Part B

Sant Gadge Baba Amravati University, Amravati

Prescribed for (Two Years- Four Semesters Master's Degree Programme- NEPv23

Programme: MSc (Chemistry) following Three Years UG Programme wef 2023-24

Scheme for Teaching, Learning, Examination and Evaluation for

M.Sc. Part-II (Chemistry) Semester III

Subject	**Teaching hours per week**	**Credits**	**Theory Exam**		**Practical Exam**		**Total**	**Minimum Passing**	
			Internal	**External**	**Internal**	**External**		**Internal**	**External**
DSC – I.3	04	04	40	60			100	16	24
DSC – II.3	04	04	40	60			100	16	24
DSC – III.3	03	03	40	60			100	16	24
DSE-III (i/ii/iii/iv/v)	03	03	40	60			100	16	24
LAB–05 (based on DSC I.3 to III.3)	04	02			50	50	100	50	
LAB – 06 (based on DSE-III)	04	02			50	50	100	50	
Res Project-I	(2+4) = 06	04			50		50	25	
Total	30	22					650		

Subject	**Course Code**	**Course Title**	**Hrs/week**	**Credits**
DSC – I.3	CHE 301	Contemporary topics in Chemistry	04	04
DSC – II.3	CHE 302	Spectroscopy-I	04	04
DSC – III.3	CHE 303	Physical Organic Chemistry	03	03
DSE - III (i)	CHE 304 (i)	Solid State Chemistry	03	03
DSE - III (ii)	CHE 304 (ii)	Advanced Organic Synthesis	03	03
DSE - III (iii)	CHE 304 (iii)	Physical Chemistry -III	03	03
DSE - III (iv)	CHE 304 (iv)	Advanced Analytical Chemistry	03	03
DSE - III (v)	CHE 304 (v)	Fuels and Heavy Chemicals	03	03
Lab - 05 (based on DSC I.3 +II.3+III.3)	CHE 305	Lab 05-	04	02
Lab - 06 (based on DSE III)	CHE 306 (i)	Inorganic Chemistry Special Practical	04	02
	CHE 306 (ii)	Organic Chemistry Special Practical		
	CHE 306 (iii)	Physical Chemistry special Practical		
	CHE 306 (iv)	Analytical Chemistry special Practical		
	CHE 306 (v)	Industrial Chemistry special Practical		
Lab 07 Research Project I	CHE 307	Research Project Phase-I	06	04

M.Sc. Part-II (Chemistry) Semester IV

Subject	Teaching hours per week	Credits	Theory Exam		Practical Exam		Total	Minimum Passing	
			Internal	External	Internal	External		Internal	External
DSC – I.4	04	04	40	60			100	16	24
DSC – II.4	03	03	40	60			100	16	24
DSC – III.4	04	04	40	60			100	16	24
DSE-IV (i/ii/iii/iv/v)	03	03	40	60			100	16	24
Lab -08 (based on DSC I.4 +II.4+III.4)	04	02			50	50	100	50	
Lab 09 Research Project II	(2+8) = 10	06			75	75	150	75	
Total	28	22					650		

Subject	Course Code	Course Title	Hrs/week	Credits
DSC – I.4	CHE 401	Principles of Organic Synthesis	4	4
DSC – II.4	CHE 402	Spectroscopy-II	3	3
DSC – III.4	CHE 403	Analytical (Separation Techniques)	4	4
DSE - IV (i)	CHE 404 (i)	Material Chemistry	3	3
DSE – IV (ii)	CHE 404 (ii)	Natural products and Medicinal chemistry	3	3
DSE–IV (iii)	CHE 404 (iii)	Physical Chemistry-IV	3	3
DSE –IV (iv)	CHE 404 (iv)	Applied Analytical Chemistry	3	3
DSE - IV (v)	CHE 404 (v)	Polymer, Dyes and Paints	3	3
Lab-08 (based on DSC IV.1 +IV.2+IV.3)	CHE 405	Lab 08	4	2
Lab 09 Research Project II	CHE 406	Research Project Phase II Lab 09	10	6

M.Sc. (Chemistry) Second Year Semester- III [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 301	**Contemporary Topic in Chemistry (DSC–I.3)**	**60 hrs (4 hrs/week)**

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

1. Comprehend and apply fundamental concepts of nano-chemistry, green chemistry, molecular interactions, supramolecular chemistry, drug discovery, and catalysis.
2. Describe the structural characterization techniques like XRD, TEM, and AFM.
3. Apply green chemistry principles to specific syntheses such as styrene, urethane, paracetamol, and Ibuprofen.
4. Describe the molecular and thermodynamic basis of the hydrophobic effect.
5. Analyze the role of noncovalent interactions in biological and chemical systems.
6. Explain the principles of molecular recognition, supramolecular reactivity, and catalysis
7. Describe the methods of molecular descriptor selection and 3D-QSAR approaches like COMFA and COMSIA.
8. Apply molecular docking and virtual screening techniques in drug discovery.
9. Classify and explain the different theories of catalysis, including homogeneous and heterogeneous catalysis.
10. Evaluate the selectivity, stereochemistry, and reactivity of different catalytic systems.

Unit-I: Nano-chemistry: 10L

Introduction, classification, Types, compositions, and structures, Porous inorganic nanoparticles, Organic (latexes), Carbon-based nanoparticles (carbon nanotubes, grapheme), Porous inorganic nanoparticles, Nanoparticle synthesis: Basic synthesis and fabrication methods for nanomaterials (CVD, sol-gel, microemulsion, template, hydrothermal). Structural characterization: XRD, TEM, AFM, Deviations between bulk and near-surface crystal structures.

Unit-II: Green Chemistry: 10L

Introduction to Green chemistry, Basic principle of green chemistry Examples of green chemistry, Designing a green synthesis, Rearrangements reaction, Addition reaction, substitution, elimination reaction. Synthesis involving basic principles of green chemistry, some examples. Synthesis of styrene, Synthesis of urethane, Free radical bromination, Synthesis of paracetamol, Synthesis of Ibuprofen.

Unit-III: Molecular Interactions or Noncovalent Interactions: 10L

Introduction to molecular interactions**,** Short range repulsion, Electrostatic interactions, Ion pairs in proteins, Dipolar Interactions: Electronegativity and molecular dipoles, Dipole-dipole interactions (Keesom interactions), Dipole-induced dipole interactions (Debye interactions), Charge-dipole interactions. Fluctuating dipolar interactions (Dispersive interactions, London Forces), Cation-Π interactions. Hydrogen Bonding: Geometry of hydrogen bonds, Cooperativity of hydrogen bonds**.** Molecular basis of the hydrophobic effect, Thermodynamic basis of the hydrophobic effect.

Unit-IV: Supramolecular Chemistry: 10L

History, Basic concept and principles; Molecular recognition, supramolecular reactivity and catalysis, supramolecular devices, Supramolecular photochemistry, supramolecular electronic, ionic and switching devices. Biological supramolecular systems: Ionophores, Porphyrin and other Tetrapyrrolic Macrocycles, DNA and Biochemical Self-assembly.

Unit-V: Computer Aided Drug Discovery: 10L

Introduction to Drug Discovery and Development, Stages of drug discovery and development, Lead discovery and Analog Based Drug Design, Bioisosterism, Classification, Bioisosteric replacement, SAR versus QSAR, History and development of QSAR, Types of molecular descriptors, Methods of molecular descriptor selection, 3D-QSAR approaches like COMFA and COMSIA, Molecular docking and virtual screening techniques.

Unit-VI: Catalysis: 10L

Basic principles, thermodynamic and kinetic aspects, classification, theories of catalysis, homogeneous and heterogeneous catalysis. Selectivity, stereochemistry, and reactivity. Catalytic reactions of coordination and Organometallic compounds including polymerization activation of small molecules, addition to multiple bonds, hydrogenation, Zeigler-Natta polymerization of olefins, hydroformylations, oxidations, carbonylations and epoxidation.

