APPENDIX – A-1, A-2

General Model Scheme

Sant Gadge Baba Amravati University Amravati

Scheme of teaching, learning &Examination leading to the Degree Master of Science (Choice Based Credit System) (Two Years ... Four Semesters Degree Course- C.B.C.S)

(M.Sc. Part-I) Semester- I, Subject: Chemistry/Industrial Chemistry

Sr. No	Subjects	Subject Code	Teaching & Learning Scheme								Duration of Exams Hrs.	Examination & Evaluation Scheme						
			Teaching Period Per week				Credits					Maximum Marks					Minimum Passing	
			L	T	P	Total	Theory L/T	Internal Ass.	Practical	Total		Theory + M.C.Q External	Theory Internal	Practical		Total Marks	Marks	Grade
														Internal	External			
1	DSC-I (Inorganic Chemistry)	CY101	04	--	--	04	04		--	04	03	80	20	--	--	100	40	P
2	DSC-II (Organic Chemistry)	CY102	03	--	--	03	03		--	03	03	80	20	--	--	100	40	p
3	DSC-III (Physical Chemistry-I)	CY103	04	--	--	04	04		--	04	03	80	20	--	--	100	40	p
4	DSC-IV (Analytical Chemistry-I)	CY104	04	--	--	04	04		--	04	03	80	20	--	--	100	40	p
5	AEC-I on DSC-II (Structural Chemistry)	CY105		01		01	01			01	01		25		--	25	10	P

6	**Lab-I (Physical Chemistry)**	**CY106**			**09**	**09**			**4.5**	**4.5**	**06**		**--**	**20**	**80**	**100**	**50**	**p**
7	**Lab-II (Organic Chemistry)**	**CY107**			**09**	**09**			**4.5**	**4.5**	**06**			**20**	**80**	**100**	**50**	**p**
8	**#Internship/Field Work/Work Experience@ Open elective/GIC/Open skill/MOOC***																	
	Total		**15**	**01**	**18**	**34**	**16**		**09**	**25**						**625**		

- **L: Lecture, T: Tutorial, P: Practical**
- **# Students may complete their internship/field work/work experience in first or second or third semester of M.Sc. (Chemistry/Industrial) according to their convenience; @denotes non-examination credit**
- **Note: Internship/Apprenticeship/field work/work experience (During vacations of semester I to semester III) for duration of minimum 60 hours to maximum 90 hours mandatory to all the students, to be completed during vacations of semester I to III. This will carry 2 credits for learning of 60 hours or 3 credits for learning of 90 hours. Its credits and grades will be reflected in final semester IV credit grade report.**
- **OEC (optional) can be studied during semester I to IV.**

Suggested Activities for assessment for AEC:

Mini-project, internal evaluation: Class test or surprise test, Demonstration of task or activity assigned, assignment, seminar, or any other innovative pedagogical method.

APPENDIX – A-1,A-2

General Model Scheme

Sant Gadge Baba Amravati University Amravati

Scheme of teaching, learning &Examination leading to the Degree Master of Science (Choice Based Credit System) (Two Years ... Four Semesters Degree Course- C.B.C.S)

(M.Sc. Part-I) Semester- II , Subject : Chemistry/Industrial Chemistry

Sr. No	Subjects	Subject Code	Teaching & Learning Scheme								Duration of Exams Hrs.	Examination & Evaluation Scheme						
			Teaching Period Per week				Credits					Maximum Marks					Minimum Passing	
			L	T	P	Total	Theory L/T	Internal Ass.	Practical	Total		Theory + M.C.Q External	Theory Internal	Practical		Total Marks	Marks	Grade
														Internal	External			
1	DSC-V (Advance Inorganic Chemistry)	CY201	04	--	--	04	04	--	--	04	03	80	20	--	--	100	40	P
2	DSC-VI (Organic Reaction Mechanism)	CY202	03	--	--	03	03	--	--	03	03	80	20	--	--	100	40	p
3	DSC-VII (Physical Chemistry-II)	CY203	04	--	--	04	04	--	--	04	03	80	20	--	--	100	40	p
4	DSC-VIII (Analytical Chemistry-II)	CY204	04	--	--	04	04	--	--	04	03	80	20	--	--	100	40	p
5	AEC- II on DSC-VI (Acid and Bases and Virtual Lab)	CY205	--	01	--	01	01	--		01	01	--	25	--	--	25	10	P

6	**Lab-III (Physical Chemistry)**	**CY206**			**09**	**09**			**4.5**	**4.5**	**06**			**20**	**80**	**100**	**50**	**p**
7	**Lab-IV (Inorganic Chemistry)**	**CY207**			**09**	**09**			**4.5**	**4.5**	**06**			**20**	**80**	**100**	**50**	**p**
8	**#Internship/Field Work/Work Experience@**																	
9	**Open elective/GIC/OpenSkill/MOOC***																	
	Total		**15**	**0 1**	**18**	**34**	**16**		**09**	**25**						**625**		

- **L: Lecture, T: Tutorial, P: Practical**
- **# Students may complete their internship/field work/work experience in first or second or third semester of M.Sc. (Chemistry/Industrial) according to their convenience; @denotes non-examination credit**
- **Note: Internship/Apprenticeship/field work/work experience (During vacations of semester I to semester III) for duration of minimum 60 hours to maximum 90 hours mandatory to all the students, to be completed during vacations of semester I to III. This will carry 2 credits for learning of 60 hours or 3 credits for learning of 90 hours. Its credits and grades will be reflected in final semester IV credit grade report.**
- **OEC (optional) can be studied during semester I to IV.**

Suggested Activities for assessment for AEC:

Mini-project, internal evaluation: Class test or surprise test, Demonstration of task or activity assigned, assignment, seminar, or any other innovative pedagogical method.

General Model Scheme

Sant Gadge Baba Amravati University Amravati

Scheme of teaching, learning &Examination leading to the Degree Master of Science (Choice Based Credit System) (Two Years ... Four Semesters Degree Course- C.B.C.S)

(M.Sc. Part-II) Semester- III , Subject : Chemistry/Industrial Chemistry

Sr. No	Subjects	Subject Code	Teaching & Learning Scheme								Duration of Exams Hrs.	Examination & Evaluation Scheme						
			Teaching Period Per week				Credits					Maximum Marks					Minimum Passing	
							Theory L/T	Internal Ass.	Practical	Total		Theory + M.C.Q External	Theory Internal	Practical		Total Marks	Marks	Grade
			L	T	P	Total								Internal	External			
1	**DSC-IX** (Spectroscopy-I)	CY301	04	--	--	04	04		--	04	03	80	20	--	--	100	40	P
2	**DSC-X** (Selected topics in Chemistry-I)	CY302	04	--	--	04	04		--	04	03	80	20	--	--	100	40	p
3	**DSE-I (**Any one based on the specialization from **CY303(i) to CY303(v))**	CY303	04	--	--	04	04		--	04	03	80	20	--	--	100	40	p
4	**DSE-II (**Any one based on the specialization from	CY304	04	--	--	04	04		--	04	03	80	20	--	--	100	40	p

	CY304(i) to CY304(v))																	
5	**Lab-V based on DSE** (Any one based on the specialization from **CY305(i) to CY305(v))**	**CY305**			**09**	**09**			**4.5**	**4.5**	**06**		**--**	**20**	**80**	**100**	**50**	**p**
6	**Lab-VI Research Project Phase-I [$]**	**CY306**			**09**	**09**			**4.5**	**4.5**	**-**		**-**	**100**	**-**	**100**	**50**	**p**
7	**#Internship/Field Work/Work Experience@ Open elective/GIC/Open skill/MOOC***																	
	Total		**16**		**18**	**35**	**16**		**09**	**25**						**600**		

- **L: Lecture, T: Tutorial, P: Practical**
- **# Students may complete their internship/field work/work experience in first or second or third semester of M.Sc. (Chemistry/Industrial) according to their convenience; @denotes non-examination credit**
- **Note: Internship/Apprenticeship/field work/work experience (During vacations of semester I to semester III) for duration of minimum 60 hours to maximum 90 hours mandatory to all the students, to be completed during vacations of semester I to III. This will carry 2 credits for learning of 60 hours or 3 credits for learning of 90 hours. Its credits and grades will be reflected in final semester IV credit grade report.**
- **OEC (optional) can be studied during semester I to IV.**

[$-] Research Project Phase I: It should be based on rigorous literature survey , finding research gaps, preparation of research proposal to be executed in the next semester. There is a presentation on the topic selected for the research project. Students need to submit the synopsis of the proposed research work.

APPENDIX – A-1,A-2

General Model Scheme

Sant Gadge Baba Amravati University Amravati

Scheme of teaching, learning &Examination leading to the Degree Master of Science (Choice Based Credit System) (Two Years ... Four Semesters Degree Course- C.B.C.S)

(M.Sc. Part-II) Semester- IV , Subject : Chemistry/Industrial Chemistry

Sr. No	Subjects	Subject Code	Teaching & Learning Scheme								Duration of Exams Hrs.	Examination & Evaluation Scheme						
			Teaching Period Per week				Credits					Maximum Marks					Minimum Passing	
			L	T	P	Total	Theory L/T	Int. Ass.	Practical	Total		Theory + M.C.Q External	Theory Internal	Practical		Total Marks	Marks	Grade
														Internal	External			
1	**DSC –XI** (Spectroscopy-II)	CY401	04	--	--	04	04		--	04	03	80	20	--	--	100	40	P
2	**DSC-XII** (Selected topics in Chemistry-II)	CY402	04	--	--	04	04		--	04	03	80	20	--	--	100	40	p
3	**DSE-III** (Any one based on the specialization) from **CY403 (i) to CY403 (v)**	CY403	04	--	--	04	04		--	04	03	80	20	--	--	100	40	p
4	**DSE-IV** (Any one based on the specialization) from **CY404 (i) to CY404 (v)**	CY404	04	--	--	04	04		--	04	03	80	20	--	--	100	40	p
5	**(SEC) Lab-VII** (Any one based on the specialization) from **CY405 (i) to CY 405 (v)**	CY405			09	09			4.5	4.5	06		-	20	80	100	50	p
6	**Lab-VIII (Research Project Phase - II)$**	CY406			09	09			4.5	4.5	03			20	80	100	50	p

7	**#Internship/Field Work/Work Experience@ Open elective/GIC/Open skill/MOOC***																	
	Total		**16**		**18**	**34**	**16**		**09**	**25**						**600**		

- **L: Lecture, T: Tutorial, P: Practical**
- **# Students may complete their internship/field work/work experience in first or second or third semester of M.Sc. (Chemistry/Industrial) according to their convenience; @denotes non-examination credit**
- **Note: Internship/Apprenticeship/field work/work experience (During vacations of semester I to semester III) for duration of minimum 60 hours to maximum 90 hours mandatory to all the students, to be completed during vacations of semester I to III. This will carry 2 credits for learning of 60 hours or 3 credits for learning of 90 hours. Its credits and grades will be reflected in final semester IV credit grade report.**
- **OEC (optional) can be studied during semester I to IV.**

$- The project/dissertation must be submitted in the hardbound copy to the University Department/College/Institute. For internal evaluation, the students shall have to give a presentation of the project/dissertation in a given Semester. Further, for external examination, Project/Dissertation shall be evaluated by the concerned teacher/supervisor/guide in the University Department/College / Institute as an Internal Examiner along with an External Examiner appointed by the University.

Sant Gadge Baba Amravati University, Amravati

Syllabus Prescribed for Two Year PG Programme
Programme: MSc Chemistry (Choice Based Credit System)

MSc Chemistry (Sem 3 and 4)

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Sant Gadge Baba Amravati University, Amravati

Syllabus Prescribed for Two Year PG Programme

Programme: MSc Chemistry (Choice Based Credit System)

Semester III

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY301	**Spectroscopy-I (DSC IX)**	**60 hrs (4 hrs/week)**

Course Outcomes: At the end of the course, students will be able to:

1. apply spectroscopic techniques such as Microwave spectroscopy, Raman, UV, IR and other spectroscopic methods for structure determination.
2. compute approximate wavelength regions for different types of transitions involved in UV spectroscopy.
3. deduce structures and reactivity patterns of organic, organometallic, and inorganic materials using spectroscopic data.
4. elucidate the structure of organic and inorganic compounds using spectroscopic methods.
5. utilizes zero-field spectra in Mössbauer spectroscopy to determine oxidation state, spin state, and coordination geometry.

Unit I : **15h**

A) Principles of Spectroscopy: Electromagnetic spectrum, Interaction of EMR with matter, Natural line width and Broadening- Intensity of spectral transitions. Electronic transitions, Franck-Condon principle, Fluorescence and phosphorescence. Stark effect, Zeeman effect.

B) Rotational (Microwave) spectroscopy: Classification of molecules according to their moments of inertia, rigid rotor model, rotational energy levels of Diatomic Molecules, Selection rule for Microwave spectra, intensity, effect of substitution on Microwave spectra, non-rigid rotor, Spectra of symmetric top and asymmetric top type molecules, Effect of isotopic substitution.

Unit II : **15h**

A) Raman spectroscopy: Classical and quantum theories of Raman effects, Normal, Resonance and Laser Raman spectroscopies, Pure rotational and vibrational and vibrational rotational Raman spectra, selection rules, mutual exclusion Raman spectroscopy, coherent antistokes Raman spectroscopy (CARS). Rotational Raman- spectra, Vibrational Raman Spectra, polarization of light and Raman effect,

Applications for the study of active sites of metalloproteins. Structure determination by symmetry selection rules (Normal Coordinate analysis) and applications.

B) Infrared spectroscopy:

Simple harmonic oscillator, vibrational energies of diatomic molecules, zero point energy, force constant and bond strength, anharmonic oscillator, Morse potential energy diagram, vibration of polyatomic molecules, selection rules, identification of functional groups. Fingerprint region-factors influencing vibrational frequencies- Effect of hydrogen bonding and solvent effect on vibrational frequencies; overtones; combination bands and Fermi resonance.

Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols, amines and carbonyl compounds. Instrumentation, FT-IR, IR of

gaseous solids and polyatomic materials. Application of IR spectroscopy in investigating mode of bonding in ambidentate ligand (NO_2, CN and SCN), metal carbonyl and metal nitrosyl.

Unit III : 15h

A) Ultraviolet and visible spectroscopy :

Laws of photochemistry-Basic law of absorption- Beer-Lambert law, electronic absorption transitions- correlation of electronic structure with molecular structure-simple chromophoric groups - effects of conjugation- effect of solvent on electronic transition,

B) Woodward -Fisher rules for α, β unsaturated carbonyl compounds, dienes & aromatic systems with extended conjugation – Ultraviolet spectra of aromatic and heterocyclic compounds, Fieser-Kuhn rule, Steric effect in biphenyls. Instrumentation**,** Applications to organic and inorganic compounds-

Unit IV : 15h

Mossbauer spectroscopy: Basic principle, Mossbauer effect, Spectrometer, Doppler shift, isomer shift, quadrupole splitting, nuclear Zeeman splitting, quadrupole coupling constants and asymmetry Parameters.

Bonding and structure of Fe^{+2} and Fe^{+3} compounds including those of intermediate spin (2) Sn^{+2} and Sn^{+4} compounds - Nature of M-L bond, coordination number, structure and detection of oxidation state and in equivalent MB atoms. Structural problems, Mossbauer spectroscopy of Biological Systems. pure NQR and Zeeman spectra of spin 1 and spin 3/2 systems.

Course Material/Learning Resources

Text books:

1. Organic spectroscopy-William kemp,ELB with McMillan.
2. Spectroscopy of organic molecule-PS Kalsi,Wiley,Esterna,New Delhi.
3. Elementary Organic chemistry: Principles and chemical Applications, Y. R. Sharma, (Revised V Edition), New Delh : S. Chand and Company LTD.
4. Spectroscopy: H.Kaur (First Edition 2005), Pragati Prakashan, Meerut

Text & Reference Books:

1. R. M. Silverstein, F. X. Webster, D. J. Kiemle, and D. L. Bryce, Spectrometric Identification of Organic Compounds, 8th ed., Wiley, 2014.
2. W. Kemp, Organic Spectroscopy, 2nd ed., Macmillan, 2019.
3. L. D. Field, S. Sternhell, J.R. Kalman, Organic Structures from Spectra, 5th ed., Wiley, 2012.
4. M. H. Levitt, Spin Dynamics, 2nd ed., Wiley, 2008.
5. S. Braun, H. O. Kalinowski, and S. Berger, 150 and More Basic NMR Experiments, 2nd Revised ed., Wiley-VCH, 1998.
6. D. L. Pavia, G. M. Lampman, G. S. Kriz, J. A. Vyvyan, Introduction to Spectroscopy 5th ed., Cengage, 2014.
7. R. S. Drago; Physical Methods in Inorganic Chemistry, Affiliated East-West Press, 2015.
8. L. Que, Jr.; Physical Methods in Bioinorganic Chemistry, University Science Books, 2000.
9. Fundamentals of molecular spectroscopy-CN Banwell

10. Spectroscopy in organic chemistry-CNR Rao and JR Ferraro
11. Photoelectron spectroscopy-Baber and Betteridge
12. Electron spin resonance spectroscopy-J Wertz and JR Bolten

Weblink to Equivalent MOOC on SWAYAM if relevant:

Weblink to Equivalent Virtual Lab if relevant:

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

Rotational Spectroscopy: https://onlinecourses.nptel.ac.in/noc20_cy08/unit?unit=37&lesson=40

https://onlinecourses.nptel.ac.in/noc20_cy08/unit?unit=37&lesson=41

https://onlinecourses.nptel.ac.in/noc20_cy08/unit?unit=53&lesson=54

Raman Spectroscopy: https://onlinecourses.nptel.ac.in/noc20_cy08/unit?unit=83&lesson=85

https://onlinecourses.nptel.ac.in/noc20_cy08/unit?unit=83&lesson=89

https://onlinecourses.nptel.ac.in/noc20_cy08/unit?unit=91&lesson=93

UV Spectroscopy: https://onlinecourses.swayam2.ac.in/5231-online-refresher-course-in-chemistry-for-higher-education-faculty/unit?unit=75&lesson=77
https://onlinecourses.swayam2.ac.in/5231-online-refresher-course-in-chemistry-for-higher-education-faculty/unit?unit=75&lesson=79

IR Spectroscopy: https://onlinecourses.nptel.ac.in/noc21_cy09/unit?unit=24&lesson=30
https://onlinecourses.nptel.ac.in/noc21_cy09/unit?unit=41&lesson=46
https://onlinecourses.nptel.ac.in/noc21_cy09/unit?unit=57&lesson=60

Sant Gadge Baba Amravati University, Amravati

Syllabus Prescribed for Two Year PG Programme

Programme: MSc Chemistry (Choice Based Credit System)

Semester III

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY302	**Selected topics in Chemistry-I (DSC X)**	**60 hrs (4 hrs/week)**

Course Outcomes: At the end of the course students will be able to

1. Apply the principles of diffraction techniques, including X-ray diffraction, electron diffraction, and neutron diffraction, and their applications in structural analysis.
2. Explain the principles of electron diffraction, including scattering intensity and the Wierl equation, and utilize them to elucidate the structure of simple gas-phase molecules and surfaces.
3. Explain the principles of ion-selective electrodes, including the glass electrode and solid-state electrodes, and utilize them for selective ion measurements.
4. Demonstrate knowledge of coulometry, including coulometry at constant current and constant potential, and perform coulometric titrations for analysis.
5. Implement laboratory safety protocols, including safe working procedures, protective apparel, emergency procedures, and first aid.
6. Describe the principles and classification of chemical weapons, including their physical and chemical properties and toxicity.
7. Identify and explain the given scientific problems based on an advanced analytical approach.
8. Design and specify applications of advanced analytical techniques in various fields and develop capability to apply different techniques to assess physicochemical properties.

Unit I :Diffraction Techniques **15h**

A) X-ray diffraction: Interaction of x-ray with matter, scattering and diffraction. Brags method Debye-Sherrer method of Xray 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.

B) Electron diffraction : Scattering intensity Vs scattering angle, Wierl equation, measurement techniques, elucidation of structure of simple gas phase molecules. Low energy electron diffraction and structure of surface.

C) Neutron diffraction: Scattering of neutrons by solids and liquids magnetic scattering, measurement techniques. Elucidation of structure of magnetically ordered unit cell.

Unit II : Electroanalytical Methods **15h**

A] Electrogravimetry: Theory, Principle and types of electrogravimetry, electrode reactions, over voltage, characteristics of deposits and completion of deposition, separation of metals and applications.

B] **Ion-selective electrode:** Principle of ion-selective electrode, Types of ion-selective electrode Advantages and limitations of ion-selective electrode ,The glass electrode, glass electrodes for pH measurement, Solid-state electrode, Liquid-based electrode, Selectivity coefficients, Biopotential Electrodes, Uses of ion-selective electrode, Applications of ion selective electrode in determination of some toxic metals and some anions (F-, Cl-, Br-, I- and NO3), Biomedical Applications

Unit III :Electroanalytical Technique **15h**

A]] Coulometry : Principal, coulometry at constant current, coulometry at constant potential coulometric method of analysis, instrumentation, coulometric titrations, Advantages of coulometric titrations, Applications of coulometric titrations, problems

B] Voltammetry: Basic principles, Instrumentation, Cyclic voltammetry- Principle, Instrumentation and applications, Voltammograms, Stripping Technique: Anodic and cathodic stripping voltammetry and their applications in the trace determination of metal ions and biologically important compounds . Enzyme catalyzed reactions and applications of voltammetry in monitoring such reactions.

Unit IV : **Lab Safety, Explosives and Chemical Weapons**: **15h**

A] Lab Safety:

Safe working procedure and protective environment, protective apparel, emergency, procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals

B] Explosives and Chemical Weapons:

Chemical explosives: Origin of explosive properties in organic compounds, classification, characteristics-special explosives-nitrocellulose- T.N.T, Picric acid, preparation and explosive properties of lead azide, PETN, cyclonite (RDX), Dynamite-cordite and Gunpowder. Introduction, Classification of chemical weapons, Chemical warfare agents, physical and chemical properties, toxicity and data, Better regulation of potential chemical weapons

Course Material/Learning Resources:

1. Fundamentals of molecular spectroscopy-CN Banwell.
2. Atomic Structure and Chemical Bond: Including Molecular Spectroscopy: Manas Chanda
3. "Introduction to X-ray Powder Diffractometry" by Ron Jenkins and Robert L.
4. Electrochemical Methods: Fundamentals and Applications" by Allen J. Bard and Larry R. Faulkner
5. "Analytical Electrochemistry" by A.K. Singh and S.N. Tiwari
6. Chemical Sensors: Fundamentals and Applications" by G. U. Kulkarni and M. B. Sreedhar
7. S. M. Khopkar: Basic Concept of Analytical Chemistry.
8. S. A. Skoog and D. W. West: Fundamental of Analytical Chemistry
9. G. D. Christian: Analytical Chemistry
10. Meites and Thomas: Advanced Analytical Chemistry.
11. G. W. Ewing: Instrumental Methods of Chemical Analysis
12. Laboratory Safety for Chemistry Students" by Robert H. Hill Jr. and David C. Finster
13. "Safety in Academic Chemistry Laboratories" by Robert H. Hill Jr. and David C. Finster
14. Laboratory Safety and Chemical Hazard Control" by P. Raghuram and P.K.

Krishnan Namboori
15. Forensic Science: Fundamentals and Investigation" by R.C. Sharma and S.S. Aggarwal
16. "Explosives and Blasting Technique" by V.M. Sivakumar and Ajoy K. Ghose

Weblink to Equivalent MOOC on SWAYAM if relevant:

Weblink to Equivalent Virtual Lab if relevant:

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. Explosive Lab manual of directorate of forensic science (http://dfs.nic.in>downloads)

Sant Gadge Baba Amravati University, Amravati
Syllabus Prescribed for Two Year PG Programme
Programme: MSc Chemistry (Choice Based Credit System)

Semester III

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-303 (i)	**Inorganic Chemistry special paper-I (Bio-inorganic Chemistry) (DSE-I)**	60 hrs (4 hrs/week)

Course Outcomes: At the end of the course students would be able to

1. Describe the principles and concepts of bio-inorganic chemistry, including the role of inorganic elements and compounds in biological systems.
2. Describe the coordination chemistry of metal ions in biological processes, such as metalloenzymes, metalloproteins, and metallocofactors.
3. Explain the biochemical processes involving essential inorganic elements, including their transport, uptake, and metabolism in living organisms.
4. Analyze the electronic structure, bonding, and spectroscopic properties of metal complexes in biological systems.
5. Analyze the interplay between bio-inorganic chemistry and other areas of chemistry and biology, such as bioorganic chemistry, medicinal chemistry, and environmental chemistry.
6. Apply the principles of chelate therapy to propose rational solutions and approaches for addressing biological and biomedical challenges, such as drug design, metal toxicity, and biomaterials development.

Unit-I: Essential trace elements in biological systems: 15 hrs

Perspective of essential trace elements viz V, Cr, Mn, Fe, Co, Cu & Zn and their influence of excess and deficiency, regulation and storage of trace elements, genetic defects in the absorption of trace elements; Role of minerals; Coordination by proteins, tetrapyrrole ligands and other macrocycle and biomineralization with respect to ferritin, transferrin and siderophores; Role of calcium in transport and regulation in living cells; Transport & Storage of dioxygen by Perutz mechanism showing structural changes in porphyrin ring system; Cyanide poisoning and treatment; Vanadium storage and transport.

