of e-resource, Website link, Applications and uses **C. Chemical Databases and Scientific Literature** 1. Study of ChemSpider database for searching, retrieving, and downloading chemical structure and molecular information. 2. Study of chemistry journals and scientific publishers by preparing a document containing journal names, publishers, subject areas, and website links. 3. Study and analysis of research and review articles in chemistry through identification of article components (Title, Authors and affiliations, Abstract, Materials and Methods, Results and Discussion, Conclusion) and preparation of article summary. **D. Academic and Professional Networking (Activity based only)** 1. Study of Google Scholar for scientific literature searching, citation tracking, and academic profile management. 2. Study of ResearchGate as a platform for scientific networking, publication sharing, and academic collaboration. 3. Study of LinkedIn for academic communication, professional networking, and career development in chemistry. **E. Basic Chemoinformatics and Molecular Visualization** 1. Illustration of resonance structures showing the directive influence of activating and deactivating groups on aromatic rings using curly arrows and preparation of scientific documents using MS Word or MS PowerPoint. *(Examples: –OH, –CH_3, –Cl, –NO_2 groups)* 2. Visualization and comparison of structural, geometrical, and optical isomers using MolView or KingDraw. *(Examples: n-Butane & isobutane, cis/trans-2-butene, D- and L-lactic acid)* 3. Study of the three-dimensional structure and molecular properties of paracetamol using PubChem molecular visualization tools. 4. Study and analysis of molecular geometry, polarity, dipole moment, hydrogen bonding, and physicochemical properties of molecules using PubChem/ Discovery Studio Visualizer or related molecular visualization tools.	ICT tools, chemoinformatics software, online databases, molecular visualization platforms, and virtual chemistry resources. • **Project-Based Learning:** Preparation of scientific reports, presentations, article summaries, and chemistry-related digital content. • **Research-Oriented Learning:** Exposure to scientific literature, academic networking platforms, citation tracking, and modern computational chemistry techniques. • **Assessment through Reflective Learning:** Evaluation through practical performance, digital assignments, seminars, report writing, presentations, and viva voce.
Activities	Suggested list of activities (may be extended according to the wisdom of the instructor): 1. Preparation of a scientific PowerPoint presentation using molecular drawing and visualization software and submission of soft copy to the instructor. 2. Preparation of a report on chemistry e-resources, scientific databases, and academic networking platforms including their applications in chemical sciences. 3. Preparation and presentation of a seminar on chemoinformatics and molecular visualization topics using digital tools and scientific software. 4. Students shall prepare a short educational video on any chemistry-related topic using screen recording software such as OBS Studio or similar tools, upload the video to YouTube or another digital platform, and submit the video link to the instructor	
References	**References:** 1. Kalsi, P. S. Stereochemistry, Conformation and Mechanism (8th ed.). New Age International Publishers, 2015. 2. Clayden, J., Greeves, N., & Warren, S. Organic Chemistry (2nd ed.). Oxford University Press, 2012. 3. Vogel, A. I. Vogel's Textbook of Practical Organic Chemistry (5th ed.). Pearson Education, 1989. 4. Gasteiger, J., & Engel, T. *Chemoinformatics: A Textbook*. Wiley-VCH, 2003. **Web source:** 1. https://sourceforge.net/projects/openbabel 2. https://jmol.sourceforge.net/ 3. Jmol Application - 3D chemical structure viewer By Prof Kannan Moudgalya, https://onlinecourses.swayam2.ac.in/aic20_sp63/preview 4. https://discover.3ds.com/discovery-studio-visualizer 5. https://pubchem.ncbi.nlm.nih.gov.com	

	6. https://molview.org.com 7. https://www.chemspider.com 8. https://scholar.google.com 9. https://www.researchgate.net.com 10. https://www.linkedin.com 11. https://chemaxon.com/products/marvin?utm_source=chatgpt.com
Model questions	NA

Distribution of Marks and the scheme of (SEC) Practical Examination is as follows:

Section I: Continuous Internal Assessment

- Continuous Assessment Tests (CAT) (At least three tests) * 15 Marks
- Submission of duly certified practical record 10 Marks

Total 25 Marks

Section II: End Semester Examination (Internal only)

- Exercise 1 20 Marks
- Viva-Voce (internal) 05 Marks

Total 25 Marks

Total (Section I And II) 50 Marks

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Course Category: **FP/CES**

108244 Chemistry Lab- 20 (FP/ CES in Chemistry - III)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108244**	**Chemistry Lab- 20 (FP/ CES in Chemistry - III)**	2	60	--	50

Course Objectives:	The intended objectives are: • To develop an appreciation of rural culture, lifestyle and wisdom amongst students. • To learn about the status of various agricultural and development programmes. • To understand the causes of distress and poverty faced by vulnerable households and explore solutions for the same. • To apply classroom knowledge of courses to field realities and thereby improve the quality of learning.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Gain an understanding of rural life, Indian culture and ethos and social realities 2. Develop a sense of empathy and bonds of mutuality with the local community 3. Appreciate significant contributions of local communities to Indian society and Economy 4. Learn to value the local knowledge and wisdom of the community 5. Identify opportunities for contributing to community's socio-economic improvements

Guidelines/ SoP for FP/CEP

For understanding key principles of CE, forms of CE, operational guidelines and implementation strategy please refer https://www.ugc.gov.in/pdfnews/4187860_Revised-Final-Guidelines.pdf

As per NEP 2020, students of B Sc. III of Semester V need to perform a Field Project (FP) for TWO (2) credits i.e. 50 Marks. The guidelines regarding the field project are as follows:

1) The total time allocation for the student to carry out field project is 60 hours.
2) Students should participate in field-based projects under the supervision of faculty.
3) Assignment of project topics to individual students or groups of students (max 4 students in one group) and one faculty member from the department will act as Guide for the student or group of students.
4) For a SURVEY based project related questionnaire (15 or more questions) should be prepared.
5) The departmental coordinator/guide should check the questions and finalize the questionnaire. The question that may create unnecessary complications should be avoided. The questions should be qualitative as well as quantitative.
6) If the project is related to work that does not involve survey work, then the questionnaire part can be replaced accordingly (e.g. Sample collection/Data collection/ Experimental base etc).
7) The student should compile all the relevant data and carry out its analysis.
8) A project report should be written individually in the standard format (2 Copies): Index, Introduction, Materials, Methods, Result, Conclusion/output, References (Numeric citation type) etc.
9) The project report should be of minimum 6 pages (excluding Title page, Certificate, Index, Acknowledgement etc.). Submit the project report with the Guide's signature to the department.
10) The oral /poster presentation for all the projects should be arranged in the department. To evaluate the project, examiner should be appointed by HoD.
11) The total project work including preparation of questionnaire to presentation should be evaluated for 2 credits (50 Marks).

Some suggested forms of FP/ CEP are:

1. **Linking learning with community service:** For example, students of chemistry can conduct water and soil testing in local areas and share the results with the local community.
2. **Linking research with community knowledge:** Community-based Participatory Research (CBPR) approaches are gaining recognition in this regard. For example, students of chemistry can undertake research in partnership with the community on solid and liquid waste disposal.
3. **Knowledge sharing and knowledge mobilization:** These can take the forms of enumerations, surveys, awareness camps and campaigns, training, learning manuals/films, maps, study reports, public hearings, policy briefs, cleanliness and hygiene teachings, legal aid clinics, etc. For example, students can undertake a 'swachhta survekshana' and/or nutrition survey for mothers and children, and educate them about hygiene and nutrition.
4. **Social innovations by students:** The students can be encouraged to initiate learning projects with a social impact and supported by HEIs. Incubation of such social innovation projects by students can also have meaningful links to existing curriculum and courses.

A few suggested (not exclusive) areas which not only provide practical applications of chemistry concepts but also foster collaboration, education, and sustainable practices within the community. are:

1. Understanding the chemical footprints of household products such as toothpaste, haircare, facecare food products etc
2. Enhance science literacy among school students through interactive chemistry demonstrations.
3. Managing organic waste to composting and improve soil health.
4. Explore the extraction and application of natural dyes as alternatives to synthetic dyes.
5. Identify and mitigate lead exposure risks in the community.
6. Implement a community-wide recycling initiative focusing on chemical waste and recyclable materials.
7. Introduce and demonstrate the principles of renewable energy sources, such as biofuels or solar energy.
8. Assess local air quality and raise awareness about pollution sources and mitigation strategies.
9. Educate community members on the safe use, storage, and disposal of household chemicals.
10. Assist local farmers in understanding soil nutrient content and composition to optimize crop production.
11. Evaluate local water sources for contaminants such as heavy metals, nitrates, and pH levels.

References	1. https://www.ugc.gov.in/pdfnews/4187860_Revised-Final-Guidelines.pdf 2. https://en.wikipedia.org/wiki/OU_Citizen_Science_Soil_Collection_Program 3. https://www.immerse.education/study-tips/100-ideas-for-research-projects-in-chemistry/ 4. https://pubs.rsc.org/en/content/articlelanding/2021/rp/d0rp00374c 5. https://www.acs.org/education/student-communities/activities.html 6. https://www.nettercenter.upenn.edu/academically-based-community-service-chemistry-outreach
Model Questions:	**NA**

Distribution of Marks and the scheme of FP/CEP Examination is as follows:

- Students' performance 20 Marks
- Submission of duly certified FP/CEP report 20 Marks
- Presentation (PPT or Poster) 10 Marks

Total **50 Marks**

Course Category: **Non-Credit**

Foundation of Artificial Intelligence

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V		**Foundation of Artificial Intelligence**	Non credit	30	2 Hrs	30+20=50

Introduction :

The National Education Policy (NEP) 2020 emphasizes the integration of Artificial Intelligence (AI) across all undergraduate levels and disciplines to foster digital literacy and problem-solving skills. 'It can enhance the employability of the youth and prepare professionals in cutting-edge areas.'(pg. 46, R.D Kulkarni Report)

The Foundations of Artificial Intelligence course offers an overview of the key concepts, structures, applications, and ethical aspects of AI. It helps learners understand how intelligent systems work and shape modern life. The course covers AI's definition, evolution, types, and practical uses, along with its basic architectures like rule-based systems, machine learning, and neural networks. Learners will explore AI's role in education, healthcare, and commerce while reflecting on ethical and social concerns such as privacy, bias, and automation. In line with NEP 2020, it fosters digital literacy and responsible AI awareness for all disciplines.

A) Objective

i) Introduce all undergraduate students of all the faculties to the basic concepts, uses, and importance of AI.

ii) Enable learners to understand AI's principles, applications, limitations, and effectively use AI tools.

iii) Encourage students to recognize AI's role in enhancing life and engage with its social and ethical implications.

B) Outcomes

i) Understand the fundamental concepts, types, and evolution of Artificial Intelligence.

ii) Apply basic AI techniques and tools to real-world problems across different domains.

iv) Evaluate the social, ethical, and professional implications of AI in everyday life.

C) Implementation of Syllabus, Scheme of Examination and Teaching.

1) Curriculum, Teaching and Examination Scheme Given in Appendix A

2) This course given in Appendix A shall be compulsory course in **fifth semester** of all undergraduate programs of all faculties in Sant Gadge Baba Amravati University, Amravati.

2) Medium of instruction, paper setting and writing of Answer paper shall be in English, Marathi and Hindi.

3) Question paper shall be set and valuated by the College/ Department.

4) Duration of external examination shall be of 2 hours and paper shall be of 30 marks.

5) Internal 20 marks shall be distributed, 5 to attendance, 15 marks to assignment/class test/viva voce/presentation.

6) Distribution of 30 external marks shall be based on 4 units, 15 marks to short and 15 marks to long answer type questions.

7) It shall be obligatory on part of the college/department to conduct examination on prescribed date by the university and submit the candidate wise information as follows on university portal on due date after valuation answer books.

Grade A -- mark secured 30 to 50,

Grade B -- 25 to 29,

Grade C -- 20 to 24,

FAIL 19 and below

8) The final Grade shall be determined by the combined performance in internal and external assessments. A student must secure a minimum of 30% in the internal assessment, 30% in the external assessment, and at least 40% overall to pass. Failure to meet any of these criteria will result in a grade of "Fail."

9) In case of failure, student need to appeared in backlog examination by paying prescribed fees.

10) Valuated answer book shall be kept in college custody for one academic year and random verification may be done by the University if required.

11) Result of final year of respective degree shall not be declared of an examination unless secured any of the grades out of A to C in Foundation of Artificial intelligence.
12) Grade secured by an examinee in examination of said course shall be shown on fifth and last semester marksheet.
13) The candidates shall have to pay Rs 150 /- in 5th semester to the college to meet out the expenses by the college on teaching of course, question paper setting and printing, paper valuation, providing answer sheet, and filling grade on University portal. In case of failure student need to pay Rs 20 /- for conduction of examination. There shall not have any facility of revaluation of answer book.
14) For teaching of the subject person having PG degree in any faculty with second class shall be considered eligible, provided priority shall be given to Ph.D., NET, SET, regular teacher.