Course Material/Learning Resources:

1. An Introduction to Medicinal Chemistry, Fifth Edition, Graham L. Patrick, Oxford University Press
2. Drug-like Properties: Concepts, Structure Design and Methods, Edward H. Kerns and Li Di, Elsevier, 2008
3. Medicinal Chemistry, Ashutosh Kar, New Age International Publishers, Fourth Edition
4. Supramolecular Chemistry by J. W. Steed & J. L. Atwood, 2ndEdn John Wiley, 2009.
5. Crystal Engineering. The Design of Organic Solids by G.R. Desiraju, Elsevier, 1989.
6. J. M. Lehn, Supramolecular Chemistry, VCH, Weinheim, 1995
7. G.B. Sergeev, K.J. Klabunde, Nanochemistry, Elsevier, 2013, ISBN: 978-0-444-59397-9
8. Robert Kelsall, Ian W. Hamley , Mark Geoghegan, Nanoscale Science and Technology, Wiley | 2005-04-29 | ISBN: 0470850868

Web resources:

Nano chemistry:
https://onlinecourses.nptel.ac.in/noc21_mm38/preview
https://onlinecourses.nptel.ac.in/noc19_mm22/preview
Green Chemistry: https://www.epa.gov/greenchemistry/basics-green-chemistry
https://ecology.wa.gov/waste-toxics/reducing-toxic-chemicals/green-chemistry
Molecular Interactions:
https://williams.chemistry.gatech.edu/structure/molecular_interactions/mol_int.html
Computer Aided Drug Design:
https://microbenotes.com/computer-aided-drug-design-cadd/
https://www.mdpi.com/1424-8247/17/1/22
Catalysis: https://www.classcentral.com/classroom/youtube-catalysis-91341

M.Sc. (Chemistry) Second Year Semester- III [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 302	**Spectroscopy-I (DSC–II.3)**	**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. apply major spectroscopic techniques such as mass spectrometry, NMR spectroscopy, 2D- NMR, C-13 NMR and Mossbauer Spectroscopy for structure determination.
4. interpret spectra to identify functional groups, chemical shifts, coupling patterns, and fragmentation patterns.
5. deduce structures from the fragmentation pattern.
6. understand the principles and applications of multidimensional NMR and dynamic processes by NMR.
7. elucidate the structure of organic and inorganic compounds using spectroscopic methods

Unit-I: 10L

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) Ultraviolet and visible spectroscopy:

Basic law of absorption- Beer-Lambert law, electronic transitions, effects of conjugation, effect of solvent on electronic transition, 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-II: Infrared spectroscopy: 10L

A) 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 fundamental groups. Fingerprint region- factors influencing vibrational frequencies- Effect of hydrogen bonding and solvent effect on vibrational frequencies; overtones; combination bands and Fermi resonance.

B) 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: Nuclear Magnetic Resonance Spectroscopy: 10L

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. Dynamic NMR to study hindered rotation (DMF, DMA, biphenyls, annulenes); cyclohexane ring inversion.

Unit-IV: 10L

A) Applications of NMR: Simplification of complex spectra; high field spectra, nuclear magnetic double resonance; shift reagent; solvent effect, Nuclear Overhauser Effect [NOE]. Hetero nuclear coupling in ^{1}HNMR – deuterium exchange, Fourier transforms technique.

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-V: 10L

A) 2D NMR:

COSY, NOESY, HETCOR, INPET, INADEQUATE. General idea about inorganic solid state NMR, Drug Analysis -Magnetic Resonance Imaging (MRI)

B) Multinuclear NMR of B, Al, Si, N, F and P nuclei:

Structure and dynamics of representative inorganic molecules, deriving activation and thermodynamic parameters; application of NMR to magnetism and magnetic susceptibility measurements of

paramagnetic metal complexes.

Unit-VI: 10L

A) X-ray diffraction: Interaction of x-ray with matter, scattering and diffraction. Brags method Debye-Sherrer method of X-ray structural analysis of crystals, index reflection, identification of unit cell from systematic absence in diffraction pattern structure of simple lattice and x-ray intensities structure factor , its relation to intensity of electron density procedure for x-ray structure analysis.

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.

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

Web resources:

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

UVSpectroscopy: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

M.Sc. (Chemistry) Second Year Semester- III [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 303	**Physical Organic Chemistry (DSC–III.3)**	**45 hrs (3 hrs/week)**

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

1. Analyze the Hammond Postulate and its applications in predicting reaction transition states.
2. Evaluate the principles of reactivity vs. selectivity and the Curtin-Hammett Principle in determining reaction pathways
3. Assess the impact of structure on reactivity using resonance, field effects, and steric effects, and quantify these relationships with the Hammett and Taft equations.
4. Apply the "Like-Dissolves-Like" paradigm to predict solubility
5. Analyze solute mobility using diffusion principles and Fick's Law.
6. Identify the mechanisms and outcomes of photochemical reactions
7. Apply the Woodward-Hoffmann rules using FMO and PMO approaches to predict the outcomes of pericyclic reactions.
8. Explain suprafacial and antarafacial shifts of hydrogen and carbon moieties.

Unit I Reaction mechanism: Structure and Reactivity 8L

A) Postulates and Principles Related to Kinetic Analysis:

The Hammond Postulate
The Reactivity vs. Selectivity Principle
The Curtin–Hammett Principle
Microscopic Reversibility
Kinetic vs. Thermodynamic Control
Methods of determining mechanisms, kinetic isotope effects

B) Effect of Structure on reactivity:- Resonance and field effects, Steric effect, quantitative treatment. The Hammett equation and linear free energy relationship, substituent and reaction constants. Taft equation.

Unit II: Solutions and Non-Covalent Binding Forces 7L

Solvent and Solution Properties, Nature Abhors a Vacuum, Solvent Scales-Dielectric Constant, Heat of Vaporization, Surface Tension and Wetting, Water, other solvent scales
Solubility- General Overview, Shape, Using the "Like-Dissolves-Like" Paradigm
Solute Mobility-Diffusion, Fick's Law of Diffusion, Correlation Times
The Thermodynamics of Solutions-Chemical Potential, The Thermodynamics of Reactions, Calculating $\Delta H°$ and $\Delta S°$.

Unit III: Photochemistry-II 8L

Photochemical reactions of organic compound Norrish type I reaction, Norrish type II reaction, Paterno-Buchi reaction, photoreduction, Barton's reaction, Photo-Fries rearrangement photochemistry of enones, cyclohexadienone and parabenzoquinones, photochemistry of aromatic compounds, isomerization, additions and substitutions, addition of singlet oxygen reactions, di-pimethane rearrangement, photooxygenation, photo fragmentation.

Unit IV: Pericyclic Reactions-I 7L

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

Unit V: Pericyclic Reactions-II 8L

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.

Unit VI: Sigmatropic rearrangements 7L

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.

Course Material/Learning Resources:

Text & Reference Books:

1. E. V. Anslyn, D. A. Dougherty, Modern Physical Organic Chemistry Illustrated Edition, University Science, 2005.

2. Ian Fleming, Molecular Orbitals and Organic Chemical Reactions-Student Edition, Wiley, London, 2009
3. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Structure and Mechanisms, Part A, 5th Edition, Springer, 2007.
4. M. B. Smith and J. March, March Advanced Organic Chemistry, 6th edition, Wiley, 2007.
5. A. J. Kirby, Stereoelectronic Effects, Oxford University Press, 1996.
6. Peter Sykes, A Guide Book to Mechanism in Organic Chemistry, 6th edition, Pearson Education.
7. E. L. Eliel and S. H. Wilen, Stereochemistry of Organic Compounds Wiley Student Edition, 2008.