Unit II: 15 hrs

A) Transport of Electrons and Metal Ions:

Transport of Electrons by Iron-Sulphur Proteins: Rubredoxins and Ferredoxins (2Fe, 3Fe, 4Fe, 8Fe Proteins) - High Potential Iron-Sulphur Proteins – Structural and Spectral features of Iron-Sulphur Proteins; Electron-transport by Cytochromes, Azurin and Plastocyanin -Importance of Structures of Azurin and Plastocyanin in facilitating Rapid Electron Transport; Transport and Storage of Metal Ions: Iron-Transport by Transferrin and Siderophores-Ferritin in Iron Storage - Transport of Na^+ and K^+ across Cell Membranes by Na^+- K^+ ATPase-Transport of Calcium across Sarcoplasmic Reticulam by Ca^{2+}-ATPase.

B) Bio-energetics and ATP cycle:

DNA polymerization, metal complexes in transmission of energy, chlorophylls, photosystem-I and photosystem-II in cleavage of water;

Unit III: Metalloenzymes: 15 hrs

Apoenzymes, Haloenzyme & Coenzyme; The principle involved and role of various metals enzymes- i) Zn-enzyme: Carboxyl peptidase & Carbonic anhydrase; ii) Fe-enzyme: Catalase Peroxidase & Cytochrome P-450; iii) Cu-enzyme: Super Oxide dismutase; iv) Molybdenum: Oxatransferase enzymes, Xanthine oxidase, Co-enzyme vitamin B_{12} : Structure, Co-C bond cleavage and mutase activity; Alkylation reactions of methyl cobalamin, synthetic model of enzyme action, stability and ageing of enzyme; v**)** Nickel Enzyme**:** Urease, Hydrogenase and factor F430: Reactions catalysed, mechanistic aspects.

Unit IV: Chelate therapy and metallotherapy: 15 hrs

- A brief introduction to chelate therapy and its types;
- Therapeutic spectra of different chelating drugs in metal ion detoxification;
- Chelating drugs containing sulphydryl group, the polyaminocarboxylic acids, polyethyleneamines, desferrioxamines;
- Radioprotective chelating drugs, limitations and hazards in chelation therapy;
- Medicinal use of metal complexes as antibacterial and anticancer;
- Aanticancer activity of platinum(II) and platinum(IV) complexes, mechanism of the anticancer activity of platinum complexes;
- Anticancer activities of rhodium, gold, copper and cobalt complexes.

Text books/Reference books:

1. Das A. K.: A Text Book on Medicinal Aspects of Bio-inorganic Chemistry.
2. Akhmetov, N.: General and Inorganic Chemistry.
3. Aylett, B. and Smith, B.: Problems in Inorganic Chemistry, (English University Press)
4. Bertini, et al: Bioinorganic Chemistry (Viva)
5. Charlot, G and Bezier, D.: Quantitative Inorganic Analysis (john Wiley).
6. Douglas, B. E. Mc Danirl, D. H. et al: Concept and Models of Inorganic Chemistry (4th edt.) J. Wiley
7. Dutt P. K.: General and Inorganic Chemistry. (Sarat Books House)
8. Fenton, David E.: Bio-coordination chemistry, Oxford
9. Jolly, W. L.: Inorganic Chemistry (4th edn.) Addison-Wesley.
10. Katakis, D. and Gordon, G.: Mechanism of Inorganic Reactions. (J. Wiley).
11. Leigh, G. J.: IUPAC Nomenclature of Inorganic Chemistry (1990; Jain-Interscience)
12. Massey, A. G.: Main Group Chemistry.
13. Porterfield, W. W.: Inorganic Chemistry-A unified approach (Holt Saunders)
14. Banerjee, D.: Coordination Chemistry, TMH
15. Lee J. D., Concise Inorganic Chemistry, ELBS
16. Lippard S.J and Berg, J. M.: Principal of Bioinorganic Chemistry, University Sci. Book., Mill Valley
17. Hay R. W.: Bioinorganic Chemistry, Ellis Horwood, Chichester and NY
18. Das A.K.: Text Book of Medicinal Aspects of Bioinorganic Chemistry, CBS
19. Sigel H.: Metal ions in Biological systems, Marcell Dekker, NY(Vol.1-31)
20. Reddy K.H., Bioinorganic Chemistry, New Age Int. Pub.
21. Kaim W. and Schwederski B.: Bioinorganic Chemistry: Inorganic elements in the Chemistry of Life, John Wiley & Sons.
22. Medicinal Inorganic Chemistry, Edited by Jonathan L. Sessler, Oxford University Press.

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Semester III

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-303 (ii)	**Organic Chemistry special paper-I (Organic Synthesis-I) (DSE-I)**	**60 hrs (4 hrs/week)**

Course Outcomes: Upon successful completion of a course the students will be able to:

1. Develop a comprehensive understanding in research and advancements in the field of organic chemistry.
2. Modify the method to solve complex synthetic problems.
3. Appraise various synthesis and transformation processes.
4. Develop understanding to write the product with proper stereochemistry.
5. Devise problem-solving skills and critical thinking ability through the analysis of complex reaction mechanisms

Unit I: Photochemistry **15h**

A. Interaction of radiation with matter

Types of excitation, rate of excited molecules, quenching, quantum efficiency, quantum yield, transfer of excitation energy, actinometry, FRET (Förster resonance energy transfer), singlet and triplet states.

B. Photochemical reactions of organic compound

Norrish type I reaction, Norrish type II reaction, Paterno-Buchi reaction, photoreduction, photochemistry of enones, hydrogen abstraction rearrangement of unsaturated ketones and cyclohexadienones, photochemistry of parabenzoquinones, photochemistry of aromatic compounds, isomerization, additions and substitutions, singlet oxygen reactions, di-pi-methane rearrangement, Barton's reaction, Photo-Fries rearrangement, photooxygenation, photo fragmentation, photochemistry of aromatic compounds.

Unit II: **15h**

A] Umpolung concept

Reversal of carbonyl group polarity, dipole inversion

Formyl and acyl anions derived from 1,3-dithiane species, nitroalkanes, cyanide, acetylide, metallated enol ethers

B] Phosphorus and Sulfur ylides

Preparation, synthetic applications with stereochemistry.

Carbonyl methylenation: Tebbe reagent, Petasis reagent, Nystedt reagent

C] Protecting functional groups

Protection and deprotection of hydroxy groups, carboxyl groups

carbonyl groups, amino groups, chemo- and regioselective protection and deprotection

Unit III: Functional group transformations **15h**

A. Oxidation:

1. Selective oxidation of alkyl side chain in aromatic compounds using Cr (IV and VI, II) Oxidation of aromatic ring by chromic oxidation.
2. Epoxidation of olefins, Shi and Jacobsen epoxidation and Sharpless asymmetric epoxidation
3. Oxidation of alcohols to aldehydes and ketones- chromic acid, PCC, PDC, DMSO Swern oxidation, silver carbonate, manganese dioxide, oppenauer oxidation, CAN, TEMPO and oxidation of allylic alcohols
4. Dihydroxylation by $KMnO_4$ and OsO_4
5. Oxidation of alcohols: oxidation of 1,2- diols (Lead tetra-acetate, periodates, asymmetric dihydroxylation
6. Oxidative cleavage by ozonolysis, Lemieux reagent, formation of ketones by Wacker process.

B. Reduction:

1. Selectivity in reduction, catalytic homogeneous and heterogeneous hydrogenation,. Lindlar Catalyst. Hydrogenation of aromatic rings,
2. Metal based reductions using Li/Na in liquid ammonia, sodium, magnesium, zinc, and samarium.
3. Hydride transfer reagents: $LiAlH_4$, $NaBH_4$, N_2H_2, Luche reagent, DIBAL-H, Red-Al, Complex metal hydrides, AlH_3, BH_3,
4. Enantioselective reductions (Chiral Boranes, Corey-Bakshi -Shibata) and Noyori asymmetric hydrogenation, Bakers yeast.

Unit IV **15h**

A) Name Reactions: Synthetic applications of-

Stark-Enamine reaction, Reformatiskii,, Darzens, Mukaiyama reaction, Prins reaction, Fries reaction, Peterson olefination, Julia olefination, , Pummerer rearrangement.

C-C and C-X coupling reactions: Suzuki coupling, Heck coupling, Stille coupling, Sonogishira cross-coupling, Buchwald-Hartwig coupling, Negishi-Kumada coupling and Tsuji–Trost reaction.

B. Reagents in Organic Synthesis:

L-Selectride, K-Selectride, LDA (Lithium Diisopropylamide), DCC (Dicyclohexylcarbodiimide), Trimethylsilyl halide, Woodward and Prevost Hydroxylation, DDQ (2,3-Dichloro-5,6-dicyano-1,4-benzoquinone), Chloranil, Selenium Dioxide, RuO_4 (Ruthenium Tetroxide), IBX (Iodoxybenzoic Acid), DMP (Dess-Martin Periodinane)

C. Phase Transfer Catalysis:

Quaternary ammonium and phosphonium salts, crown ethers, methods of preparation and application in organic synthesis, mechanism of phase transfer reaction, ozone phase transfer catalyst.

Text books/Reference books:

1. "Photochemistry" by Angelo Albini and Maurizio Fagnoni
2. "Organic Photochemistry" by James H. Coxon and B. Halton
3. "Organic Photochemistry and Pericyclic Reactions" by Jagdamba Singh and S. J. Singh
4. "Molecular Photochemistry: Principles and Applications" by V. Ramamurthy and Kirk S. Schanze

5. "Principles of Molecular Photochemistry: An Introduction" by Nicholas J. Turro, V. Ramamurthy, and J.C. Scaiano
6. "Photochemistry and Organic Synthesis" by A. Albini and M. Fagnoni
7. "Photochemistry: Past, Present and Future" edited by Angelo Albini and Maurizio Fagnoni
8. "Photochemistry and Photophysics: Concepts, Research, Applications" by Virender K. Sharma
9. "Introduction to Photochemistry" by Jack Saltiel
10. "Organic Chemistry" by Jonathan Clayden, Nick Greeves, and Stuart Warren
11. "Advanced Organic Chemistry" by Francis A. Carey and Richard J. Sundberg
12. "Organic Chemistry" by Paula Yurkanis Bruice
13. "Modern Organic Synthesis: An Introduction" by Michael H. Nantz and G. Marc Loudon
14. "Protecting Groups" by Philip J. Kocienski:
15. "Phosphorus Ylides: Chemistry and Applications in Organic Synthesis" edited by Oleg I. Kolodiazhnyi
16. "Sulfur Ylides: Emerging Synthetic Intermediates" edited by Michael P. Doyle and Richard A. Batey.
17. "Organic Synthesis: Strategy and Control" by Paul Wyatt and Stuart Warren
18. "Oxidation in Organic Chemistry" by K. Barry Sharpless and Michael G. Finn
19. "Reduction of Organic Compounds: Theory and Practice" by A. Zaks and A. B. Sowers
20. "Name Reactions and Reagents in Organic Synthesis" by Bradford P. Mundy, Michael G. Ellerd, and Frank G. Favaloro Jr.
21. "Strategic Applications of Named Reactions in Organic Synthesis" by Laszlo Kurti and Barbara Czako.
22. "Comprehensive Organic Name Reactions and Reagents" edited by Zerong Wang
23. "The Art of Writing Reasonable Organic Reaction Mechanisms" by Robert B. Grossman.

24. “Principle of Organic Synthesis” by R. O. C Norman and J. H. Coxon, 1st Ed, ELBS, 1993.
25. “Organic synthesis” by Micheal B Smith

26. “Modern methods of organic synthesis” by W. Carruthers
27. “Principle of Organic Synthesis” by R. O. C Norman and J. H. Coxon, 1st Ed, ELBS, 1993.
28. “Reagents for Organic synthesis” by L. W. Paqueette (Ed), John Wiley, 1995.
29. “Handbook of Reagents for Organic Synthesis: Reagents for Heteroarene Synthesis” by Andre B. Charette, Wiley-Blackwell, 1 edition, 2017.
30. “Protective Groups in Organic Synthesis” by T.W. Greene Wiley-VCH, 1999. 2. B. P.
31. “Name Reactions and Reagents in Organic Synthesis” by Mundy, M. G. Ellerd, and F. G. Favaloro Jr., Wiley, 2nd Ed. 1988.

Web links:

1. Organic Syntheses: Organic Syntheses is a peer-reviewed journal that publishes detailed experimental procedures for various organic transformations, including Name Reactions. You can access their website here: https://www.orgsyn.org/
2. Organic Chemistry Portal - Name Reactions: The Organic Chemistry Portal offers a comprehensive collection of articles, reviews, and resources on various Name Reactions in organic synthesis. You can access it here: https://www.organic-chemistry.org/namedreactions/
3. Organic Chemistry Portal - Reagents in Organic Synthesis: The Organic Chemistry Portal also provides a section on Reagents in Organic Synthesis, where you can find information on various reagents used in organic transformations. You can access it here: https://www.organic-chemistry.org/topics/reagents/
4. Organic photochemistry and pericyclic reactions
https://nptel.ac.in/courses/104105038

5. Reagents in Organic Synthesis https://onlinecourses.nptel.ac.in/noc21_cy42/preview
6. Principles of Organic Synthesis https://onlinecourses.nptel.ac.in/noc21_cy41/preview

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Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-303 (iii)	**Physical Chemistry special paper-I (Polymer Chemistry) (DSE-I)**	**60 hrs (4 hrs/week)**

Course outcomes:

1. Demonstrate a comprehensive understanding of the basic concepts of polymers, including monomers, repeat units, and degree of polymerization.
2. Identify and classify different types of polymers based on their structure, composition, and polymerization techniques.
3. Apply knowledge of polymer processing techniques to produce plastic, elastomer, and fiber-based products using various processing methods.
4. Analyze and interpret the chemical reactions involved in polymerization, including condensation, addition, and copolymerization reactions.
5. Utilize different characterization techniques to determine the molecular weight, polydispersity, and other properties of polymers.
6. Perform chemical analysis, X-ray diffraction, microscopy, and physical testing to evaluate the properties of polymers.
7. Evaluate the degradation mechanisms of polymers and understand the impact of thermal, mechanical, and environmental factors on polymer stability.
8. Analyze the structure and properties of polymers, including crystalline morphology, glass transition temperature, and the influence of molecular weight and chemical structure on polymer properties.
9. Apply knowledge of polymer composites to design and fabricate materials with enhanced properties through the incorporation of reinforcement materials.
10. Examine the characteristics and applications of specific polymers such as polyethylene, polyvinyl chloride, polyamide, polyester, phenolic resin, epoxy resin, silicone polymer, and electrically conducting polymers.
11. Synthesize and apply theoretical concepts to solve numerical problems related to polymer properties, molecular weight, and processing parameters.

Unit-I: Polymers, Polymer Processing and Reactions (15 hours)

A) ***Basic concepts:*** Monomers, repeat units, degree of polymerization, linear branches, and network polymers. Classification of polymers. Polymerization: condensation, addition, radical chain, ionic and coordination, and copolymerization. Polymerization conditions and polymer reactions, polymerization in homogeneous and heterogeneous systems.

B) ***Polymer processing:*** Plastics, elastomers, and fibers. Compounding, processing techniques: calendaring, die casting, rotational casting, film casting, injection molding, blow molding, extrusion molding, thermoforming, foaming, reinforcing, and fiber

spinning.

C) ***Polymer reactions:*** Hydrolysis, acetolysis, aminolysis, hydrogenation, addition and substitution reactions, reactions of various specific groups, cyclization reactions, and cross-linked reactions, reactions leading to graft and block copolymers, miscellaneous reactions.

Unit-II: Polymer Characterization and Degradation (15 hours)

A) ***Molecular weight of polymers:*** Polydispersion, average molecular weight concept. Number, weight, and viscosity average molecular weight. Polydispersity and molecular weight distribution. The practical significance of molecular weight. Measurement of molecular weight. End groups, viscosity, light scattering, osmotic, and ultra-centrifugation methods. Numerical problems.

B) ***Analysis and testing of polymers:*** chemical analysis of polymers, X-ray diffraction study, microscopy. Thermal analysis and physical testing: tensile strength, fatigue impact, tear resistance, hardness, and abrasion resistance.

C) ***Polymer degradation:*** Definition, types of degradation, including thermal, mechanical, degradation by ultrasonic waves, photo degradation, degradation by high-energy radiation, oxidative and hydrolytic degradation.

Unit-III: Structure and Properties of Polymers (15 hours)

A) ***Structure:*** Morphology and order in crystalline polymers, configuration of polymer chains. Crystal structure of polymers. Morphology of crystalline polymers, strain-induced morphology, crystallization, and melting.

B) ***Properties:*** Physical properties, crystalline melting point, Tm (melting point) of homogeneous series, effect of chain flexibility and other steric factors. Entropy and heat of fusion, the glass transition temperature, the relation between Tg (glass transition temperature) and Tm. Effect of molecular weight, diluents, chemical structures, chain topology, branching, and cross-linking. Property requirements and polymer utilization. Numerical problems.

Unit-IV: Polymer Composites and Functional Polymers (15 hours)

A) ***Polymer composites:*** Polymer matrix materials, reinforcement, properties of composites and composite systems. Fabrication of polymer composites, processing science, and quality assurance of composites, environmental effects on composites, smart composites.

B) ***Study of specific polymers:*** Polyethylene, polyvinyl chloride, polyamide, polyester, phenolic resin, epoxy resin, and silicone polymer. Functional polymer: electrically conducting polymers.

Text & Reference Books:

1. A Textbook of Polymer Science by Billmeyer, Jr. Wiley
2. Polymer Science by V.R. Gowarikar, N.V. Vishwanathan & J. Sreedhar, Wiley Eastern.
3. Physical Chemistry Polymers by D.D. Deshpande, Tata McGraw Hill.
4. Principles of Physical Chemistry by P.J. Flory, Cornell University Press.
5. Introduction to Polymer Chemistry by R.B. Seymour, McGraw Hill.
6. A Practical Course in Polymer Chemistry by S.J. Pnnea, Program Press.
7. Polymer Composites by M.C. Gupta & A.P. Gupta, New Age International Publication

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Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-303 (iv)	**Analytical Chemistry special paper-I (Advanced Analytical Techniques: Sampling, Optical Methods of Analysis) (DSE-I)**	**60 hrs (4 hrs/week)**

Course outcomes:

1. Demonstrate knowledge of sampling techniques and sample treatment methods for different types of samples.
2. Understand the principles and operational aspects of atomic absorption spectrometry.
3. Explain the working principles and applications of atomic emission and atomic fluorescence spectrometry.
4. Discuss the instrumentation and methodologies used in X-ray fluorescence, emission spectroscopy, and electron microscopy.
5. Analyze and interpret data obtained from these analytical techniques.
6. Identify and troubleshoot common issues and interferences in analytical measurements.
7. Apply the learned techniques in practical applications and research projects in the field of chemical analysis.

Syllabus:

Unit-I: Sampling and Quantification (15 hours)

Sampling and Sample Treatment:

- Criteria for obtaining a representative sample
- Techniques for sampling gases (ambient air and exhaust gases), liquids (water and milk samples), solids (soil and coal samples), and particulates
- Sampling of hazardous materials and safety considerations in handling hazardous chemicals

Sample Dissolution Methods for Elemental Analysis:

- Dry and wet ashing techniques
- Acid digestion method
- Fusion processes for sample dissolution
- Dissolution methods for organic samples

Detection and Quantification:

- Concepts and distinctions among sensitivity, limit of detection, and limit of quantification in analytical techniques
- The role of noise in determining the detection limit of analytical methods
- Units used in chemical analysis and their interconversion

Unit-II: Atomic Absorption Spectrometry (15 hours)

Atomic Absorption Spectroscopy (AAS):

- Principle of AAS and the concept of atomic energy levels
- Understanding Grotrian diagrams and population of energy levels
- Instrumentation involved in AAS analysis
- Sources used in AAS: Hollow cathode lamp and electrodeless discharge lamp, and factors affecting spectral width
- Atomizers used in AAS: Flame atomizers, graphite rod, and graphite furnace
- Cold vapor and hydride generation techniques in AAS
- Factors influencing atomization efficiency and flame profile
- Monochromators and detectors used in AAS analysis
- Beam modulation techniques in AAS
- Detection limit, sensitivity, and considerations for AAS analysis
- Interferences in AAS and methods for interference removal
- Comparison between AAS and flame emission spectrometry
- Applications of AAS in analytical chemistry

Unit-III: Atomic Emission & Atomic Fluorescence Spectrometry (15 hours)

Atomic Emission Spectrometry(AES):

Principle of Atomic Emission Spectrometry

- Overview of atomic emission spectrometry
- Atomic emission spectrometry using plasma sources
- Introduction to different types of plasma sources

Plasma and its Characteristics

- Inductively Coupled Plasma (ICP)
- Direct Current Plasma (DCP)
- Microwave Induced Plasma (MIP)
- Reasons for using argon as the plasma gas

Instrumentation for ICP-AES

- Sample introduction techniques in ICP-AES
- Monochromators for wavelength selection
- Detectors for signal detection
- Processing and readout devices for data analysis

Types of Instruments for ICP-AES

- Sequential spectrometers
- Simultaneous spectrometers

Analytical Methodology in ICP-AES

- Qualitative analysis using ICP-AES
- Quantitative analysis using ICP-AES

Interferences in ICP-AES

- Spectral interferences
- Physical interferences
- Chemical interferences

Applications of ICP-AES

- Overview of application areas for ICP-AES

Atomic Fluorescence Spectrometry

Origin of Atomic Fluorescence

- Explanation of atomic fluorescence phenomenon
- Atomic fluorescence spectrum
- Types of atomic fluorescence transitions

Principle of Atomic Fluorescence Spectrometry

- Understanding the relationship between fluorescence intensity and analyte concentration
- Factors influencing fluorescence intensity

Instrumentation for Atomic Fluorescence Spectrometry

- Overview of AFS instrumentation
- Radiation sources used in AFS
- Atom reservoirs for sample introduction
- Monochromators for wavelength selection
- Detectors for signal detection
- Readout devices for data analysis

Applications of Atomic Fluorescence Spectrometry

- Overview of application areas for AFS
- Interferences in AFS analysis
- Merits and limitations of AFS technique

Unit-IV: *X-ray Fluorescence, Emission Spectroscopy and Electron Microscopy* (15 hours)

X-ray Fluorescence Spectroscopy (XRF):

- Principle of XRF spectroscopy
- Instrumentation: Wavelength dispersive XRF and energy dispersive XRF devices
- Sources and detectors used in XRF analysis
- Comparison between wavelength dispersive and energy dispersive techniques
- Sample preparation methods for XRF analysis
- Matrix effects in XRF analysis
- Applications of XRF in qualitative and quantitative analysis

Particle Induced X-ray Emission (PIXE):

- Basic principle of PIXE
- Instrumentation used in PIXE analysis
- Applications of PIXE in analytical chemistry

Electron Microscopy:

- Principle of electron microscopy
- Instrumentation involved in scanning electron microscopy (SEM) and transmission electron microscopy (TEM)
- Applications of SEM and TEM in various fields of study

Textbooks & Reference Books:

1. "Principles of Instrumental Analysis" by Douglas A. Skoog, F. James Holler, and Stanley R. Crouch
2. "Atomic Absorption Spectrometry" by Bernard L. Sharp
3. "Introduction to X-ray Spectrometry" by Ronald Jenkins and Robert L. Snyder
4. "Scanning Electron Microscopy and X-ray Microanalysis" by Joseph I. Goldstein, Dale E. Newbury, et al.
5. "Analytical Chemistry: Principles and Techniques" by Higson, Barry R.
6. "Handbook of X-ray Spectrometry" by Rene Van Grieken and Andrzej Markowicz
7. "Introduction to Analytical Electron Microscopy" by J. Hren, J. I. Goldstein, et al.
8. "Atomic Spectroscopy: Introduction to the Theory of Hyperfine Structure" by K. Siegbahn

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Semester III

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-303 (v)	**Industrial Chemistry special paper-I (Heat Transfer, Mass Transfer and Unit Processes) (DSE-I)**	**60 hrs (4 hrs/week)**

Course Outcomes: At the end of the course students will be able to

1. understand the basics of heat Transfer and Fluid Flow.
2. Apply the principles involved in unit operations in industry.
3. have mechanistic aspects of various Industrial Equipment's.
4. understand the mode of action of various agents used during organic process synthesis.
5. solve the Material balance calculations.

Unit – I : **15 H**

A) Fundamentals of Heat transfer: Methods of heat transfer, Fourier s law, Newton s law, heat transfer by conductance, by convection and by radiation. Heat exchanger, types of heat exchanger, overall heat transfer co-efficient, double pipe heat exchanger, Shell & tube type etc.

B) Fluid flow: Fluid flow phenomenon, introduction, Laminar flow, Turbulant flow, Reynolds number, Bernoulli equation, fans, blowers, compressors, pumps etc.

Unit – II: **A) Unit Operations:** **15 H**

i) Distillation: Flash distillation, differential distillation, rectification, plate columns, packed columns.

ii) Evaporation: Introduction, short tube evaporator, forced circulation evaporator, falling film,climbing film, agitated evaporators.

iii) Crystallization: Introduction, solubility, super-saturation, nucleation, crystal growth,equipments: tank crystallizer, Vacuum Crystallizer, Draft Tube Crystallizer.

iv) Drying: Introduction, free moisture, bound moisture, drying curve, equipments: tray dryer,fluid bed dryer, drum dryer, spray dryer.

v) Extraction: Introduction, selection of solvent, single stage and multistage extraction, spray column, packed column, mixer settler.