15) **Format of question paper**
Distribution of 30 external marks shall be based on 4 units, 15 marks to short and 15 marks to long answer type questions with internal choice.
1a) Long or short answer questions based on unit number 1 having 8 marks

Or

1b) Long or short answer questions based on unit number 1 having 8 marks
2a) Long or short answer questions based on unit number 2 having 7 marks

Or

2b) Long or short answer questions based on unit number 2 having 7 marks
3a) Long or short answer questions based on unit number 3 having 8 marks

Or

3b) Long or short answer questions based on unit number 3 having 7 marks
4a) Long or short answer questions based on unit number 4 having 8 marks

Or

4b) Long or short answer questions based on unit number 4 having 8 marks

Program:				**Semester:**	**V**	
Course:	**Foundation of Artificial Intelligence**			**Code:**		
Teaching Scheme				**Evaluation Scheme**		
Level	**Lecture**	**Hours**	**Credit**	**Internal**	**External**	**Total**
5.5	2	2	2	20	30	50
Methods of Internal Assessment: 15 Marks to Class Tests, /Assignments/ Viva voce/ Presentation & 5 Marks to Attendance						
Course Objectives: To introduce AI concepts in a simple, real-life way with focus on understanding applications, ethics, and future opportunities.						
Course Outcomes: After completion of the course, the students will be able to:						

CO	**Course Outcomes**	**BT Level**
CO-1	Explain the basic concepts, history, and types of AI with real-life examples.	L1 – Knowledge, L2 – Understanding
CO-2	Describe AI structures and architectures using simple real-world analogies.	L2 – Understanding, L3 – Application
CO-3	Identify and analyze applications of AI in the area of arts, commerce, humanities, and daily life.	L3 – Application, L4 – Analysis
CO-4	Evaluate ethical, social issues and predict future opportunities of AI in their own fields.	L4 – Analysis, L5 – Evaluation

Unit 1: Introduction to Artificial Intelligence (8 Hours)

Definition of AI: What is Intelligence? Natural vs. Artificial, Simple definition of AI; History & Evolution of AI: From early computers to modern AI; Types of AI: Narrow AI vs. General AI vs. Super AI; AI in Everyday Life: Google Maps, E-commerce suggestions, Chatbots, Social Media feeds; Key Components: Data, Algorithms, Computing Power

Unit 2: AI Structures, Architectures & Techniques (7 Hours)

Basic Structure of an AI System; AI Architectures (Simplified): Rule Based System, Machine Learning, Neural Networks; Key Concepts: Knowledge Representation (using symbols, facts), Search & Problem Solving (maze example, finding shortest route), Natural Language Understanding (Google Translate, chatbots)

Unit 3: Applications of AI in Society (7 Hours)

AI in Different Fields: Education (Personalized learning apps, plagiarism checkers), Healthcare (Disease prediction, medical chatbots), Commerce (Fraud detection in banking, stock market predictions, customer support), Daily Life (Smart home devices, language translation, travel assistants); AI & Decision Making: Hiring, Loan Approval, Court Decisions; Advantages of AI, Limitations of AI

Unit 4: Ethical, Social & Future Aspects of AI (8 Hours)

Ethical Concerns in AI: Privacy issues (CCTV, online data), Bias & Fairness (AI preferring certain groups), Job Displacement (automation replacing humans); Responsible AI: Transparency, Accountability, Human oversight; Future Trends in AI: Self-driving cars, AI in governance, creative industries; AI and You (Career Perspective): Opportunities in Digital Marketing, Content Creation, Business Analytics, HR Tech, Creative Industries (non-programming roles)

Textbook:

Melanie Mitchell – *Artificial Intelligence: A Guide for Thinking Humans*

Reference Books:

1. Boden, Margaret A., *Artificial Intelligence*: A Very Short Introduction
2. Elaine Rich – *Artificial Intelligence* (3rd Edition)
3. Godbole, Achyut, *Artificial Intelligence* (आर्टिफिशियल इंटेलजन्स), Bookganga Publication.
4. Kulkarni, Dr Anand, आर्टिफिशियल इंटेलजन्सच्या वाटेवर, Sakal Media Pvt. Ltd.
5. Stuart Russell – *Human Compatible* (2019)
6. Thorpe, Josh, *AI for Students: Creative Hacks for Academic Success*, Promplty Books

Course Category: **Major (Theory)**

108245 Inorganic Chemistry 3

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108245**	**Inorganic Chemistry 3**	2	30	2 Hrs	30+20=50

Course Objectives:	1. To develop a fundamental understanding of inner transition elements and their characteristics properties. 2. To develop comprehensive understanding of formation of coordination compounds on the basis of CFT and electronic spectra. 3. To know the organo-metallic compounds and the role of metal ions in biological processes.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Describe the general properties of f-block elements 2. Compare lanthanoids and actinoids with respect to electronic configuration, oxidation state and chemical behaviour. 3. Explain the nature of metal-ligand bonding in coordination compound by CFT 4. Calculate CFSE of complexes. 5. Describe various factors affecting CFSE 6. Explain the electronic transitions occurs in coordination compounds 7. Distinguish between complex and chelate. 8. Explain the organometallic compounds and the nature of metal carbon bonds in them. 10. Identify the essential and trace elements in biological processes. 11. Realize the role of haemoglobin and myoglobin in human body.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Inner Transition(f-block) Elements:** Definition and properties of f-block elements (Lanthanoids and Actinoids); Lanthanoids: comparative study w.r.t (i) electronic configuration (ii) variation in atomic and ionic radii, lanthanoids contraction-definition and cause, effect of lanthanoids contraction on basicity of their oxides and hydroxides (iii) oxidation states (iv) magnetic properties (v) color of salts (vi) complex formation behavior; Occurrence of lanthanoids; Actinides-Electronic configuration and oxidation states. Comparison of lanthanides and actinides.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply
Unit II	**Coordination Chemistry-3 (CFT)** Postulates of CFT; Crystal field splitting in octahedral, distorted octahedral, square planar and tetrahedral complexes; concept of CFSE, high spin and low spin octahedral complexes on the basis of Δ_o and pairing energy, distribution of electrons in t_{2g} and e_g orbitals in high spin and low spin octahedral complexes; Factor affecting magnitude of crystal field splitting in octahedral complexes. Spectrochemical series.	7 Hrs	7 Marks	
Unit III	**A) Electronic Spectra of Transition Metal Complexes: [5]** Introduction to electronic spectra, selection rules for d-d transitions, spectroscopic terms: determination of ground term symbols for d^1 to d^{10}, Orgel diagram for d^1 and d^9 states, electronic spectrum of $[Ti(H_2O)_6]^{3+}$ complex ion. **B) Chelates: [3]** Definition, classification and applications of chelates in analytical chemistry. Stability of chelate with special reference to chelate effect.	8 Hrs	8 Marks	

Unit IV	**A) Organometallic Chemistry : [4]** Definition and classification of organometallic compounds; Metal carbonyls: definition and classification, Structure and bonding in $Ni(CO)_4$, $Fe(CO)_5$, $Cr(CO)_6$; Nature and evidences of metal-carbon bond in metal carbonyls. **b) Bio-inorganic Chemistry: [3]** Essential and trace elements in biological processes. Biological role of Na^+, K^+, Ca^{2+} and Mg^{2+} ions. Metalloporphyrins-Haemoglobin and Myoglobin and their role in oxygen transport.	7 Hrs	7 Marks	theoretical knowledge. **Any other innovative pedagogy as applicable.**
References:	1. Principles of Inorganic Chemistry by Puri, Sharma and Kalia- S. Naginchand& Co., Delhi. 2. Inorganic Chemistry by A.K. De, Wiley East Ltd. 3. Selected Topics in Inorganic Chemistry by Malik, Tuli and Madan, S. Chand & Co. 4. Concise Inorganic Chemistry by J.D. Lee, ELBS. 5. Inorganic Chemistry by J.E. Huheey- and Kettle, Harper & Row. 6. Advanced Inorganic Chemistry, Vol-I, Satya Prakash, Madan, Tuli, Basu. 7. Advanced Practical Inorganic Chemistry by Gurdeep Raj, GoelPulishing House, Meerut. **Web resources:** 1. MIT OpenCourseWare: https://ocw.mit.edu 2. Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) Define Lanthanoid contraction. 2) What is the position of 4d series elements in the periodic table? 3) Write general electronic configuration of f-block elements. 4) What is spectro-chemical series? 5) Give the relationship between Δ_o and Δ_t. 6) Define chelate. 7) What are organometallic compounds? 8) Calculate the EAN of Ni in $[Ni(CO)_4]$			
	Answer in brief (At least 6) (3 Marks each) 1) Explain the basicity of oxides and hydroxides of lanthanoids. 2) Write any three postulates of CFT. 3) Draw crystal field splitting diagram for octahedral geometry and tetrahedral geometry 4) Explain the selection rules of electronic transitions in complexes 5) Discuss the electronic spectrum of $[Ti(H_2O)_6]^{3+}$ ion. 6) Explain the role of hemoglobin and myoglobin in oxygen transport. 7) Discuss structure and bonding in $[Cr(CO)_6]$ on the basis of VBT. 8) What is chelate effect? Explain the stability of chelate with respect to chelate effect.			
	Answer in Detail (At least 4) (6 Marks each) 1) Write the similarities and difference between lanthanoids and actinoids. 2) Discuss the factors affecting crystal field stabilization energy. 3) Explain the crystal field splitting in square planar geometry. 4) Draw an explain Orgel diagram for d^1 and d^9 octahedral as well as tetrahedral geometry. 5) Give the classification of chelates of bidentate and tridentate ligands. 6) Explain the role of sodium and magnesium ions in biological processes along with their deficiency and toxic effect. 7) What are metal carbonyls? Explain the nature of metal carbon bond in metal carbonyls with at least two evidences.			
	MCQs for Internal Assessment (At least 4) 1) Lanthanide contraction can be observed in a) At b) Gd c) Ac d) Lw 2) Which of the following is most basic oxide? a) Ce_2O_3 b) Pr_2O_3 c) La_2O_3 d) Er_2O_3 3) Among the lanthanoids, the radioactive element is/are… a) all lanthanoids b) only Pr c) only Pr and Pm d) only Pm 4) In which of the following series all the elements are radioactive. a) s-block elements b) p-block elements c) Lanthanoids d) Actinoids 5) According to CFT, the electronic configuration of $[Co(CN)_6]^{3-}$ ion is a) $(t_{2g})^3 (e_g)^2$ b) $(t_{2g})^4 (e_g)^2$ c) $(t_{2g})^6 (e_g)^1$ d) $(t_{2g})^6 (e_g)^0$ 6) On the basis of CFT predict the number of electrons in c) $[Cr(NH_3)_6]^{3+}$ a) 1 b) 2 c) 3 d) 0			

	7) Which of the following is low spin complex? a) $[Fe(H_2O)_6]^{2+}$ b) $[Co(NH_3)_6]^{3+}$ c) $[Cr(NH_3)_6]^{3+}$ d) $[V(NH_3)_6]^{3+}$ 8) The term letter used for the resultant azimuthal quantum numbers, L=2 is a) S b) P c) D d) F 9) The ground term symbol for Fe^{2+} ion is. a) ^2D b) ^2F c) ^5D d) ^5F 10) The chelates are stable complexes due to a) formation of heterocyclic ring between metal and ligand b) ligands stabilize the oxidation state of central metal ion c) monodentate ligands are present in coordination sphere d) highest solubility in solvent. 11) Which of the followings is not an organometallic compound? a) Nickel tetracarboyl b) Methyl magnesium bromide c) Ethyl lithium d) sodium acetate 12) The metal ion present in heamoglobin is a) Mg^{2+} b) Fe^{2+} c) Fe^{3+} d) Co^{2+}

Course Category: **Major (Theory)**

108246 Organic Chemistry-3

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108246**	**Organic Chemistry-3**	2	30	2 Hrs	30+20=50

Course Objectives:	To provide fundamental understanding of organometallic compounds, heterocyclic compounds, drugs, dyes, and polymers with emphasis on their synthesis, properties, and applications
Course Outcomes:	After successful completion of the course, a student will be able to- 1) Explain the synthesis, properties, and synthetic applications of organometallic compounds such as Grignard reagents and organolithium compounds. 2) Describe the structure, basicity, and electrophilic/nucleophilic substitution reactions of important heterocyclic compounds such as pyrrole and pyridine. 3) Discuss the synthesis, classification, and applications of important drugs and dyes used in pharmaceutical and industrial chemistry. 4) Explain the classification, polymerization mechanisms, structure, properties, and applications of important synthetic polymers. 5) Apply mechanistic and structural concepts to predict the reactivity and practical applications of organic, heterocyclic, and polymeric compounds