Web resources:

https://www.alchemyst.co.uk/pdf/Organic/pericyclics.pdf
https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/chemistry/organic_chemistry_iii/27.classification_of_pericyclic_reactions/et/4821_et_et.pdf
https://www.hhrc.ac.in/ePortal/Chemistry/I%20MSc%20Chemistry-18PCHE1-Dr.M.Subramanian-UNIT%203,4,5.pdf
https://youtu.be/oio3RJHAxOw?si=0BQn_xYuzXxQJup8
https://youtu.be/zDok_HKM-aA?si=FH67VF8okJtb_es

M.Sc. (Chemistry) Second Year Semester- III [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 304(i)	**Solid State Chemistry (Inorganic special) (DSE–III (i))**	**45 hrs (3 hrs/week)**

Course Outcomes: At the end of the course, students will 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: Crystal Structure of Some Simple Compounds :8L

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.

Unit-II: Lattice Defects: 07L

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. Defects & their concentrations, ionic conductivity in solids, Non stoichiometric compounds. Electronic properties of Non-stoichiometric oxides, pyknometric & electrical conductivity methods of study of defects, radiation effects on solid nature and properties, photography, colour centers.

Unit-III: Electronic Properties of materials: 8L

Metals, Insulators and Semiconductors, Electronic structure of solid, band theory, band structure of metals, insulators and semiconductors, Intrinsic and extrinsic semiconductors, doping of semiconductors and conduction mechanism, the band gap, temperature dependence of conductivity, Seebeck effect and Hall effect ,carrier density and carrier mobility in semiconductors, 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.

Unit-IV: Superconductivity and Magnetic properties of material 7L

A) Superconductivity:

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

B) Magnetic Properties of Materials:

Introduction, Magnetization, Classification of materials, on the basis of magnetic susceptibility, ferromagnetic metals, ferromagnetic compounds (CrO_2), Antiferromagnetism- transition metal monoxides, ferrimagnetism (ferrites), magnetic anisotropy, magneto striction, cooperative phenomena-magnetic domains, Domain Theory, hysteresis loops (hard & soft magnets) magnetic storage & applications of magnetic materials. Spin glasses

Unit-V: Lasers in Chemistry 8L

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; Photo-dissociation of ICN.

Unit-VI: Solid State Reaction 7L

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

Course Material/Learning Resources:

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. Page 29
23. Masterton W. L. and Hurley C.N. Chemistry, principals and reactions, Harcourt.

Web resources:

M.Sc. (Chemistry) Second Year Semester- III [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 304(ii)	**Advanced Organic Synthesis (Organic special) (DSE–III (ii))**	**45 hrs (3 hrs/week)**

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

1. Devise and prioritize organic reactions and reagents for different types of organic transformation
2. Analyze and develop reaction mechanisms for a reactions
3. Design and execute own synthetic route for the organic synthesis
4. Compare the role of protection and deprotection in organic synthesis.
5. Correlate the stereochemistry of reactant and product for better understanding of organic transformations.
6. Name heterocyclic compounds and plan their synthesis
7. Identify and utilize specialized reagents in organic synthesis for specific functional group transformations and protective group strategies.
8. Comprehend the structure, synthesis, and reactivity of heterocyclic compounds, understanding their importance in natural products and pharmaceuticals.

Unit I: Reagents in Organic Synthesis 8L

General Introduction to Oxidation and Reduction their selectivity in Organic Synthesis.L-Selectride, K-Selectride, LDA (Lithium Diisopropylamide), Lithium, Silane reagents trialkylsilyl halides, trimethylsilyl cyanide, trimethylsilane, DCC (Dicyclohexylcarbodiimide), Trimethylsilyl halide, Woodward and Prevost Hydroxylation, DDQ (2,3-Dichloro-5,6-dicyano-1,4-benzoquinone), Chloranil, Selenium Dioxide, RuO4 (Ruthenium Tetroxide), IBX (Iodoxybenzoic Acid), DMP (Dess-Martin Periodinane),Diazomethane.

Unit-II: Protection and Deprotection: 7L

General aspects, Role of protecting group in organic synthesis, minimal versus globalprotection, Protecting functional groups - Protection and deprotection of hydroxy groups (alcohol and phenol), carboxyl groups carbonyl groups (Aldehyde & Ketone), amino groups [amine – (primary, secondary) and amide, chemo- and regioselective protection and deprotection.

Unit-III: Umpolung: 8L

Umpolung concept , Reversal of carbonyl group polarity, dipole inversion. Umpolung reactivity – formyl and acyl anion equivalents. Formyl and acyl anion cyanohydrin ethers using 1,3-dithiane species, nitroalkanes, cyanide, acetylide, metallated enol ethers. phosphorous ylides - Wittig and related reactions, sulphur ylides

Unit IV: Selected Name Reactions and Reagents 7L

1. Epoxidation of olefins, Shi and Jacobsen epoxidation and Sharpless asymmetric epoxidation
2. Enantioselective reductions (Chiral Boranes, Corey-Bakshi-Shibata) and Noyori asymmetric hydrogenation, Enzymatic reduction of Keto groups-Bakers yeast.
3. Aminohydroxylation, Asymmetric Aminohydroxylation,Corey-Gillman-Ganem Reaction.

Unit V: Heterocyclic Chemistry-I: 8L

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

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

Unit VI Heterocyclic Chemistry-II: 7L

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

B) 6-Membered heterocyclic compounds-synthesis, reactions, and basicity of pyridine, quinolone (Skraup), isoquinoline (Bischler–Napieralski)

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

Course Material/Learning Resources:

1. "Organic Chemistry" by Jonathan Clayden, Nick Greeves, and Stuart Warren
2. "Advanced Organic Chemistry" by Francis A. Carey and Richard J. Sundberg
3. "Strategic Applications of Named Reactions in Organic Synthesis" by Laszlo Kurti and Barbara Czako
4. "Strategic Applications of Advanced Synthetic Methodologies" edited by Anthony W. Czarnik

5. "Organic Synthesis: Strategy and Control" by Paul Wyatt and Stuart Warren
6. "Organic Chemistry" by Paula Yurkanis Bruice
7. "Modern Organic Synthesis: An Introduction" by Michael H. Nantz and G. Marc Loudon
8. "Organic Synthesis: Strategy and Control" by Paul Wyatt and Stuart Warren
9. "Oxidation in Organic Chemistry" by K. Barry Sharpless and Michael G. Finn
10. "Reduction of Organic Compounds: Theory and Practice" by A. Zaks and A. B. Sowers
11. "Name Reactions and Reagents in Organic Synthesis" by Bradford P. Mundy, Michael G. Ellerd, and Frank G. Favaloro Jr.
12. "Strategic Applications of Named Reactions in Organic Synthesis" by Laszlo Kurti and Barbara Czako.
13. "Comprehensive Organic Name Reactions and Reagents" edited by Zerong Wang
14. "The Art of Writing Reasonable Organic Reaction Mechanisms" by Robert B. Grossman.
15. “Principle of Organic Synthesis” by R. O. C Norman and J. H. Coxon, 1st Ed, ELBS, 1993.
16. “Organic synthesis” by Micheal B Smith
17. “Modern methods of organic synthesis” by W. Carruthers
18. “Reagents for Organic synthesis” by L. W. Paqueette (Ed), John Wiley, 1995.
19. “Handbook of Reagents for Organic Synthesis: Reagents for Heteroarene Synthesis” by Andre B. Charette, Wiley-Blackwell, 1 edition, 2017.
20. “Name Reactions and Reagents in Organic Synthesis” by Mundy, M. G. Ellerd, and F. G. Favaloro Jr., Wiley, 2nd Ed. 1988.
21. "Heterocyclic Chemistry" by John A. Joule and Keith Mills
22. "Heterocyclic Chemistry" by Raj K. Bansal
23. "Comprehensive Heterocyclic Chemistry III" edited by Alan R. Katritzky, Charles W. Rees, and Eric F. V. Scriven
24. "Heterocyclic Chemistry in Drug Discovery" edited by Jie Jack Li and E. J. Corey
25. "Heterocyclic Chemistry" by Thomas L. Gilchrist
26. "Heterocyclic Chemistry: Synthesis of Alprazolam" by Abdur-Rahman