B) Material balance without chemical reactions, flow diagram, without recycle or by-pass for above processes. Concept of limiting reactant, excess reactant, yield and selectivity, stoichiometric coefficient and stoichiometric equation Problems based on above.

Unit – III : **15 H**

A) Nitration: Introduction, nitrating agents, equipment for nitration, manufacturing and mechanism of nitrobenzene, Ortho and para nitrochlorobenzene

B) Amination by reduction: Introduction, methods of reduction, metal & acid reduction, sulphide reduction, metal & alkali reduction, manufacturing and mechanism of aniline, meta nitro aniline.

C) Halogenation: introduction, halogenating agents, aromatic halogenation, manufacturingand mechanism of chlorobenzene, dichlorofluromethane

Unit – IV : **15 H**

A) Sulphonation: Introduction, sulphonating agents, factors affecting sulphonation, equipment, manufacturing and mechanism of benzene sulphonic acid, sulphonation of anthraquinone

B) Oxidation: Introduction, oxidizing agents, vapour & liquid phase oxidation, manufacturing and mechanism of acetic acid, acetaldehyde, benzoic acid

C) Alkylation: Introduction, alkylating agents, factors affecting alkylation, manufacturing and mechanism of ethyl benzene, phenyl ethyl alcohol.

Books Suggested:

1) Heat transfer By Arora and Damkondwar, Pune
2) Heat and Mass transfer by A, G. Gavhane, Nirali Prakashan. Pune VOL I & II.
3) McCabe and Smith, Unit operations of Chemical Engineering, McGraw Hill.
4) Budger and Banchero, Introduction to Chemical Engineering McGraw Hill.
5) Text Book of Industrial Chemistry Pragati Agencies Pune.
6) Engineering Chemistry By Dr. S. S. Dara.
7) Unit Process in Organic Synthesis, by P. H. Grogins.
8) Shreve s Chemical Process Industries edited by Austin, McGraw-Hill.
9) Dryden s outlines of Chemical Technology, edited by M.Gopal Rao and M.Sittig,
10) Industrial Chemistry by B.K.Sharma
11) Hand book of industrial chemistry Vol I & II K. H. Davis & F.S. Berner Edited by S.C.Bhatia, CBS publishers

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CY-304 (i)	**Inorganic Chemistry special paper-II Solid State Chemistry (DSE-II)**	**60 rs (4 hrs/week)**

Course outcomes: At the end of the course students would be able to

1. Explain principles and concepts of solid state chemistry, including crystal structures, crystallography, and crystal systems.
2. Corelate crystal structures with physical properties of solids, such as electrical conductivity, thermal conductivity, magnetism, and optical properties.
3. Describe the various types of crystal defects and their impact on the properties and behavior of solid materials.
4. Analyze the structure-property relationships in different classes of materials, including metals, semiconductors, insulators, ceramics, and polymers.
5. Classify the material on the basis of their magnetic properties

Unit-I: 15 hrs

A) **Crystal Structure of Some Simple Compounds:** Ionic Crystals & their structures, radius ratio rule, effect of polarization on crystals; Covalent structure type-Diamond, Sphalerite & Wurtzite; Geometry of different types of crystals of binary compounds- AB type: NaCl, CsCl & NiAs &Wurtzite, AB_2 type: Fluorite, antifluorites, Rutile structures. Li_2O, Na_2O, etc. $CdCl_2$, CdI_2 structures and difference between them, AB_3 type: ReO_3, BiI_3, $CrCl_3$ etc. and A_2B_3 type: Fe_2O_3, Corundum Al_2O_3, Mn_2O_3 etc.; Geometry of Ternary Compounds-ABO_3 type: Perovskite, Barium titanate & lead titanate, AB_2O_4 type compounds- Normal & inverse spinel structures, Factors causing distortion in spinel.

B) **Lattice Defects:** Perfect &Imperfect crystals, point defects**,** Interstitial, Schottky defect, Frenkel defect, line defect & other entities, thermodynamics of Schottky & Frankel defects; Dislocation, theory of dislocation, plane defects-Lineage boundary, grain boundary, stacking fault, 3D defects. pyknometric & electrical conductivity methods of study of defects, colour centers.

Unit-II : 15 hrs

A) Electronic Properties of materials:Electronic structure of solid (metals, Insulators and semiconductors); Structure of metals, insulators and semiconductors on the basis of band theory; Intrinsic and extrinsic semiconductors, doping of semiconductors and conduction mechanism; temperature dependence of conductivity, Seebeck effect & Hall effect; synthesis and purification of semiconducting materials, single crystal growth, zone refining, fractional crystallization, photoconductors, photovoltaic cells, solar batteries; Types of ionic conductors, mechanism of ionic conduction, diffusion, superionic conductors, Phase-transitions & mechanism of conduction in super ionic conductors, applications of ionic conductors; Metal complexes as semiconductors.

B) Dielectric polarization: Introduction, piezo-electricity, pyroelectricity, ferrielectricity, antiferroelectricity, ferroelectricity & their applications.

Unit III : 15 hrs

A) Superconductivity: Introduction, discovery, magnetic properties of super conductor, theory of super conductivity, Meissner effect, type I & II superconductors, Josephson effects; High-temperature superconductor; crystal structure of high temperature semiconductors & their applications.

B) Magnetic Properties of Materials: Introduction, electronic spin and magnetic moment, magnetic susceptibility and magnetization; Classification of materials; diamagnetism and paramagnetism in metal complexes, ferromagnetic metals and compound (CrO_2), antiferromagnetic transition metal monoxides, ferrimagnetisms(ferrites); Magnetic anisotropy, magnetostriction;

Cooperative phenomena- magnetic domains, domain theory of ferromagnetism, hysteresis loops (hard & soft magnetic materials); Magnetic storage & applications of magnetic materials; Spin glasses.

Unit IV: Lasers in Chemistry: 15 hrs

General principles of laser action, stimulated emission, rates of absorption and emission; Einstein coefficients, population inversion, three-level and four-level laser systems, methods of Pumping action; Laser cavity – resonant modes; Laser pulses and their characteristics; Sol id-state lasers, gas lasers, chemical and excimer lasers;

Applications of lasers in chemistry; Femtochemistry, the pump-probe technique; Photodissociation of ICN; Lasers and multiphoton spectroscopy – underlying principles. Two-photon spectra of diphenyloctatetraene; Lasers in fluorescence spectroscopy and Raman spectroscopy.

Text books/Reference books:

1. Azaroff L. V., Introduction to solids, TMH.
2. West A. R., Solid state chemistry and its applications, Plenum.
3. Rao C. N. R, Solid state chemistry, Dekkar.
4. Hagenmuller, Preprative methods in solid state chemistry.
5. Keer H.V., Principal of the solid state, Wiley Eastern.
6. Hannay N. B, Solid state chemistry.
7. Chakrabarty D. K., Solid state chemistry, New Age Int.
8. West A. R., Solid state chemistry, John Wiley.
9. Pillai S. O., Solid state physics, Academic press.
10. Rey T. J., The defects solid state, Interscience.
11. Azoroof L. V. and Brophy J.J., Electronic process in materials, McGraw Hills.
12. Anderson and Leaver, Materials science.
13. Kirkendale, Analytical methods of materials investigations.
14. Greenwood N. N., Ionic crystals, lattice defects and nonstoichiometry, Butter worth
15. Kroger Chemistry of imperfect crystals, Holland.
16. Callister W. D. Jr., Material science and engineering, an introduction, Wiley India
17. Van Bueren H. G., Imperfection in crystals, Wiley-Interscience.
18. Brandon D and Kaplan W. D., Microstructural characterization of materials, Wiley NY.
19. Hummel R. E., Electronic Properties of materials, Springer-Verlag.
20. Solymar L. and Walsh D., Electrical properties of materials, Oxford University Press.
21. Jiles D., Introduction to magnetism and magnetic materials, Nelson Thornes, Cheltenham.
22. Kotz J.C. and Treichel P. Jr. chemistry and chemical reactivity, Saunders.

23. Masterton W. L. and Hurley C.N. Chemistry, principals and reactions, Harcourt.

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CY-304 (ii)	**Organic Chemistry special paper-II (Drugs Chemistry) (DSE-II)**	**60 hrs (4 hrs/week)**

Course outcomes:

1. Demonstrate knowledge of the molecular targets for drug action, such as enzymes, receptors, and nucleic acids, and their role in disease processes.
2. Explain the principles of structure-activity relationship (SAR) and the importance of molecular recognition and binding interactions in drug design.
3. Analyze the principles and techniques of computational drug design, including molecular modeling, virtual screening, and quantitative structure-activity relationship (QSAR) studies.
4. Describe the methods used for target identification, validation, and selection in the drug discovery process.
5. Apply knowledge of drug metabolism and pharmacokinetics to optimize drug candidates for improved bioavailability, efficacy, and safety.
6. Analyze the role of medicinal chemistry in drug design, including the design and synthesis of small molecules as drug candidates.
7. Apply the principles of drug design to propose rational strategies and approaches for the development of novel therapeutic agents for specific diseases or targets.

Unit I: 15h

A) General aspects of drug:

I. Historical Aspects: Overview of the historical development of drugs

II. Definitions Used in Drug Chemistry-Pharmacy: Definitions in drug chemistry, pharmacy, pharmacology, and pharmacodynamics, understanding terms such as IC50, LD50, ED50 (Mathematical derivatives of equations included), metabolites, antimetabolites, gram-positive and gram-negative bacteria, viruses, actinomycetes, mutation, chemotherapy, and nomenclature of medicinal compounds

B) Chemotherapeutic Agents: Introduction to cancer chemotherapy, Synthesis of specific chemotherapeutic agents, including mechloraethamine, cyclophosphamide, mephalan, and uracils, Recent developments in cancer chemotherapy

C) Pharmacodynamic Agents and Mechanism of Chemotherapeutic Action: Overview of pharmacodynamic agents, Understanding the mechanisms of chemotherapeutic action, including biological defenses, chemical defenses, surface-active agents, and metabolic antagonism

Unit II 15h

A) Drugs Design:

I. Classification of Drugs: Overview of drug classification based on various criteria

II. Procedures Followed in Drug Design: Introduction to the general procedures followed in drug design

III. Concept of Lead Compound and Modification: Understanding the concept of lead compounds in drug design. Importance of modification in optimizing drug properties

IV. Concept of Prodrugs and Soft drugs: Understanding the concept of prodrugs and their applications in drug design, Introduction to the concept of soft drugs and their advantages

B) Structure-Activity Relationship (SAR): Factors affecting bioactivity in SAR, Resonance, inductive effect, isosterism, biosterism, spatial considerations, Free Wilson analysis, Structure-Based Drug Design, Theories of drug activity: occupancy theory, rate theory, induced fit theory, Virtual Screening, Ligand-Based Drug Design, Quantitative structure-activity relationship (QSAR): history, development, Hansch analysis, and applications

C) Drug-Receptor Interaction and Physico-Chemical Parameters: Concept of drug-receptor interaction, Physico-chemical parameters influencing drug activity, Lipophilicity, Partition coefficient, Electronic and ionization constants, Steric, shelton, and surface activity parameters, Redox potential

Different Approaches in Drug Design:

Fragment-Based Drug Design, Natural Products-Based Drug Discovery

Unit III Classes of Drugs-I 15h

A) Antibiotics:

Introduction to antibiotics, Synthesis, mode of action, pharmacokinetics, pharmacodynamic data, and secondary metabolism of:

1. Penicillin V and G
2. Streptomycin
3. Chloramphenicol
4. Tetracyclines

B) Antimalarial Drugs:

Chemotherapy of malaria, Synthesis, mode of action, pharmacokinetics, pharmacodynamic data, and secondary metabolism of:

1. Aminoquinolines
2. Pamaquine
3. Chloroquine
4. Sulphones

C) Antipyretic and Analgesic Drugs:

Synthesis, mode of action, pharmacokinetics, pharmacodynamic data, and secondary metabolism of:

1. Aspirin
2. Salol
3. Phenacetin
4. Antipyrin

D) Anti-inflammatory Drugs:

Synthesis, mode of action, pharmacokinetics, pharmacodynamic data, and secondary metabolism of:

1. Ibuprofen
2. Oxyphenylbutazone
3. Diclofenac
4. Indomethacin

E) Sedatives and Hypnotics:

Barbiturates: mode of action, Synthesis, mode of action, pharmacokinetics, pharmacodynamic data, and secondary metabolism of:

1. Diazepam
2. Caffeine
3. Mescaline
4. Hermine

Unit IV Classes of Drugs- II 15 h

A) Antitubercular and Antileprotic Drugs:

Synthesis, mode of action, pharmacokinetics, pharmacodynamic data, and secondary metabolism of:

1. Ethambutol
2. Isoniazid
3. Dapsone

B) Anaesthetics:

Synthesis, mode of action, pharmacokinetics, pharmacodynamic data, and secondary metabolism of:

1. Lidocaine
2. Thiopental

C) Antihistamines:

Synthesis, mode of action, pharmacokinetics, pharmacodynamic data, and secondary metabolism of:

1. Phenobarbital
2. Diphenylhydramine

D) Tranquilizers:

Synthesis, mode of action, pharmacokinetics, pharmacodynamic data, and secondary metabolism of:

1. Diazepam
2. Trimeprazine

E) Cardiovascular Drugs:

Synthesis of:

1. Diltiazem
2. Quinidine
3. Methyldopa

Text books/Reference books:

1. "Basic & Clinical Pharmacology" by Bertram G. Katzung.
2. "Goodman & Gilman's The Pharmacological Basis of Therapeutics" by Laurence L. Brunton, Bjorn C. Knollmann, and Randa Hilal-Dandan.
3. "Pharmacology: Principles and Practice" by Miles Hacker, William S. Messer Jr., and Kenneth A. Bachmann.
4. "Pharmacology" by Rang, Dale, Ritter, Flower, and Henderson.
5. "Basic Concepts in Pharmacology: What You Need to Know for Each Drug Class" by Janet L. Stringer.
6. "Principles of Pharmacology: The Pathophysiologic Basis of Drug Therapy" by David E. Golan, Armen H. Tashjian Jr., Ehrin J. Armstrong, and April W. Armstrong.
7. "Drug-like Properties: Concepts, Structure Design and Methods" by Li Di and Edward H. Kerns.

8. "Drug Design: Structure- and Ligand-Based Approaches" by Kenneth M. Merz Jr. and Dagmar Ringe.
9. "Computer-Aided Drug Design: Methods and Applications" edited by Jürgen Bajorath.
10. "Principles of Drug Design and Drug Discovery" by Dike G. Mba.
11. "Drug Discovery: A Casebook and Analysis" by Walter Cabri and Gérard Dijoux.
12. "The Art of Drug Discovery: From Nature to the Lab" by Oleg Ursu, Tudor I. Oprea, and Alexey Lagunin.
13. "Classification and Nomenclature of Drugs" by David E. Golan and Armen H. Tashjian Jr.
14. "Goodman & Gilman's The Pharmacological Basis of Therapeutics" by Laurence L. Brunton, Bjorn C. Knollmann, and Randa Hilal-Dandan.
15. "Pharmacology" by Rang, Dale, Ritter, Flower, and Henderson.
16. "Lippincott Illustrated Reviews: Pharmacology" by Karen Whalen and Richard A. Harvey.
17. "The Top 100 Drugs: Clinical Pharmacology and Practical Prescribing" by Andrew Hitchings, Dagan Lonsdale, and Daniel Burrage.

Web links

1. Drugs.com - Drug Classes: Drugs.com provides a comprehensive database of drugs and their classifications. You can search for specific drugs or explore different drug classes and categories. Visit the website here: https://www.drugs.com/drug-class/
2. World Health Organization (WHO) - ATC Classification: The WHO uses the Anatomical Therapeutic Chemical (ATC) Classification System to categorize drugs. You can find information on different drug classes and their respective codes on the WHO website. Visit the website here: https://www.whocc.no/atc_ddd_index/
3. U.S. Food and Drug Administration (FDA): The FDA website provides comprehensive information on various aspects of drugs, including drug approval, safety, labeling, and regulations. Visit the website here: https://www.fda.gov/drugs
4. World Health Organization (WHO) - Medicines: The WHO website offers resources and information on medicines, including topics such as drug safety, regulations, and access to essential medicines. Explore it here: https://www.who.int/medicines/en/
5. National Institute on Drug Abuse (NIDA): NIDA provides information on drugs, drug abuse, and addiction. Their website offers resources, research findings, and educational materials on drug-related topics. Visit the website here: https://www.drugabuse.gov/
6. Centers for Disease Control and Prevention (CDC) - Prescription Drug Overdose: The CDC website provides information on prescription drug overdose, including statistics, prevention strategies, and resources for healthcare professionals and the general public. Explore it here: https://www.cdc.gov/drugoverdose/index.html
7. National Library of Medicine (NLM) - Drugs and Lactation Database (LactMed): LactMed is a database provided by the NLM that provides information on drugs and their potential effects during breastfeeding. Access it here: https://toxnet.nlm.nih.gov/newtoxnet/lactmed.htm

Sant Gadge Baba Amravati University, Amravati
Syllabus Prescribed for Two Year PG Programme
Programme: MSc Chemistry (Choice Based Credit System)
Semester III

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-304 (iii)	**Physical Chemistry special paper-II (Electrochemical Processes and Applications) (DSE-II)**	**60 hrs (4 hrs/week)**

Course outcomes: By the end of the course, students will be able to:

1. Define and explain the key terms and concepts in electrochemistry.
2. Balance redox equations and determine the standard electrode potentials.
3. Calculate cell EMF and understand the thermodynamic feasibility of electrochemical reactions.
4. Apply the Nernst equation to analyze the effects of temperature and concentration on cell potential.
5. Describe the kinetics of electrode reactions using the Butler-Volmer equation and the Tafel plot.
6. Analyze the factors influencing the reversibility of electrochemical processes.
7. Understand the principles and applications of electrochemical instrumentation and techniques.
8. Explain the structure and dynamics of electrical double layers and their role in energy devices.
9. Differentiate between Faradaic and non-Faradaic charging mechanisms in energy storage systems.
10. Discuss the working principles and mechanisms of operation of electrochemical capacitors.
11. Evaluate the materials development and advancements in supercapacitor technology.
12. Describe the redox reactions and operation mechanisms of batteries, including metal-ion and metal-based rechargeable batteries.
13. Discuss the evolution of battery technologies and emerging trends.
14. Understand the principles and challenges of battery management systems.
15. Identify real-life applications of electrochemical processes in energy storage, renewable energy systems, and electronic devices.

UNIT I **15 h**

Unit 1A: Introduction to Basics of Electrochemical Processes

1. *General electrochemical concepts*
   - Definition and scope of electrochemistry
   - Importance of electrochemical processes in various fields
   - Key terms and definitions in electrochemistry
2. *Redox reactions*
   - Oxidation and reduction processes
   - Balancing redox equations
   - Redox couples and their notation
3. *Reference electrodes*
   - Purpose and function of reference electrodes
   - Standard hydrogen electrode (SHE) and other reference electrodes

- Construction and potential measurement of reference electrodes

4. *Galvanic and electrolytic cells*
   - Distinction between galvanic and electrolytic cells
   - Cell notation and representation of cell reactions
   - Cell potential and EMF (Electromotive Force)

Unit 1B: Thermodynamics of Electrochemical Cells

1. *Electrode potentials*
   - Standard electrode potentials and their determination
   - Significance of electrode potentials in redox reactions
2. *Half reactions and reduction potentials*
   - Definition and representation of half reactions
   - Reduction potentials and their relation to standard electrode potentials
3. *Reversibility*
   - Reversible and irreversible electrochemical processes
   - Factors influencing the reversibility of reactions
4. *Free energy and cell EMF*
   - Relationship between free energy and cell EMF
   - Calculation of ΔG and ΔG° from cell potential
5. *Nernst Equation*
   - Derivation and applications of the Nernst equation
   - Temperature and concentration dependence of cell potential
6. *Liquid junction potentials*
   - Causes and effects of liquid junction potentials
   - Mitigation strategies for liquid junction potential effects

UNIT II **15h**

Unit 2A: Kinetics of Electrode Reactions

1. *Homogeneous kinetics*
   - Rate equations and rate constants for homogeneous reactions
   - The Arrhenius equation and its significance in electrochemistry
2. *Butler-Volmer model of electrode kinetics*
   - Derivation and interpretation of the Butler-Volmer equation
   - Influence of overpotential on electrode kinetics
3. *The standard rate constant and the transfer coefficient*
   - Definition and determination of the standard rate constant
   - Relationship between the transfer coefficient and electrode kinetics
4. *Microscopic theories of charge transfer*
   - Introduction to Marcus theory and its application to electron transfer reactions
   - Concepts of electron tunneling and reorganization energy
5. *Tafel plot*
   - Interpretation and application of Tafel plots in electrochemical kinetics

- Determination of rate constants and reaction mechanisms

6. *Multistep electrode reactions*
   - Description and analysis of multistep electrode reactions
   - Rate-determining steps and reaction intermediates
7. *Charge transfer at electrode-solution interfaces*
   - Description of charge transfer processes at the electrode-electrolyte interface
   - Influence of adsorption and surface phenomena on electrode reactions
8. *Quantization of charge transfer*
   - Introduction to charge quantization and its implications in electrochemical reactions

Unit 2B: Mass Transfer by Migration and Diffusion

1. *General mass transfer equation*
   - Overview of mass transfer phenomena in electrochemical systems
   - Governing equations for migration and diffusion processes
2. *Migration*
   - Definition and mechanisms of migration in electrolytes
   - Migration velocities and their dependence on electric field and ion mobility
3. *Diffusion*
   - Fick's Laws of diffusion and their applications in electrochemistry
   - Diffusion coefficients and concentration profiles in solutions
4. *Combined migration and diffusion*
   - Effects of migration and diffusion on species distribution near electrodes
   - Concentration polarization and its consequences in electrochemical cells

UNIT III **15h**

Unit 3A: Electrochemical Instrumentation and Techniques

1. *Linear sweep voltammetry*
   - Principles and applications of linear sweep voltammetry
   - Determination of electrochemical parameters from voltammograms
2. *Cyclic voltammetry*
   - Basics of cyclic voltammetry and its experimental setup
   - Interpretation of cyclic voltammograms and identification of redox processes
3. *Chronopotentiometry*
   - Principles and applications of chronopotentiometry
   - Measurement of current and potential transients
4. *Chronoamperometry*
   - Theory and applications of chronoamperometry
   - Analysis of current-time transients and determination of rate constants
5. *Concepts of impedance*
   - Introduction to impedance spectroscopy and its principles
   - Interpretation of impedance spectra and determination of electrochemical parameters

Unit 3B: Applied Electrochemistry with a Focus on Energy Devices

1. *Electrical Double Layers*
   - Introduction to electrical double layers (EDL)
   - Components of EDL: Stern layer and diffuse layer
   - Charge distribution and potential distribution across the EDL
2. *Structure and Dynamics of Double Layers*
   - The Gouy-Chapman theory and the concept of surface potential
   - The Helmholtz layer and the development of the Stern layer
   - Effect of electrolyte concentration on the EDL structure
3. *Faradaic and Non-Faradaic Charging Mechanisms*
   - Faradaic processes: Redox reactions at the electrode-electrolyte interface
   - Non-Faradaic processes: Ion adsorption/desorption without redox reactions
   - Contribution of Faradaic and non-Faradaic processes to charge storage

UNIT IV **15h**

Unit 4A: Electrochemical Capacitors

1. *Generation and Storing of Charges*
   - Introduction to electrochemical capacitors (ECs)
   - Mechanisms of charge storage in ECs
   - Double-layer capacitance and pseudocapacitance
2. *Derivation of Capacitance Equations*
   - Derivation of the parallel-plate capacitor equation
   - Extended capacitance equations for ECs
   - Relationship between charge, voltage, and capacitance
3. *Evolution of Capacitor Technologies*
   - Historical development of capacitor technologies
   - Advancements in ECs and their applications
4. *Materials Development for Supercapacitors*
   - Electrode materials for ECs
   - Carbon-based materials (activated carbon, carbon nanotubes)
   - Transition metal oxides and conducting polymers
   - Hybrid and composite electrode materials
5. *Working Principles and Mechanism of Operation*
   - Electrode-electrolyte interface and electrical double layer (EDL)
   - Faradaic and non-Faradaic charge storage mechanisms
   - Ion adsorption and ion desorption processes
6. *Real-life Applications of Supercapacitors*
   - Energy storage in renewable energy systems
   - Power backup and peak load management
   - Electric vehicle applications
   - Hybrid energy storage systems
   - Portable electronic devices

- Industrial and grid-scale applications

Unit 4B: Batteries

1. *Redox Reactions in Batteries*
   - Introduction to redox reactions in electrochemical cells
   - Oxidation and reduction half-reactions in batteries
   - Electrode materials and their redox properties
2. *Cell EMF*
   - Definition and significance of cell electromotive force (EMF)
   - Calculation of cell EMF using standard reduction potentials
   - Relationship between cell EMF and thermodynamic feasibility
3. *Evolution of Battery Technologies*
   - Historical development of battery technologies
   - Primary and secondary batteries
   - Advancements and emerging trends in battery technology
4. *Operation Mechanism of a Battery*
   - Basic components of a battery: electrodes, electrolyte, and separator
   - Working principles of galvanic cells and rechargeable batteries
   - Charge and discharge processes in a battery
5. *Advanced Batteries - Metal-Ion and Metal-Based Rechargeable Batteries*
   - Overview of metal-ion batteries (e.g., lithium-ion batteries)
   - Electrode materials and redox reactions in metal-ion batteries
   - Challenges and advancements in metal-ion battery technology
   - Introduction to metal-based rechargeable batteries (e.g., sodium-ion, magnesium-ion batteries)
   - Electrode materials and redox reactions in metal-based batteries
6. *Battery Management Systems*
   - Overview of battery management systems (BMS)
   - Battery charging and discharging control strategies
   - State-of-charge (SOC) and state-of-health (SOH) estimation
     Battery safety and protection mechanisms

Text & Reference Books & Journals:

1. Bard, A. J., & Faulkner, L. R. (2000). Electrochemical Methods: Fundamentals and Applications (2nd ed.). Wiley.
2. Newman, J., & Thomas-Alyea, K. (2012). Electrochemical Systems (3rd ed.). Wiley.
3. Compton, R. G., Banks, C. E., & Meadows, R. (2018). Understanding Voltammetry: Simulation of Electrode Processes (4th ed.). World Scientific Publishing.
4. Wang, J. (2008). Electrochemical Supercapacitors: Scientific Fundamentals and Technological Applications. Springer.
5. Argyropoulos, P., Gude, V. G., & Katsaounis, A. (Eds.). (2019). Redox Flow Batteries: Fundamentals and Applications. Elsevier.
6. Armand, M., & Tarascon, J. M. (2008). Building better batteries. Nature, 451(7179), 652-657.