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Organometallic Chemistry:** **Grignard reagent**: Methyl magnesium bromide- Synthesis from methyl bromide, Synthetic applications: Electrophilic substitution reactions, formation of alkanes, alkenes, higher alkynes and other organometallic compounds, Nucleophilic substitution reactions- Reaction with aldehydes and ketones, ethylene oxide, acetyl chloride, methyl cyanide and CO_2. **Methyl lithium**- Synthesis and reaction with water, formaldehyde, acetaldehyde, acetone, ethylene oxide and CO_2.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between
Unit II	**Heterocyclic Chemistry** Nomenclature, Pyrrole: Synthesis from acetylene, succinimide and furan, Basicity, Electrophilic substitution reactions (orientation) – nitration, sulphonation, acetylation and halogenation, Molecular orbital structure. Pyridine: Synthesis from acetylene and pentamethylene diamine hydrochloride, Basicity, Electrophilic substitution reactions (orientation) – nitration, sulphonation,	7 Hrs	7 Marks	

	nucleophilic substitution reactions (orientation)- with $NaNH_2$, C_6H_5Li and KOH.			different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit III	**Drugs and Dyes** **A) Drugs:** Analgesic and antipyretics: Synthesis and uses of phenylbutazone. Sulpha drugs: Synthesis and uses of sulphanilamide and sulphadiazine. Antimalarials: Synthesis of chloroquine from 4,7 dichloroquinoline and its uses. **B) Dyes :** Classification on the basis of structure and mode of application, Preparation and uses of Methyl orange, Crystal violet, Phenolphthalein , Alizarin and Indigo.	8 Hrs	8 Marks	
Unit IV	**Polymers:** Introduction and history of polymeric materials: Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers. Polymerization reactions – addition and condensation, mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Preparation, structure, properties and applications of the following polymers: polyolefins (polyethylene, polypropylene), polystyrene, polyvinyl chloride, polyvinyl acetate, polyacrylamide, fluoro polymers (Teflon).	7 Hrs	7 Marks	
References:	1. Organic Chemistry Vol. I, II and III by Mukharjee, Singh and Kapoor- Wiley Eastern. 2. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 3. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007) 4. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008). 5. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford Universitiy Press. 6. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher, (2000). 7. Synthetic Organic Chemistry, by: G. R. Chatwal. 8. Modern Organic Chemistry by M. K. Jain and S. C. Sharma. 9. Organic Chemistry, Reactions, Rearrangements and Reagents, by: O. P. Agarwal. 10. Organic Chemistry by L.G. Wade. Prentice Hall. 11. A Text book of organic chemistry by Bahl and Bahl. 12. A Text book of organic chemistry by P. L. Soni. 13. Heterocyclic Chemistry by Raj K. Bansal, New Age International 14. Heterocyclic Chemistry by J. A. Joule and K. Mills, Blackwell Science **Web resources:** 1. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Organic_Chemistry_(OpenStax)/24%3A_Amines_and_Heterocycles 2. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Polymers 3. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Map%3A_Organic_Chemistry_(Bruice)/11%3A_Organometallic_Compounds 4. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Map%3A_Organic_Chemistry_(Bruice)/31%3A_The_Organic_Chemistry_of_Drugs-_Discovery_and_Design 5. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Map%3A_Organic_Chemistry_(Bruice)/21%3A_More_About_Amines_(Heterocylic_Compounds)			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) Write the chemical equation for the synthesis of Methyl magnesium bromide from methyl bromide. 2) Name the gas evolved when Methyl lithium reacts with water. 3) Identify the product of the reaction between Methyl lithium and ethylene oxide after hydrolysis.			

	4) Draw the structure & name the product formed when Pyridine reacts with $NaNH_2$. 5) Draw the structure of Pyrrole and number the ring positions according to IUPAC nomenclature. 6) Which is the reagent used to convert Furan into Pyrrole. 7) Define the term 'Antipyretic' and give one example. 8) Write the structure of Crystal Violet dyes. 9) Name and draw the structure of heterocyclic ring present in Sulphadiazine 10) Define the term 'Degree of Polymerization. 11) Give the IUPAC name for the polymer commonly known as PVC. 12) Define a 'Copolymer'.
	Answer in brief (At least 6) (3 Marks each) 1) Explain the reaction of methyl magnesium bromide with aldehyde and ketone. 2) How will you prepare alkane and alkene from Grignard reagent? 3) Describe the reaction of CH_3Li with CO_2. Compare this with the reaction of CH_3MgBr with CO_2. 4) Describe the synthesis of Pyrrole from Succinimide. 5) Explain the synthesis of Pyridine from Acetylene and Hydrogen Cyanide. 6) Explain Molecular orbital structure of Pyrolle. 7) Explain the synthesis of Sulphanilamide starting from Acetanilide. 8) Write the preparation of Methyl Orange. 9) Explain the synthesis of Phenylbutazone. 10) Explain the difference between 'Natural', 'Synthetic', and 'Semi-synthetic' polymers with one example each. 11) Describe the preparation and two major industrial applications of Polystyrene. 12) Describe the synthesis of polyvinyl acetate (PVAc) and its common use in adhesives and emulsions
	Answer in Detail (At least 4) (6 Marks each) 1) Discuss the reaction of Methyl lithium with water, formaldehyde, and ethylene oxide. 2) Discuss the reaction of Methyl magnesium bromide with acetaldehyde, acetone and acetyl chloride. 3) Explain the synthesis of pyridine from acetylene and pentamethylene diamine hydrochloride. 4) Explain the synthesis of pyrrole from acetylene and furan. 5) Explain the synthesis and uses of phenylbutazone and chloroquine. 6) Describe the synthesis, properties, and uses of Alizarin and Indigo. 7) Explain the synthesis of Teflon (PTFE) and its applications 8) Explain the synthesis, chemical properties, and applications of Polyvinyl Chloride (PVC) and Polyacrylamide.
	MCQs for Internal Assessment (At least 4) 1) Methyl magnesium bromide reacts with ethyl alcohol to give: A) Ethane B) Methane C) Propane D) Ethyl methyl ethe 2) Organolithium reagents are typically prepared in: A) Water B) Ethanol C) Non-polar solvents like Hexane or Ether D) Concentrated H_2SO_4 3) Methyl lithium reacts with formaldehyde to give: A) Methanol B) Ethanol C) Propanol D) Ethanoic acid 4) Pyrrole is a _____ base than Pyridine. A) Stronger B) Weaker C) Equal D) None of the above 5) In the MO structure of Pyrrole, the number of \pi electrons contributed by Nitrogen is: A) 0 B) 1 C) 2 D) 6 6) Reaction of Pyridine with KOH at 300^0 C produces**:** A) 2-Hydroxypyridine B) 3-Hydroxypyridine C) Pyridine N-oxide D) Benzene 7) Sulphanilamide is synthesized starting from: A) Benzene B) Aniline C) Acetanilide D) Phenol 8) Phenylbutazone is primarily used to treat: A) Malaria B) Bacterial infections C) Rheumatoid arthritis and inflammation D) Tuberculosis 9) Alizarin is an example of an: A) Azo dye B) Anthraquinone dye C) Nitro dye D) Phthalein dye 10) Which of the following is a step-growth polymer? A) Polyethylene B) Polyvinyl Chloride

	C) Nylon-6,6 D) Polypropylene 11) Bakelite is an example of a: A) Thermoplastic polymer B) Thermosetting polymer C) Elastomer D) Fiber 12) Which of the following is a natural polymer? A) Buna-S B) Starch C) PVC D) Terylene

Course Category: **Major (Theory)**

108247 Physical Chemistry-3

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108247**	**Physical Chemistry-3**	2	30	2 Hrs	30+20=50

Course Objectives:	1. To understand crystal structure, symmetry elements, and X-ray diffraction methods in solid-state chemistry. 2. To study electrode systems, EMF, potentiometric and pH metric methods, 3. To understand principles and applications of nuclear chemistry and nuclear reactions.			
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Explain crystal systems, Bravais lattices, and Miller indices. 2. Apply Bragg's equation for crystal structure determination. 3. Understand different electrodes and potentiometric titrations. 4. Determine pH using various electrochemical methods. 5. Explain principles and applications of electroanalytical techniques. 6. Differentiate between nuclear and chemical reactions. 7. Explain nuclear fission, fusion, and nuclear models. 8. Apply numerical methods in solid-state chemistry, electrochemistry, and nuclear chemistry.			
Unit System	**Contents**	**Workload Allotted**	**Weightage of Marks Allotted**	**Incorporation of Pedagogies**
Unit I	• **Crystalline/Solid state:** Introduction, Symmetry in crystal, plane of symmetry, axis of symmetry and point of symmetry. Law of constancy of interfacial angles. Elements of symmetry in cubic crystals. Laws of symmetry. Law of rational indices, Weiss and Miller indices of a lattice planes, calculation of interplanar distance d(h,k,l) from Miller indices in a cubic system. Seven crystal systems and fourteen Bravais lattices, Bravais lattices of cubic system. Simple cubic system (S.C.C.), body centered cubic system (B.C.C.) and face centered cubic system (F.C.C.). Calculation of number of constituent units in S.C.C., B.C.C. and F.C.C. Ratio of interplanar distances for 100, 110 and 111 lattice plane in S.C.C., B.C.C. and F.C.C. (No geometrical derivation). Derivation of Bragg's equation for X-ray diffraction, Bragg's X-ray spectrometer method for the determination of crystal structure of NaCl and KCl. Anomalous behaviour of KCl towards X-ray. Numericals	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:**
Unit II	• **Electrochemistry II** **Introduction**: Electrochemical cells and electrolytic cells and their differences. **Electrode Reactions and Electrode Potentials**: Oxidation and reduction reactions at electrodes Electrode potential, representation and sign convention. **Types of electrodes**: Gas-metal ion. Metal-metal ion, metal-insoluble salt-anion electrode and redox electrodes **Representation and Working of Electrochemical Cells:** Cell notation, Construction and working of electrochemical cells, EMF of a cell **Nernst Equation:** Derivation of EMF of electrochemical cell electrode potential, Applications of Nernst equation. Numericals	7 Hrs	7 Marks	

	Reference electrode: Construction and working of Standard Hydrogen Electrode and Calomel electrode **Electrochemical Series:** Electrochemical series and its significance (Prediction of spontaneity using EMF data). **Concentration cells** – Introduction and types of concentration cells. Determination of emf concentration cell without transfer. Numericals			Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit III	**Potentiometry and pH-Metry** A) Principle of Potentiometric titration. Study of acid-base, redox and precipitation titration (Interpretation of potentiometric titration curve). Advantages of potentiometric titrations. B) Definition of pH and pKa. Determination of pH of a solution using hydrogen, quinhydrone and glass electrodes. Advantage and disadvantage of these electrodes. pH-metric titrations. Determination of pka of a weak acid by pH-metric measurement. C) Buffer solution- Types of Buffer solution and mechanism of buffer action. Henderson-Hasselbalch equation for pH of a buffer solution.	8 Hrs	8 Marks	
Unit IV	• **Nuclear Chemistry** A) Introduction, Shell model of a nucleus - Assumptions, evidences for existence of magic numbers, advantages and limitations. Liquid drop model of a nucleus - Assumptions, similarities between nucleus and liquid drop, advantages and limitations, explanation of nuclear fission reaction on the basis of liquid drop model. Nuclear force and its explanation on the basis of Meson theory. B) Characteristics of nuclear reaction, difference between nuclear and chemical reactions. Calculation of Q value of a nuclear reaction. Characteristics of nuclear fission reaction, fission yield. Fission reaction as an alternative source of energy. Nuclear fusion reaction - Characteristic of a nuclear fusion reaction. Thermonuclear reactions as a source of energy of sun and other stars. Fusion reactions as a potential future source of energy. C) Applications of radio isotopes in industry, agriculture, medicines and bio-sciences with two examples each. Numericals.	7 Hrs	7 Marks	
References:	1. Physical Chemistry: Walter, J. Moore, 5th edn., New Delhi. 2. Physical Chemistry: G.M. Barrow, McGraw Hill, Indian Edn. 3. Principles of Physical Chemistry: Maron and Prutton. 4. Principles of Physical Chemistry: Puri, Sharma, and Pathania. 5. Physical Chemistry: P.W. Atkins, 6th Edn. 6. Physical Chemistry: Levine 7. Essential of Physical Chemistry: Bahl and Tuli 8. A Textbook of Physical Chemistry: K.L. Kapoor 9. Solid State Chemistry and its Applications by Anthony R. West 10. Elements of X-ray Diffraction by B. D. Cullity 11. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma & M. S. Pathania 12. Advanced Physical Chemistry by Gurdeep Raj 13. Nuclear Chemistry by Satya Prakash 14. Essentials of Nuclear Chemistry by H. J. Arnikar **Web resources:** 1. https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Chemistry_-_The_Central_Science_(Brown_et_al.) 2. https://ocw.mit.edu/courses/3-091sc-introduction-to-solid-state-chemistry-fall-			