Web Resources:

1. Essentials of Oxidation, Reduction and C_C Bond Formation. Application in Organic Synthesis https://nptel.ac.in/courses/104101127
2. Reagents in Organic Synthesis https://onlinecourses.nptel.ac.in/noc21_cy42/preview
3. Principles of Organic Synthesis https://onlinecourses.nptel.ac.in/noc21_cy41/preview
4. Transition Organometallic Chemistry Principles to Application https://onlinecourses.nptel.ac.in/noc21_cy36/preview
5. A Study Guide In Organic Retrosynthesis: Problem Solving Approach https://onlinecourses.nptel.ac.in/noc23_cy28/preview
6. 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
7. 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
8. Heterocyclic chemistry https://archive.nptel.ac.in/courses/104/105/104105034/

M.Sc. (Chemistry) Second Year Semester- III [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 304(iii)	**Physical Chemistry III (Physical special) (DSE–III (iii))**	**45 hrs (3 hrs/week)**

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

1. Understand the principle involved in fundamental physical chemistry
2. Understand the concept of nuclear chemistry, solid state chemistry, photochemistry, macromolecules.
3. Solve numerical problems associated with mathematical concept, phase rule, nuclear chemistry, solid state chemistry, photochemistry, macromolecules.

Unit-I: Polymers :8L

Basic concepts of polymers, classification of polymers, condensation, addition, radical chain ionic and co-ordination, co-polymerisation, polymerisation condition and polymer reaction, polymerisation in homogeneous and heterogenous system. Polymer processing: plastic, elastomer and fibers. Compounding processing technique: calendaring, die casting, rotational casting, film casting, injection molding, glow molding, extrusion molding, thermoforming, foaming, reinforcing and fibers spinning.

Unit-II: The Phase Rule: 07L

Recapitulation of Gibbs Phase rule (Without Derivation), degrees of freedom, reduced phase rule, construction of phase diagram, one component systems, Water, Sulphur, carbon, 1st and 2nd order phase transition, lambda line, Helium system, Eutectic systems, two component systems forming solid solutions having congruent and incongruent melting point, Construction of a phase diagram, partially miscible solid phase, three component systems, graphical presentation, Numerical based on these concepts.

Unit-III: Photochemistry-I: 8L

Introduction, photochemical reactions, quantum yield and its measurement, Jablonski diagram, Photosensitization reactions, Fluorescence (resonance fluorescence, sensitized fluorescence and quenching of fluorescence) Phosphorescence, Stern-Volmer equation, Photochemistry of environment, Greenhouse effect**,** Numerical based on these concepts.

Unit-IV: Macromolecules: 7L

Introduction and definition of macromolecules (Polymer), Types of polymers, Random coils, Configuration and Conformation of macromolecules, Electrically conducting molecular wires, Fire resistant, liquid crystal polymers, Kinetics of polymerisation, Mechanism of polymerisation, Application of polymers, Number average and mass average molecular mass, Determination of molar mass, Viscometry, Numerical based on these concepts.

Unit-V: Solid State Chemistry I 8L

Ionic Crystals and their structures, radius ratio rule, effect of polarization on crystals. Covalent structure type: Sphalerite and Wurtzite. Geometry of simple crystal AB type: NaCl, CsCl and NiAs. AB_2 type: Fluorite, antifluorites, Rutile structures. Li_2O, Na_2O, $CdCl_2$, CdI_2 structures. Ternary Compounds ABO type: Perovskite, Barium titanate, lead titanate, Calcium Titanate, Tolerance factor, charge neutrality and deviation structures of $FeTiO_3$.

Unit-VI: Nuclear chemistry 7L

Introduction, radioactive decay and equilibrium, thermonuclear reactions, photonuclear reactions, Radiometric titration, isotopic dilution analysis, NAA.

Nuclear models: Fermi gas model, shell model, liquid drop model, application of liquid drop models semiempirical mass equation.

Counters: proportional counter, GM counter, scintillation counter, ionization chamber counter.

Course Material/Learning Resources:

1. "Fundamentals of Polymer Science" by Anil Kumar Bhattacharya.
2. "Introduction to Polymer Chemistry" by R. J. Young and Peter A. Lovell.
3. "Handbook of Polymer Science and Technology" by K. R. Krishnan and M. V. Rajagopalan
4. "Phase Transformations in Metals and Alloys" by David A. Porter, Kenneth E. Easterling, and Mohamed Sherif.
5. "Phase Equilibria: Basic Principles, Applications, Experimental Techniques" by Stanley M. Walas.
6. "Photochemistry" by James F. Norris and Geoffrey F. Weiss

7. "Principles of Molecular Photochemistry: An Introduction" by Nicholas J. Turro, V. Ramamurthy, and Juan C. Scaiano.
8. "Photochemistry: Past, Present and Future" by Angelo Albini and Maurizio Fagnoni
9. "Principles of Polymerization" by George Odian
10. "Introduction to Polymers" by Robert J. Young and Peter A. Lovell
11. "Polymer Chemistry" by Charles E. Carraher Jr.
12. "Physical Chemistry of Macromolecules" by S. F. Sun
13. "Solid State Chemistry and its Applications" by Anthony R. West
14. "Introduction to Solid State Chemistry" by C.N.R. Rao
15. "Solid State Chemistry" by Steven H. Strauss
16. "Introduction to Solid State Chemistry" by Richard C. Ropp
17. "Nuclear and Radiochemistry" by Gerhart Friedlander, Joseph W. Kennedy, Edward S. Macias, and Julian M. Mille
18. "Nuclear Chemistry" by Raymond L. Murray and David A. Johnson
19. "Modern Nuclear Chemistry" by Walter D. Loveland, David J. Morrissey, and Glenn T. Seaborg
20. "Nuclear and Radiochemistry: Fundamentals and Applications" by Karl Heinrich Lieser

Web resources:

1. https://www.coursera.org/learn/polymer-science
2. https://www.plasticstechnology.com/
3. https://www.researchgate.net/
4. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Thermodynamics_and_Chemical_Equilibrium_(Ellgen)/06%3A_Equilibrium_States_and_Reversible_Processes/6.08%3A_Gibbs'_Phase_Rule
5. https://www.khanacademy.org/science/chemistry/quantum-chemistry
6. https://www.researchgate.net/publication/225789844_Stern-Volmer_Equation
7. https://www.plasticstoday.com/
8. https://ocw.mit.edu/courses/10-569-synthesis-of-polymers-fall-2006/c7b7a987f7d5b66e0832be42fbf52b7d_lec03_09112006.pdf
9. https://www.sciencedirect.com/topics/chemistry/polarization
10. https://www.sciencedirect.com/science/article/pii/B9780124159339000072

M.Sc. (Chemistry) Second Year Semester- III [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 304 (iv)	**Advanced Analytical Chemistry (Analytical special) (DSE–III (iv))**	**45 hrs (3 hrs/week)**

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

1. Apply appropriate techniques for Food analysis, nutrient analysis, organic matter assessment, and contaminant analysis.
2. Analyze food for nutrient content and understand the quality control processes.
3. Perform clinical analysis and evaluate the environmental impacts.
4. Conduct chemical and mineralogical analysis of oil & Fats using wet chemical and instrumental methods. 5. Analyze coal for proximate and ultimate composition and determine its calorific value.
5. Conduct chemical analysis of Portland cement to assess its quality and performance..