7. Bruce, P. G., Freunberger, S. A., & Hardwick, L. J. (2012). Li-O2 and Li-S batteries with high energy storage. Nature Materials, 11(1), 19-29.
8. Goodenough, J. B., & Park, K. S. (2013). The Li-ion rechargeable battery: A perspective. Journal of the American Chemical Society, 135(4), 1167-1176.
9. Tarascon, J. M., & Armand, M. (2001). Issues and challenges facing rechargeable lithium batteries. Nature, 414(6861), 359-367.

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Syllabus Prescribed for Two Year PG Programme

Programme: MSc Chemistry (Choice Based Credit System)

Semester III

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-304 (iv)	**Analytical Chemistry Special Paper-II** **Chemical Analysis of Environmental and Industrial Samples (DSE-II)**	**60 hrs (4 hrs/week)**

Course Learning Outcomes: Upon completion of this course, students will be able to:

1. Apply appropriate techniques for soil analysis, including pH determination, nutrient analysis, organic matter assessment, and contaminant analysis.
2. Analyze fertilizers for nutrient content and understand the quality control processes.
3. Perform pesticide analysis and evaluate the environmental impacts of pesticide use.
4. Conduct chemical and mineralogical analysis of ores using wet chemical and instrumental methods.
5. Analyze coal for proximate and ultimate composition and determine its calorific value.
6. Conduct chemical analysis of Portland cement to assess its quality and performance.

Unit I: Soil Analysis (15 hours)

1. *Introduction to Soil Analysis:*
   - Importance of soil analysis in agriculture and environmental studies
   - Soil sampling techniques and sample collection methods
2. *Physical and Chemical Properties of Soil:*
   - Soil texture, structure, and composition
   - pH determination and soil acidity
   - Cation exchange capacity (CEC) and nutrient retention
3. *Nutrient Analysis in Soil:*
   - Determination of macro and micronutrients (N, P, K, Ca, Mg, Fe, Zn, etc.)
   - Methods for assessing nutrient availability and fertility status
4. *Soil Organic Matter and Soil Health:*
   - Analysis of organic matter content and humus fraction
   - Microbial activity and soil enzymatic analysis
   - Assessment of soil health parameters
5. *Soil Contaminant Analysis:*
   - Heavy metal analysis (Cd, Pb, As, etc.)
   - Soil pollution assessment and remediation strategies
6. *Soil Microbial Analysis:*
   - Enumeration and characterization of soil microorganisms
   - Assessment of microbial diversity and activity

Unit II: Fertilizers and Pesticide Analysis (15 hours)

1. *Fertilizer Analysis (3 hours)*
   - Determination of nutrient content in fertilizers (NPK analysis)

- Quality control and certification of commercial fertilizers

2. *Pesticide Analysis (4 hours)*
   - Overview of pesticide analysis techniques
   - Residue analysis and determination of pesticide concentrations
3. *Pesticide Formulations and Adjuvants (2 hours)*
   - Analysis of pesticide formulations (emulsifiable concentrates, wettable powders, etc.)
   - Role of adjuvants in pesticide efficacy and analysis
4. *Pesticide Fate and Environmental Impacts (3 hours)*
   - Pesticide degradation and persistence studies
   - Environmental risk assessment and monitoring
5. *Analytical Instrumentation in Soil, Fertilizer, and Pesticide Analysis (3 hours)*
   - Introduction to chromatographic and spectroscopic techniques
   - Instrumentation used for soil, fertilizer, and pesticide analysis

Unit III: Ores Analysis (15 hours)

1. *Introduction to Ores Analysis (1 hour)*
   - Importance and applications of ores analysis
   - Sample preparation and handling
2. *Chemical Analysis of Ores (8 hours)*
   - Determination of major elements (e.g., iron, copper, zinc) by wet chemical methods
   - Instrumental techniques for trace element analysis (e.g., atomic absorption spectroscopy, ICP-MS)
3. *Mineralogical Analysis of Ores (6 hours)*
   - X-ray diffraction (XRD) analysis for phase identification
   - Optical microscopy for mineral identification and characterization

Unit IV: Coal and Portland Cement Analysis (15 hours)

1. *Coal Analysis (8 hours)*
   - Proximate analysis: Determination of moisture, volatile matter, fixed carbon, and ash content
   - Ultimate analysis: Determination of carbon, hydrogen, nitrogen, sulfur, and oxygen content
   - Calorific value determination
2. *Portland Cement Analysis (7 hours)*
   - Chemical analysis of cement components (e.g., calcium oxide, silica, alumina, iron oxide)
   - Determination of fineness, setting time, and compressive strength

Text and Reference Books:

1. Sparks, D. L. (Ed.). (2003). Methods of Soil Analysis: Chemical Methods (Vol. 5). Soil Science Society of America.
2. Bremner, J. M. (Ed.). (1996). Nitrogen in Agricultural Soils. American Society of Agronomy.
3. Downey, P. M., & Frew, R. D. (1994). Pesticide Analysis: Instrumentation and Techniques. Wiley.
4. Hillel, D. (2003). Introduction to Environmental Soil Physics. Academic Press.
5. Jankowski, J., & Traversa, F. L. (Eds.). (2015). Analytical Techniques in Materials Conservation. Springer.
6. Komar, P. D. (2009). Cement Chemistry (2nd ed.). Springer.
7. Proctor, C. R., & Hester, R. E. (Eds.). (2012). Chemical Analysis of Water: General Principles and Techniques. Royal Society of Chemistry.
8. Reed, S. (2010). Electron Microprobe Analysis and Scanning Electron Microscopy in Geology. Cambridge University Press.
9. Sutton, R., & Sposito, G. (2004). Environmental Soil Chemistry. Academic Press.
10. Speight, J. (2008). Coal Analysis: Sampling, Testing, and Charting. Academic Press.
11. 11. Ramachandran, V. S., & Beaudoin, J. (Eds.). (2002). Handbook of Analytical Techniques in Concrete Science and Technology: Principles, Techniques, and Applications. William Andrew.

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Syllabus Prescribed for Two Year PG Programme
Programme: MSc Chemistry (Choice Based Credit System)
Semester III

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-304 (v)	**Industrial Chemistry special paper-II (Fuels and Heavy Chemicals) (DSE-II)**	**60 hrs (4 hrs/week)**

Course Outcomes: At the end of the course students will be able to

1. Differentiate various types of Fuels and their industrial uses.
2. Calculate calorific Value of fuel.
3. The status of Petrochemical Industry in India.
4. The materials chemistry such as Cement, Ceramics and Refractories.
5. The various processes involved in sugar Industry.

Unit – I : 15 L

Fuels: Introduction, History of Fuels, History of solid fuel, Definitions and properties of solid fuels, classification of Fuels on the basis of occurrence, physical state, Formation of coal. Coal mining, proximate and ultimate analysis of coal, determination of calorific value by using Bomb calorimeter, Coal tar distillation, problems on calculation of calorific value. ecofriendly fuels, environmental aspects.

Unit – II : 15 L

Petroleum oils: Introduction, occurrence, composition of petroleum, processing of petroleum, thermal cracking, catalytic cracking, vis-breaking, octane rating (octane number), cetane number, knocking, antiknock compounds, flash point, and aniline point, petrochemicals applications, synthetic petroleum.

Lubrication oils-: Properties and uses of refrigeration oils, transformer oils and gear oil. Additives for lubrication oils antioxidant ;, passivators, pour point depressants, detergents, adhesives and emulsifiers.

Unit – III : A) Manufacture of Heavy Chemicals : 15L

Chemical processes for the manufacture of Heavy chemicals like- soda ash, bicarbonates, chlorine, caustic soda, calcium carbides, Silicon Carbide, Lime and acids like H_2SO_4, HCl, HNO_3, H_3PO_4 and their applications.

B) Sugar Industries

Manufacturing of sugar from sugarcane: Introduction, agriculture, harvesting, preparation of cane for mealing, juice extraction, diffusion, juice purification, evaporation, crystallization (production of raw sugar), centrifugation, sugar refining, decolouring, purification, filtration, crystallization grade analysis. Analysis of bagasse and molasses, byproducts of sugar industries.

Unit-IV : 15 L

A) **Cement:** Types of cement, manufacture- processes (Wet and Dry), setting and Hardening of cement, cement additives.

B) **Glass:** Types, their composition & properties, manufacture of glass, optical glass, coloured glasses, lead glass and neutron absorbing glass.

C) **Ceramics and Refractories:** Introduction, types, manufacturing process, applications of Ceramics and Refractories.

Books Suggested:

1. Engineering Chemistry By Dr. S. S. Dara.
2. Modern Petroleum Technology by G. D. Hobson and W. Pohl.
3. Petroleum refining and engineering by W. L. Nelson.
4. Petroleum refining technology and economics by J.H. Gary and G. E. Handwerk.
5. The Petroleum chemical industry by R.F. Goldstein and A.L. Waddams.
6. Petroleum processing handbook by W. E. Bland and R. L. Davidson.
7. The Text book on Petrochemical by Dr. B. K. Bhaskar Rao, Khanna Publishers New Delhi.
8. Modern Petroleum refining Processes by Dr. B. K. Bhaskar Rao, Oxford, IBH, 1984

9. Petroleum product handbook.
10. Charles E. Dryden, Outline of Chemical Technology Edited by M. Gopal Rao and
11. Marshall Siting, East West press 2nd Edition 1973.
12. Chemical Process Industries by R. N. Shreves and M.J.A. Brink. McGraw Hill Ltd. 4th Edition.
13. Manual of Chemical Technology VOL I & II by Venkateshwara Educational Development Center. IITMadras,1977.
14. Material science, O. P. Khanna, Khanna Publishers, Delhi

Syllabus Prescribed for Two Year PG Programme
Programme: MSc (Chemistry)
Semester III

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY305 (i)	**(Lab-05 based on DSE)**	**90 hrs (9 hrs/week)**

Inorganic Chemistry Special

Course Outcomes: Upon successful completion of course, students will be able to

1. determine some metals and components present in various samples
2. analyse food samples, drug samples and alloys.
3. examine water samples and assess potable and non-potable water.
4. illustrate experiments based on separation, identification and estimation of binary and ternary mixtures of metal ions.
5. acquire skills of separation of components by different chromatography techniques.
6. perform experiments based on spectrophotometric methods.

Quantitative Inorganic Analysis:

Part A:

1) Detection and determination of Ascorbic acid from biological sample.
2) Determination of iron from pharmaceutical samples and coordination compounds.
3) Determination of calcium from given drug sample by complexometrically.
4) Determination of iron, calcium and phosphorus from milk powder.
5) Drug Analysis: Aspirin, benzyl benzoate, etc.
6) Practical based on food analysis: honey, oil, tea-leaves, turmeric powder, etc.
7) Determination of capacity of anion and cation exchange resin by column method.
8) To estimate the amount of magnesium and zinc in the given sample solution by ion exchange chromatography method.
9) Separation and estimation of Fe^{2+}, Co^{2+} and Ni^{2+} by anion exchanger.
10) Separation and estimation of Halide by anion exchanger.
11) Separation and estimation of i) Cobalt and Nickel ii) Calcium and Zinc and iii) Zinc and Magnesium by anion exchange.
12) Separation and estimation of Fe^{3+} and Mg^{2+} by solvent extraction
13) Separation, identification and quantitative determination of metal ions by paper chromatography.
14) Separation and identification of sugars/ honey/halides by paper chromatography and determination of R_f values
15) Thin layer chromatographic separation, identification and determination of R_f values –
    a. Metal ions (Mn, Co, Ni, Cu, Zn, Cd, Pb, alkali metals etc)
    b. Amino acids/ Organic compounds
    c. Sulphadrugs in tablets and ointments.

Part B:

16) Analysis of stainless steel (Cr/Ni)
17) Determination of Ca content in chalk / milk powder as Ca-oxalate by permagnetometry
18) Potentiometric determination of the percentage of sodium carbonate in commercial washing soda.
19) Determination of phosphates from plant samples by spectrophotometrically.
20) Simultaneous spectrophotometric determination of
    i) Chromium and Manganese ii) Titanium and Vanadium iii) Cobalt and Chromium
21) To determine the stability constant and stoichiometry of Ferric-thiocyanate complex by spectrophotometrically.
22) To study the stoichiometry and stability of Fe^{3+} salicylate complex by Job's and mole ratio method spectrophotometrically.
23) Estimate the amount of Cu(II) with EDTA photometric titration.
24) Solvent extraction by binary mixtures i. e. Al/Mg, Cu/Ni, Cu/Co etc. and quantitative determination by spectrophotometrically.
25) Water analysis:
    a. Determination of sodium and potassium by flame photometry.
    b. Determination of hardness, alkalinity, salinity, chloride, fluoride, nitrite, nitrate, phosphate and sulphate.
    c. Determination of DO, COD and BOD.
    d. Determination of toxic metals viz As, Cd, Pb, Hg, and Ni in water and wastewater by suitable method.

CY 305 (i) Inorganic Chemistry Special (Lab 05)

Time : 6-8 Hrs. (One day Examination) Total Marks : 100

A.	**Exercise-I (Part A)**	**30**
B.	**Exercise-II (Part B)**	**30**
C.	**Viva (External + Internal)**	**20**
E.	**Internal assessment***	**20**
	Total	**100**

***-** Internal assessment will be continuous and based on the performance of a student throughout the session along with satisfactory submission of the term work

List of Books

1. Day and Underwood: Quantitative Analysis
2. Vogel A.I: A textbook of quantitative Inorganic analysis, Longman.
3. Flaschka: EDTA Titration
4. Meites and Thomas: Advanced Analytical Chemistry.
5. Ewing,G.W.: Instrumental Methods of Chemical Analysis,McGraw-Hill
6. Drago,R.S: Physical Methods in Inorganic Chemistry
7. Christian G.D.: Analytical Chemistry
8. Khopkar S.M.: Basic Concept of Analytical Chemistry.
9. Kolltath and Ligane: Polarography
10. Braun: Instrumental methods of chemical Analysis
11. Willard, Merritt and Dean: Instrumental methods of Chemical Analysis,Van Nostrand
12. Strouts, Crifillan and Wison: Analytical Chemistry.
13. Skoog S.A.and West D.W.: Fundamental of Analytical Chemistry
14. Dilts R.V.: Analytical Chemistry
15. Jahagirdar D.V.- Experiments in Chemistry
16. Chondhekar T.K.- Systematic Experiments in Physical Chemistry,RajbogS.W.,AnjaliPubn.
17. Wlehov G.J.- Standard methods of Chemical analysis, 6th Ed.
18. Ramesh R&AnbuM,Chemical Methods for Environmental Analyss:Water&Sedient, Macmillion India.

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CY-305 (ii)	**(Lab-V based on DSE) Organic Chemistry Special**	90 hrs (9 hrs/week)

Course Outcomes: Upon successful completion of a course the students will be able to:

1. Acquire knowledge of safe laboratory practices, including the handling and disposal of hazardous reagents, proper use of personal protective equipment
2. Learn about the selection of starting materials, reaction conditions, purification techniques and characterization methods.
3. They will learn to consider factors such as reaction compatibility, yield optimization and the use of protecting groups.
4. Invent new reaction condition by understanding the principles, techniques and strategies involved in multistage.
5. Students will develop skills in analyzing and interpreting estimation data.
6. Plan and design multistage synthesis routes to target specific organic compounds.
7. Students will gain practical hands-on experience in performing estimation techniques.

A **Multistage Preparations (minimum- 8)**

Perform the stepwise synthesis, include reaction mechanisms, theoretical and practical % yields. Assess the yield, melting point, TLC and predict spectral data for each step either by using instrument or by using chemistry software.

1. Preparation of p-nitroaniline from aniline
2. Preparation of p-bromoaniline from aniline
3. Benzaldehyde → Chalcone → Chalcone Epoxide
4. Synthesis of Flavone
5. Synthesis of Coumarin
6. Fischer Indole Synthesis
7. Skraup-Quinoline Synthesis
8. Synthesis of Carbohydrates (any one)
9. Hippuric Acid → Azalactone → 4-Benzylidene 2-phenyl Oxazol-5-one
10. Benzophenone → Benzopinacol → Benzopinacolone
11. Benzoin → Benzil → Benzilic Acid (By Green Synthesis)
12. Acridone from Anthranilic Acid

B **Estimations (minimum-6)**

1. Nitrogen estimation
2. Halogen estimation
3. Sulphur estimation
4. Soxhlet extraction of oil from oil seeds and determination of saponification value and iodine value of the same oil
5. Soxhlet extraction of piperine from black pepper
6. Spectrophotometric/UV estimations of Caffeine
7. Spectrophotometric/UV estimations of Cholesterol
8. Analysis of Lindane in BHC powder
9. Analysis of some common pesticides, insecticides, plastics, and detergents

Examination: CY305 (ii) Organic Chemistry special (Lab 05)

Time : 6-8 Hrs. (One day Examination) Total Marks : 100

A.	**Exercise-I**	**30**
B.	**Exercise-II**	**30**
C.	**Viva (External + Internal)**	**20**
E.	**Internal assessment***	**20**
	Total	**100**

***-** Internal assessment will be continuous and based on the performance of a student throughout the session along with satisfactory submission of the term work

Books Suggested:

1. Modern Experimental Organic Chemistry - Royston M. Robert, John C. Gilbert, Lyu B. Rodewald, S.
2. Experimental Organic Chemistry - L. M. Harwood, C. I. Moody
3. Semi-microqualitative Organic analysis - N. D. Cheronis, J. B. Entrikin, E.M. Wodnett
4. The Systematic identification of Organic compounds - R.L. Shrine, D.Y. Curtin
5. Quantitative Chemical analysis - A.I. Vogel
6. Vogel's textbook of quantitative analysis (Revised) - J. Bassett, R.C. Denney, G.H. Jeffery, and J.
7. Experiment and technique in Organic chemistry - D. Pasto, C. Johnson, and M. Miller
8. Handbook of organic analysis - qualitative and quantitative - H. Clark, Edward Arnold.

Web link

1. Synthetic Pages (https://www.syntheticpages.org/) Synthetic Pages is an online database that provides practical protocols and procedures for organic synthesis. It offers a collection of validated synthetic procedures contributed by researchers in the field.
2. Organic Syntheses (https://www.orgsyn.org/) Organic Syntheses is a website that provides detailed, peer-reviewed procedures for the synthesis of a wide range of organic compounds. It offers step-by-step protocols, experimental details, and characterization data.
3. Organic Chemistry Portal (https://www.organic-chemistry.org/) The Organic Chemistry Portal offers a variety of resources for organic chemistry, including synthetic methods and practical procedures. It provides articles, reactions, and experimental protocols contributed by the organic chemistry community.
4. ChemTube3D (https://www.chemtube3d.com/) ChemTube3D is a website that offers interactive 3D animations and tutorials for various organic chemistry topics. It includes visualizations of reaction mechanisms, structures, and laboratory techniques relevant to organic synthesis.
5. Master Organic Chemistry (https://www.masterorganicchemistry.com/ Master Organic Chemistry is a comprehensive online resource that provides tutorials, study guides, and practical information for organic chemistry. It covers topics such as reaction mechanisms, functional group transformations, and laboratory techniques.
6. ChemSpider (http://www.chemspider.com/) ChemSpider is a free chemical structure database that offers access to millions of compounds. It provides information on chemical properties, structures, and spectral data, which can be useful for designing synthetic routes and planning organic synthesis experiments.

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Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-305 (iii)	**(Lab-V based on DSE) Physical Chemistry special**	**90 hrs (9 hrs/week)**

Course Outcomes: Upon successful completion of a course the students will be able to:

1. Perform laboratory experiments related to chemical kinetics, thermodynamics, surface chemistry, photochemistry, supramolecular chemistry, and polymer characterization.
1. Demonstrate proficiency in using laboratory instruments and techniques relevant to physical chemistry experiments.
2. Analyze experimental data, interpret results, and draw meaningful conclusions.
3. Apply fundamental principles and concepts of physical chemistry to explain experimental observations.
4. Communicate scientific findings effectively through written reports and oral presentations.
5. Demonstrate knowledge of safety protocols and ethical practices in the laboratory.

List of Experiments

Thermodynamics:

1. ***Experiment:*** Liquid-Vapor Equilibria of Binary Solvents - Azeotropic Mixtures

   Objective: To investigate the liquid-vapor equilibria of binary solvent systems (e.g., ethanol and water) and determine the composition and boiling point of azeotropic mixtures.

2. ***Experiment:*** Determination of Partial Molal Volume - Ethanol and Water Solution

   Objective: To determine the partial molal volume of ethanol and water in a binary solution by measuring the change in volume with respect to concentration and calculating the partial molal volume using the appropriate equations.

Kinetics:

3. ***Experiment:*** Kinetics of Reaction between Ferric Nitrate and Potassium Iodide using Initial Reaction Rates

   Objective: To study the kinetics of the reaction between ferric nitrate and potassium iodide using the initial reaction rates method and determine the rate equation and rate constant of the reaction.

4. ***Experiment:*** Determination of Stoichiometry and Association/Binding Constant Using UV-Vis Spectroscopy - Ferric Salicylate Complex

   Objective: To determine the stoichiometry and association constant of the complex formed between ferric ions and salicylate ions using UV-Vis spectroscopy and the Job's method.

5. ***Experiment:*** Kinetics of Oxidation of Isopropyl Alcohol/Ethanol by Potassium Dichromate

   Objective: To study the kinetics of the oxidation of isopropyl alcohol or ethanol by potassium dichromate, determine the reaction order, rate constant, energy of activation, and propose a possible mechanism for the reaction.

6. ***Experiment:*** Kinetics - Inversion of Sucrose and Mutarotation of Glucose using Polarimetry

   Objective: To study the kinetics of the inversion of sucrose and the mutarotation of glucose using polarimetry and analyze the rate of reaction and the equilibrium state of the reactions.

Surface Chemistry: Validation of Freundlich and Langmuir Adsorption Isotherms

7. ***Experiment:*** Validation of Freundlich and Langmuir Adsorption Isotherms

   Objective: To validate the Freundlich and Langmuir adsorption isotherms by analyzing the adsorption behavior of a solute onto a solid adsorbent and comparing the experimental data with the predicted isotherm models.

Photochemistry/Spectroscopy: Construction of Jablonski Diagram of Polyaromatic Compounds

8. ***Experiment:*** Construction of Jablonski Diagram of Polyaromatic Compounds using UV-Visible Spectroscopy

   Objective: To construct a Jablonski diagram for polyaromatic compounds (e.g., anthracene, pyrene, or naphthalene) using UV-Visible spectroscopy and analyze the electronic transitions and energy levels involved.

9. ***Experiment:*** Construction of Jablonski Diagram of Polyaromatic Compounds using Spectroscopy

   Objective: To construct a Jablonski diagram for a polyaromatic compound (e.g., anthracene, pyrene, or naphthalene) by studying its absorption and fluorescence spectra, and understanding the excited state relaxation processes.

Supramolecular Chemistry, Electrochemistry: Estimating the Critical Molar Concentration and Aggregation Number of Micelles

10. ***Experiment:*** Estimating the Critical Molar Concentration and Aggregation Number of Micelles in Supramolecular Chemistry using Conductivity Measurements

    Objective: To determine the critical molar concentration (CMC) and aggregation number of micelles formed by a surfactant in a solution using conductivity measurements and analyze the supramolecular behavior of the surfactant.

11. ***Experiment:*** Estimating the Critical Micelle Concentration (CMC) using Surface Tension Measurement

    Objective: To estimate the critical micelle concentration (CMC) of a surfactant solution by measuring the surface tension at different concentrations and analyzing the trend.