	2010/?utm_source 3. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry?utm_source
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1. Define Miller indices. 2. State Bragg's equation. 3. Define pH. 4. What is a glass electrode? 5. Define potentiometry. 6. Define nuclear fission. 7. What is meant by magic numbers?
	Answer in brief (At least 6) (3 Marks each) 1. Explain the law of rational indices. 2. Differentiate between S.C.C., B.C.C., and F.C.C. structures. 3. Explain the principle of potentiometric titration. 4. Describe the construction of calomel electrode. 5. Discuss the applications of potentiometry. 6. Explain the liquid drop model of nucleus. 7. Differentiate between nuclear and chemical reactions.
	Answer in Detail (At least 4) (6 Marks each) 1. Explain seven crystal systems and fourteen Bravais lattices. 2. Derive Bragg's equation and discuss determination of crystal structure of NaCl and KCl. 3. Discuss pH-metric titrations and determination of pKa of weak acid. 4. Explain concentration cells and determination of EMF of concentration cell without transference. 5. What is buffer solution? Explain the mechanism of buffer action.. Derive Henderson equation. 6. Explain shell model and liquid drop model of nucleus with advantages and limitations.
	MCQs for Internal Assessment (At least 4) 1) Miller indices are used to represent: a) Crystal defects b) Lattice planes c) Atomic masses d) Symmetry elements 2. Bragg's equation is related to: a) Conductivity b) X-ray diffraction c) Radioactivity d) Photoelectric effect 3. The standard hydrogen electrode is used as: a) Indicator electrode b) Reference electrode c) Metal electrode d) Ion-selective electrode 4. The pH of a neutral solution is: a) 0 b) 7 c) 14 d) 1

Course Category: **Major Lab**

108248 Chemistry Lab 21

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108248**	**Chemistry Lab 21**	2	60	4 h	25+25= 50

Course Objectives:	To develop practical skills in gravimetric, volumetric, complexometric, potentiometric, and pH-metric analytical techniques in Analytical Chemistry and Physical Chemistry.	
Course Outcomes:	At the end of this course students will be able to: 1. Perform gravimetric and volumetric estimations using standard analytical procedures and appropriate indicators. 2. Apply complexometric titration techniques for estimation of metal ions in different samples such as water, milk powder, fungicides, and talcum powder. 3. Determine partition coefficient, consolute temperature, solubility, heat of solution, and related physicochemical parameters experimentally. 4. Perform potentiometric and pH-metric titrations for determination of concentration, pKa, redox potential, and dissociation constants. 5. Analyze experimental data, construct graphs, perform calculations accurately, and interpret physicochemical and analytical results scientifically. 6. Demonstrate laboratory skills, safe handling of instruments and chemicals, and proper scientific documentation and reporting practices.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	1. Principles and steps involved in gravimetric analysis. 2. Calculations of molarity, normality, and EDTA equivalence in complexometric titrations. 3. Selection and role of indicators in EDTA titrations (EBT, murexide, etc.). 4. Construction and interpretation of phase diagrams of partially miscible liquids. 5. Application of Nernst distribution law in partition coefficient experiments.	By combining hands-on experiments, discussions, and real-world applications, students will gain a comprehensive understanding of chemistry lab practices. A few suggested pedagogies are: 1. Experiential and hands-on laboratory learning 2. Demonstration-based teaching for gravimetric, volumetric, potentiometric, and pH-metric techniques 3. Problem-based learning through analytical calculations and data interpretation 4. Inquiry-based learning for experimental observations and result analysis 5. Collaborative learning through group experiments and discussions 6. ICT-enabled teaching using virtual labs, simulations, and graphing software 7. Project-based learning through sample analysis and mini-projects 8. Peer learning and seminar presentations on analytical and physical chemistry concepts 9. Outcome-based continuous
Inorganic Chemistry practical	**Gravimetric Analysis (at least One)** 1. Estimation of Ba2+ as BaSO4 2. Estimation of Fe3+ as Fe2O3 3. Estimation of Ni2+ as Ni-DMG. **Volumetric Estimations: (at least 5)** 1. Estimation of Zn(II) by complexometric titration. 2. To determine the strength of unknown calcium salt solution by complexometric titration. 3. Analysis of Talcum powder 4. Analysis of Iodine from Iodized salt. 5. Analysis of Calcium from milk powder/ limestone 6. Analysis of Cu from Cu-Fungicide. 7. Estimation of calcium and magnesium in water separately by complexometric titration 8. Estimation of nickel ions using EDTA 9. Estimation of cobalt ions by EDTA titration	
Physical Chemistry Practical	**Physical Chemistry Practical (at least 6)** 1. To construct phase diagram of phenol-water system and to determine consolute temperature for the system 2. To determine partition coefficient of benzoic acid between toluene and water 3. To determine partition coefficient of iodine between CCl4/Kerosene and water. 4. To determine solubility of benzoic acid at different temperature and heat of solution 5. To determine strength of given HCl solution potentiometrically. 6. pH metric titration of strong acid against strong base by pH measurement and hence determine the concentration and strength of strong acid. 7. To determine redox potential of Fe^{+2}/Fe^{+3} system potentiometrically	

	8. To determine the pKa value of a given monobasic weak acid by potentiometric titration. 9. To determine the acid and base dissociation constant of an amino acid and hence the isoelectric point of an acid pH metrically 10. To determine the dissociation constant of oxalic acid by pH-metric titration with strong base	assessment through practical performance, assignments, viva voce, and laboratory reports
References	1. Practical Chemistry (for B.Sc. I, II and III year students) – O P Pandey, D. N. Bajpaiand S. Giri (S Chand and company Ltd) 2. *Advanced Practical Inorganic Chemistry* – Gurdeep Raj, Goel Publishing. 3. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Inorganic Chemistry: Qualitative Analysis, University Press. 4. Vogel's Textbook of Quantitative Chemical Analysis – J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, Pearson. 5. Practical Chemistry (For B.Sc. I, II and III Year Students). By Pandey O.P. & Bajpai D.N. & Giri S., S.Chand. 6. Vogel, Arthur Israel, and John Bassett. "Vogel's textbook of quantitative inorganic analysis: including elementary instrumental analysis." (1978). 7. Advanced Physical Chemistry Experiments: J N Gurtu and Amit Gurtu (Pragati Prakashan) 8. Experimental Physical Chemistry: V D Athawale and Parul Mathur (New Age Int. Publishers) 9. Advanced Practical Physical Chemistry: J B Yadav 10. Experiments in Chemistry: D V Jahagirdar **Web resources:** 11. https://vlab.amrita.edu/?sub=2 12. https://chemcollective.org/vlabs 13. https://chem.libretexts.org/ 14. MIT OpenCourseWare: https://ocw.mit.edu 15. Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry	
Model Questions:	**NA**	

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Inorganic Chem Practical) 10 Marks
- Exercise 2 (Physical Chem Practical) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **Major- Elective (Theory)**

108249 Elective Chemistry-4 (Organic Spectroscopy)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108249**	**Elective Chemistry-4 (Organic Spectroscopy)**	2	30	2 Hrs	30+20=50

Course Objectives:	The course aims to develop the ability to apply the basic terms involved in NMR for structure determination and Interpret spectra to identify functional groups, chemical shifts, coupling patterns, and fragmentation patterns.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Classify the nuclei according to their spin quantum numbers. 2. Define the terms involved in NMR and Mass spectroscopy. 3. Explain the shielding mechanism of chemical shift measurement and anisotropy effects. 4. Explain the factors affecting chemical shift of proton. 5. Interpret spectra to identify functional groups, chemical shifts, coupling patterns, and fragmentation patterns. 6. Explain methods for estimation of carbon and nitrogen in organic compounds 7. Determine empirical and molecular formulae using elemental analysis data 8. Interpret combined spectral data to deduce structures of organic compounds. 9. Solve unknown spectral problems systematically using analytical data.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**NMR Spectroscopy I** Introduction, Spin quantum number of some common nuclei, The NMR phenomenon. Nuclear Transition, Experimental Method,. Number of PMR Signals: Equivalent and Non-equivalent protons, Shielding and Deshielding and Chemical shift, Measurement of Chemical shift: TMS as reference, NMR Scale, Factors Affecting chemical Shift, Numericals	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply
Unit II	**NMR Spectroscopy II** Peak Area and Proton Counting. Splitting of Signal- Spin Spin splitting, Coupling constant (J), Karplus curve variation of coupling constant with dihedral angle. Explanation of PMR Spectra of Simple Molecules. Deuterium exchange. Identification of simple organic compounds using NMR spectral data. Distinction between the pair of compounds using NMR spectra.	7 Hrs	7 Marks	
Unit III	**Mass Spectrom**etry Basic principles of mass spectrometry, Components of a mass spectrometer, Ionization process and mass-to-charge ratio (m/z). Molecular ion peak, base peak, Isotope abundance and isotopic patterns (Cl and Br), Nitrogen rule, Metastable ions. Fragmentation processes- homolysis, heterolysis and hemi heterolysis. Retro Diels–Alder rearrangement, McLafferty rearrangement. Mass spectral fragmentation of organic compounds (Alkanes, Alcohols,	8 Hrs	8 Marks	

	Carbonyl compounds, Aromatic compounds, Amines) Interpretation of simple mass spectra.			theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit IV	**Elemental Analysis and Structure Elucidation using spectral data** • Quantitative elemental analysis: Estimation of carbon and hydrogen, Estimation of nitrogen by Kjeldahl method. • Empirical and molecular formula determination • Degree of unsaturation (DBE calculations) • Problems based on joint application of elemental analysis, chemical reactions, UV, IR, PMR, and Mass spectroscopic techniques.	7 Hrs	7 Marks	
References:	1. Advanced Organic Chemistry Part-A &B by Carey, Francis A, Sundberg, Richard J 2. Advanced Organic Chemistry by Michael B. Smith, Jerry March. 3. Banwell.,(2017). Fundamentals of Molecular; Spectroscopy (IV Edition), McGraw-Hill Education (India) Pvt. Limited. 4. Sharma, Y. R. (2013). Elementary Organic Spectroscopy: Principles and Chemical. 5. Organic Structure From Spectra by L D Field, S Sternhell 6. P S Kalsi,(2016). Spectroscopy of Organic Compounds, 7th edition. Delhi: New age international publisher. 7. Robert M. Silverstein, Francis X. Webster, (1996).Spectrometric Identification of Organic Compounds, 6th Edition. New York: John Wiley & Sons. **Web resources:** Nuclear Magnetic Resonance Spectroscopy: https://onlinecourses.swayam2.ac.in/arp20_ap02/unit?unit=40&lesson=43 https://onlinecourses.swayam2.ac.in/arp20_ap02/unit?unit=40&lesson=44 https://storage.googleapis.com/swayam1-pub-data/stomhrdproddoc01.blob.core.windows.net/wcsourcepre/300831_636831504535573071.mp4 https://onlinecourses.swayam2.ac.in/5231-online-refresher-course-in-chemistry-for-higher-education-faculty/unit?unit=69&lesson=73 https://onlinecourses.swayam2.ac.in/5231-online-refresher-course-in-chemistry-for-higher-education-faculty/unit?unit=75&lesson=76 Mass Spectrometry: https://onlinecourses.swayam2.ac.in/arp20_ap02/unit?unit=65&lesson=68 https://onlinecourses.swayam2.ac.in/arp20_ap02/unit?unit=65&lesson=69			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) What is chemical shift in NMR? 2) Define molecular ion and molecular in peak 3) What is Coupling constant (J)? 4) What is Nitrogen rule in Mass spectrometry 5) What are the scales used to measure the chemical shift in NMR? 6) What are general fragmentation modes in Mass spectrometry			
	Answer in brief (At least 6) (3 Marks each) 1) What do you mean by molecular ion peak and base peak? 2) Why TMS is used as reference in NMR Spectroscopy? 3) Predict the signal pattern of the CH_3 protons in the NMR spectra of CH_3CHBr_2 and $CH3CH_2Br$ 4) Hydrocarbon with molecular formula C_7H_{12} exhibits peak at m/z 96,54 Assign the structure. 5) Explain Kjeldahl's method for estimation nitrogen. 6) Why deuterated solvents are used in NMR spectroscopy?			
	Answer in Detail (At least 4) (6 Marks each) 1) Explain the shielding and deshielding with suitable examples. 2) Discuss the factors affecting chemical shift 3) Discuss the Mclaffertty rearrangement with example in mass spectrometry 4) In the 1-H NMR spectrum recorded at 293 K, an organic compound A having molecular formula is (C3H7NO), exhibited signals at 8 7.8 (1H, s), 2.8 (3H, s) and 2.6 (3H, s). The compound A is? 5) A compound of MF $C_5H_{12}O$ gave following spectral data: IR: 3400 (cm-1); 1H-NMR: 0.95 (d, 6H), 1.8-1.9 (m, 3H), 2.70 (s, 1H), 3.9 (t, 2H). Peak at 2.70 disappears on shacking with D2O. Find out structure of the compound. 6) Explain the following spectral data systematically and deduce the structure of an organic molecule containing C, H and O: UV: Amax 278 and 319 nm.			