Unit-I: Pharmaceutical Analysis: 8L

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

Unit-II: Clinical Analysis: 07L

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

Unit-III: Food Analysis and Adulteration: 8L

A). 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.

B) Food adulteration: common adulterants in food and their determination. Contamination of food stuffs. Analysis of milk for fat and added water.

Unit-IV: Analysis of Oils, Fats, Enzymes: 7L

A) 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).

Biological significance, analysis and assay of enzymes: pepsin, monoaminoxidase, and tyrosinase**.**

B) 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

Unit-V: Coal and Portland Cement Analysis 8L

A) Coal Analysis: 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

B) Portland Cement Analysis: Chemical analysis of cement components (e.g., calcium oxide, silica, alumina, iron oxide), Determination of fineness, setting time, and compressive strength

Unit-VI: Fuel analysis 7L

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

Course Material/Learning Resources:

1. Principles of Instrumental Analysis, D. A Skoog, F. J. Holler, & S. R. Crouch, Cengage l Learning.
2. Textbook of Pharmaceutical Analysis, K. A. Connors, Wiley.

3. Analysis of Pesticides in Food and Environmental Samples, J. R. Dean & P. Vreča (2nd ed.). CRC Press.
4. Fennema's Food Chemistry Fennema, O. R., Damodaran, S., Parkin, K. L., & Fennema, CRC Press.
5. The Lipid Handbook with CD-ROM (3rd ed.) F. D. Gunstone, Harwood, J. L., & Dijkstra, A. J. (2007). CRC Press.
6. Alcoholic Beverages: L. Settanni & C. Sannino, (2018). Sensory Evaluation and Consumer Research. Wiley.
7. Coal Analysis: Sampling, Testing, and Charting, Speight, J. (2008). Academic Press.
8. Handbook of Analytical Techniques in Concrete Science and Technology: Principles, Techniques, and Applications, Ramachandran, V. S., & J. Beaudoin, William Andrew. (Eds.). (2002).
9. Handbook of Fuel Analysis" by James G. Speight.

Web resources:

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

M.Sc. (Chemistry) Second Year Semester- III [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 304(v)	**Fuels and Heavy Chemicals (Industrial special) (DSE–III (v))**	**45 hrs (3 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: Fuels: 8L

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, environment aspects.

Unit-II: Oils 07L

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

B) 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: Manufacture of Heavy Chemicals: 8L

Chemical processes for the manufacture of Heavy chemicals like- soda ash, bicarbonates, chlorine, caustic soda, bleaching power, calcium carbides, Silicon Carbide, Lime and gypsum and their applications.

Unit-IV: 7L

Manufacture of Following: Manufacturing of acids like H_2SO_4, HCl, HNO_3, H_3PO_4. Manufacturing of ammonia, Urea, ammonium sulphate, ammonium nitrate, ammonium phosphate with respect to their consumption pattern.

Unit-V: Cement , Glasses and Ceramics 8L

A) Cement: Types of cement, manufacturing processes of cement by Wet and Dry method, setting and Hardening ofcement, cement additives.

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

C) Ceramics: Introduction, types, manufacturing process, applications of ceramics and refractories. High alumina refractories and fire clay brick.

Unit-VI: Sugar Industries 7L

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.

Course Material/Learning Resources:

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. Hardwork.
5. The Petroleum chemical industry by Goldsteim and 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 NewDelhi.
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 Venketesharul Educational Development Center. IITMadras,1977.
14. Material science, O. P. Khanna, Khanna Publishers, Delhi
15. Elements of Materials Science and Engineering by L H Van Vlack.

Web Resources:

1) Cement: https://nptel.ac.in/courses/105104157
2) Fuels: https://nptel.ac.in/courses/113104008
3) Heavy and Fine Chemicals: https://nptel.ac.in/courses/103106108
4) Material Science: https://nptel.ac.in/courses/113107078
5) https://www.youtube.com/watch?v=AfzcRo8EJ_4&list=PLidJKPid3sndtVQwEIHTZ-hcossJ6Q07k&index=12

M.Sc. (Chemistry) Second Year Semester- I I I [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 305	**Lab 05 (based on DSC–III.1, 2 and 3)**	**60 hrs (4 hrs/week)**

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

1. Identify and draw structural isomers, enantiomers, diastereomers, and conformations of organic compounds.
2. Represent reaction mechanisms using curly arrows, including intermediates and transition states, and transfer these drawings to digital formats
3. convert 2D structures to SMILES notations and 3D-optimized structures, use cheminformatics tools.
4. apply green chemistry principles through various organic synthesis reactions that emphasize sustainability, reduced waste, and environmentally friendly practices
5. perform reactions such as the Grignard-like reaction in water and one-pot synthesis, enhancing their ability to execute complex procedures in a simplified, eco-friendly manner.
6. utilize skills in setting up and performing laboratory experiments, analyzing results, and understanding the mechanisms behind green reactions.

Exercise I: Computer Aided Chemistry experiments:

1. Generate structural isomers for a given molecular formula: C_6H_{14}, draw all the possible isomers of hexane.
2. Draw the complete curly arrow mechanism of a chemical reaction. Choose a reaction (e.g., nucleophilic substitution, addition reaction) and draw the step-by-step mechanism, including any intermediates and transferring it to MS Word and/or MS PowerPoint (Overall Reaction and its mechanism expected).
3. Draw enantiomers and diastereomers for a given compound possessing two or more chiral centers. Highlight the stereocenters and demonstrate how the isomers differ.
4. Select a molecule with rotatable bonds and draw its various conformations. Emphasize the most stable conformation and explain the reasons behind its stability. (Drawing 2D- structures of conformations of ethane, butane, and cyclohexane.)
5. Draw three coordination complex with a transition metal center and ligands. Specify the coordination number and geometry of the complex. (Note: Ligands should be a combination of mono-, bi-, and tri-dentate ligands).
6. Drawing 2D- structures of ten heterocyclic compounds and their bi- and tri-substituted derivatives (four derivatives each).
7. Drawing the 2D-structures of at least five marketed drugs and reporting their IUPAC name, usage, and mechanism of action.
8. Conversion of 2D- structures of compounds drawn in Experiment 7 and 8 to their SMILES notations and transferring it to MS Excel spreadsheet in a tabular format.
9. Conversion of 2D- structures of compounds drawn in experiments 7 and 8 to 3D- optimized structures using MMFF94 forcefield and saving as .sdf or .mol file format.
10. Drawing the 2D- structures of five and six membered monosaccharides (Glucose and ribose).
11. Drawing well labelled diagram of simple distillation assembly using ChemSketch.
12. 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))

Exercise II; Green Chemistry Experiments:

1. HALOGEN ADDITION TO C=C BOND (Bromination of trans-stilbene)
2. [4+2] CYCLOADDITION REACTION (Diels-Alder reaction between furan and maleic acid)
3. COENZYME CATALYZED BENZOIN CONDENSATION (Thiamine hydrochloride catalyzed synthesis of benzoin)
4. ELECTROPHILIC AROMATIC SUBSTITUTION REACTION-I (Nitration of phenol)
5. ELECTROPHILIC AROMATIC SUBSTITUTION REACTION-II (Bromination of acetanilide)
6. GREEN PHOTOCHEMICAL REACTION (Photoreduction of benzophenone to benzopinacol)