Acid-Base Equilibrium: Determination of pKa of poly-basic acid with the pH meter

12. ***Experiment:*** Determination of pKa of a Polybasic Acid using a pH Meter

    Objective: To determine the pKa values of a polybasic acid (e.g., phosphoric acid or citric acid) by titration using a pH meter and analyze the acid-base equilibrium of the polybasic acid.

13. ***Experiment***: Determination of pKa of a Polybasic Acid using spectrophotometric Method

    Objective: To determine the pKa values of a polybasic acid (e.g., phosphoric acid or citric acid) using spectrophotometric measurements.

Polymer characterization: Determination of Molecular Weight of Polymers

14. ***Experiment:*** Determination of Molecular Weight of Polymers using Viscosity Measurement

    Objective: To determine the average molecular weight of a polymer sample using viscosity measurements and understand the relationship between molecular weight and polymer viscosity.

15. ***Experiment:*** Determination of Average Molecular Weight of a Polymer using Vapor Pressure Osmometry

    Objective: To determine the average molecular weight of a polymer sample by measuring the change in vapor pressure above a dilute polymer solution using vapor pressure osmometry.

    Any other experiment/exercise/computer programming suggested by the instructor.

Examination: CY305 (iii) Physical Chemistry special (Lab 05)

Time : 6-8 Hrs. (One day Examination) Total Marks : 100

A.	**Exercise-I**	**30**
B.	**Exercise-II**	**30**
C.	**Viva (External + Internal)**	**20**
E.	**Internal assessment***	**20**
	Total	**100**

***-** Internal assessment will be continuous and based on the performance of a student throughout the session along with satisfactory submission of the term work

Text & Reference Books:

1. M. Halpern and G. C. McBane, Experimental Physical Chemistry: A Laboratory Text Book, 3rd ed., W. H. Freeman, 2006
2. D. P. Shoemaker, G. W. Garland and J. W. Nibler, Experiments in Physical Chemistry, 5th ed., McGraw Hill, London.
3. Manual provided by the Course Instructor

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Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-305 (iv)	**(Lab-V based on DSE) Analytical Chemistry special**	90 hrs (9 hrs/week)

Course Outcomes: Upon successful completion of a course the students will be able to:

1. Perform analytical techniques such as *p*H-metry, conductometry, potentiometry, polarimetry, colorimetry/spectrophotometry, flame photometry, turbidimetry, and nephelometry.
2. Analyze and interpret data obtained from various analytical methods.
3. Use specialized instruments and equipment for accurate measurements and analysis.
4. Apply quantitative and qualitative analysis principles to solve analytical problems.
5. Demonstrate proficiency in performing simultaneous determination of multiple components in complex mixtures.
6. Follow laboratory safety protocols and quality control measures.
7. Apply analytical chemistry techniques in practical applications across various industries.
8. Effectively communicate analytical results and findings.

Syllabus:

pH-metry

1. Determination of percent Na_2CO_3 in soda ash by pH-metric titration.
2. Determination of the isoelectric point of an amino acid.

Conductometry

3. Displacement titration of CH_3COONa with HCl.

Potentiometry

4. Determination of percent purity of phenol by potentiometric titration with NaOH.

Polarimetry

5. Determination of the percentage of two optically active substances (*d*-glucose and *d*-tartaric acid) in a mixture.

Colorimetry/Spectrophotometry

6. Simultaneous determination of chromium and manganese in a given mixture.
7. Simultaneous determination of two dyes in a mixture.
8. Estimation of Mn in steel.
9. Estimation of Cu/Ni in alloys.
10. Estimation of iron in a water sample using 1,10-phenanthroline.
11. Estimation of Fe(III) in a given solution by photometric titration with EDTA (salicylic acid method).

Flame Photometry

12. Estimation of Li, Na, K, Ca in rock/soil/water samples.

Turbidimetry and Nephelometry

13. Determination of the molecular weight of a polymer.
14. Estimation of sulphate in a water sample by turbidimetry.
15. Estimation of phosphate by nephelometry.

Demonstrations

16. UV-spectrophotometry

Examination: CY305 (iv) Analytical Chemistry special (Lab 05)

Time : 6-8 Hrs. (One day Examination) Total Marks : 100

A.	**Exercise-I**	**30**
B.	**Exercise-II**	**30**
C.	**Viva (External + Internal)**	**20**
E.	**Internal assessment***	**20**
	Total	**100**

***-** Internal assessment will be continuous and based on the performance of a student throughout the session along with satisfactory submission of the term work

Text and Reference Books:

Textbook:

1. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). Principles of Instrumental Analysis. Cengage Learning.

Reference Books:

1. Miller, J. N., & Miller, J. C. (2010). Statistics and Chemometrics for Analytical Chemistry. Pearson Education.

2. Christian, G. D. (2013). Analytical Chemistry. John Wiley & Sons.

3. Sawyer, D. T., Sobkowiak, A., & Roberts, J. L. (1995). Electrochemistry for Chemists. Wiley.

4. Chauhan, A. (2018). Pharmaceutical Analysis: Principles and Applications. CRC Press.

5. Vogel, A. I., & Mendham, J. (2018). Vogel's Qualitative Inorganic Analysis. Pearson Education.

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Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-305 (v)	**(Lab-V based on DSE) Industrial Chemistry special**	**90 hrs (9 hrs/week)**

Course Outcomes: Upon successful completion of a course the students will be able to:

1. Understand the mechanism involved during synthesis of organic materials.
2. Apply the various unit operations in the organic process synthesis to obtain good quality product.
3. Use the industrial equipments, during production of organic materials.
4. Apply the skill to analyze the Industrial Fuels.

List of Experiments:

1. Synthesis of Nitrobenzene - m-dinitrobenzene
2. Synthesis of m-nitroaniline- m-nitrophenol.
3. Synthesis of Cyclohexanone n-cyclohexanone oxime-caprolactam.
4. Preparation of P- bromoaniline from aniline.
5. Preparation of P-bromo acetanilide from acetanilide.
6. Preparation of acetanilide from aniline.
7. Determination of Iron and Calcium from Cement by suitable methods.
8. Determination of Lead (Pb) from Opal Glass by suitable methods.
9. Experiments based on distillation under reduced pressure, fractional and steam distillation.
10. Measurement of flash point, ignition point, kinematic viscosity by U-tube method.
11. Determination of reducing sugar in cane juice.
12. Experiments based on simple & fractional distillation.
13. Estimation of Manganese from Tea leaves-component
14. Preparation of biodiesel from vegetable/ waste cooking oil
15. Determination of calorific value of fuels.
16. Preparation and characterization of inorganic complexes containing Fe, Co, Ni, Cu, Zn, with N, and P containing ligands.
17. Determination of moisture content and ash content of wood sample.
18. Extraction of essential oils from medicinal plants (Tikhadi).
19. Analysis and estimation of phenolic group by bromination method.
20. Estimation of Iron in Cement.

Examination: CY305 (v) Analytical Chemistry special (Lab 05)

Time : 6-8 Hrs. (One day Examination) Total Marks : 100

A.	**Exercise-I**	**30**
B.	**Exercise-II**	**30**
C.	**Viva (External + Internal)**	**20**
E.	**Internal assessment***	**20**
	Total	**100**

***-** Internal assessment will be continuous and based on the performance of a student throughout the session along with satisfactory submission of the term work

List of Books-

1. Practical Engineering by S. S. Dara.
2. Laboratory Preparation of Microchemistry by E. M. M. Jeffrey, McGraw Hill.
3. Methods of testing for petroleum and petroleum products. IS 1448-1960 Part I to Part IV. ISI NewDelhi
4. IP Stands for Petroleum and products Published Applied Service Publisher Ltd. London, 33rd Edition 1974.
5. 5.American Stds. For testing Materials, New York 1967.
6. Industrials Chemicals, Faith et. al. Wiley Inter science New York
7. Textbook of Practical Organic Chemistry by Vogel.
8. Industrial Organic Chemistry by Hans Arpe.

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Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-306	**(Lab-VI) Research Project Phase-I**	90 hrs (9 hrs/week)

Course Outcome: On completion of this course, the student should be able to:
1. Identify a research problem and carry out literature survey
2. Analyse the research gap and formulate the problem
3. Interpret the data and synthesize research findings

Research Project Phase I: It should be based on rigorous literature survey, finding research gaps, preparation of research proposal to be executed in the next semester. There will be a presentation on the topic selected for the research project. Students need to submit the synopsis of the proposed research work.

Modalities:

1. Individual or group projects can be taken up
2. Involve in literature survey in the chosen field.
3. Use Science/Engineering principles to solve identified issues.
4. Adopt relevant and well-defined / innovative methodologies to fulfill the specified objective
5. Submission of scientific report in a specified format

Examination: CY306 Research project Phase I (Lab 06) Max Marks 100

A.	**Submission of Research proposal synopsis**	**50**
B.	**Presentation on the research proposal synopsis**	**50**
	Total	**100**

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Code of the Course/Subject Title of the Course/Subject (Total Number of Periods)

CY401 Spectroscopy -II 60 hrs (4 hrs/week)
(DSC XI)

Course Outcomes: At the end of the course, students will be able to:

1. apply major spectroscopic techniques such as mass spectrometry, NMR spectroscopy, 2D- NMR, C-13 NMR and Mossbauer Spectroscopy for structure determination.
2. interpret spectra to identify functional groups, chemical shifts, coupling patterns, and fragmentation patterns.
3. deduce structures from the fragmentation pattern.
4. understand the principles and applications of multidimensional NMR and dynamic processes by NMR.
5. accomplish structure elucidation of organic and inorganic compounds using advance spectroscopic methods.
6. correlate ESR spectroscopic data with molecular structure
7. analyze isotropic and anisotropic ESR spectra.

Unit-I : 15h

A) Mass spectrometry: Introduction, theory, Ionization techniques (EI, CI, FD, FAB), Low and High resolution mass spectrometry. molecular ion, meta stable ions and peaks - fragmentation processes - isotope abundance. intensity of molecular ion peak, base peak, fragment ion peak and isotope peak (M+1, M+2);
Analysis of spectra-determination of molecular formulae - Nitrogen rule- Stevenson's rule - RetroDiels –Alder rearrangement –McLaffertty rearrangement- ortho effect .
Fragmentation associated with functional groups - aldehydes, ketones, carboxylic acids, esters, amides, alcohols, thiols, amine, ethers, sulphides and halides.
Interpretation of Mass spectra from fragment to molecule;

B) Advance Methods for characterization: Elementary study of GCMS, FTMS, ESI-MS,MALDI-MS, examples from macromolecules and supramolecules, study of in-organic, co-ordination & organometallic compounds.

Unit-II: 15h

A) **Nuclear Magnetic Resonance Spectroscopy:**
Recapitulation of basic principle and general terms; equivalence and magnetic equivalence (Homotopic proton, Enantiotopic proton, Diastereotopic proton), shielding and deshielding, chemical shift, factors affecting chemical shifts, spin-spin coupling (n+1) rule, Factors affecting coupling constant; Karplus curve variation of coupling constant with dihedral angle., first order (interaction between two, three, four, and five nuclei) and non-first order spectra - classification of spin system like AX,AX_2,ABX,AMX,ABC,A_2B_2 etc. Hetero nuclear coupling in ^1HNMR – deuterium exchange.
Simplification of complex spectra; high field spectra, nuclear magnetic double resonance; shift reagent; solvent effect, nuclear overhauser effect [NOE]. Fourier transforms technique.
Dynamic NMR to study hindered rotation (DMF, DMA, biphenyls, annulenes); cyclohexane ring inversion.
B) Carbon-13 NMR spectroscopy: - C-13 Nucleus, Chemical Shift and factor affecting ^{13}C NMR, Types of ^{13}C NMR Spectra: proton coupled (spin-spin splitting), Proton decoupled, Off resonance, DEPT, APT and NOE, Applications in organic chemistry.

Unit-III : 15h

A) 2D NMR:
COSY, NOESY, HETCOR, INPET, INADEQUATE. General idea about inorganic solid state NMR, interaction with other nuclei- P, F. Drug Analysis -Magnetic Resonance Imaging (MRI):

B) Determination of structures of organic molecules by spectroscopic methods: Problems based on joint application of UV, IR, PMR, CMR, Mass and 2-D NMR spectroscopic techniques.

Unit-IV: 15h

A) Electron Spin Resonance Spectroscopy : Introduction ,basic principle. zero field splitting

and Kramer_s degeneracy, factors effecting the _g_ values, hyperfine splitting, hyperfine and super hyperfine coupling constants, determination of _g_ values. Instrumentation, working of instruments, sensitivity, concentration, choice of solvent. Presentation of ESR spectra, Eldor and Eldor techniques. The EPR of triplet states, McConnel relation.

B) Application of ESR to study the free radicals, structure determination, reaction velocities, application to inorganic free radicals such as PH_4^-, F_2^-, $[BH_3]^-$,determination of oxidation state of metals. Applications to biological molecules containing Cu and Fe. Structural applications to transition metal complexes (Mn^{2+}, Fe^{2+}, Cu^{2+}, Mo^{+5}).

Course Material/Learning Resources

Text books:

1. Organic spectroscopy-William Kemp,ELB with McMillan.
2. Spectroscopy of organic molecule-PS Kalsi,Wiley,Esterna,New Delhi.
3. Elementary Organic chemistry: Principles and chemical Applications, Y. R. Sharma, (Revised V Edition), New Delh : S. Chand and Company LTD.
4. Spectroscopy: H.Kaur (First Edition 2005), Pragati Prakashan, Meerut

Reference Books:

1. Spectrometric Identification of Organic Compounds, Silverstein, R. M., and Webster, F. X., (6th Edition), John Wiley and Sons, New York, 1998.
2. Application of spectroscopy to organic compound-JR Dyer,Printice Hall.
3. Organic Spectroscopy, William Kemp; ELBS/ Macmillan
4. Organic structure from Spectra, L.D.Field, S. Sternhell, J.R. Kalman, (4^{th} Edition), John Wiley and Sons, New York.
5. Organic Spectroscopy, William Kemp; ELBS/ Macmillan
6. Hollas, J. M., *Basic Atomic and Molecular Spectroscopy*, Wiley, Chichester, UK, 2002.
7. Spectroscopic methods in organic chemistry-DH Willson,I. Fleming
8. Interpretation of NMR spectra-Roy H. Bible.
9. Interpretation of IR spectra-N.B. Coulthop
10. Mass spectrometry organic chemical applications ,J.H. Banyon

Weblink to Equivalent MOOC on SWAYAM if relevant:

Weblink to Equivalent Virtual Lab if relevant:

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

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

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

C-13 NMR Spectroscopy: https://onlinecourses.nptel.ac.in/noc22_cy44/course
https://onlinecourses.nptel.ac.in/noc22_cy44/unit?unit=112andlesson=113
Mossbauer Spectroscopy: https://onlinecourses.nptel.ac.in/noc22_cy51/unit?unit=26andlesson=118
https://onlinecourses.nptel.ac.in/noc22_cy51/unit?unit=23andlesson=100

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Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY402	**Selected topics in Chemistry-II (DSC XII)**	**60 hrs (4 hrs/week)**

Course Outcomes: At the end of the course students will be able to

1. Explain the principles, instrumentation, and applications of Auger electron microscopy and compare it with ESCA (electron spectroscopy for chemical analysis) techniques.
2. Demonstrate knowledge of different electron microscopy techniques (e.g., TEM, SEM, STEM) and their applications in surface characterization.
3. Apply analytical methods to determine the approximate composition of food, including moisture, fat, protein, fiber, and carbohydrate.
4. Evaluate the composition of cosmetics, including creams, lotions, and face powder, by determining water content, non-volatile matter, ash content, and specific chemical components.
5. Classify different types of poisons, understand their mode of action, and estimate poisonous materials (e.g., lead, mercury, arsenic) in biological samples.
6. Apply chemical sensors in various fields such as the food industry, agriculture, and biotechnology.
7. Outline the terms and role of forensic science, analytical toxicology and different units of crime lab
8. Formulate and compile scientific problems based on analytical spectroscopy.
9. Specify the applications of analytical spectroscopy in chemistry and interdisciplinary fields.

Unit I : Electron Microscopy and Surface Characterization 15h

A] **Electron spectroscopy**: Introduction, principle of Ultraviolet photoelectron spectroscopy (UPS) and X-ray photoelectron spectroscopy (XPS), types of peaks, chemical shifts, Instrumentation, Applications, Auger electron microscopy-principle, instrumentation and applications, similarities and differences in ESCA and AES, advantages and disadvantages.

B] **Surface Characterization by spectroscopy and microscopy**

Introduction to study of surface, Electron stimulated microanalysis methods- (electron microprobe, Transmission Electron Microscope, Scanning Electron Microscope, Scanning Transmission Electron Microscope, Analytical Electron Microscopy, Scanning-Probe Microscopes) – principle, instrumentation and applications

Unit II : Food and Cosmetic Analysis 15h

A) The chemical analysis of food: Importance of food analysis, Determination of approximate composition: Moisture, fat, protein, fiber, carbohydrate, etc. Quantitative analysis for food quality and safety - Determination of minerals, vitamins, anti-oxidants, toxins and preservatives. General idea of the properties of drugs for their characterization and quantification. Quantitative methods of analysis - Gravimetric and volumetric analysis, potentiometry, coulometry and amperometry titrations, colorimetry, fluorimetry and polarimetry methods, Analysis of artificial sweeteners in food and colouring agents.

B) Analysis of Cosmetics-Composition of creams and lotions- determination of water, propylene glycol, non-volatile matter and ash content. Determination of borates, carbonates, sulphates, Phosphates, chlorides, titanium and zinc oxides.

Analysis of face powder- estimation of boric acid, Mg, Ca, Zn, Fe, Al and Ba

Unit III : Forensic & Fuel analysis 15h

A]Forensic Analysis: Special features of forensic analysis, sampling, sample storage, sample dissolution, classification of poisons, lethal dose, significance of LD-50 and LC-50. general discussion of poisons with special reference to mode of action of cyanide, organophosphate and snake venom. Estimation of poisonous materials such as lead, mercury and arsenic in biological samples.

B] Fuel analysis :Solid, Liquid and gaseous fuels. Characteristics of ideal fuels. Ultimate and proximate analysis of coal, heating values, grading of coal, liquid fuels-flash point, aniline point, knocking, antiknock compounds, octane number, cetane number and carbon residue. Gaseous fuels, producer gas and water gas, determination of calorific value. Analysis of fuel Gas.

Numerical problems.

Unit IV : Chemical, biochemical and biosensors: 15h

Chemical Sensors, Chemical Sensor Characteristics, Electrochemical Sensor, Potentiometric Sensors, Conductometric Sensors, Amperometric Sensors, Chronoamperometry and Chronopotentiometry, Acoustic Wave Devices, Electrochemical Impedance Spectroscopy, Chemical and Biological Recognition, Application of Chemical Sensors in the Food Industry, Agriculture and Biotechnology,

Biosensors and Their Principles, Types of Biosensors, Amperometric Immunosensors, Cholesterol Biosensor, Electrochemical Glucose Biosensors, Electrochemical biosensors, Drug Delivery Systems, Microbial Biosensors for Environmental Applications.

Course Material/Learning Resources:

Text & Reference Books:

1. Principles of Electron Spectroscopy" by G. F. Turrell
2. "X-Ray Photoelectron Spectroscopy: An Introduction to Principles and Practices" by Paul van der Heide
3. "Practical Surface Analysis: Auger and X-ray Photoelectron Spectroscopy" by David Briggs and Michael P. Seah
4. "Scanning Electron Microscopy and X-Ray Microanalysis" by Joseph Goldstein, Dale E. Newbury, and Joseph R. Michael
5. "Introduction to Food Analysis" by P. S. Belton and R. F. Smith
6. "Analytical Methods for Food and Dairy Powders" by Amitava Dasgupta and Satinder Ahuja
7. "Handbook of Cosmetic Science and Technology" edited by André O. Barel, Marc Paye, and Howard I. Maibach
8. "Forensic Chemistry Handbook" by Lawrence Kobilinsky, Thomas F. Liotti, and P. K. Gupta
9. "Handbook of Fuel Analysis" by James G. Speight
10. "Chemical Sensors: An Introduction for Scientists and Engineers" by Peter Gründler
11. "Biosensors: Fundamentals and Applications" by Anthony Turner and Ian Karube
12. Introduction to instrumental analysis by R. D. Braun, MC. Graw Hill- International edition.
13. Instrumental methods of chemical analysis by Willard, Dean and Merittee- Sixth edition
14. G. D. Christian: Analytical Chemistry
15. S. M. Khopkar: Basic Concept of Analytical Chemistry.
16. Amparo Salvador and Albetro Chisvert : Analysis of cosmetics Products
17. H.E. cox and David Pearson : The chemical analysis of foods
18. Forensic Chemistry, 1st edition, By Suzanne Bell, Person Education Ltd
19. Toxicology Lab manual of directorate of forensic science (http://dfs.nic.in>downloads)
20. Analytical Chemistry / Instrumentation : epgp.inflibnet.ac.in

Weblink to Equivalent MOOC on SWAYAM if relevant:

Weblink to Equivalent Virtual Lab if relevant:

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. Analytical Sciences Digital Library (ASDL): ASDL is a comprehensive digital library that provides resources, tutorials, and educational materials on analytical techniques, including spectroscopy and microscopy. Website: http://www.asdlib.org/
2. Analytical Chemistry Division of the American Chemical Society (ACS Analytical Division): The division's website offers resources, publications, and information on analytical chemistry and related topics. Website: https://acsanalytical.org/
3. Royal Society of Chemistry (RSC): RSC provides a wide range of resources and publications on analytical chemistry, surface characterization, and related topics. Website: https://www.rsc.org/

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Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-403 (i)	**(DSE-III) Inorganic Chemistry special paper-III (Photo-inorganic and Organometallic Chemistry)**	60 hrs (4 hrs/week)

Course Outcomes: On completion of course, students would be able to
1. explain the principle of photochemistry and examine radiative and non radiative processes
2. understand principle and techniques of photochemistry and photochemical kinetics.
3. apply the principle of photochemistry to study different photochemical reactions of coordination compounds.
4. describe the role of photocatalysts and its application to photochemical reactions
5. explain the role of organometallic compounds as heterogeneous catalyst in synthesis of organic compounds and different reactions.
6. describe phase transfer catalysis and application in green chemistry.

Unit-I: **15 hrs**

A) Basics of Photochemistry:
Basics of photochemical processes: Absorption, excitation, photochemical laws, quantum yield, Frank-Condon principles; Photochemical stages-primary & secondary processes, electronically excited states-life times-measurements of the times; Flash photolysis and stopped flow techniques; Energy dissipation by radiative and non-radiative processes

B) Properties of excited states:
Photochemical kinetics, Calculation of rates of radiative processes.

Unit-II: Ligand field photo chemistry of transition metal complexes **15 hrs**

Electronically ligand field excited states of metal complexes containing d^1 to d^{10} configuration, charge transfer spectra, charge transfer excitations, methods for obtaining charge transfer spectra; Photochemistry of Cr(III)complexes: Photo-substitutions reactions, Photo aquation reactions, photorecimization reactions, Adamson's rules for photoreactions; Photochemistry of Co(III) complexes: Introduction, energy level diagram, photoaquations and photoredox reactions in Co(III) amine, Co(III) cyanide complexes, photoisomerization; Photo redox properties of Ru(III), Ce(III) and Ce(IV) complexes; Application of redox processes of electronically excited states for catalytic purposes,transformation of low energy reactants in to high-energy products, chemical energy in to light;

Unit III: Photochemical reaction on solid surface: **15 hrs**

Introduction, basic principle of photocatalysis**,** photocatalysts, photoreactive oxides; Relation between solar spectrum & band gap, acceptor and donor level of photocatalyst, generation of electron–holepair; Needs of modification of photocatalysts, semiconductor supported metal oxide systems, synthesis methods, Characterization, water photolysis; Application of photocatalytic materials for degradation of organic pollutants,end product of organic pollutants with suitable examples. Nitrogen fixation & carbon dioxidereduction.

Unit-IV: Organometallics as catalysts: **15 hrs**

Applications of transition metal complexes as catalyst in synthesis of chiral pharmaceuticals, hydrogenation of alkenes by Willkinsons catalyst, and olefin metathesis by Grubbs catalyst; Heterogeneous catalysis: Ziegler Natta Polymerization, Water gas reduction, carbonylation; Coupling reactions - Suzuki coupling, Heck coupling and relatedcross coupling reactions; Alkene oligomerization and metathesis; Catalytic oxidations and reductions, epoxidation, dihydroxylations, decarbonylation, olefin isomerization, arylation, polymerization, asymmetric synthesis; Heterogenised homogeneous catalysts, phase transfer catalysis; Catalysis in green chemistry.

Books:

1. Elschenbroich Ch.and Salzer A.: Organometallics,VCH,Weinheim,NY.
2. Balzani Vand Cavassiti V.:Photochemistry of Coordination compounds,AP,London
3. Purcell K.F.and KotzJ.C., An Introduction to Inorganic Chemistry,Holt Sounder,Japan.

4. Rohtagi K.K.and Mukharjee,Fundamentals of Photochemistry,Wiley eastern
5. Calverts J.G.and Pits.J.N.,Photochemicals of Photochemistry, John Wiley
6. Wells,Introduction of Photochemistry
7. Paulson,Organometallic Chemistry,Arnold
8. Rochow,Organometallic Chemistry,Reinhold
9. Zeiss,Organometallic Chemistry,Reinhold
10. Gilbert A.and Baggott,J,Essential of Molecular Photochemistry,Blackwell Sci.Pub.
11. Turro N.J.and Benjamin W.A.,Molecular Photochemistry
12. CoxAand Camp,T.P.Introductory Photochemistry,McGraw-Hill
13. KundallR.P.and GilbertA,Photochemistry, Thomson Nelson Coxon J and Halton
14. Organic Photochemistry,CambridgeUniversity Press.