	IR: Significant absorption bands at 3070-3010, 2970-2860, 1685, 1605, 1580 and 1450 cm-1• PMR: 82.1 (3H, *s)* and 7.5 (5H, *m).* Be NMR: *8* 198 and 137 (two singlets), 134, 129 and 128 (three doublets) and 26 (one quartet). MS: *mle* 120 (W), 105, 77, 51 and 43.
	MCQs for Internal Assessment (At least 4) 1.Which of the following combinations of peaks appears in the 1H NMR spectrum of diethyl ether $CH_3CH_2OCH_2CH_3$? A) a triplet and a quartet B) a. triplet and a singlet C) a quartet and a sextet D)a triplet and a doublet 2. Equivalent protons in a molecules will have (a) Same environment (b) Same shielding effect (c) Same chemical shift (d) All of the above 3. Mass spectrometers are used to determine which of the following? (a) Composition in sample (b) Relative mass of atoms (c) Concentration of elements in sample (d) Properties of sample 4. In Kjeldahl's method, nitrogen present in an organic compound is converted into: A) NO_2 B) NH_3 C) N_2 D) HNO_3 **5.** The absorption band around 1700 cm^{-1} in IR spectroscopy generally indicates: A) O–H group B) N–H group C) C=O group D) C=C group

Course Category: **Major Elective Lab**

108250 Chemistry Lab 22A (Elective Chemistry 4)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108250**	**Chemistry Lab 22A (Elective Chemistry 4)**	2	60	4 h	25+25= 50

Course Objectives:	1. To provide hands-on training in reaction mechanisms, stoichiometric calculations, and preparation of important organic compounds and derivatives. 2. To enhance understanding of spectral interpretation using UV, IR, NMR, mass spectra, and elemental analysis for structure elucidation of organic molecules.	
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Perform synthesis, purification, and characterization of organic compounds using standard laboratory methods. 2. Apply TLC, melting point determination, and recrystallization techniques for assessment of purity and compound identification. 3. Explain mechanisms of important organic reactions such as acetylation, benzoylation, bromination, nitration, and aldol condensation. 4. Interpret PMR spectra, assign chemical shifts and multiplicity, and analyze spin-spin coupling patterns. 5. Identify molecular ion peaks, isotopic patterns, and fragmentation pathways in mass spectra. 6. Determine empirical and molecular formulae, calculate degree of unsaturation, and interpret combined UV, IR, NMR, and mass spectral data for structure elucidation of organic compounds.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	1. Interpretation of TLC results and calculation of Rf values. 2. Mechanism of acetylation, benzoylation, bromination, nitration, and aldol condensation reactions. 3. Stoichiometric calculations in organic preparations 4. Assignment of PMR signals, multiplicity, and chemical shift values in simple organic compounds. 5. Problems based on spin-spin splitting and coupling constants. 6. Identification of molecular ion peak, base peak, Fragmentation pattern and isotopic peaks in mass spectra. 7. Determination of empirical and molecular formula from elemental analysis data.and calculation of	1. Experiential and hands-on laboratory learning 2. Demonstration-based teaching for organic synthesis, TLC, recrystallization, and spectral interpretation 3. Problem-based learning through reaction mechanism and spectral analysis exercises 4. Inquiry-based learning for identification and

	degree of unsaturation (DBE) for organic molecules. 8. Combined spectral interpretation problems involving UV, IR, NMR, and mass spectra.	structure elucidation of organic compounds 5. ICT-enabled teaching using spectral databases, molecular visualization tools, and virtual labs 6. Collaborative learning through group experiments, discussions, and peer learning 7. Project-based learning through mini-projects on organic synthesis and spectral characterization 8. Flipped classroom approach for pre-lab study of reactions and spectra 9. Outcome-based continuous assessment through laboratory performance, assignments, viva voce, and reports **10. Any other innovative pedagogy as applicable.**
Organic Preparations	**Organic Preparations** (Collected solid samples may be used for recrystallization, melting point and TLC) **(At least 6 preparations)** 1. Acetylation of one of the following compounds: amines (aniline, o-, m-, p-toluidines and o-, m-, p-anisidine) (Using conventional method) 2. Benzoylation of one of the amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) 3. Iodoform from ethanol or acetone 4. P-nitroacetanilide from acetanilide 5. P-bromoacetanilide from acetanilide 6. 2,4,6-tribromophenol from phenol 7. Preparation of methyl orange 8. Preparation methyl red 9. Benzoic acid from toluene 10. Aniline from nitrobenzene 11. Hydrolysis of benzamide 12. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde. 13. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid). 14. Aldol condensation with either conventional or green method.	
Spectral Interpretation	**NMR Spectroscopy** (Reference spectra may be obtained from literature) 1. Identification of equivalent and non-equivalent protons in given molecules. (p-Xylene, ethylbenzene and Acetophenone) 2. Determination of chemical shift values using standard PMR spectra (Chloroform, Acetaldehyde, Benzaldehyde and Anisole) 3. Interpretation of splitting patterns and coupling constants. (Ethyl bromide Isopropyl alcohol, Ethyl acetate) 4. Proton counting using integrated peak areas**.** **(**Acetone, Toluene, Acetic acid) 5. Identification of simple compounds using PMR spectral data. 6. Distinction between structural isomers using ^{1}H NMR spectra**.** (o-Xylene, m-Xylene, p-Xylene and 1-propanol and 2-propanol) 7. Interpretation of ^{1}H NMR spectra of simple aliphatic organic compounds. 8. Interpretation of ^{1}H NMR spectra of simple aromatic organic compounds **Mass Spectroscopy** (Reference spectra may be obtained from literature) 1. Identification of molecular ion peak and base peak in: Toluene, Acetophenone, Cyclohexanone 2. Study of isotopic patterns in: Chlorobenzene and Bromobenzene	

	3. Fragmentation pattern studies of: Ethanol, Acetone, Acetophenone and Aniline 4. Identification of McLafferty rearrangement in: 2-Hexanone , Butanone , Hexanoic acid ester 5. Nitrogen rule and molecular formula determination using: Aniline, m-dinitrobenzene and Benzamide 6. Mass spectral analysis of aromatic compounds: Toluene, Ethylbenzene and Cumene **Combined Spectral Interpretation / Structure Elucidation (At least 6)** (References from standard spectroscopy books may also be taken for such purpose for enhancing students understanding and skill) 1. Determination of empirical and molecular formula of: Acetanilide, Aspirin etc. 2. Degree of unsaturation calculations for: Benzene, Cyclohexene and Acetophenone 3. Structural elucidation of simple organic compounds by elemental analysis, UV, IR NMR and Mass spectroscopy (Sample spectra may be provided for simple organic compounds like Ethanol, Aniline, Phenol, acetic acid, other simple aldehydes, carboxylic acid, etc.).	
Suggested Student Activities	• **Organic Synthesis Demonstration Activity:** Students perform and present synthesis of selected organic compounds highlighting reaction mechanism and yield calculation. • **TLC Analysis Activity:** Comparative TLC study of synthesized compounds and calculation of Rf values for purity assessment. • **Spectral Interpretation Workshop:** Group-based interpretation of UV, IR, NMR, and mass spectra of simple organic compounds. • **Reaction Mechanism Chart Preparation:** :Preparation of flowcharts/mechanistic pathways for acetylation, benzoylation, nitration, bromination, and aldol condensation reactions. • **Mini Project on Organic Compound Characterization:** Synthesis, purification, and spectral characterization of an assigned organic compound. • **Structure Elucidation Competition:** Identification of unknown compounds using combined spectral and elemental analysis data. • **Poster Presentation** • **ICT-Based Learning Activity**: Use of spectral databases, ChemDraw, MolView, or virtual spectroscopy tools for molecular visualization and spectral assignment.	
References	1. Morgan, E. D. "Vogel's textbook of practical organic chemistry. 5th edn.: By BS Furniss, AJ Hannaford, PWG Smith and AR Tatchell. Pp. 1514. Longman, Harlow. (1990): 148. 2. Handbook of Organic Analysis: Qualitative and Quantitative – H. T. Clarke, CBS Publishers. 3. Practical Chemistry (For B.Sc. I, II and III Year Students). By Pandey O.P. & Bajpai D.N. & Giri S., S.Chand. 4. Ahluwalia, V. K., and Renu Aggarwal. Comprehensive practical organic chemistry: preparation and quantitative analysis. Universities Press, 2001. 5. Sethi, Arun. Systematic lab experiments in organic chemistry. New Age International, 2006 6. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press. 7. Advanced practical Organic Chemistry: O P Agrawal 8. Spectrometric Identification of Organic Compounds, Robert M. Silverstein, FrancisX. Webster, David J. Kiemle, John Wiley & Sons, 7th Edition, 2005 9. Green Chemistry Experiments: A Monograph, R. K. Sharma, Indu Tucker Sidhwani, M. K. Chaudhuri, I. K. International Pvt. Ltd., 1st Edition, 2009 10. Sharma, Rakesh K., Indu Tucker Sidhwani, and Mihir K. Chaudhuri. *Green Chemistry Experiments: A Monograph*. IK International Pvt Ltd, 2012. Web resources: https://nanohub.org/modelsimulate	

	https://sdbs.db.aist.go.jp/SearchInformation.aspx https://avogadro.cc/ https://molview.org/ Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry ChemCollective Virtual Labs: http://chemcollective.org PhET Interactive Simulations (University of Colorado Boulder): https://phet.colorado.edu
Model Questions:	**NA**

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Organic Preparations) 10 Marks
- Exercise 2 (Spectral Interpretation) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **Major- Elective (Theory)**

108251 Elective Chemistry-5 (Green Chemistry and Nanochemistry)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108251**	**Elective Chemistry-5 (Green Chemistry and Nanochemistry)**	2	30	2 Hrs	30+20=50

Course Objectives:	To introduce the principles of Green Chemistry and Nanochemistry with emphasis on sustainable chemical processes, green technologies, and unique properties of nanomaterials.
Course Outcomes:	After successful completion of the course, a student will be able to-. 1. Explain the principles and importance of Green Chemistry and sustainable chemical processes. 2. Apply the Twelve Principles of Green Chemistry to minimize waste, hazards, and energy consumption in chemical processes. 3. Describe green synthesis methods, renewable resources, safer solvents, and catalytic approaches used in sustainable chemistry. 4. Explain the fundamental concepts, classification, and unique properties of nanomaterials in Nanochemistry. 5. Differentiate between bulk materials and nanoscale materials based on their physicochemical properties and applications.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Introduction to Green Chemistry** • Definition, scope, and importance of green chemistry • Need for sustainable chemical processes • Difference between environmental chemistry and green chemistry • Concept of sustainability and circular economy	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Any other innovative pedagogy as applicable.**
Unit II	**Twelve Principles of Green Chemistry I** • Prevention of waste • Atom economy: Atom economy calculations in some reactions. • Less hazardous chemical synthesis • Designing safer chemicals with examples • Safer solvents and auxiliaries • Energy efficiency: Energy-efficient techniques: microwave and ultrasound-assisted synthesis	7 Hrs	7 Marks	
Unit III	**Twelve Principles of Green Chemistry II** • Use of renewable feedstocks • Reduce derivatives and protecting groups • Catalysis: Examples of Catalysts in green synthesis • Design for degradation: Biodegradable materials and polymers • Real-time analysis for pollution prevention • Inherently safer chemistry for accident prevention	8 Hrs	8 Marks	
Unit IV	**Introduction to Nano chemistry** • Definition and scope of Nano chemistry. • Historical development of nanoscience and nanotechnology. Size scale and classification of nanomaterials. • Unique properties of nanomaterials: • Surface area effects, Quantum confinement, • Optical, electrical, and magnetic	7 Hrs	7 Marks	