7. RADICAL COUPLING REACTION (Preparation of 1,1-bis-2-naphthol)
8. Ionic Liquid, 1-methyl-3-pentyl-imidazolium bromide, [pmIm]Br and its application
9. To produce biodiesel from vegetable oil via transesterification, a process that minimizes waste and uses renewable resources.
10. A Grignard-like Organic Reaction of allyl bromide with benzaldehyde in Water
11. One-Pot Synthesis of Chalcone Epoxides via Claisen Schmidt Condensation and Epoxidation (https://pubs.acs.org/isbn/9780841231771)
12. THREE COMPONENT COUPLING (Synthesis of dihydropyrimidinone)
13. Preparation of 2- phenylbenzothiazoles
14. Preparation of Manganese(III) acetylacetonate, Mn(acac)3 or $Mn(C_5H_7O_2)_3$

Examination: CHE 305 Lab 05 (based on DSC–III.1, 2 and 3)

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

A.	**Exercise-I**	**20**
B.	**Exercise-II**	**20**
C.	**Viva (External + Internal)**	**10**
E.	**Internal assessment***	**50**
	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

Course Material/Learning Resources:

1. Experiments and technique in organic experiments- D. Pasto, C. Johnson and M. Miller prentice Hall.
2. Macro- scale and micro-scale organic experiments-K.L. Williaman, D. C. Heath.
3. Systematic quantitative organic analysis – H. Middleton, Edward Arnold.
4. Vogel's Textbook of practical organic chemistry Fifth Edition-Brain S. Furniss, Antoy J. Hannaford, Peter W,G. Smith, Austin R. Tatchell.
5. Experiment organic chemistry Vol.I&II –P.R. Singh, D. S. Gupta and K.S. Bajpai.
6. The Golden book of chemistry experiments- Robert Brent

Web resources:

1. Green chemistry Experiments: https://green-chem.sites.olt.ubc.ca/files/2021/11/A-Guide-to-Green-Chemistry-Experiments-for-Undergraduate-Organic-Chemistry-Labs.pdf
2. https://pubs.acs.org/doi/10.1021/bk-2016-1233.ch002
3. Procedure for synthesis : http://orgsyn.org/Default.aspx
4. Monograph on Green Chemistry Laboratory Experiments: https://faculty.ksu.edu.sa/sites/default/files/green-chem.pdf

M.Sc. (Chemistry) Second Year Semester- I I I [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 306(i)	**Inorganic Chemistry special Practical (Lab 06)**	**60 hrs (4 hrs/week)**

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

1) understand various analytical methods for analysis of inorganic samples.
2) apply different separation techniques depending upon the nature of sample
3) analyze an inorganic sample by complexometric and spectrophotometric methods..
4) apply advanced analytical techniques for the analysis of inorganic material.
5) find the purity of water sample from various region.
6) interpret and analyze data obtained from various analytical methods.
7) apply critical thinking in analysis of unknown samples.
8) able to synthesize nanomaterial and find their applications.

Exercise I: (Students should perform at least ten experiments)

a) Water analysis and Complexometric titrations:

1. Estimation of total hardness of a given sample of water by complexometric titration.
2. Water analysis of sample by determining DO, COD and BOD.
3. Water analysis of sample by determining alkalinity, salinity, fluorides, chlorides, phosphates and sulphates.
4. Determination of calcium from given drug sample by complexometrically
5. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} ions by complexometric titrations using EDTA.
6. Analysis of given sample of brass alloy for its copper content iodometrically and zinc content complexometrically.
7. Analysis of given sample of bronze alloy for its Cu content by complexometrically and tin content gravimetrically.
8. Analysis of Mangesium alloy for its Al content gravimetrically as basic succinate and Mg content complexometrically.

b) Spectrophotometric, conductometric and potentiometric determinations:

9. Determination of the stability constant and stoichiometry of Ferric-thiocyanate complex by spectrophotometrically.
10. To study the stoichiometry and stability of Fe^{3+} salicylate complex by Job's and Mole ratio method spectrophotometrically.
11. Estimate the amount of copper(II) ion with EDTA by photometric titration.
12. Determination the composition and formation constant of a Fe-SSA complex by conductometrically
13. Determination stepwise proton-ligand and metal-ligand stability constant of complex by Irving-Rossotti method.
14. Determination of stability constant of $[Zn(NH_3)^4]^{2+}$ potentiometrically.
15. Determination of stability constant of $[Fe(SCN)]^{2+}$ by slope ratio method.
16. Determine the amount of iron present in a sample using 1,10-phenathroline spectrophotometrically.

Exercise II: (Students should perform at least five experiments)

1. Synthesis of nano size material and their characterization by spectral methods. (e.g. NiO, Fe_3O_4, MnO_2, ZnO or Gold nano particles)
2. Analysis of N. P. K. from fertilizer
3. Analysis of cement.
4. To estimate the amount of Mg and Zn in the given sample solution by ion exchange chromatographic method..
5. Separation and estimation of Fe^{2+}, Co^{2+} and Ni^{2+} by cation exchanger.
6. Separation and estimation of halide ions by anion exchanger.
7. Separation and estimation of Fe^{3+} and Mg^{2+} by solvent extraction.
8. Solvent extraction of binary mixture Al/Mg, Cu/Ni or Cu/Co and their quantitative determination by spectrophotometrically.
9. Separation, identification and determination of Rf values of metal ions by paper chromatography.
10. Separation, identification and determination of Rf values of metal ions by thin layer chromatography.

Examination: CHE 306 (i) Inorganic Chemistry special Practical (Lab 06)

Time : 6-8 Hrs. (One day Examination) Total Marks : 50+50=100

A.	**Exercise-I**	**20**
B.	**Exercise-II**	**20**
C.	**Viva (External + Internal)**	**10**
E.	**Internal assessment***	**50**
	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. Instrumental Methods of Chemical Analysis, Ewing G.W., Mcgraw Hill. (CBS, Delhi).
8. Basic Concepts of Analytical Chemistry, Khopkar S. M.
9. Experiments in chemistry, Jahagirdar D.V.
10. Instrumental Methods of Chemical Analysis, Yelri Lalikov
11. Fundamental of Analytical Chemistry, Skoog D.A. &West D.M Holt Rinehart &Winston Inc.
12. Experimental Inorganic Chemistry, W.G.Palmer, Cambridge.
13. Solid state Chemistry, N.B.Hanney
14. Preparation and Properties of solid state Materials, Wilcox, Vol. I&II, Dekker
15. The Structure and Properties of Materials Vol. IV, JohnWulff, Wiley Eastern
16. Chemical Methods for environmental Analysis: Water & Sedient, Ramesh R. and Anbu M., Macmillion, India.

M.Sc. (Chemistry) Second Year Semester- I I I [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 306(ii)	**Organic Chemistry special Practical (Lab 06)**	**60 hrs (4 hrs/week)**

Course Outcomes: At the end of the course 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

Exercise I: Multistage Preparations (minimum- 6)

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. Benzoin → Benzil → Benzilic Acid (By Green Synthesis)
11. Acridone from Anthranilic Acid
12. Chemo selective Reduction of 3-Nitroacetophenone to 3-aminoacetophenone with Tin and Hydrochloric Acid

Exercise II: 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.

Identify the compounds present in each mixture based on the Rf (retention factor) values or other characteristic features (Melting Point and Boiling Point).

Examination: CHE 306 (ii) Organic Chemistry special Practical (Lab 06)

Time : 6-8 Hrs. (One day Examination) Total Marks : 50+50=100

A.	**Exercise-I**	**20**
B.	**Exercise-II**	**20**
C.	**Viva (External + Internal)**	**10**
E.	**Internal assessment***	**50**
	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. 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 Resources:

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.

M.Sc. (Chemistry) Second Year Semester- I I I [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 306(iii)	**Physical Chemistry special Practical (Lab 06)**	**60 hrs (4 hrs/week)**

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

1. Understand the basic principle involved in physical chemistry.
2. Evaluate various physical parameters
3. Interpreted the experimental results.
4. Calculation involved in interpreting results.