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Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-403 (ii)	**(DSE-III) Organic Chemistry special paper-III (Organic Synthesis -II)**	60 hrs (4 hrs/week)

Course Outcomes: At the end of the course students would be able to

1. Devise and prioritize organic reactions and reagents for different types of organic transformation
2. Analyse and develop reaction mechanisms for a reactions
3. Design and execute own synthetic route for the organic synthesis
4. Criticise and modify the role of organometallic reagents in organic synthesis.
5. Correlate the stereochemistry of reactant and product for better understanding of organic transformations.

Unit-I **15h**

A) Formation of carbon-carbon bonds via organometallic reagents:

Preparation and synthetic applications of organolithium reagents, organomagnesium reagents, organocopper reagents, organochromium reagents, organozinc reagents, organotitanium reagents, , organocerium reagents and organoborane reagents.

B) Transition metal complexes in organic synthesis catalysis :

Reppe reaction, Pauson–Khand reaction, Nicholas reaction, Hydroformylation (Oxo process) and Collman's Reagent.

Unit II **15h**

Pericyclic Reactions:

A) Symmetry of molecular orbitals, frontier orbitals: ethylene, 1,3-butadiene, 1,3,5-hexatriene, allyl system, Woodward-Hoffmann correlation diagrams, FMO (Frontier Molecular Orbital) approach, PMO (Peturbation molecular orbital) approach

B.)Types of pericyclic reactions

Electrocyclic reactions: Conrotatory and disrotatory motions, 4n systems, 4n+2 systems, allyl systems

Cycloaddition reactions: Antarafacial and suprafacial addition, 4n systems, 4n+2 systems, 2+2 addition of ketenes, 1,3-dipolar cycloadditions, cheletropic reactions, Stereochemical effects and effect of substituents on rate of cycloaddition reaction.

Sigmatropic rearrangements: Suprafacial and antarafacial shifts of hydrogen, sigmatropic shifts involving carbon moieties, 3,3-sigmatropic rearrangements, (3,5) -sigmatropic rearrangements, (5,5)-sigmatropic rearrangements, claisen rearrangement, cope rearrangement, aza-cope rearrangement, ene reaction

Unit III **15h**

Retrosynthesis: Introduction, basic concepts, donor & acceptor synthons, target molecule and synthetic equivalent, retrons, guidelines for disconnection, retrosynthetic analysis, steps in planning a synthesis involving chemoselectivity and regioselectivity, functional group interconversion (FGI)

One group C-C and C-X disconnections

1. One group C-C disconnections in alcohols and carbonyl compounds
2. One group C-X disconnections in carbonyl compounds, alcohols, ethers, and sulphides

Two group C-C and C-X disconnections

A. Two group C-C disconnections: Diels-Alder reaction, 1,3-difunctionalized compounds, 1,5-difunctionalized compounds

Two group C-X disconnections in 1,1-difunctionalized, 1,2 difunctionalized, and 1,3-difunctionalized compounds

Unit IV **15h**

Heterocyclic Chemistry:

A) Heterocycles and Aromaticity: Introduction, natural sources and importance, criteria for aromaticity, aromatic and nonaromatic heterocycles, chemical behaviour of aromatic compounds, nomenclature of heterocyclic compounds.

B) 3-Membered heterocyclic compounds-synthesis and reactions of aziridine, oxirane, thirane

C) 5-Membered heterocyclic compounds-synthesis and reactions of pyrrole, furan, thiophene, indole, diazoles (imidazole and pyrazole)

D) 6-Membered heterocyclic compounds-synthesis, reactions, and basicity of pyridine, quinolone, isoquinoline

E) Biologically important heterocycles- uracils (pyrimidines), purines

Text books/Reference books:

1. "Organometallic Chemistry" by Gary O. Spessard and Gary L. Miessler
2. "Organotransition Metal Chemistry: From Bonding to Catalysis" by John F. Hartwig
3. "Organometallics" by Manfred Bochmann
4. "Organometallics in Synthesis: A Manual" by Manfred Schlosser
5. "Organometallic Reagents in Organic Synthesis" edited by A. J. Pearson
6. "Organometallics: A Concise Introduction" by Christoph Elschenbroich
7. "Pericyclic Reactions: A Mechanistic and Problem-Solving Approach" by Ian Fleming
8. "Organic Chemistry" by Jonathan Clayden, Nick Greeves, and Stuart Warren
9. "Pericyclic Reactions" by Paul D. Bartlett
10. "Advanced Organic Chemistry" by Francis A. Carey and Richard J. Sundberg
11. "Molecular Orbitals and Organic Chemical Reactions" by Ian Fleming
12. "Pericyclic Reactions and Organic Photochemistry" by Jagdamba Singh and S. J. Singh
13. "Organic Synthesis: The Disconnection Approach" by Stuart Warren and Paul Wyatt:
14. "Strategic Applications of Named Reactions in Organic Synthesis" by Laszlo Kurti and Barbara Czako
15. "Strategic Applications of Advanced Synthetic Methodologies" edited by Anthony W. Czarnik
16. "Organic Synthesis: Strategy and Control" by Paul Wyatt and Stuart Warren
17. "Retrosynthetic Analysis" by Stuart Warren
18. "Heterocyclic Chemistry" by John A. Joule and Keith Mills
19. "Heterocyclic Chemistry" by Raj K. Bansal
20. "Comprehensive Heterocyclic Chemistry III" edited by Alan R. Katritzky, Charles W. Rees, and Eric F. V. Scriven
21. "Heterocyclic Chemistry in Drug Discovery" edited by Jie Jack Li and E. J. Corey
22. "Heterocyclic Chemistry" by Thomas L. Gilchrist
23. "Heterocyclic Chemistry: Synthesis of Alprazolam" by Abdur-Rahman

Web links

1. Organic Chemistry Portal - Heterocyclic Compounds: The Organic Chemistry Portal provides a comprehensive collection of articles, reviews, and resources related to Heterocyclic Compounds. You can explore it here: https://www.organic-chemistry.org/topics/heterocycles.shtm
2. ResearchGate - Heterocyclic Chemistry: ResearchGate is a platform for researchers and scientists to share and access scientific publications. You can find research papers, articles, and discussions on Heterocyclic Chemistry by searching the topic on their website: https://www.researchgate.net/search/publications?q=heterocyclic+chemistry
3. Heterocyclic chemistry https://archive.nptel.ac.in/courses/104/105/104105034/
4. Pericyclic Reaction https://onlinecourses.nptel.ac.in/noc23_cy11/preview
5. Advanced Transition Metal Chemistry https://onlinecourses.nptel.ac.in/noc22_cy60/preview
6. Reagents in Organic Synthesis https://onlinecourses.nptel.ac.in/noc21_cy42/preview
7. Principles of Organic Synthesis https://onlinecourses.nptel.ac.in/noc21_cy41/preview
8. Transition Organometallic Chemistry Principles to Application https://onlinecourses.nptel.ac.in/noc21_cy36/preview
9. A Study Guide In Organic Retrosynthesis: Problem Solving Approach https://onlinecourses.nptel.ac.in/noc23_cy28/preview

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CY-403 (iii)	**(DSE-III) Physical Chemistry special paper-III (Computational Quantum Chemistry)**	60 hrs (4 hrs/week)

Course Outcomes: At the end of the course students would be able to

1. Demonstrate a thorough understanding of various electronic structure and molecular modeling strategies in computational quantum chemistry.
2. Apply computational chemistry methods to perform calculations and simulations for chemical systems.
3. Analyze and interpret molecular properties and behavior using computational results obtained from electronic structure calculations.
4. Apply theoretical concepts and computational techniques to study molecular bonding, molecular orbital theory, hybridization, and band theory of solids.
5. Understand the principles and techniques of many-electron systems, configuration interaction, perturbation theory, and density functional theory.
6. Utilize molecular modeling techniques for geometry optimization, potential energy surface analysis, and simulations of molecular systems.
7. Apply molecular mechanics and force fields to describe molecular structures, non-bonded interactions, and molecular dynamics.
8. Evaluate and critically analyze the strengths and limitations of computational methods in quantum chemistry.
9. Demonstrate proficiency in using computational software and programming languages commonly used in computational quantum chemistry.
10. Communicate scientific concepts and computational results effectively through written reports, presentations, and discussions

Theories and Methods used in Electronic Structure Calculations

UNIT-I:

1. *Basic Methods and Theories*
    - Review of solutions to the electronic Schrödinger equation for hydrogen and helium atoms
    - Slater determinants and Pauli's antisymmetry principle
    - Coulomb and exchange integrals
    - Rayleigh-Ritz variation method
    - Effective nuclear charge
    - Born-Oppenheimer approximation
    - Bonding in H2
    - LCAO-MO approach
    - Confocal elliptic coordinates
    - Evaluation of Coulomb, resonance, and overlap integrals
    - Valence bond and molecular orbital descriptions of H2
    - Slater determinants
    - Configuration interaction treatment of H2
    - Molecular orbital theory (MOT) of diatomics, bond lengths, bond orders, and bond energies
    - Concept of hybridization, Hybridization (sp, sp2, sp3)
    - *Treatment of unsaturated π-systems*
    - π-electron approximation
    - Free electron MOT
    - Hückel MOT
    - π-bond order, σ-bond order, atomic charges, and Hückel (4n+2) rule

UNIT-II:

1. *Many-electron systems*
    - Hartree and Hartree-Fock (HF) methods
    - Slater orbitals
    - Koopmans' theorem
    - Roothaan equations
    - Restricted and unrestricted HF methods
    - Gaussian-type orbitals
    - Basis sets
    - Complete basis set limit

- Basis set superposition error
- Population analysis
- Molecular electrostatic potential

2. *Configuration interaction (CI)*
    - Limited CI
    - CI singles
    - CI doubles
    - CI singles and doubles
    - Brillouin theorem
    - Slater-Condon rules
    - Static electron correlation
    - Non-dynamical correlation
    - Dynamical correlation
    - Multiconfiguration and multireference methods
    - Size extensivity and size consistency
3. *Moller-Plesset (MP) perturbation theory*
    - MP0, MP1, and MP2 methods

UNIT-III

1. *Density functional theory (DFT)*
    - Concepts of functionals and electron density
    - Thomas-Fermi model
    - Hohenberg-Kohn theorem
    - Kohn-Sham equations
    - Illustration of key exchange-correlation functionals
2. *Electronic Structure of solids*
    - Band theory of solids
    - Tight-binding approximation
    - Density of states
    - Kronig-Penney model
    - Brillouin zone

Molecular Modeling and Simulations

3. *Geometry optimization*
    - Born-Oppenheimer approximation
    - Potential energy surfaces
    - Geometry optimization
    - Single point energies
    - Stationary points
    - Gradients
    - Hessian
    - Transition states
    - Intrinsic reaction coordinates
    - Minimum energy path

UNIT-IV:

1. *Normal modes of vibration*
    - Internal coordinates
    - Mass-weighted coordinates
    - Normal mode analysis in diatomics and polyatomics
2. *Molecular mechanics*
    - Force fields
    - Stretching, bending, torsions
    - Non-bonded interactions, and illustrative examples
    - Ion-ion, ion-dipole, dipole-dipole, dipole-induced dipole, induced dipole-induced dipole interactions
    - Quantum mechanical description of dispersion interactions
3. *Molecular dynamics*
    - Hard sphere potential
    - Lennard-Jones potential
    - Verlet and velocity Verlet algorithms
    - Ergodic hypothesis
    - Estimation of averages

Text & Reference Books:

1. P. Atkins and R. Friedman, Molecular Quantum Mechanics, 5th Ed., Oxford University Press, 2011.
2. A. Szabo and N. S. Ostlund, Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory, Dover Publications, 1996.
3. F. Jensen, Introduction to Computational Chemistry, 2nd ed., John Wiley, 2006.
4. D. A. McQuarrie, Quantum Chemistry, Viva Student ed., Viva, 2011.
5. A. Leach, Molecular Modelling: Principles and Applications, 2nd ed., Pearson, 2009.

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Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-403 (iv)	**(DSE-III) Analytical Chemistry special paper-III (Analytical Techniques in Thermal and Electrochemical Analysis)**	60 hrs (4 hrs/week)

Course Outcomes: Upon successful completion of this course, students will be able to:

1. Describe the principles and techniques of thermal analysis methods.
2. Interpret thermograms and DTA/DSC curves to analyze thermal behavior.
3. Apply thermogravimetric titration for analytical purposes.
4. Explain the principles of voltammetry and its applications in metal ion and organic analysis.
5. Understand the working principles and applications of ion-selective electrodes.
6. Comprehend the concepts and techniques of electrochemical microscopy.
7. Perform electrogravimetric analysis and understand its applications.
8. Apply coulometric methods for titration and analysis of various substances.
9. Analyze and interpret experimental data obtained from thermal and electrochemical analysis techniques.
10. Evaluate the advantages, limitations, and practical considerations of different analytical techniques.

Syllabus:

Unit-I: Thermal Methods of Analysis (15 hours)

Introduction to Different Thermal Methods:

- Overview of various thermal analysis techniques
- Thermogravimetry (TG and DTG)
- Static thermogravimetry
- Quasistatic thermogravimetry
- Dynamic thermogravimetry

Instrumentation:

- Balances for accurate measurements
- X-Y recorder for data visualization
- Stanton-Redcroft TG-750 instrument for thermogravimetry analysis
- Thermogram and its interpretation
- Factors influencing thermogram patterns

Applications of Thermogravimetry:

- Practical applications of thermogravimetry in different fields

Differential Thermal Analysis (DTA):

- Theories underlying differential thermal analysis
- DTA curves and their interpretation
- Factors affecting DTA curves
- Applications of DTA in thermal analysis
- Simultaneous determination in thermal analysis

Differential Scanning Calorimetry (DSC):

- Introduction to differential scanning calorimetry
- Instrumentation used in DSC analysis
- DSC curves and their interpretation
- Factors influencing DSC curves
- Applications of DSC in various industries

Thermogravimetric Titration:

- Theoretical foundations of thermogravimetric titration
- Instrumentation involved in thermogravimetric titration
- Applications of thermogravimetric titration in analytical chemistry

Unit-II: Voltammetry and Electrochemical Analysis (15 hours)

1. Stripping Voltammetry: Principles and techniques in anodic and cathodic stripping voltammetry
2. Applications of stripping voltammetry in metal ion analysis
3. Limitations of stripping voltammetry
4. Adsorptive stripping voltammetry: Principles, techniques, and applications in metal ion and organic analysis
5. Advantages of adsorptive stripping voltammetry over anodic stripping voltammetry
6. Catalytic effects in voltammetry
7. Working electrodes: Mercury electrodes, carbon electrodes, film electrodes
8. Cyclic voltammetry: Principles, techniques, Randles-Sevcik equation, interpretation of voltammogram (reversible, irreversible, and quasi-reversible systems)
9. Applications of cyclic voltammetry in the study of reaction mechanisms and adsorption processes
10. Comparison of voltammetry with AAS and ICP-AES

Unit-III: Ion Selective Electrodes and Electrochemical Microscopy (15 hours)

11. Ion selective electrodes: Theory of membrane potential, types of ion-selective electrodes
12. Construction of solid-state electrodes, liquid membrane electrodes, glass membrane electrodes, and enzyme electrodes
13. Selectivity coefficients
14. Glass electrodes with reference to H^+, Na^+, and K^+ ions
15. Applications of ion selective electrodes in the analysis of environmentally important anions (F^-, Cl^-, Br^-, I^-, NO_3^-, CN^-)
16. Advantages of ion selective electrodes
17. Introduction to electrochemical microscopy: Scanning probe microscopy (SPM), scanning tunneling microscopy (STM), atomic force microscopy (AFM), scanning electrochemical microscopy (SECM)

Unit-IV: Electrogravimetry and Coulometry (15 hours)

- *Electrogravimetric Analysis:* Introduction to electrogravimetry and its principles, Electrodeposition mechanisms in electrogravimetry
- *Polarization and Electrogravimetry:* Polarization effects in electrogravimetric measurements, Minimizing polarization in electrogravimetry
- *Types of Electrogravimetric Methods:* Constant current electrolysis in electrogravimetry, Constant potential electrolysis in electrogravimetry
- *Application of Electrogravimetry:* Examples of electrogravimetry applications in analysis, Environmental, metallurgical, and quality control applications
- *Coulometry: Principles and Techniques:* Introduction to coulometry and its principles, Faraday's laws and their application in coulometry
- *Types of Coulometric Methods:* Controlled potential coulometry (potential coulometry), Constant current coulometry (amperostatic coulometry)
- *Application of Coulometry:* Overview of coulometric titrations and their applications, Analysis of pharmaceuticals, metals, and other substances using coulometry

Textbook & Reference Books:

1. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). Principles of Instrumental Analysis. Cengage Learning.
2. Brown, M. E., & Gallagher, P. K. (2016). Introduction to Thermal Analysis: Techniques and Applications. Springer.
3. Bard, A. J., & Faulkner, L. R. (2000). Electrochemical Methods: Fundamentals and Applications. Wiley.
4. Kissinger, P. T., & Heineman, W. R. (1996). Laboratory Techniques in Electroanalytical Chemistry. CRC Press.
5. IUPAC. (2009). Compendium of Analytical Nomenclature: Definitive Rules 2007 (3rd ed.). The Royal Society of Chemistry.
6. Fritz, J. S., & Schenk, G. H. (2003). Handbook of Electrochemistry. Wiley-VCH.
7. Šesták, J., & Berggren, G. (2014). Thermal Analysis of Polymeric Materials. CRC Press.

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Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-403 (v)	**(DSE-III) Industrial Chemistry special paper-III (Polymers, Dyes and Paints)**	60 hrs (4 hrs/week)

Course Outcomes: At the end of the course students would be able to

1. The chemistry of polymerization, and types of polymer.
2. The present status of Polymer Industry in India.
3. The various dyes and their industrial applications.
4. To identify the root causes of corrosion and its prevention.
5. Mechanism of Paper industry and processes involved during manufacturing of paper.

Unit – I : 15L

Polymer Chemistry: Basic concepts, degree of polymerization, classification of polymerization reactions, thermodynamic. Types of polymerization: dendrimer, copolymerization, block copolymerization, graft copolymerization, stereo isomers, isotactic and syndiotactic polymers. Mechanism of polymerization: Free radical and ionic ; characterization and rheology of polymers, heterogeneous polymerization, Zeigler-Natta catalysis.

A) Commercial polymers-: Manufacturing process, properties and uses of Nylon-66, Polyethylene, Polypropylene, Polyvinylchloride, Polystyrene and Teflon. Effect of stereochemistry on the structure and properties of polymers.

B) Degradation of polymers: Oxidation, thermal, photo and hydrolytic degradation methods.

Unit – II : 15L

Dyes: Introduction, Chromophore, Auxochrome. classification of dye on the basis of mode of application and structure. Acid Dye, Basic Dye, Pigment Dye. Dye Intermediates, preparation of dye intermediates, structural features of a dye, preparation and applications of Picric acid, Methyl Orange, Fluorescence, Methyl Red, Indigo, Phthalenes, Xanthenes, cyanine, anthraquinone dye. Industrial uses of Dye.

Unit - III: 15L

Paper and Pulp: Raw materials, classification, methods of pulping, production of sulphate and sulphite pulp, general principles of some mechanical and chemical pulping kinetics.

Paper Industry: Production of paper, wet process, paper properties testing, process instrumentation , Emission: Solid and gas waste ;Applied processes and techniques: Sizing, coating, dyeing, addition of chemicals, and calendering ; Fibre recovery: Broke system

Unit - IV: A) Paints and Pigments: 15L

Introduction of paints, ingredients and classification, new technologies ; properties of coatings ; solvents, plasticizers, dyes and bioactive additives ; paint formulations, testing and evaluation. Pigments: Introduction, classification and general physical properties.

B) Corrosion-:

Introduction, Principle of corrosion, Types of corrosion relevant to chemical industries,

Mechanism of electrochemical corrosion, Factor influencing corrosion, Corrosion testing methods - Weight loss method, electrochemical approach, corrosion rate at short time intervals. Mechanism of corrosion and Corrosion prevention Methods- Galvanizing, tinning and electroplating. Corrosion Hazards and its industrial implications.

Books Suggested-

1) Textbook of polymer science by F. Bill Mayer, Wiley Inter Science.
2) Plastic materials, J.A. Brydson (London)
3) Polymer science, Billmeyer, F. W. John Wiely & sons
4) Introduction to plastics, J.H. Briston and C.C. Gosselin, Newnes, London
5) Polymeric Materials, C. C. Winding and G. D. Hiatt McGraw Hill Book Co. Polymer Science byGowarikar
6) Physical chemistry of polymers by D. D. Deshpande, Tata McGraw Hill.
7) Principles of polymer chemistry By P.J. Flory, Cornell Univ. Press.
8) Introduction to polymer chemistry by R. B. Seymour McGraw Hill.
9) A Practical Course in polymer chemistry by S.J. Pnnea, Pergamon press.
10) Laboratory preparation of macro chemistry by E. M. M. Jeffery McGraw Hill.
11) The Chemistry of Synthetic dyes by Venkatraman (VOL I &II)
12) Fundamental processes of dye chemistry, by Fierz.
13) The Complete Technology Book on Dyes and Dye Intermediates By Himadri Panda, NPCS.
14) Paints, coatings and solvents by D. Stoye, WILEY-VCH.
15) Paints and surface coating theory and practice by R. L. Lambourna
16) Pigments handbook by T. C. Patton
17) Coating technology handbook by D. Satas.
18) Experiments in polymer science, D.G Hundiwale, V.D. Athawale, U. R Kapadi, V.V. Gite New age International Pvt. Ltd - New Delhi.
19) Polymer Chemistry - Practical approach in Chemistry, F.J. Davis, Oxford University press.
20) Polymer Science - V.R Gowarikar, N.V. Viswanathan, Jayadev Shredhar, New Age International Pvt. Ltd. New Delhi – 1997

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Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-404 (i)	**(DSE-IV) Inorganic Chemistry special paper-IV (Material Chemistry)**	60 hrs (4 hrs/week)

Course Outcomes: At the end of the course students would be able to

1. classify solid state materials on the basis of their properties.
2. manufacture solid state materials and find their applications .
3. understand the principal involved in nanochemistry and synthesis nanoscale materials by different techniques.
4. describe the role and application of nanoparticles as catalysts in different areas.
5. classify nano-porous materials and explain their role in catalysis.
6. describe solid state reactions and their mechanisms.
7. classify fertilizers and describe their manufacture processes.
8. synthesize coordination polymer by following different synthetic routes.

Unit-I: Glasses, Ceramics & Composite and Bio-materials: **15 hrs**

Glass: Glassy state and its properties, classification (silicate and non-silicateglasses), Manufacture and processing of glass, glass formers and glass modifiers; Ceramics:Ceramic structure. Mechanical properties, High technology ceramics and their applications; Composite materials:Definition, glass transition temperature, fibres, concrete and asphaltmaterials, polymer composites, application;

Ceramic & Refractory:Introduction, classification, properties, raw materials, manufacturing and applications; Bio-materials:Biomineralisation, controlled formation of biological composits, bone & othermineralised tissues, materials of construction, applications (General aspect only).

Unit-II: Nano Chemistry: **15 hrs**

Introduction: Definition of nanoscale materials, different types, different physical and chemicalsynthetic routes, characterization of nanoscale materials by modern instrumental techniques; Physical and Chemical Properties of Nanoscale Materials: Electrical properties, magneticproperties, optical extinction properties, unique optical signatures of various nanostructures,fluorescence, chemical reactivity, self-assembly of various nanostructures and its importance; Catalytic Aspects of Nanoscale Materials: Catalysis using nanoparticles of metals and metaloxides with different sizes and shapes, useful chemical conversions using nanoparticles; Nanoscale Materials in Emerging Technologies: Useful properties that can be exploited forapplications, applications in the areas such as environmental remediation, adsorption, drugdelivery, medical imaging, future prospects, precautions in using nanoparticles.

Unit III: **15 hrs**

A) **Nanoporous Materials-Zeolites:**
Natural occurrence, classifications, structures and characteristic properties; Hydrothermal synthesis of zeolites; Factors affecting the zeolite preparations, modification and methods of characterizations; Catalytic and other applications.

B) **Solid State Reactions:** Types; sintering; nucleation; Factors influencing the reactivity of solids;Precursors to solid state reactions; Tammann and Hedvall mechanism; Wagner's diffusion theoryofreaction; Material transport in solid state reaction-counter diffusion, Kirkendall effect;Huttig'smechanism; Kinetic model: Reaction in powder compact, parabolic rate law, Jander's rateequation.