	properties • Difference between bulk and nanoscale materials			
References:	1. 1.Ahluwalia, V.K., Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers (2005). 2. Anastas, P.T. & Warner, J.K, *Green Chemistry- Theory and Practical*, Oxford University Press (1998). 3. Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001). 4. Cann, M.C.and Connely, M.E. *Real-World cases in Green Chemistry*, ACS (2000). 5. Ryan, M.A. and Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, (2002). 6. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, Second Edition,2010 7. Poole, C.P. & Owens, F.J. *Introduction to Nanotechnology* John Wiley 2003 8. Chattopadhyay, Kalyan K., and A. N. Banerjee. *Introduction to nanoscience and nanotechnology*. PHI Learning Pvt. Ltd., 2009. 9. Rao, C N R, Achim Müller, and A K. Cheetham, eds. *The chemistry of nanomaterials: synthesis, properties and applications*. John Wiley & Sons, 2006. **Web resources:** 1. https://www.epa.gov/greenchemistry/basics-green-chemistry 2. https://chemicals.gov.in/green-chemistry 3. https://www.acs.org/green-chemistry-sustainability/principles/12-principles-of-green-chemistry.html 4. https://sc.uobaghdad.edu.iq/wp-content/uploads/sites/64/mainfiles/lectures/chem/NANOCH1.pdf			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1. Define Green Chemistry. 2. Define circular economy. 3. What is atom economy? 4. State the principle of waste prevention in green chemistry. 5. What are safer solvents? 6. Define biodegradable polymers. 7. Name two energy-efficient techniques used in green synthesis. 8. Define Nanochemistry. 9. What is the size range of nanomaterials? 10. What is quantum confinement effect?			
	Answer in brief (At least 6) (3 Marks each) 1. Discuss the concept of sustainability and circular economy. 2. Explain the principle of atom economy with suitable examples. 3. Write a short note on safer solvents and auxiliaries. 4. Discuss microwave-assisted synthesis as an energy-efficient green technique. 5. Explain the importance of biodegradable materials and polymers. 6. Define Nanochemistry and discuss its scope. 7. Discuss the classification of nanomaterials based on size and dimensions. 8. Explain surface area effects in nanomaterials. 9. Write a short note on quantum confinement effect. 10. Discuss the optical, electrical, and magnetic properties of nanomaterials. 11. Differentiate between bulk materials and nanoscale materials			
	Answer in Detail (At least 4) (6 Marks each) 1. Explain the Twelve Principles of Green Chemistry and discuss their significance in sustainable chemical processes. 2. Discuss atom economy, safer solvents, renewable feedstocks, and catalysis as important tools of green chemistry with suitable examples. 3. Explain energy-efficient green synthesis techniques such as microwave-assisted and ultrasound-assisted synthesis and discuss their advantages over conventional methods. 4. Define Nanochemistry and discuss the classification, unique properties, and applications of nanomaterials. 5. □ Explain the surface area effect and quantum confinement effect in nanomaterials and discuss how nanoscale materials differ from bulk materials in their optical, electrical, and magnetic properties.			
	MCQs for Internal Assessment (At least 4) 1. The term “Green Chemistry” mainly focuses on: A) Increasing reaction rate B) Reducing environmental hazards			

	C) Producing colored compounds D) Increasing yield only 2. Atom economy was introduced by: A) Arrhenius B) Paul Anastas C) Rutherford D) Bohr 3. Which of the following is considered a green solvent? A) Benzene B) Carbon tetrachloride C) Water D) Chloroform 4. Nanomaterials generally possess dimensions in the range of: A) 1–100 nm B) 100–1000 nm C) 1–10 µm D) 10–100 µm 5. Quantum confinement effect is mainly observed in: A) Bulk materials B) Macroscopic crystals C) Nanomaterials D) Solutions only

Course Category: **Major Elective Lab**

108252 Chemistry Lab 22B (Elective Chemistry 5)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108252**	**Chemistry Lab 22B (Elective Chemistry 5)**	2	60	4 h	25+25= 50

Course Objectives :	1. To provide thorough knowledge of the green chemistry principles, and new remediation technologies for the cleaning up of hazardous substances. 2. To develop basic skills to be able to design, develop and run chemical processes in a sustainable way	
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Design and develop materials/ processes that reduce the use and generation of hazardous substances in industry. 2. Describe how injudicious use of chemicals can have an adverse/potentially damaging effect on humans and the environment. 3. Propose ideas for innovative approaches to environmental and societal challenges. 4. Critically analyse the existing traditional chemical pathways/processes and creatively think about bringing environmentally benign reformations in these protocols. 5. Convert biomass into valuable chemicals through green technologies.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	• Definition and Importance of green chemistry. • Introduction to the prevention of waste/ by products and waste/ pollution prevention hierarchy. • Provide the scheme for the traditional as well as green method for the synthesis of ibuprofen and ask students to compare the amount and hazards of waste generated in both the processes.	• Atom economy calculations of reactions • Comparative study of conventional vs green synthesis • Literature review on green industrial processes • Seminar on one principle of green chemistry
Green Chemistry Experiments	1. Use of molecular model kit to stimulate the reaction Green Methods in Chemistry to investigate how the atom economy can illustrate Green Chemistry. For eg. Preparation of propene by two methods can be studied (I) Hoffman elimination (II) Dehydration of propanol (https://www.acs.org/content/dam/acsorg/greenchemistry/education/resources/cleaning-up-with-atom-economy.pdf 2. Preparation of biodiesel from waste cooking oil and characterization 3. Nitration of salicylic acid using green method 4. Preparation of dibenzalacetone by cross aldol condensation reaction using base catalysed green method 5. Acetylation of primary aromatic amine using the green method 6. Manganese (III) acetylacetonate using green method in water 7. Benzil- Benzilic acid rearrangement in solid State under solvent-free Condition 8. Mechanochemical solvent free, solid–solid synthesis of azomethine using p- toluidine and o-vanillin/p-vanillin 9. Photoreduction of benzophenone to benzopinacol in the presence of sunlight 10. Rearrangement of diazoamino benzene to p-aminoazo benzene using K10 montmorillonite clay 11. Synthesis of Benzimidazole by green method 12. Synthesis of 1,4 – dihydropyridine by green method 13. Preparation of nanoparticles of using plant extracts.	

Group Activities	1. Green synthesis project using household or natural materials 2. Preparation and comparative study of nanoparticles using different plant extracts 3. Poster presentation on green chemistry principles 4. Mini-project on waste minimization in chemistry laboratories 5. Demonstration of green laboratory techniques 6. Seminar on the topics (suggested): i. Applications of nanotechnology in medicine and environment ii. Bhopal Gas Tragedy and safer route to carbaryl synthesis iii. Flixiborough accident and safer route to cyclohexanol iv. Use of Surfactants for SC-CO2 for precision cleaning and dry cleaning of garments replacing PERC. v. A brief study of Green Chemistry Challenge Awards (Introduction, award categories and study about five last recent awards) vi. Healthier Fats and oils by Green Chemistry: Enzymatic Interesterification for production of No Trans-Fats and Oils	
References	1. Anastas, P.T., Warner, J.C. (2014), Green Chemistry, Theory and Practice, Oxford University Press. 2. Alhuwalia, V.K.; Kidwai, M.R. (2012), New Trends in Green chemistry, Kluwer Academic Publishers, Springer 3. Kirchoff, M., Ryan, M.A. (2002), Greener approaches to undergraduate chemistry experiment, American Chemical Society, Washington DC. 4. Sharma, R.K., Sidhwani, I.T., Chaudhari, M.K. (2013), Green Chemistry Experiments: A monograph, I.K. International Publishing House Pvt Ltd. New Delhi. 5. Pavia, D.L., Lamponam, G.H., Kriz, G.S.W. (2006), Introduction to organic Laboratory Technique- A Microscale approach, 4th Edition, Brooks-Cole Laboratory Series for Organic chemistry. **Web resources:** 1. MIT OpenCourseWare: https://ocw.mit.edu 2. Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry 3. ChemCollective Virtual Labs: http://chemcollective.org 4. NPTEL (IIT Online Courses): https://nptel.ac.in/courses/104 5. LibreTexts Chemistry: https://chem.libretexts.org 6. PhET Interactive Simulations (University of Colorado Boulder): https://phet.colorado.edu	
Model Questions:	**NA**	

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Green Chem Practical) 10 Marks
- Exercise 2 (Group activity) Presentation 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **Major- Elective (Theory)**

108253 Elective Chemistry-6 (Chemistry of Consumer and Industrial Products)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108253**	**Elective Chemistry-6 (Chemistry of Consumer and Industrial Products)**	2	30	2 Hrs	30+20=50

Course Objectives:	To introduce students to the chemistry, manufacture, quality control, and applications of food products, soaps, detergents, and petrochemicals used in everyday life and industry.
Course Outcomes:	After successful completion of the course, a student will be able to-. 1. Explain the composition, nutritional value, preservation, and quality aspects of food products. 2. Identify common food adulterants and discuss food quality control and safety measures. 3. Describe the chemistry, manufacture, properties, and applications of soaps and detergents. 4. Explain petroleum refining, petrochemical products, and their industrial applications. 5. Evaluate environmental issues and sustainability concerns associated with food, detergent, and petrochemical industries.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Food Chemistry:** Composition of food: • Carbohydrates • Proteins • Fats and oils Nutritional importance of food constituents • Food additives: • Preservatives • Sweeteners • Colouring agents • Flavouring agents Food spoilage and preservation methods	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Any other innovative pedagogy as applicable.**
Unit II	**Food Quality and Analysis** Food adulteration: • Milk • Edible oils • Honey • Spices Detection of common food adulterants Food quality control Food packaging and labeling Food safety standards and regulations	7 Hrs	7 Marks	
Unit III	**Soap and Detergent** **Soaps: -**Introduction, Manufacture of soaps by i) Kettle's process, ii) Hydrolyser process, cleansing action of soap. **Synthetic Detergents:** Introduction, Synthetic detergent classification, i) Anionic detergent, ii) Cationic detergents, iii) Non-ionic detergents. Synthetic detergent versus soaps, Soft versus Hard detergents	8 Hrs	8 Marks	
Unit IV	**Petrochemical Products** Petroleum: Composition and classification Fractional distillation of crude oil Petrochemical feedstocks Manufacture and applications of: • LPG • Petrol • Diesel	7 Hrs	7 Marks	

	• Kerosene Petrochemical products: • Ethylene • Propylene • Benzene			
References:	1. Srilakshmi, B. *Food science*. New Age International, 2003. 2. Sharma, B. K. *Industrial chemistry*. Krishna Prakashan Media, 1991. 3. Austin, George T. "Shreve's chemical process industries." (1984): 136-138. 4. Sukumar Maiti*, Introduction to Petrochemicals*, Oxford & Ibh, 2002 **Web resources:** **https://www.fssai.gov.in** **https://www.nin.res.in** **https://www.fao.org** **https://www.iocl.com**			
Model Questions:	**Short Type (At least 6) (1 Marks each)** **1.** What is saponification? **2.** Name the main constituent of natural fats and oils. **3.** What is a food preservative? Give one example. **4.** What is food adulteration? **5.** Name the process used for refining crude petroleum. **6.** Which petrochemical is commonly used for the manufacture of polyethylene? **7.** What is a biodegradable detergent? **8.** Name one synthetic detergent used in household cleaning products.			
	Answer in brief (At least 6) (3 Marks each) **1.** Explain the composition and nutritional importance of carbohydrates, proteins, and fats in food. **2.** Describe the causes of food spoilage and the methods used for food preservation. **3.** Discuss the role of food additives in food processing with suitable examples. **4.** Explain common food adulterants found in milk, edible oils, and spices and their effects on health. **5.** Describe the chemistry of saponification and the manufacture of soaps. **6.** Differentiate between soaps and synthetic detergents. **7.** Explain the fractional distillation of crude petroleum and its products. **8.** Discuss the applications and environmental impact of petrochemical products and polymers.			
	Answer in Detail (At least 4) (6 Marks each) 1. Discuss the composition of food and explain the nutritional significance of carbohydrates, proteins, fats, vitamins, and minerals. 2. Describe the causes of food spoilage and explain various methods of food preservation used in the food industry. 3. What are food additives? Discuss the types, functions, and applications of preservatives, sweeteners, colouring agents, and flavouring agents. 4. Explain food adulteration and discuss common adulterants in milk, edible oils, honey, and spices along with their detection methods. 5. Describe the chemistry of fats and oils. Explain the process of saponification and the manufacture of soaps. 6. Classify detergents and discuss the preparation, properties, applications, and environmental impact of synthetic detergents. 7. Discuss the composition of petroleum and explain the fractional distillation of crude oil with a neat flow diagram.			
	MCQs for Internal Assessment (At least 4) 1. The major constituents of soaps are: A) Alcohols B) Esters C) Sodium or potassium salts of fatty acids D) Hydrocarbons 2. Which of the following is commonly used as a food preservative? A) Sodium benzoate B) Glucose C) Urea D) Ethanol 3. The process used to separate petroleum into different fractions is called: A) Cracking B) Polymerization C) Fractional distillation D) Hydrogenation 4. Adulteration of milk with water mainly reduces its: A) Acidity B) Density C) Nutritional value D) Colour			

Course Category: **Major Elective Lab**

108254 Chemistry Lab 22C (Elective Chemistry 6)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108254**	**Chemistry Lab 22C (Elective Chemistry 6)**	2	60	4 h	25+25= 50