Exercise I:

1. Determination of molecular mass of a polymer by viscometry method.
2. Distribution of succinic acid in H_2O -benzene, H_2O-ether and comparison of distribution coefficient.
2. To construct the phase diagrams of two components system- phenol -urea, diphenyl amine benzophenone; α-naphtyl amine-phenol (forming compounds with congruent melting points).
3. To study the mutual solubility of glycerol-m-toluidine and to determine congruent points.
4. To determine equilibrium constant of the equation $KI+I_2$-KI, by distribution method
2. To find out the strength of ammonia solution by titrating against acetic acid solution pH metrically.
3. To find out the strength of HCl and acetic acid in mixture of both by titrating it against NaOH solution pH metrically.
4. To find out the dissociation constant of poly basic acid against sodium hydroxide solution.
5. To determine pK_a value of a given organic acid pH metrically.
6. To find out the strength of borax solution by titrating it against HCl pH metrically.

Exercise-II

1. Statistical Analysis using MS Excel program (mean, average deviation, standard deviation, variance, F-test, t-test, chi-square test, correlation coefficient, slope, intercept, etc).
2. To determine the molecular weight of given polymer by turbimetry.
3. To determine the isosbestic point of given indicator (Methyl red) Spectrophotometrically.
4. To determine the transition temperature of sodium sulphate decahyadrate by thermometric method.
5. Determination of dissociation constant of acetic acid and mixture of Acetic acid with HCl potentiometrically.
6. To determination of the equivalence point by titrating a solution of 0.1N NaOH against 0.1 N HCl spectrophotometrically.
7. To determine concentration of Cu(II) and Fe(III) solution photometrically by titrating with EDTA.
8. To obtain calibration curve for given compound and verify Beer's Lambert's law and determine the known concentration of given compound.
9. To obtain spectral absorption curve for a given substance using a spectrometer and also find the wavelength of maximum absorption.
10. To determine the phosphate concentration in soft drink

Examination: CHE 306 (iii) Physical Chemistry special Practical (Lab 06)

Time : 6-8 Hrs. (One day Examination) Total Marks: 50+50=100

A.	**Exercise-I**	**20**
B.	**Exercise-II**	**20**
C.	**Viva (External + Internal)**	**10**
D.	**Internal assessment***	**50**
	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. Das and Behra, Practical Physical Chemistry
2. Carl W. Garland, Joseph W. Nibler and David P. Shoemaker, Experiments in Physical Chemistry, Mc-Graw Hill, Sh Edition, 2009.
3. Alberty, Experimental Physical Chemistry, Mc-Graw Hill, Fifth Edition, 1956.
4. John W. Shriver and Michael George, Experimental Physical Chemistry, Lab Manual and Data Analysis, The University of Alabama in Huntsville, Fall 2006
5. Merits And Thomas: Advanced Analytical Chemistry
6. Ewing, G. W.: Instrumental Methods of Chemical Analysis, Mcgraw-Hill
7. Khopkar S.M.:Basic Concept Of Analytical Chemistry
8. Jahgirdar D.V:Experiments In Chemistry
9. Chondhekar T.K: Systematic Experiments In Physical Chemistry, Rajbog S.W., Aniali Pubn.
10. Jagdamba Singh, Advance Practical chemistry, Pragati Prakshan.
11. B.S. Bahl, Arun Bahl, and G.D. Tuli "Practical Physical Chemistry"
12. S. Venkatachalam "Practical Physical Chemistry"
13. Dr. N.K. Verma "Practical Chemistry"

14. Shoemaker, Garland, and Nibler "Experiments in Physical Chemistry"
15. George E. P. Box, William G. Hunter, and Stuart Hunter "Statistics for Experimenters: An Introduction to Design, Data Analysis, and Model Building"
16. Michael R. Middleton and Kenneth J. Hintz "Data Analysis Using Microsoft Excel: Updated for Office XP"
17. Daniel C. Harris "Quantitative Chemical Analysis"
18. Richard N. West and Joseph M. Haile "Experimental Thermodynamics Volume X: Principles and Methods"
19. Daniel C. Harris "Quantitative Chemical Analysis"
20. Steven C. Chapra and Raymond P. Canale "Numerical Methods for Engineers"
21. Quantitative Chemical Analysis by Daniel C. Harris
22. Vogel's Textbook of Quantitative Chemical Analysis by G.H. Jeffery, J. Bassett, J. Mendham, and R.C. Denney
23. Analytical Chemistry: Principles and Techniques by Larry G. Hargis
24. Principles of Instrumental Analysis by Douglas A. Skoog, F. James Holler, and Stanley R. Crouch
25. Chemistry Experiments for Instrumental Methods by Donald T. Sawyer, William R. Heineman, and Janice M. Beebe
26. "Instrumental Methods of Chemical Analysis" by B.K. Sharma
27. "Spectroscopy: Principles and Applications" by K. S. K. Rao and B. V. R. Babu.

Web resources:

1. https://vlab.amrita.edu/
2. https://ocw.mit.edu/
3. https://chem.libretexts.org/
4. https://www.excel-easy.com/examples/t-test.html
5. https://www.researchgate.net/publication/303632877_Turbidimetric_method_for_determining_molecular_weights
6. https://www.labster.com/
7. https://chem.libretexts.org/

M.Sc. (Chemistry) Second Year Semester- I I I [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 306(iv)	**Analytical Chemistry special Practical (Lab 06)**	**60 hrs (4 hrs/week)**

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

1. Apply advanced analytical techniques for the analysis of food, cement, 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. Apply critical thinking and problem-solving skills to solve analytical challenges
6. Effectively communicate analytical results and findings.
7. Understand the practical applications of analytical chemistry in various industries

Exercise I:

A. Analysis of Drugs:

1) Determination of Fe in a capsule
2) Determination of ascorbic acid in a vitamin-C tablet
3) Diazotization method for determining sulpha drug
4) Determination of Mg in milk of magnesia

B. Bleaching Powder:

5) Determination of available chlorine
6) Break point chlorination

C. Food:

7) Moisture content determination by Karl-Fischer titration
8) Determination of phosphoric acid in cola beverages by pH titration

Exercise-II

A. Analysis of Oils:

1. Determination of Carbon residue
2. Determination of Acid value
3. Determination of Saponification value
4. Determination of Iodine value
5. Measurement of viscosity
6. Determination of Flash point
7. Determination of Cloud point
8. Determination of Aniline point

B. Analysis of Cement:

1. Analysis of Silica, alumina, ferric oxide, calcium and magnesium oxide, sodium and potassium oxide

Examination: CHE 306 (iv) Analytical Chemistry special Practical (Lab 06)

Time : 6-8 Hrs. (One day Examination) Total Marks: 50+50=100

A.	**Exercise-I**	**20**
B.	**Exercise-II**	**20**
C.	**Viva (External + Internal)**	**10**
E.	**Internal assessment***	**50**
	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. Food Analysis: A. G. Woodman (McGraw-Hill)
2. Aids of Analysis of Food and Drugs: Wicholls
3. Handbook of Drugs and Cosmetics Aids: Mehrotra
4. Analytical Chemistry: A. Gupta (Pragati Prakashan)
5. Applied Chemistry: Vermani and Narula (New Age International)
6. Experiments in Chemistry - Jahagirdar D.V.-
7. Standard methods of Chemical analysis, Wlehov G.J. 6th Ed. 17.
8. Industrial Chemistry: B. K. Sharma

M.Sc. (Chemistry) Second Year Semester- I I I [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 306(v)	**Industrial Chemistry special Practical (Lab 06)**	**60 hrs (4 hrs/week)**