Unit IV: **15 hrs**

A) **Fertilizers:**

Different types of fertilizers; Manufacture of the fertilizers: Urea,ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate,superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

B) **Coordination Polymers**:

Homo and heterocatenated inorganic polymers;Polyphosphazenes:synthetic routes and bonding features, polymerization of organo/organometallic substitutedphosphazenes and their applications;Polysilanes: synthesis and characterization of polysilanes, sigma bond delocalization and itsimplications;Polysiloxanes: synthetic routes viaanionic and cationic polymerization, properties and environmental aspects;

Books Suggested:

1) Barsoum,M.W.,Fundamentals of Ceramics,McGraw Hill ,New Delhi
2) Ashcroft,N.W. and Mermin,N.D.,Solid Stae Physics,Saunders College
3) Callister W.D.,Material Science and Engineering, An Introduction,Wiley
4) Keer,H.H,Principals of Solid State,Wiley Eastern
5) Anderson J.C.,Lever K.D.,Alexander J.M and Rawlings,R.D.,ELBS
6) Kalbunde K.I.,Nanoscale Materials in Chemistry,John Wiley,NY.
7) Shull R.D.,McMichael R.D. and Swartzendrub L.J.,Studies of Magnetic Properties of Fine particles andtheir relevance to Materials Science, Elsevier Pub.Amsterdam
8) Breck D.W.,Zeolite Molecular Sieves:Structure Chemistry and Use,WileyChichester,Eng.
9) MorrishA.H.,HanedaK.,ZhouX.Z.InNanophasematerials:synthesis,properties,applications ,Kulwer,London.
10) Shriver & Atkins. Inorganic Chemistry, Peter Alkins, Tina Overton, Jonathan Rourke, Mark Weller and
11) Fraser Armstrong, 5th Edition, Oxford University Press (2011-2012)
12) Adam, D.M. Inorganic Solids: An introduction to concepts in solid-state structural chemistry. John Wiley& Sons, 1974.
13) Poole, C.P. & Owens, F.J. Introduction to Nanotechnology John Wiley & Sons, 2003.
14) Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.

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Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-404 (ii)	**(DSE-IV) Organic Chemistry special paper-IV (Natural Products)**	60 hrs (4 hrs/week)

Course Outcomes: At the end of the course students would be able to

1. Gain a comprehensive understanding of the structures, properties, and functions of steroids, hormones, alkaloids, and terpenoids.
2. Learn about the diversity and biological significance natural products in different organisms.
3. Explore the biosynthesis of natural products
4. Study the enzymatic reactions, intermediates, and regulation involved in the biosynthetic pathways of compounds.
5. Develop an understanding of the chemical and enzymatic mechanisms underlying the biosynthesis of natural products
6. Analyze and interpret the key steps and transformations involved in these biosynthetic pathways.
7. Investigate the relationship between the chemical structures of steroids, hormones, alkaloids, and terpenoids and their biological activities.
8. Understand how specific structural features influence the interactions and functions of the compounds in biological systems.
9. Explore the pharmacological, ecological, and industrial applications of steroids, hormones, alkaloids, and terpenoids.
10. Understand the importance of natural compounds in areas such as medicine, agriculture, and natural product-based industries.
11. Develop the ability to critically evaluate scientific literature and research findings related to natural compounds

Unit I **15h**

A) Polymers:

Mechanism of polymerization, Study of polyesters, Study of polyamides, Polyvinyl chloride (PVC), Polystyrene, Polyvinyl acetate and polyvinyl alcohol, Polyethylenes, Viscous rayon, Synthesis of polyethylene and polypropylene, Synthetic Rubber: Styrene-butadiene, Butyl polyisoprene, polyurethane, Vulcanization mechanism, Phenol formaldehyde resin, Stereo regulated polymers (Atactic, Isotactic, and Syndiotactic), Plasticizers and foaming agents, Antioxidants for polymers.

B) Dyes:

General introduction to dyes, Optical brighteners, Thermal sensitive dyes, Disperse dyes, Fiber swelling in dyeing, Use of carriers in dyeing, Use of heat energy in dyeing, Study of specific dyes: Quinoline yellow, Cyamine dye, Ethyl red, Methylene blue, Alizarin, Cyamine-green, Fluorescein, Cosin, Erythrosine, Rhodomines, Indigo

C) Agrochemicals: Carbamate pesticides:

1. Carbaryl
2. Baygon
3. Ziram

Organophosphorous pesticides:

1. Malathion
2. Monocrotophos
3. Dimethoate

Unit II **15h**

A) Carbohydrates:

Types of naturally occurring sugars, Deoxy sugars, Amino sugars, Branched chain sugars, Methyl ethers and acid derivatives of sugars, General methods of structure determination, Ring size determination, Specific carbohydrates to study: Maltose, Lactose, Sucrose, Starch, Cellulose

B) Lipids:

Fatty acids, Essential fatty acids, Structures and function of triglycerides, Glycerophospholipids, Sphingolipids, Cholesterol, Bile acids, Prostaglandins, Lipoproteins: composition and function, Role of lipids

Unit III **15h**

A) Amino Acids, Proteins, and Peptides:

Amino acids: Structural characteristics, Acid-base properties, Stereochemistry of amino acids, Optical resolution, Strecker synthesis

Peptides and proteins: Structure of peptides and proteins, Primary structure, Secondary structure, Tertiary structure, Quaternary structure, Reactions of polypeptides, Structure determination of polypeptides, End group analysis

Nucleic acids: Purines and nucleic acids: Chemistry, structure, and functional relation to genes of DNA and RNA, Biosynthesis of amino acids (Lysine and phenylalanine)

B) Enzymes:

- Identification of active sites: Use of inhibitors
- Mechanism of enzyme action: Orientation and steric effects
- Examples: ribonuclease and carboxypeptidase

Enzyme-catalyzed reactions: Carboxylation, Decarboxylation, Rearrangement, Isomerization

C) Steroids and Hormones: Occurrence of steroids and hormones, Nomenclature of steroids, Basic steroid skeleton, Diel's hydrocarbon and stereochemistry, Biosynthesis of steroids

Structure determination and synthesis of specific steroids: Cholesterol, Testosterone, Progesterone, Estrone, Cortisol

Unit IV **15h**

A) Alkaloids: Classification of alkaloids, Nomenclature of alkaloids, Occurrence of alkaloids in natural sources, Isolation of alkaloids, General methods of structure determination

Specific alkaloids to study: Papaverine, Morphine, Reserpine, Nicotine

B) Terpenoids: Classification of terpenoids**,** Nomenclature of terpenoids**,** Occurrence of terpenoids in natural sources, Isoprene rule in terpenoid structures**,** General methods of structure determination

Specific terpenoids to study: Camphor**,** Geraniol, Abietic acid**,** Squalene

C) Biosynthesis of Terpenes and Alkaloids: Biosynthesis of terpenes**,** Biosynthesis of alkaloids

Text books/Reference books:

1. "Polymer Chemistry: Principles and Applications" by David R. Williams and Michael P. C. Garnett
2. "Polymer Chemistry: An Introduction" by Malcolm P. Stevens
3. "Industrial Dyes: Chemistry, Properties, Applications" by Klaus Hunger and Thomas M. Klapötke
4. "Introduction to Agrochemicals" by C. N. Chandrasekhar.
5. "Carbohydrates: The Essential Molecules of Life" by Robert V. Stick
6. "Lipids: Structure, Physical Properties and Functionality" by Peter J. Barnes
7. "Principles of Biochemistry" by Albert L. Lehninger, David L. Nelson, and Michael M. Cox
8. "Proteins: Structures and Molecular Properties" by Thomas E. Creighton
9. "Peptide Chemistry and Drug Design" by Ben M. Dunn and Tony J. Ripka
10. "The Organic Chemistry of Biological Pathways" by John McMurry
11. "Steroid Chemistry at a Glance" by Daniel Lednicer
12. "Plant Hormones: Biosynthesis, Signal Transduction, Action!" edited by Peter J. Davies
13. "Alkaloids: Biochemistry, Ecology, and Medicinal Applications" edited by Margaret F. Roberts and Michael Wink
14. "Introduction to Terpenes: Nature's Most Diverse Source of Chemicals" by E. J. Corey
15. "The Biosynthesis of Natural Products" edited by Jonathan B. Spencer
16. "Biosynthesis: Aromatic Polyketides, Isoprenoids, Alkaloids" edited by K. G. Ramawat and Jean-Michel Merillon

Web links

1. PubChem (https://pubchem.ncbi.nlm.nih.gov/) PubChem is a comprehensive database maintained by the National Center for Biotechnology Information (NCBI). It provides information on the chemical structures, properties, and biological activities of various

compounds, including steroids, hormones, alkaloids, and terpenoids. You can search for specific compounds and access their data sheets.

2. ChemSpider (http://www.chemspider.com/) ChemSpider is a freely accessible chemical structure database provided by the Royal Society of Chemistry. It contains information on millions of compounds, including steroids, hormones, alkaloids, and terpenoids. You can search for specific compounds, explore their structures, and access related data.
3. Phytochemical and Ethnobotanical Databases (https://phytochem.nal.usda.gov/phytochem/) The USDA Phytochemical and Ethnobotanical Databases provide information on plant-based compounds, including alkaloids and terpenoids. These databases offer access to the chemical structures, properties, and biological activities of various natural products. They also provide links to relevant literature and references.
4. KEGG (Kyoto Encyclopedia of Genes and Genomes) (https://www.kegg.jp/) KEGG is a valuable resource for biological pathways and molecular interactions. It includes information on the biosynthesis of various compounds, including terpenes and alkaloids. KEGG pathways and databases provide insights into the genes, enzymes, and metabolic pathways involved in the biosynthesis of these compounds.
5. The Plant List (http://www.theplantlist.org/) The Plant List is a comprehensive database of plant species and their names. It includes information on botanical names, synonyms, and classifications. It can be useful for identifying plants that produce specific alkaloids or terpenoids.

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CY-404 (iii)	**(DSE-IV) Physical Chemistry special paper-IV (Physical Chemistry of Materials)**	60 hrs (4 hrs/week)

Course/Learning Outcomes: By the end of this course, students will:

1. Acquire knowledge of the fundamental principles and properties of soft materials, including liquid crystals, colloids, polymers, glasses, ceramics, composites, and materials.
2. Understand the characterization techniques used for these materials.
3. Develop an understanding of the applications of these materials in various devices.
4. Gain insight into the behavior and unique properties of high Tc materials.
5. Familiarize themselves with the physical chemistry behind the materials and their practical implications

Syllabus:

UNIT-I: 15 h

1. *Thin Films and Langmuir-Blodgett films*
   - Preparation techniques: evaporation/sputtering, chemical processes, MOCVD, sol-gel, etc.
   - Langmuir-Blodgett (LB) film: growth techniques, photolithography, properties, and applications.
2. *Liquid crystals*
   - Mesomorphic behavior: thermotropic liquid crystals, positional order, bond orientational order.
   - Nematic and smectic mesophases, smectic-nematic transition, and clearing temperature.
   - Optical properties of liquid crystals, dielectric susceptibility, and dielectric constants.
   - Lyotropic phases and ordering in liquid crystals.
3. *Colloids*
   - Types of colloids and forces between colloidal particles.
   - Characterization of colloids and colloidal dispersions.
   - Charge and steric stabilization, effect of polymers on colloid stability.
   - Sols, gels, clays, foams, emulsions, and concentrated colloidal dispersions.

UNIT-II: 15h

1. *Polymer*
   - Polymer melts: tube model, viscoelastic behavior, Rouse and Zimm models.
   - Polymer blends, copolymers, and incompatibility.
   - Segregation and experimental observations of single-chain dynamics.
2. *Glasses and ceramics*
   - Glassy state, glass formers, and glass modifiers.
   - Ceramic structures, mechanical properties, and clay products.
   - Refractories, characterization, properties, and applications.
   - *Composites and nanomaterials*
   - Microscopic composites, dispersion strengthened, particle-reinforced, and fiber-reinforced composites.
   - Nanocrystalline phases, preparation procedures, special properties, and applications.

UNIT-III: 15h

1. *Ionic conductors*
   - Types of ionic conductors and mechanisms of ionic conduction.
   - Interstitial and vacancy mechanisms, diffusion superionic conductors, and phase transitions.
   - Examples and applications of ionic conductors.
2. *High Tc materials*
   - Defect perovskites and high Tc superconductivity in cuprates.

- Preparation and characterization of high Tc materials.
- Normal state properties, anisotropy, and temperature dependence of electrical resistance.
- Superconducting state, heat capacity, coherence length, and microwave absorption.
- Multigap structure and applications of high Tc materials.

UNIT-IV: **15h**

1. *Materials for solid-state devices*
   - Rectifiers, transistors, and capacitors IV-V compounds.
   - Low-dimensional quantum structures and optical properties.
   - Organic solids, fullerenes, and molecular devices.
2. *Nonlinear optical materials*
   - Nonlinear optical effects, molecular hyperpolarizability, and second/third-order electric susceptibility.
3. Materials for second and third harmonic generation.

Text & Reference Books:

1. Ashcroft, N. W. & Mermin, N. D. Solid State Physics Holt-Saunders (1976)
2. Callister, W. D., Jr. Materials Science & Engineering: An Introduction John Wiley & Sons: New York (2000).
3. Keer, H. V. Principles of the Solid State Wiley Eastern Ltd.: New Delhi (1993).
4. Gray, G. W., Ed. Thermotropic Liquid Crystals John Wiley & Sons: New York (1987).
5. Serpone, N. & Pelizzetti, E. Photocatalysis: Fundamentals and Applications John Wiley & Sons (1989).
6. Cowie, J. M. G. Polymers: Chemistry and Physics of Modern Materials 2nd Ed. CRC Press (1991)

   Hamley, I. W. Introduction to Soft Matter: Polymers, Colloids, Amphiphiles and Liquid Crystals John Wiley & Sons (2000).

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Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-404 (iv)	**(DSE-IV) Analytical Chemistry special paper-IV (Pharmaceutical, Clinical, Food, and Beverage Analysis)**	60 hrs (4 hrs/week)

Course Learning Outcomes: Upon successful completion of this course, students will be able to:

1. Describe the pharmaceutical industry and classify different types of drugs.
2. Explain the requirements of a quality control laboratory in pharmaceutical units.
3. Identify common sources of impurities in pharmaceutical chemicals and raw materials.
4. Standardize finished pharmaceutical products and apply official methods of control.
5. Compare classical and modern methods of drug analysis and select appropriate techniques.
6. Perform clinical analysis methods and interpret data for blood and urine parameters.
7. Apply immunoassay techniques such as RIA, fluorescence immunoassay, and enzyme immunoassay.
8. Perform food analysis for moisture, ash, proteins, fats, carbohydrates, vitamins, and trace elements.
9. Detect common adulterants in food and analyze milk for fat and added water.
10. Analyze oils and fats for iodine value, saponification value, acid value, and rancidity.
11. Understand the biological significance of enzymes and perform their analysis and assay.
12. Analyze alcoholic beverages for quality parameters including extract, alcohol content, pH, and dissolved oxygen.

Syllabus:

Unit-I: Pharmaceutical Analysis (15 hours)

1. General idea about pharmaceutical industry, definition and classification of drugs.
2. Requirements of a quality control laboratory for pharmaceutical units
3. Source of impurities in pharmaceutical chemical and raw materials.
4. Standardization of finished products and their characteristics, official method of control, use of pharmacopoeia.
5. Classical and modern methods of drug analysis.
6. General overview and analysis of common drugs: analgesics, antipyretics, antimalarial, antiallergic (anti-histamines) and antibiotics.

Unit-II: Clinical Analysis (15 hours)

1. Composition of blood and its significance in clinical analysis.
2. Sample collection techniques for blood and urine.
3. Clinical analysis methods and procedures.
4. Estimation and interpretation of data for blood sugar, haemoglobin, urea and cholesterol.
5. Immunoassay techniques:
    a. Radioimmunoassay (RIA): Setting up and applications
    b. Fluorescence immunoassay
    c. Enzyme immunoassay
6. Blood gas analyzer and its applications
7. Analysis of trace elements in the body

Unit-III: Food Analysis (15 hours)

1. ***Food analysis:*** Determination of moisture (Oven drying Karl-Fischer Titration, Colorimetry), Ash (Dry and Wet ash method), crude protein (Kjeldahl's method, Dumas method and Biurett method), Fat (Soxhlet method; Mojonnier Method, Gerber method), Crude fibre, carbohydrate (Phenol-Sulfuric Acid method for determination of total carbohydrates; Nelson-Somogyi method for determination of reducing sugars; Enzymatic method), calcium, potassium, sodium, phosphates and vitamins (A, B1, B2, C, E) in food.
2. ***Food adulteration*** – common adulterants in food and their determination. Contamination of food stuffs. Analysis of milk for fat and added water.
3. ***Pesticide residues*** in foods determination of chlorinated organic pesticides. (4 hours)

Unit-IV: Analysis of Oils, Fats, Enzymes, Alcoholic Beverages (15 hours)

1. ***Oils and fats and their analysis:*** iodine value, iodine bromine value, saponification value and acid value and their significances. Rancidity-detection and determination (peroxide number).
2. ***Biological significance, analysis and assay of enzymes:*** pepsin, monoaminoxidase, and tyrosinase. (3 hours)
3. ***Analysis of alcoholic beverages:*** determination of quality parameters such as original extract, alcohol, extract, CO2, O2. Brix, degree of inversion, pH value, ethyl carbamate, carbohydrate, and dissolved oxygen

Textbooks and Reference Books:

1. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). Principles of Instrumental Analysis. Cengage Learning.
1. Connors, K. A. (2010). A Textbook of Pharmaceutical Analysis (4th ed.). Wiley.
2. Dean, J. R., & Vreča, P. (2017). Analysis of Pesticides in Food and Environmental Samples (2nd ed.). CRC Press.
3. Fennema, O. R., Damodaran, S., Parkin, K. L., & Fennema, O. (2016). Fennema's Food Chemistry (5th ed.). CRC Press.
4. Gunstone, F. D., Harwood, J. L., & Dijkstra, A. J. (2007). The Lipid Handbook with CD-ROM (3rd ed.). CRC Press.
5. Settanni, L., & Sannino, C. (2018). Alcoholic Beverages: Sensory Evaluation and Consumer Research. Wiley.

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Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-404 (v)	**(DSE-IV) Industrial Chemistry special paper-IV (Chemical Process Industries, Green Chemistry and Process Economics)**	60 hrs (4 hrs/week)

Course Outcomes (COs): After completion of course students will able to understand

1. The synthesis, structure and applications of Insecticides, Herbicides,Fungicides, Rodenticides and pesticides.
2. The Manufacture, storage, hazards and uses of Industrial gases.
3. The principals of Green Chemistry and apply their knowledge to synthesize the material by green method.
4. The Present status of Fertilizer Industry in India.
5. The Pharmaceutical products and their mode of action.
6. Calculate the depreciation by different methods.

Syllabus

Unit – I : **15L**

Agrochemicals : General introduction, synthesis, structure and application:
Insecticides: DDT, BHC, aldrin, endosulphan, malathion, parathion.
Herbicides: 2,4-dichloro phenoxy acetic acid, dalapon, paraquat, basalin, butachlor, alachlor,sulphonyl urea.
Fungicides: Bordeaux mixture, copper oxychloride, benomyl.
Rodenticides: Warfarin, sodium mono-fluoroacetate, zinc phosphide.**Pesticides:** Endosulphan, methyl parathion.

Unit – II : **15L**

Pharmaceuticals: Product profile study of the following drugs and intermediates with particular stress on the manufacturing process engineering problems involved, quality control and equipments;
Sulpha drugs:- Sulphaguanidine, sulfamethoxazole.

i) Antimicrobial:- chloramphenicol, streptomycin, Tetracyclines. Amoxicillin, Erythromycin.
ii) Analgesic:- Anti-Inflammatory, Acetyl Salicylic acid, Ibuprofen, paracetamol.
iii) Vitamin:- Vit. A. Vit. B6, Vit. C
iv) Barbiturates:- Pentobarbital
v) Cardiovascular agent:- Methyldopa
vi) Antidepressants:- Risperidone, sertraline.

Unit – III : **15L**

A) Industrial Gases: Heavy chemicals and production of gases. Chemistry, manufacture, storage, hazards & uses:- Hydrogen, Oxygen, nitrogen, carbon dioxide, chlorine, fluorine, SO_2 , phosgene, acetylene, argon, neon & helium.
B) Fertilizers: Fertilizer industries in India, Manufacture, uses and major engineering problems of Ammonium sulphate, Urea, Ammonium nitrates, Ammonia, Ammonium Phosphate, superphosphates, complex fertilizers.
C) Safety: General occupational safety, flammable materials, Handling, fuel fighting equipments, control measures for Toxic chemicals. Safety with chemical engineering operations, hazardous chemicals process. Safety in Laboratories and pilot plant. Safety in transportation & storage of chemicals, management of safety & loss prevention.

Unit – IV : **15L**

A) Principles and Concepts of Green Chemistry: Introduction.

i) Atom economic reactions - Rearrangement reactions, Addition reactions.
ii) Atom un-economic reactions - Substitutions reactions, Elimination reactions,

iii) Witting reaction
iv) Reducing toxicity - Measuring toxicity.

Synthesis involving basic principle of Green Chemistry - Introduction, Synthesis of Styrene, Adipic acid, Urethane, Aromatic amine, Selective alkylation of active methylene group, Synthesis of Acetaldehyde, Furfural from biomass, Synthesis of S-metolachlor (herbicide), Ibuprofen, Paracetamol.

B) Chemical Process Economics: Cash flow for Industrial operation, factors affecting project cost and investment, cumulative cash position, salvage value, estimation methods employed for the estimation of capital investment. Interest, Depreciation, Methods of determining depreciation: Straight Line Method, Declining Balance Method and Sum of Years digit Method. Economics of selecting alternatives. Break-even point, production scheduling.

Books Suggested:

1) Pesticides-Color Publications. L. Bombay.
2) Elements of Plant Protection by L. L. Pyenson, John Wiley and sons.
3) Chemistry of Pesticides by N. N. Melnikov Springer-Verlag, New York.
4) Fungicides in Plant Disease control by Y. L. Nines, Oxford and IBH Publishing company.
5) Methods of Pesticides Analysis by SriRamulu, U. I. Oxford and IBH Publishers.
6) Chemical Process Industries by R.N. Shreves and M.J.A.Brink. McGraw Hill Ltd. 4th Edition.
7) Outline of Chemical Technology, Charles E. Dryden, Edited by M. Gopal Rao and
8) Marshall Siting, East West press 2nd Edition 1973.
9) Indian Pharmacopoeia, 1985.
10) British pharmacopoeia, 1990.
11) Text book of Organic Medicinal and Pharmaceutical Chemistry by Wilson, Gisvolds.
12) Essentials of Medicinal Chemistry by Korolkovas and Burckhalter-Wiley-Inter science.
13) Pharmaceutical Dosage forms.
14) Chemical Process Safety D. A. Crowl & J.F. Louvar, (Fundamentals with applications), Prentice Hall
15) Safety and Accident Prevention in Chemical Operations, H. H. Fawcett and W. S. Wood, Wiley and sons.
16) Green Chemistry: Theory and Practice Paperback by Paul Anastas, John Warner.
17) Introduction to Green Chemistry, John Andraos, A.S. Matlack, CRC Press
18) Green Chemistry: Environmentally Benign Reactions, Second Edition V. K. Ahluwalia.

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Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-405 (i)	**(Lab-VII (SEC) Inorganic Chemistry Special**	**90 hrs (9 hrs/week)**

Course Outcomes: Upon successful completion of course, students will be able to

1. analyze some elements and components present in the given samples
2. synthesis nanomaterials by different techniques and characterize them.
3. synthesis and characterize coordination compounds of divalent metal ions.
4. determine the stability and composition of coordination compounds by different methods
5. perform kinetic experiments of substitution reactions of complexes.
6. characterize the complexes on the basis of elemental analysis, solution, magnetic and spectral studies.
7. determine thermal parameters of the compounds under thermogravimetric studies
8. correlate spectral data of coordination compounds with magnetic studies in the determination of geometry of complexes.

Part A) Synthesis and Analysis:

1) Extraction and absorption spectral study of chlorophylls from green leaves.
2) Determination of phosphates from cold drink samples by spectrophotometry.
3) Analysis of talcum and nyclin powders (Mg-complexometry, ZnO/H_3BO_3)
4) Determination of iron in soap bar.
5) Analysis of N, P, K from fertilizer.
6) Analysis of cement/paint/soil.
7) Synthesis of oxides and mixed oxides: Zinc Ferrite, $ZnMn_2O_4$, NiO, Nickel Ferrite, $CuMn_2O_4$ Nanoparticles of MnO_2
8) Preparation of Gold Nanoparticles using Tea
9) Synthesis of nano size ZnO, its characterization by UV-Visible spectroscopy and removal of dye by ZnO-photocatalysis
10) Preparation of Silica and Alumina by sol-gel technique.
11) To study the electrical conductivity and DRS of ferrites, Magnetites, doped oxides and pure samples and determine band gap.
12) Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II).
13) Solvent free and one pot synthesis of Phthalocyanine complex of Copper (II).
14) Synthesis of Zinc(II) /Copper(II)/ Cobalt(II)/ Nickel(II) complexes of Schiff base derived from salicylaldehyde and aniline/ substituted aniline.
15) Synthesis and characterization of coordination polymers of Zinc(II) /Copper(II)/ Cobalt(II)/ Nickel(II).