Course Objectives:	3. To provide thorough knowledge of the green chemistry principles, and new remediation technologies for the cleaning up of hazardous substances. 4. To develop basic skills to be able to design, develop and run chemical processes in a sustainable way	
Course Outcomes:	Upon successful completion of this course, students will be able to:	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	• Definition and Importance of green chemistry. • Introduction to the prevention of waste/ by products and waste/ pollution prevention hierarchy. • Provide the scheme for the traditional as well as green method for the synthesis of ibuprofen and ask students to compare the amount and hazards of waste generated in both the processes.	• Hands-on laboratory learning • Demonstration-based experiments • Industry-oriented practical training • Group projects and sample analysis • Case-study-based learning • Continuous assessment through reports, viva, and practical performance
Food and Oil analysis	1. Determination of moisture content in food samples. 2. Estimation of Vitamin C in fruit juice. 3. Detection of adulterants in milk (water, starch, urea, detergent). 4. Detection of adulterants in edible oils. 5. Detection of adulterants in honey, turmeric, chili powder, and black pepper. 6. Determination of acidity in fruit juices or beverages. 7. Determination of acid value of edible oils. 8. Determination of saponification value of oils. 9. Determination of iodine value of oils. 10. Determination of peroxide value of oils. 11. Determination of specific gravity of oils. 12. Detection of rancidity in fats and oils.	
Soap, Detergent and Petrochemical Analysis	1. Preparation of soap by saponification. 2. Determination of total alkali content in soap. 3. Determination of moisture content in soap. 4. Comparison of cleansing efficiency of different detergents. 5. Determination of foaming capacity of soaps and detergents. 6. Study of hard water effect on soaps and detergents. 7. Determination of density/specific gravity of petroleum products. 8. Determination of viscosity of lubricating oil. 9. Determination of flash point of petroleum products (demonstration). 10. Determination of cloud point and pour point of lubricating oils (demonstration). 11. Comparative study of petrol, diesel, kerosene, and lubricating oils. 12. Determination of refractive index of petroleum products.	
Suggested Student Activities	• Market survey of food adulteration. • Comparative study of commercial edible oils. • Comparative evaluation of detergent brands. • Analysis of nutritional labels on packaged foods. • Preparation of herbal soap formulations. • Mini-project on quality control of consumer products.	
References	1. Bailey's Industrial Oil and Fat Products, 6th Edition, Wiley, 2005. 2. The Analysis of Fats and Oils, Springer. 3. The Chemical Analysis of Foods, 8th Edition, Churchill Livingstone. 4. Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, Pearson Education. 5. Shreve's Chemical Process Industries, 5th Edition, McGraw-Hill, 1984. **Web resources:**	

	1. https://fssai.gov.in/upload/uploadfiles/files/Manual_Food_Additives_25_05_2016(1).pdf 2. https://www.iocl.com 3. https://www.iocl.com 4. LibreTexts Chemistry: https://chem.libretexts.org
Model Questions:	**NA**

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40%) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (**Food and Oil analysis**) 10 Marks
- Exercise 2 (**Soap, Detergent and Petrochemical Analysis**) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category**: Minor (Theory)**

108255 Minor Chemistry-4

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108255**	**Minor Chemistry-4**	2	30	2 Hrs	30+20=50

Course Objectives:	1. To develop fundamental comprehensive understanding of formation of coordination compounds on the basis of VBT and CFT. 2. To provide fundamental understanding of the structure, preparation, properties, and reactions of carboxylic acids, esters, and nitrogen-containing organic compounds
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Understand the nature of metal-ligand bonding in coordination compound by VBT and predict their geometries. 2. Define different types of isomerism in coordination compounds. 3. Explain the nature of metal-ligand bonding in coordination compound by CFT 4. Calculate CFSE of complexes and describe various factors affecting CFSE 5. Explain the structure, preparation, properties, and reactions of carboxylic acids and esters, including mechanisms of esterification and hydrolysis 6. Analyze the synthesis, reactivity, and applications of nitrogen-containing organic compounds such as nitrogen containing compounds.

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Coordination Chemistry-2** **A) Valence bond theory (VBT):** Steps involved in describing metal-ligand bonding in coordination compounds using VBT; Types of hybridization, geometries and magnetic properties to understand formation of complexes of 3d elements with coordination number 6 (Inner and outer orbital complexes) and 4 (Tetrahedral and square planar). Limitations of VBT. **B) Isomerism in coordination Compounds:** Structural or constitutional isomerism: ionization, linkage, coordination and hydrate; Stereoisomerism: Geometrical isomerism in square planar {type: Ma_2b_2, Ma_2bc &Mabcd} and in octahedral complexes {type: Ma_4b_2, $Ma_2b_2c_2$, Ma_3b_3 & Mabcdef}, Optical isomerism in octahedral complexes {type: cis-$Ma_2b_2c_2$, $M(AA)_3$ & $Ma_2(AA)_2$)} and in tetrahedral complexes {type: Mabcd}	8 Hrs	8 Marks	To enhance conceptual understanding and practical skills, a **blended teaching methodology** is employed, integrating the following strategies: **1. Conceptual & Visual Learning** • **Concept Mapping & Digital Simulations** (PhET, ChemSketch) for bonding, reaction mechanisms, and isomerism. • **3D Molecular Models & Interactive Discussions** for stereochemistry and hybridization. **2. Inquiry-Based & Experimental Learning** • **Hands-on Lab Work & Virtual Labs** for volumetric analysis, calorimetry, and synthesis. • **Problem-Solving & Data Analysis** for numerical applications (molarity, bond order,
Unit II	**Coordination Chemistry-3:** Postulates of CFT; Crystal field splitting in octahedral, distorted octahedral, square planar and tetrahedral complexes; concept of CFSE, high spin and low spin octahedral complexes on the basis of Δ_o and pairing energy, distribution of electrons in t_{2g} and e_g orbitals in high spin and low spin octahedral complexes; Factor affecting magnitude of crystal field splitting in octahedral complexes. Spectro-chemical series.	7 Hrs	7 Marks	
Unit III	**Carboxlyllic acids and Esters** **Carboxylic acids:** Structure and reactivity of carboxylic groups. Acidity of carboxylic acids, effects of substituents on acidic strength.	8 Hrs	8 Marks	

	Oxalic acid: Preparation from ethylene glycol and cyanogens, reactions with ethanol, ammonia, glycerol and action of heat. **Lactic acid:** Preparation from acetaldehyde and pyruvic acid, reaction with ethanol, PCl_5, action of heat, oxidation and reduction. **Benzoic acid**: Preparation from toluene, benzyl alcohol and benzamide, reactions with ethanol, PCl_5 and ammonia. **Salicylic acid:** Preparation by Reimer-Tiemann reaction. Reactions with CH_3COCl, CH_3OH and C_6H_5OH. **B) Ester**: Structure and nomenclature of esters, Preparation of ester by reaction of acetic acid, benzoyl chloride with ethanol; acetic anhydride with ethanol and salicylic acid; propanoic acid with diazomethane; silver acetate with methyl bromide. Reaction of methyl acetate with ammonia, PCl5, hydrolysis. Mechanism of esterification and hydrolysis (acidic and basic)..			thermodynamics). **3. Digital & Flipped Learning** • **Pre-Class Video Lectures & Online Quizzes** for self-paced learning. • **Gamification & Case Studies** to relate theory to real-world applications. **4. Application & Research-Based Learning** • **Case-Based & Interdisciplinary Approach** connecting chemistry with industrial and environmental applications. • **Mini-Projects & Literature Reviews** to encourage analytical thinking. This **integrated approach** fosters **engagement, critical thinking, and practical competence**, ensuring a **dynamic and research-oriented** chemistry learning experience.
Unit IV	**Nitrogen containing compounds** **A) Aromatic nitro compounds:** Nitrobenzene: Resonance structure, synthesis from benzene, Reductions: i) in acidic medium, ii) In neutral medium, iii) In alkaline medium. **B) Amino Compounds:** Aniline: Basicity and effect of substituents. Preparation of aniline from nitrobenzene, reactions with acetyl chloride and benzoyl chloride, Br_2 (aq) and $Br_2(CS_2)$, carbylamine reaction, alkylation, Hoffmann's exhaustive methylation and its mechanism. **Diazo Compounds:** Preparation benzene diazonium chloride, Synthetic applications- Preparation of benzene, phenol, halobenzene, nitrobenzene, benzonitrile, coupling with phenol and aniline.	7 Hrs	7 Marks	
References:	1. Principles of Inorganic Chemistry by Puri, Sharma and Kalia- S. Naginchand & Co., Delhi. 2. Inorganic Chemistry by A.K. De, Wiley East Ltd. 3. Selected Topics in Inorganic Chemistry by Malik, Tuli and Madan, S. Chand & Co. 4. Concise Inorganic Chemistry by J.D. Lee, ELBS. 5. Inorganic Chemistry by J.E. Huheey- and Kettle, Harper & Row. 6. Advanced Inorganic Chemistry, Vol-I, Satya Prakash, Madan, Tuli, Basu. 7. Advanced Practical Inorganic Chemistry by Gurdeep Raj, Goel Pulishing House, Meerut. 8. Organic Chemistry Vol. I, II and III by Mukharjee, Singh and Kapoor- Wiley Eastern. 9. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 10. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007) 11. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008). 12. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford Universitiy Press. 13. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism,			

	Kluwer Academic Publisher, (2000). 14. Organic Chemistry by S.K. Ghosh. 15. Reaction Mechanism in Organic Chemistry by S.M. Mukharjee and S.P. Singh. 16. Organic Chemistry by TWG Solomons, 8th edition, John Wiley 17. Organic Chemistry by R. K. Bansal **Web resources:** 1. https://www.masterorganicchemistry.com/reaction-guide/ 2. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Carboxylic_Acids 3. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Esters 4. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Amines
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) Write an example of ionization isomers in complexes. 2) Predict the geometry of $[Fe(H_2O)_6]^{2+}$ ion on the basis of VBT 3) Give the relationship between Δ_o and Δ_t. 4) Give the IUPAC name for the ester formed from acetic acid and ethanol. 5) Define the term 'Esterification'. 6) What is the action of heat on Lactic acid 7) What is the IUPAC name of the product obtained from the acetylation of aniline? 8) Why does the nitro group in nitrobenzene decrease the electron density of the benzene ring?
	Answer in brief (At least 6) (3 Marks each) 1) Write any three postulates of CFT. 2) Draw crystal field splitting diagram for octahedral geometry and tetrahedral geometry. 3) How is Lactic acid prepared from Pyruvic acid? 4) Explain the reaction of benzoic acid with ethanol and PCl5. 5) Write the Reimer-Tiemen reaction. 6) Explain the mechanism of the nitration of nitrobenzene. 7) Define Hoffmann's exhaustive methylation. What is the end product of this process? 8) What happens when aniline reacts with bromine in the presence of carbon disulphide.
	Answer in Detail (At least 4) (6 Marks each) 1) Discuss the factors affecting crystal field stabilization energy. 2) Explain the crystal field splitting in square planar geometry 3) Explain the reaction of oxalic acid with ethyl alcohol, ammonia and glycerol. 4) Explain acidic and basic hydrolysis of ester. 5) Discuss the reduction of nitrobenzene in detail under acidic, neutral, and alkaline conditions. 6) Explain the mechanism of Hoffmann's exhaustive methylation followed by Hoffmann elimination.
	MCQs for Internal Assessment (At least 4) 1. In which there is outer orbital hybridization? a) $[Zn(NH_3)_6]^{2+}$ b) $[Co(NH_3)_6]^{3+}$ c) $[Cr(NH_3)_6]^{3+}$ d) $[V(NH_3)_6]^{2.}$ $[Co(NH_3)_4Cl_2]NO_2$ and $[Co(NH_3)_4ClNO_2]Cl$ exhibit which type of isomerism? [MP PMT 1993] a) Geometrical b) Optical c) Linkage d) Ionization 3. Lactic acid contains which of the following functional groups? A) Only Carboxylic acid B) Carboxylic acid and Ketone C) Carboxylic acid and Hydroxyl D) Carboxylic acid and Aldehyde 4. Saponification is the: A) Acidic hydrolysis of an ester B) Basic hydrolysis of an ester C) Oxidation of an alcohol D) Dehydration of an acid 5. The reaction of Aniline with Benzoyl chloride is known as: A) Friedel-Crafts reaction B) Schotten-Baumann reaction C) Hoffmann reaction D) Perkin reaction 6. The Carbylamine reaction is performed by heating a primary amine with: A) $CHCl_3$ and alcoholic KOH B) CCl_4 and alcoholic KOH C) CHCl and alcoholic OH D) $CHCl_3$ and HCl

Course Category**: Minor Lab**

108256 Minor Chemistry Lab- 23

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108256**	**Minor Chemistry Lab- 23**	2	60	4 h	25+25= 50

Course Objectives:	1. To develop practical skills in gravimetric, volumetric, and complexometric analytical techniques for quantitative estimation of inorganic substances. 2. To provide hands-on training in qualitative analysis and identification of organic compounds containing mono- and bifunctional groups.
Course Outcomes:	1. Perform gravimetric and volumetric estimations using standard analytical procedures and appropriate indicators. 2. Apply complexometric titration techniques for estimation of metal ions in water, milk powder, fungicides, talcum powder, and other samples. 3. Carry out systematic qualitative analysis and identification of unknown organic compounds containing different functional groups. 4. Interpret preliminary tests, solubility behavior, and functional group reactions for characterization of organic compounds. 5. Analyze experimental data, perform analytical calculations accurately, and report results scientifically. 6. Demonstrate laboratory skills, safe handling of chemicals and instruments, and proper scientific documentation practices.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	1. Principles and steps involved in gravimetric analysis. 2. Concepts of precipitation, digestion, filtration, ignition, and weighing in gravimetry. 3. Selection and role of indicators in EDTA titrations (EBT, murexide, etc.). 4. Principles and applications of complexometric titrations in industrial and environmental analysis. 5. Classification and identification of organic compounds based on solubility behavior.	• Experiential and hands-on laboratory learning • Demonstration-based teaching for gravimetric, volumetric, and qualitative organic analysis techniques • Problem-based learning through analytical calculations and compound identification exercises • Inquiry-based learning for interpretation of observations and selection of suitable analytical procedures • Collaborative learning through group experiments and discussions • ICT-enabled teaching using virtual labs, digital flowcharts, and molecular visualization tools • Project-based learning through sample analysis and mini-projects • Peer learning and seminar presentations on analytical and organic chemistry methods • Outcome-based continuous assessment through laboratory performance, viva voce, assignments, and reports
Inorganic Experiments	**Gravimetric Analysis (at least One)** 1. Estimation of Ba2+ as BaSO4 2. Estimation of Fe3+ as Fe2O3 3. Estimation of Ni2+ as Ni-DMG. **Volumetric Estimations: (at least 5)** 1. Estimation of Zn(II) by complexometric titration. 2. To determine the strength of unknown calcium salt solution by complexometric titration. 3. Analysis of Talcum powder 4. Analysis of Iodine from Iodized salt. 5. Analysis of Calcium from milk powder/ limestone 6. Analysis of Cu from Cu-Fungicide. 7. Estimation of calcium and magnesium in water separately by complexometric titration 8. Estimation of nickel ions using EDTA 9. Estimation of cobalt ions by EDTA titration	
Organic Experiments	**Organic Qualitative analysis (at least 8)** Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc.	

Suggested Student Activities	• **Complexometric Titration Workshop:** Group activity on estimation of calcium, magnesium, zinc, nickel, and cobalt using EDTA titration methods. • **Organic Compound Identification Activity:**Students perform systematic qualitative analysis of unknown organic compounds and prepare identification flowcharts. • **Preparation of Functional Group Charts:**Groups prepare charts summarizing characteristic tests for carbohydrates, nitro compounds, amines, amides, aryl halides, and bifunctional compounds. • **Poster Presentation**

References	1. Vogel's Textbook of Practical Organic Chemistry, 5th Edition by B. S. Furniss, A. J. Hannaford, Peter W. G. Smith, A. R. Tatchell; Pearson. 2. Organic Chemistry: Laboratory Manual by R. K. Bansal, New Age International Publisher 3. Advanced Practical Organic Chemistry by N. K. Vishnoi, Vikas Publishing House 4. Practical Organic Chemistry by Mann & Saunders, Pearson 5. Practical Chemistry (for B.Sc. I, II and III year students) – O P Pandey, D. N. Bajpai and S. Giri (S Chand and company Ltd 6. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press. 7. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press. 8. Advanced practical Organic Chemistry: O P Agrawal **Web resources:** 1. **Royal Society of Chemistry (www.rsc.org/learn-chemistry)** – Free chemistry resources and lab techniques. 2. Organic Syntheses (www.orgsyn.org) – Peer-reviewed procedures for organic compound synthesis. 3. MIT OpenCourseWare: https://ocw.mit.edu 4. https://vlab.amrita.edu/?sub=2 5. https://chemcollective.org/vlabs
Model Questions:	**NA**

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities — 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * — 10 Marks
- Submission of duly certified practical record — 05 Marks

Total — **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Inorganic Chem Practical) — 10 Marks
- Exercise 2 (Organic Chem Practical) — 10 Marks
- Viva-Voce (external) — 05 Marks

Total — **25 Marks**

Course Category: **Vocational Skill Course VSC**

108257 Chemistry Lab- 24 (Water and Soil Analysis)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108257**	**Chemistry Lab- 24 (Water and Soil Analysis)**	2	60	4 Hrs	50

Course Objectives:	To develop practical skills in sampling, analysis, and quality assessment of water and soil using standard chemical methods for environmental and agricultural applications
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Perform sampling and preservation of water and soil samples using standard procedures. 2. Analyze important physicochemical parameters of water and soil. 3. Interpret analytical data for assessment of water quality and soil fertility. 4. Apply laboratory analytical skills in environmental monitoring and agricultural testing.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	1. Sampling and preservation of water samples 2. Collection and preparation of soil samples 3. Preparation of standard solutions.	To enhance student engagement and learning outcomes, the following pedagogical approaches will be incorporated: • **Experiential Learning (Hands-on Laboratory Work)** • **Inquiry-Based Learning** • **Collaborative Learning** a. Facilitate group-based experimental work to enhance teamwork and problem-solving skills. b. Conduct peer discussions on challenges and improvements in experimental procedures. • **Case-Based and Problem-Solving Approach** • **Assessment through Reflective Learning** a. Encourage students to maintain lab journals for recording observations and interpretations. b. Conduct oral presentations and report writing to develop scientific communication skills. • **Environmental Awareness Campaign** a. Students prepare posters/models on water pollution, soil degradation, and sustainable agriculture. b. Conduct awareness sessions within campus or nearby schools/villages.
Water Analysis	1. Determination of pH of water samples 2. Estimation of hardness of water by complexometric titration 3. Measurement of salinity of water samples 4. Estimation of total alkalinity of water samples (CO32-, HCO3-) using double titration method 5. Estimation of chloride content 6. Estimation of calcium in the given water sample 7. Determination of dissolved oxygen (DO) 8. Estimation of chemical oxygen demand (COD) / biological oxygen demand (BOD) 9. Measurement of Turbidity 10. Measurement of TDS in water samples	
Soil Analysis	1. Determination of soil pH 2. Determination of soil moisture content 3. Estimation of organic carbon in soil 4. Determination of available nitrogen in soil 5. Estimation of phosphate content 6. Estimation of potassium in soil 7. Measurement of Electrical conductivity of soil	
Suggested Group Activities	**1. Water Quality Survey Project** i. Students collect water samples from different sources (tap water, river, pond, borewell, etc.). ii. Analyze parameters such as pH, hardness, alkalinity, and chloride content. iii. Compare results with standard permissible limits and prepare a report **2. Soil Fertility Mapping** i. Groups collect soil samples from agricultural fields or gardens. ii. Analyze pH, moisture, organic carbon, and nutrient content. **iii.** Prepare a comparative soil fertility chart and suggest suitable crops/fertilizers	

References	5. Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3rdEd. ELBS (1964) 6. Vogel's textbook of quantitative chemical analysis, Sixth Ed. Mendham, Denny, Barnes, 7. Thomas, Pearson education Girard J, Principles of Environmental Chemistry, Jones Bartlett Learning, 20142. 8. Glasson, J., Therivel, R., Chadwick, A. 1994. Introduction to Environmental ImpactAssessment. London, Research Press, UK. 9. H.S. Peavy, D.R. Rowe & G. Tchobanoglous, "Environmental Engineering". McGraw HillInternational Edition.4. Jacob D. J, Introduction to Atmospheric Chemistry, Princeton, 200 10. Essential Oils: Extraction Methods and Applications by by Inamuddin, Tariq Altalhi, Jorddy Neves Cruz, Wiley-Scrivener **Web resources:** 1. **Royal Society of Chemistry (www.rsc.org/learn-chemistry)** – Free chemistry resources and lab techniques.
Model Questions:	**NA**

Distribution of Marks and the scheme of (VSC) Practical Examination is as follows:

Section I: Continuous Internal Assessment

- Continuous Assessment Tests (CAT) (At least three tests) * 15 Marks
- Submission of duly certified practical record 10 Marks

Total 25 Marks

Section II: End Semester Examination (Internal only)

- Exercise 1 20 Marks
- Viva-Voce (internal) 05 Marks

Total 25 Marks

Total (Section I And II) 50 Marks

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Course Category: **Internship / Apprenticeship/ OJT**

108258 Internship / Apprenticeship/ OJT (On the Job Training)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108258**	**Internship / Apprenticeship/ OJT (On the Job Training)**	4	80	--	100

Course Objectives:	1. To provide hands-on training in chemistry-related industries, laboratories, and research organizations. 2. To expose students to industrial practices, instrumentation, quality control, and safety 2. procedures. 3. To enhance problem-solving, teamwork, communication, and technical skills. 4. To create awareness regarding entrepreneurship and employment opportunities in chemistry.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Apply theoretical chemistry concepts in practical and industrial environments. 2. Operate and understand basic analytical instruments and laboratory techniques. 3. Demonstrate professional ethics, laboratory safety, and teamwork. 4. Analyze chemical processes, observations, and experimental data effectively. 5. Prepare technical reports and communicate scientific findings professionally. 6. Explore employability and entrepreneurship skills in chemistry-related sectors.

Guidelines/ SoP for Internship / Apprenticeship/ OJT

For understanding key principles of Intrnship/Apprentiship/OJT operational guidelines and implementation strategy please refer

1. https://www.ugc.gov.in/pdfnews/2051511_Internship-Research-Internship-Guidelines.pdf
2. https://www.sgbau.ac.in/pdf/1092Internship%20Policy.pdf

As per NEP 2020, students of B Sc. III need to undertake Internship / Apprenticeship/ OJT for FOUR (4) credits i.e. 100 Marks.

The guidelines for Internship / Apprenticeship/ OJT are as follows:

2. **Credit: 04**
3. **Duration: 120 Hrs**
4. **Internship Period**: Ideally, the internship should be completed during the summer break between the second and third year. Students who are unable to complete the internship during this period must ensure its completion by the end of the VI semester, either in a part-time manner during Semester V, or during the Diwali break, or winter break or through an alternative arrangement subject to prior approval by the parent institution (University School/College).
5. **Internship Categories:**
   i. **Internship for enhancing the employability:** Employability is a set of skills and attributes developed through a range of experiences at workshops and workplaces.
   ii. **Internship for developing the research aptitude:** Research internship aims at providing hands-on training to work on research tools, techniques, methodologies, equipment, policy framework and various other aspects in pursuing quality research.
6. **Implementation and assessment**: For implementation and assessment of this vertical a separate SoP or relevant document that shall be provided by the University will be applicable.
7. These can be implemented through:
   1. Industries
   2. Research labs
   3. Government testing laboratories
   4. Colleges/departments
   5. MSMEs and startups
   6. Online/virtual internships with report and viva evaluation

Some suggested forms of Internship / Apprenticeship/ OJT are:

Laboratory and Analytical Training:

1. Water quality testing laboratory internship
2. Soil and fertilizer analysis training
3. Food and dairy testing laboratory apprenticeship
4. Edible oil analysis and quality control training
5. Pharmaceutical quality control laboratory training

6. Clinical pathology and diagnostic laboratory exposure
7. Environmental monitoring and pollution analysis internship
8. Industrial analytical chemistry laboratory training

Chemical Industry-Based OJT

1. Internship in chemical manufacturing units
2. Paint, dye, pigment, and polymer industry training
3. Soap, detergent, and cosmetic industry apprenticeship
4. Agrochemical and pesticide formulation training
5. Distillery, sugar, or fermentation industry exposure
6. Cement, ceramic, or glass industry laboratory training
7. Electroplating and metal finishing industry training

Research and Academic Exposure

1. Internship in university or research laboratories or premier institutes like IITs/IISERs etc.
2. Spectroscopy and instrumentation laboratory training
3. Computational chemistry or chemoinformatics training
4. Nanochemistry and material characterization exposure
5. Scientific documentation and laboratory management training

Entrepreneurship and Skill-Based OJT

1. Small-scale chemical product preparation: Oil, Soap, Sanitizer, Phenyl, Detergent, Herbal products etc.
2. Food preservation and quality analysis training
3. Entrepreneurship in chemical products and formulations
4. Laboratory chemical preparation and packaging training

References	https://www.ugc.gov.in/pdfnews/2051511_Internship-Research-Internship-Guidelines.pdf https://www.sgbau.ac.in/pdf/1092Internship%20Policy.pdf
Model Questions:	**NA**