Part B: Kinetics and Complex:

16) Kinetics of Aquation/Isomerisation /Substitution reactions in octahedral complexes (Acid/Base hydrolysis)
17) Isomerization reaction of octahedral complexes.
18) Enzyme kinetics in presence of metal ions.
19) To determine the corrosion rate of metal strip.
20) To study the 1,10-phenanthroline as corrosion inhibitor for mild steel in sulphuric acid.
21) Kinetics of substitution reaction of $[Fe(Phen)_3]^{2+}$
22) To determine the formula and formation of a complex by spectrophotometry (Job's/ Mole/Slope ratio methods)
23) To determine stepwise proton-ligand and metal-ligand stability constant of complex by Irving Rossotti method.
24) To determine the instability constant of complex by potentiometry ($AgNH_3$, Ag-thiosulphate)
25) To determine the composition and formation constant of a Fe-SSA complex by conductometry.
26) Determination of composition and stability constant of complex by polarography.

27) Cyclic Voltametric study of i) Potassium ferricyanide ii) Ferrocene
28) Two/Three steps synthesis and characterization: Synthesis of metal complexes/Polymers and their structural characterizations by possible physical methods such as: elemental analysis (N, S, M % etc.), m.p., solubility, molar conductance, IR and electronic spectral data for electronic transitions. (minimum two)
29) Determination of magnetic Susceptibility and thermogravimetric studies (at least two samples).
30) Solution state preparation of $[Ni(en)_3]S_2O_3$, $[Ni(H_2O)_6]Cl_2$, $[Ni(NH_3)_6]Cl_2$. Record absorption spectra in solution of all three complexes and analyse it. Arrange three ligands according to their increasing strength depending on your observations.

Examination: CY405 (i) Inorganic Chemistry special (Lab 07)

Time : 6-8 Hrs. (One day Examination) Total Marks : 100

A.	**Exercise-I**	**30**
B.	**Exercise-II**	**30**
C.	**Viva (External + Internal)**	**20**
E.	**Internal assessment***	**20**
	Total	**100**

***-** Internal assessment will be continuous and based on the performance of a student throughout the session along with satisfactory submission of the term work

Book Suggested:

1. Synthesis and Characterization of Inorganic Compounds, W. L. Jolly, Prentice Hall.
2. Inorganic Experiments, J. Derck Woollins, VCH.
3. Practical Inorganic Chemistry, G. Marrand, B. W. Rockett, Van Nostrand.
4. A Text Book of Quantitative Inorganic Analysis, A. I. Vogel, Longoman.
5. EDTA Titrations. F. Laschka
6. Instrumental Methods of Analysis, Willard, Merit and Dean (CBS, Delhi).
7. Inorganic Synthesis, Jolly
8. Instrumental Methods of Chemical Analysis, Yelri Lalikov
9. Fundamental of Analytical Chemistry, Skoog D.A. &West D.M Holt Rinehart &Winston Inc.
10. Experimental Inorganic Chemistry, W. G. Palmer, Cambridge.
11. Solid state Chemistry, N. B. Hanney
12. Introduction to Thermal Analysis, Techniques & Applications, M. E. Brown, Springer
13. Preparation and Properties of solid state Materials, Wilcox, Vol. I&II, Dekker
14. The Structure and Properties of Materials Vol. IV, John Wulff, Wiley Eastern.

Syllabus Prescribed for Two Year PG Programme
Programme: MSc Chemistry (Choice Based Credit System)
Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-405 (ii)	**(Lab-VII (SEC) Organic Chemistry Special**	**90 hrs (9 hrs/week)**

Course Outcomes: Upon successful completion of a course the students will be able to:

1. apply various techniques and tests used for the identification of organic compounds.
2. acquire the ability to interpret test results and deduce the presence of specific functional groups or compounds.
3. execute the principles and limitations of different extraction techniques and how to optimize conditions for efficient extraction.
4. Gain practical hands-on experience in performing isolation and extraction techniques in the laboratory.
5. Understand the principles behind tests such as solubility, precipitation, color reactions, and functional group-specific tests.
6. calibrate instruments and prepare standard solutions for quantitative analysis.

A) Qualitative Organic Analysis: (minimum-6)

Separation, Purification and identification of **ternary mixture**:

1. **Sample Preparation:**
   a. Label the ternary mixture with a unique identifier for reference.
   b. Take an appropriate amount of the mixture for analysis.
2. **Separation:**
   a. Choose an appropriate separation technique based on the properties of the components, such as extraction, distillation, or chromatography.
   b. Perform the selected separation technique to obtain individual components.
   c. Note down the procedure and observations during the separation process.
3. **Purification:**
   a. Take each separated component and assess its purity through visual inspection and solubility tests.
   b. Purify the components using techniques like recrystallization, filtration, or distillation, depending on their physical properties.
   c. Collect the purified samples in separate labeled containers.
4. **Analysis of Individual Components:**
   a. Perform qualitative tests on each purified component to determine their characteristics:
      i. Physical appearance, color, and odor.
      ii. Solubility tests in different solvents (water, acid, base, organic solvents).
      iii. Flame test to observe any characteristic color changes.
      iv. Functional group tests specific to the compound class (if applicable).
   b. Record the observations for each component and compare them with known data or reference compounds.
5. **Detection of Elements:**
   a. Perform elemental analysis tests, such as the Lassaigne's test or combustion analysis, on each purified compound.
   b. Observe any color changes or formation of specific compounds to identify the elements present.
   c. Record the observations and correlate them with known data or reference compounds.
6. **Determination of Melting or Boiling Points:**
   a. Measure the melting or boiling points of the purified compounds using suitable apparatus.
   b. Compare the obtained values with known data or reference compounds to aid in identification.
7. **Preparation of Derivatives:**
   a. Select an appropriate derivative formation method based on the functional groups present in each compound.
   b. Carry out derivatization reactions by reacting the compounds with suitable reagents.
   c. Collect the derivatives obtained and store them in labelled containers.
8. **Identification:**

a. Perform thin-layer chromatography (TLC) on the purified compounds and their derivatives.
b. Identify the compounds present in each mixture based on the Rf (retention factor) values or other characteristic features (Melting Point and Boiling Point).

B) Miscellaneous Experiments (minimum-8)

Compare the stereochemistry (if applicable) and yield of the product obtained with the previous method, Isolate and purify the product. Assess the yield and characterize the compound using spectral data obtained from instrument or using software.

Experiment 1: Reduction Reaction of 3-Nitroacetophenone
Objective: Stereo-selective synthesis of 3-aminoacetophenone through reduction reactions.
(i) Reduction with Tin and Hydrochloric Acid:
(ii) Reduction with Sodium Borohydride:
Experiment 2: Synthesis of 5,5-Diphenylhydantoin
Objective: Synthesis of 5,5-diphenylhydantoin, an anticonvulsant, from benzil.
(i) Reaction of benzil with urea to form 5,5-diphenylhydantoin.
Experiment 3: Extraction of Limonene from Orange by Steam Distillation
Objective: Extraction of limonene, an essential oil, from oranges using steam distillation.
(i)Set up a steam distillation apparatus and extract limonene from orange peels.
Experiment 4: Synthesis of Benzocaine
Objective: Synthesis of benzocaine, a local anaesthetic drug.
(i)Perform the synthesis of benzocaine using appropriate starting materials and reactions.
Experiment 5: Synthesis of 6-Methyl Uracil
Objective: Synthesis of 6-methyl uracil, an anticancer drug.
(i)Carry out the synthesis of 6-methyl uracil using suitable starting materials and reactions.
Experiment 6: Synthesis of α-Acetylaminocinnamic Acid from Glycine
Objective: Synthesis of α-acetylaminocinnamic acid from glycine.
(i) Perform the necessary chemical transformations to convert glycine into α-acetylaminocinnamic acid.
Experiment 7: Estimation of Phenol by KBr/KBrO3
Objective: Quantitative estimation of phenol using the KBr/KBrO3 method.
(i)Perform the titration of phenol with KBr/KBrO3 solution.
Experiment 8: Estimation of Carbonyl Compound by Hydrazone Formation
Objective: Quantitative estimation of a given carbonyl compound by hydrazone formation.
(i)React the carbonyl compound with a suitable hydrazine derivative to form a hydrazone.
(ii)Measure the absorbance or conductance of the hydrazone and determine the concentration or percentage of the carbonyl compound.
Experiment 9: Estimation of Aspirin (Potentiometric/Conductometric)
Objective: Quantitative estimation of aspirin using either potentiometric or conductometric methods.
(i)Perform a titration or conductometric measurement to determine the concentration of aspirin in a given sample.
Experiment 10: Estimation of Streptomycin (Colorimetric)
Objective: Quantitative estimation of streptomycin using a colorimetric method.
(i)Utilize a colorimetric reaction specific to streptomycin and measure the absorbance of the resulting complex.
(ii)Determine the concentration of streptomycin in the sample.
Experiment 11: Estimation of Vitamin B12 (Colorimetric)
Objective: Quantitative estimation of vitamin B12 using a colorimetric method.
(i)Employ a colorimetric reaction specific to vitamin B12 and measure the absorbance of the complex formed.
Experiment 12: Assay of Diazepam by UV-Vis Spectrophotometry
Objective: Assay of diazepam using UV-Vis spectrophotometry.
(i)Prepare standard solutions of diazepam and measure their absorbance at a specific wavelength.
Experiment 13: Assay of Riboflavin by UV-Vis Spectrophotometry
Objective: Assay of riboflavin using UV-Vis spectrophotometry.
(i)Prepare standard solutions of riboflavin and measure their absorbance at a specific wavelength.
Experiment 14: Estimation of Blood Sugar, Calcium, Total Nitrogen, and Non-Protein Nitrogen in Blood
Objective: Biochemical estimation of blood sugar, calcium, total nitrogen, and non-protein nitrogen.

(i)Perform the required biochemical tests to estimate blood sugar levels, calcium concentration, total nitrogen content, and non-protein nitrogen content.

Experiment 15: Retrieval of 3D-structure of proteins/enzymes associated with two different diseases from internet and plotting their Ramchandran Plot using software.

(Note: The student will report the importance and role of protein for the disease/organism, FASTA sequence of amino acid residues, information about bound native ligand, and interpretation of Ramchandran plot. (At least 02 proteins per disease i.e total 4 proteins))

C. Structure determination using combined spectral data (UV, IR, NMR , Mass spectral data) (minimum 10 problems)

Examination: CY405 (ii) Organic Chemistry special (Lab 07)

Time : 6-8 Hrs. (One day Examination) Total Marks : 100

A.	**Exercise-I (Qualitative Organic Analysis)**	**30**
B.	**Exercise-II (Miscellaneous Experiments)**	**20**
C.	**Exercise -III (Structure determination using spectral data)**	**10**
D.	**Viva (External + Internal)**	**20**
E.	**Internal assessment***	**20**
	Total	**100**

***-** Internal assessment will be continuous and based on the performance of a student throughout the session along with satisfactory submission of the term work

Books Suggested:

1. Textbook of Practical Organic Chemistry Qualitative and Quantitative Analysis (Vol I & II) - A.I. Vogel.
2. Elementary Practical Organic Chemistry Small Scale Preparation (Langman) - A.I. Vogel.
3. A Handbook of Organic Analysis - H.T. Clark.
4. Systematic Qualitative Organic Analysis - H. Middleton.
5. Advanced Practical Organic Chemistry - N.K. Vishnoi.
6. Small Scale Organic Preparation - P.J. Hill.
7. Practical Organic Chemistry - H. Dupont Durst & George W. Gokal.
8. Experimental Organic Chemistry Part I & II - P.R. Singh, D. S. Gupta & K.S. Bajpai.
9. Vogel's Textbook of Practical Organic Chemistry - A.R. Tatchell.

Web link :

Syllabus Prescribed for Two Year PG Programme
Programme: MSc Chemistry (Choice Based Credit System)
Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-405 (iii)	**(Lab-VII (SEC) Physical Chemistry Special**	**90 hrs (9 hrs/week)**

Course Outcomes: Upon successful completion of a course the students will be able to:

1. Apply quantum chemistry methods to optimize molecular geometries and analyze bond lengths, angles, and molecular shapes.
2. Perform electronic structure calculations and interpret molecular orbitals, electron densities, and energy levels.
3. Calculate and interpret vibrational frequencies and relate them to molecular vibrations.
4. Determine reaction energies, activation energies, and transition state structures and analyze reaction pathways and kinetics.
5. Calculate molecular properties and understand their impact on chemical behavior and properties.
6. Analyze intermolecular interactions and their influence on molecular stability and reactivity.
7. Study solvent effects on molecular properties and reaction energetics.
8. Interpret excited state energies, transition wavelengths, and oscillator strengths in the context of spectroscopy.
9. Analyze UV spectra of aromatic compounds and relate the transitions to molecular orbital theory.
10. Apply ligand-field theory to understand the electronic structure and properties of transition metal complexes.
11. Utilize computational methods for drug design and analyze molecular interactions and structure-activity relationships.
12. Demonstrate proficiency in using quantum chemistry software and computational tools.

Syllabus:

1. Molecular Geometry Optimization: Perform geometry optimization calculations using quantum chemistry software to determine the optimized molecular structure of a given molecule. Compare the results with experimental data, if available, and analyze the bond lengths, angles, and overall molecular shape.
2. Electronic Structure Calculations: Conduct electronic structure calculations, such as Hartree-Fock (HF) or density functional theory (DFT), to obtain information about molecular orbitals, electron densities, and energy levels. Analyze the results to understand the electronic properties and stability of the molecule.
3. Vibrational Frequency Calculation: Calculate the vibrational frequencies of a molecule using quantum chemistry methods. Interpret the results in terms of the molecular vibrations and compare them with experimental data, if available. Explore how changes in the molecular structure affect the vibrational frequencies.
4. Reaction Energetics: Study chemical reactions by calculating reaction energies, activation energies, and transition state structures using quantum chemistry methods. Investigate the reaction pathways, reaction intermediates, and rate-determining steps. Analyze the thermodynamics and kinetics of the reactions.
5. Molecular Properties: Calculate molecular properties, such as dipole moments, polarizabilities, and ionization potentials, using quantum chemistry methods. Relate these properties to the chemical behavior and properties of the molecule. Explore how modifications to the molecular structure impact these properties.

6. Intermolecular Interactions: Investigate intermolecular interactions, such as hydrogen bonding or van der Waals interactions, using quantum chemistry calculations. Analyze the strength and nature of these interactions and their influence on molecular properties, stability, and reactivity.
7. Solvent Effects: Study the influence of solvents on molecular properties and reactions by performing quantum chemistry calculations in different solvent environments. Explore the solvation energies, solute-solvent interactions, and solvent-induced effects on electronic structure and reaction energetics.
8. Excited States and Spectroscopy: Calculate excited state energies, transition wavelengths, and oscillator strengths using time-dependent density functional theory (TD-DFT) or other suitable methods. Analyze the electronic transitions and interpret the results in the context of spectroscopic experiments.
9. Excited States and Spectroscopy: Record the UV spectra of benzene, pyridine and pyrimidine in methanol. Compare and discuss the various transitions involved in terms of MO theory.
10. Ligand-Field Theory: Apply ligand-field theory calculations to study the electronic structure and properties of transition metal complexes. Investigate the splitting of d-orbitals, crystal field stabilization energy, and magnetic properties of

Examination: CY405 (iii) Physical Chemistry special (Lab 07)

Time : 6-8 Hrs. (One day Examination) Total Marks : 100

A.	**Exercise-I**	**30**
B.	**Exercise-II**	**30**
C.	**Viva (External + Internal)**	**20**
E.	**Internal assessment***	**20**
	Total	**100**

***-** Internal assessment will be continuous and based on the performance of a student throughout the session along with satisfactory submission of the term work

Text & Reference Books:

1. Manual provided by the Course Instructor
2. “AB INITIO Molecular Orbital Theory”, by W. J. Hehre, L. Radom, J A Pople and P. v. R. Schleyer
3. "Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory" by Attila Szabo and Neil S. Ostlund.
4. "Exploring Chemistry with Electronic Structure Methods" by James B. Foresman and Æleen Frisch.
5. "Introduction to Computational Chemistry" by Frank Jensen.
6. "Quantum Chemistry and Spectroscopy" by Thomas Engel and Philip Reid.
7. "Molecular Modeling: Principles and Applications" by Andrew R. Leach.

Syllabus Prescribed for Two Year PG Programme
Programme: MSc Chemistry (Choice Based Credit System)
Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-405 (iv)	**(Lab-VII (SEC) Analytical Chemistry Special**	**90 hrs (9 hrs/week)**

Course Learning Outcomes: Upon completion of this course, students will be able to:

(1) Apply advanced analytical techniques for the analysis of ores, cement, alloys, oils, soils, ambient air, drugs, bleaching powder, polymers, cosmetics, and food.
(2) Perform accurate measurements and analysis using specialized instruments and equipment.
(3) Interpret and analyze data obtained from various analytical methods.
(4) Apply quality control measures in analytical chemistry experiments.
(5) Demonstrate proficiency in performing simultaneous determination of multiple components in complex mixtures.
(6) Apply critical thinking and problem-solving skills to solve analytical challenges.
(7) Effectively communicate analytical results and findings.
(8) Understand the practical applications of analytical chemistry in various industries

Syllabus:

1. ***Analysis of Ores:***
   (1) Determination of Ca and Mg in Dolomite
   (2) Determination of Al in Bauxite
   (3) Determination of Mn in Pyrolusite
2. ***Analysis of Cement:***
   (4) Analysis of Silica, alumina, ferric oxide, calcium and magnesium oxide, sodium and potassium oxide
3. ***Alloy Analysis:***
   (5) Colorimetric determination of Mn in steel
   (6) Colorimetric determination of Cu in brass
   (7) Back titration/extraction spectrophotometry for Ni in alloy
4. ***Analysis of Oils:***
   (8) Determination of Carbon residue
   (9) Determination of Acid value
   (10) Determination of Saponification value
   (11) Determination of Iodine value
   (12) Measurement of viscosity
   (13) Determination of Flash point
   (14) Determination of Cloud point
   (15) Determination of Aniline point
5. ***Analysis of Soils:***
   (16) Measurement of pH
   (17) Determination of alkalinity
   (18) Measurement of conductivity
   (19) Analysis of nitrogen, phosphorous, and potassium content
6. ***Ambient Air Analysis:***
   (20) Determination of SPM (Suspended Particulate Matter)
   (21) Determination of RSPM (Respirable Suspended Particulate Matter)
   (22) Determination of SOx (Sulfur Oxides)
   (23) Determination of NOx (Nitrogen Oxides)
7. ***Analysis of Drugs:***
   (24) Determination of Fe in a capsule
   (25) Determination of ascorbic acid in a vitamin-C tablet
   (26) Diazotization method for determining sulpha drug
   (27) Determination of Mg in milk of magnesia tablet

8. Bleaching Powder:

(28) Determination of available chlorine

(29) Break point chlorination

9. Polymer Analysis:

(30) Determination of molecular weight

(31) Determination of Saponification value

(32) Determination of Iodine value

10. Cosmetics Analysis:

(33) Analysis of talcum powder, toothpaste, shampoo

11. Food:

(34) Moisture content determination by Karl-Fischer titration

(35) Determination of phosphoric acid in cola beverages by pH titration

Examination: CY405 (iv) Analytical Chemistry special (Lab 07)

Time : 6-8 Hrs. (One day Examination) Total Marks : 100

A.	**Exercise-I**	**30**
B.	**Exercise-II**	**30**
C.	**Viva (External + Internal)**	**20**
E.	**Internal assessment***	**20**
	Total	**100**

***-** Internal assessment will be continuous and based on the performance of a student throughout the session along with satisfactory submission of the term work

Common list of Text and Reference Books for Analytical Chemistry Courses (Semester-I to IV)

Textbooks:

1. ISI Handbook of Food Analysis: Vol.I to X (Bureau of Indian Standards Publication, New Delhi)
2. Food Analysis: A. G. Woodman (McGraw-Hill)
3. Milk and Milk Products: Eckles, Comb, and Nacy (Tata McGraw-Hill)
4. Handbook of Analysis and Quality Control for Fruit and Vegetable Products: Ranganna (Tata McGraw-Hill)
5. Insecticides- Action and Metabolism: O. Brian (Academic Press)

Reference Books:

6. Chemistry of Insecticides and Fungicides: Sree Ramalu, Oxford, IBH, Pub.
7. Analytical Methods for Pesticides and Plant Growth Regulators and Food Additives: (Vol.I to X) Ed. G. Zweing (Academic Press)
8. Practical Pharmacognosy: T. N. Vassudevan
9. Aids of Analysis of Food and Drugs: Wicholls
10. Indian Pharmacopoeia-1985
11. British Pharmacopoeia-1990
12. Handbook of Drugs and Cosmetics Aids: Mehrotra
13. Lynch's Medical Laboratory Technology: S. S. Raphel
14. Basic Food Chemistry: F. Lee (AVI publishing company)
15. Industrial Chemistry: B. K. Sharma
16. Parikh's Textbook of Medical Jurisprudence, Forensic Medicine, and Toxicology, 6th Edn.: C.K. Parikh (CBS publishers and distributors)
17. Clarke's Analysis of Drugs and Poisons: Anthony C Moffat, M David Osselton, Brian Widdop (Pharmaceutical press)
18. A Practical Course in Polymer Chemistry: S. J. Punea (Pergamon press)
19. The Textbook on Petrochemical by Dr. B. K. Bhaskar Rao (Khanna Publishers)
20. Analytical Chemistry: A. Gupta (Pragati Prakashan)
21. Applied Chemistry: Vermani and Narula (New Age International)

Syllabus Prescribed for Two Year PG Programme

Programme: MSc Chemistry (Choice Based Credit System)
Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-405 (v)	**(Lab-VII (SEC) Industrial Chemistry Special**	**90 hrs (9 hrs/week)**

Course Outcomes (COs): After completion of course students will able to

1. Apply skills to calculate to estimate Nitrogen and Phosphorus content from fertilizers.
2. Synthesis various synthetic dyes.
3. Understand the pathway involved during preparation of various Polymers.
4. Apply acquired knowledge to analyzed the pharmaceutical products.
5. Operate sophisticated equipments effectively.

List of Experiments:

1. Determination of N and P nitrogen and phosphorus content from fertilizer by suitable methods.
2. Estimation of Copper from fungicides.
3. Determination of pesticide contents in the soil.
4. Quantitative estimations of important commercially available drugs.
5. Qualitative analysis of commercially available drugs including chromatographic technique.
6. Preparation of simple drugs involving two or three steps.
7. Analysis of nonfibrous materials used in pulp industries such as caustic soda as Na_2O, Soda ash as Na_2O, limeas CaO.
8. Preparation of selected pesticide formulations in the form of dusts, emulsions, sprays.
9. Preparation of Synthetic Zeolites.
10. Preparation of Methyl orange dye.
11. Preparation of Methyl red dye.
12. Preparation of Picric acid dye.
13. Preparation of melamine HCHO resin.
14. Determination of number average molecular weight (Mn) by end group analysis by conductometric method.
15. Determination of average molecular weight of polymer by Viscometric method.
16. Determination of chlorine content of PVC.
17. Determination of acid value of polymers.
18. Measurement of Relative Viscosity of Polymer solutions.
19. Preparation of Nylon 6,6.
20. Preparation of Phenol formaldehyde resin.
21. Preparation of Urea formaldehyde resin,

Examination: CY405 (v) Industrial Chemistry special (Lab 07)

Time : 6-8 Hrs. (One day Examination) Total Marks : 100

A.	**Exercise-I**	**30**
B.	**Exercise-II**	**30**
C.	**Viva (External + Internal)**	**20**
E.	**Internal assessment***	**20**
	Total	**100**

***-** Internal assessment will be continuous and based on the performance of a student throughout the session along with satisfactory submission of the term work

List of Books-

1. Practical Engineering by S. S. Dara.
2. Laboratory Preparation of Microchemistry by E. M. M. Jeffrey, McGraw Hill.
3. Practical Course in Polymer Chemistry by S. J. Pnnea, Pargaman Press
4. Practical Pharmacognosy by T. B. Willis.
5. Practical Pharmacognosy by T. N. Vasudevan.
6. Indian Pharmacopea-1985, British Pharmacopea-1990.
7. Handbook of Drugs and Cosmetics by Mehrotra
8. Methods of Pesticide Analysis by Sriramulu U. I. Oxford and IBH Publishing Co.
9. Textbook of Inorganic Chemistry by A. I. Vogel.
10. Instrumental Methods of Analysis by Willard, Merit and Dean
11. Industrials Chemicals, Faith et. al. Wiley Inter science New York
12. Textbook of Practical Organic Chemistry by Vogel.
13. Industrial Organic Chemistry by Hans Arpe.
14. Reagents for Organic Synthesis Fisher and Fisher.
15. Technique of Organic Chemistry Vol I, Part I- IV A. Weisberger.

Programme: MSc Chemistry (Choice Based Credit System)
Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
CY-406	**(Lab-VIII) Research Project Phase-II**	90 hrs (9 hrs/week)

Research Project Phase II:

The project/dissertation must be submitted in the hardbound copy to the University Department/College/Institute. For internal evaluation, the students shall have to give a presentation of the project/dissertation in a given Semester. Further, for external examination, Project/Dissertation shall be evaluated by the concerned teacher/supervisor/guide in the University Department/College / Institute as an Internal Examiner along with an External Examiner appointed by the University.

Examination: CY305 (ii) Organic Chemistry special (Lab 05)

Time : 6-8 Hrs. (One day Internal Examination) Total Marks : 100

A.	**Internal Assessment**	**20**
B.	**Submission of Research project**	**30**
C.	**VIVA (Internal and External Examiner)**	**50**
	Total	**100**