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

1. Apply skills to estimate calcium, iron and silica from commercial grade cement.
2. Synthesis various commercial products.
3. Understand the pathway involved during preparation of various Dyes.
4. Apply acquired knowledge to prepare analyzed the commercial polymers.
5. Operate sophisticated equipment's effectively

Exercise I: PART A

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.
1. Measurement of flash point, ignition point, kinematic viscosity by U-tube method.
2. Determination of reducing sugar in cane juice.
3. Experiments based on simple & fractional distillation.
4. Estimation of Manganese from Tea leaves-component
5. Preparation of biodiesel from vegetable/ waste cooking oil
6. Determination of calorific value of fuels.
7. Determination of moisture content and ash content of wood sample

Exercise-II PART B

1. Extraction of essential oils from medicinal plants (Tikhadi).
2. Analysis and estimation of phenolic group by bromination method.
3. Determination of Silica in Cement.
4. Preparation of Methyl orange dye.
5. Preparation of Methyl red dye.
6. Preparation of Picric acid dye.
7. Preparation of melamine HCHO resin.
8. Determination of number average molecular weight (Mn) by end group analysis by conductometric method.
9. Determination of average molecular weight of polymer by Viscometric method.
10. Determination of chlorine content of PVC.
11. Determination of acid value of polymers.
12. Measurement of Relative Viscosity of Polymer solutions.
13. Preparation of Nylon 6,6.
14. Preparation of Phenol formaldehyde resin.
15. Preparation of Urea formaldehyde resin

Examination: CHE 306 (v) Industrial Chemistry special Practical (Lab 06)

Time : 6-8 Hrs. (One day Examination) Total Marks: 50+50=100

A.	**Exercise-I**	**20**
B.	**Exercise-II**	**20**
C.	**Viva (External + Internal)**	**10**
E.	**Internal assessment***	**50**
	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

Course Material/Learning Resources:

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 New Delhi
4. IP Stands for Petroleum and products Published Applied Service Publisher Ltd. London, 33rd Edition 1974.
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.
9. Practical Course in Polymer Chemistry by S. J. Pnnea, Pargaman Press.
10. Reagents for Organic Synthesis Fisher and Fisher.
11. Technique of Organic Chemistry Vol I, Part I- IV A. Weisberger.
12. Instrumental Methods of Analysis by Willard, Merit and Dean.
13. Textbook of Inorganic Chemistry by A. I. Vogel.

M.Sc. (Chemistry) Second Year Semester- I I I [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 307	**Lab 07 (Research Project Phase I)**	**90 hrs (2Tut+4 P= 6 hrs/week)**

Course Outcomes: At the end of the course students will 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. Iindividual 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: CHE 307 Lab 7 Research project Phase I Max Marks 50 (Internal)

A.	Submission of Research proposal synopsis	25
B.	Presentation on the research proposal synopsis	25
	Total	**50**

M.Sc. (Chemistry) Second Year Semester- IV [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 401	**Principles of Organic Synthesis (DSC–I.4)**	**60 hrs (4 hrs/week)**

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

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

Unit I: Oxidation 10L

1. Selective oxidation of alkyl side chain in aromatic compounds using Cr (IV and VI, II) Oxidation of aromatic ring by chromic oxidation.

2. 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

3. Dihydroxylation by KMnO4 and OsO4

4. Oxidation of alcohols: oxidation of 1,2- diols (Lead tetra-acetate, periodates, asymmetric dihydroxylation

5. Oxidative cleavage by ozonolysis, Lemieux reagent, formation of ketones by Wacker process.

Unit II: Reduction 10L

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,

Unit-III: Retrosynthesis: 10L

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

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

Unit-IV: Two group disconnections and Selectivity in Organic Synthesis : 10L

A. Two group C-C disconnections: Diels-Alder reaction, 1,3-difunctionalized compounds, 1,5-difunctionalized compounds
B. Two group C-X disconnections in 1,1-difunctionalized, 1,2 difunctionalized, and 1,4-difunctionalized compounds.
C. Definition and Importance of Selectivity, Types of Selectivity with examples: Regioselectivity, Chemoselectivity, Stereoselectivity, Enantioselectivity, Techniques for Controlling Selectivity,

Unit-V: Phase Transfer Catalysis: 10L

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

Unit-VI: Asymmetric Synthesis: 10L

Introduction, General concept- topicity and prochirality, substrate and product selectivities Fundamentals of Stereochemistry, Classification, Resolution, chiral pool, Chiral Auxiliaries, Enantiomeric excess Chiral reagents and Chiral Catalysts, Asymmetric Induction, Enzymatic and Biocatalysis

Asymmetric Reactions: Asymmetric Aldol Reactions, Asymmetric Hydrogenation- BINAP, DIPAMP, BINAL-H, Asymmetric dihydroxylation, Cycloadditions (Diels-Alder Reactions).

Course Material/Learning Resources:

1. Principle of Organic Synthesis" by R. O. C Norman and J. H. Coxon, 1st Ed, ELBS, 1993.
2. "Organic Chemistry" by Jonathan Clayden, Nick Greeves, and Stuart Warren
3. "Pericyclic Reactions" by Paul D. Bartlett
4. "Advanced Organic Chemistry" by Francis A. Carey and Richard J. Sundberg
5. "Molecular Orbitals and Organic Chemical Reactions" by Ian Fleming
6. "Pericyclic Reactions and Organic Photochemistry" by Jagdamba Singh and S. J. Singh
7. "Organic Synthesis: The Disconnection Approach" by Stuart Warren and Paul Wyatt:
8. "Strategic Applications of Named Reactions in Organic Synthesis" by Laszlo Kurti and Barbara Czako
9. "Strategic Applications of Advanced Synthetic Methodologies" edited by Anthony W. Czarnik
10. "Organic Synthesis: Strategy and Control" by Paul Wyatt and Stuart Warren
11. "Retrosynthetic Analysis" by Stuart Warren

Web Resources:

1. Reagents in Organic Synthesis https://onlinecourses.nptel.ac.in/noc21_cy42/preview
2. Principles of Organic Synthesis https://onlinecourses.nptel.ac.in/noc21_cy41/preview
3. Transition Organometallic Chemistry Principles to Application https://onlinecourses.nptel.ac.in/noc21_cy36/preview
4. A Study Guide In Organic Retrosynthesis: Problem Solving Approach https://onlinecourses.nptel.ac.in/noc23_cy28/preview

M.Sc. (Chemistry) Second Year Semester- IV [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 402	**Spectroscopy-II (DSC–II.4)**	**45 hrs (3 hrs/week)**

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

1. deduce structures and reactivity patterns of organic, organometallic, and inorganic materials using spectroscopic data.
2. correlate ESR spectroscopic data with molecular structure
3. analyze isotropic and anisotropic ESR spectra and use ENDOR spectroscopy.
4. apply X-ray diffraction, electron diffraction and neutron diffraction techniques to determine atomic charges, oxidation state, metal-metal bonding and coordination geometry.
5. utilizes zero-field spectra in Mössbauer spectroscopy to determine oxidation state, spin state, and coordination geometry.
6. accomplish structure elucidation of organic and inorganic compounds using advance spectroscopic methods.

Unit-I: 08L

A) 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.

B) **Photoelectron spectroscopy:** Basic principle, classification of electron microscopy methods, photoelectric effect, ionization process, Koopemanss theorem PES and X-PES, PES spectra of simple molecule, ESCA, chemical information from ESCA. Auger electron spectroscopy-basic idea..

Unit-II: 7L

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.

Unit-III: Mass spectrometry: 8L

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.

Unit-IV: Mossbauer spectroscopy: 7L

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.

Unit-V: Electron Spin Resonance Spectroscopy: 8L

A) 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}).

Unit-VI: Structure elucidation by integrated spectroscopic methods: 7L

Problems based on joint application of UV, IR, PMR, CMR, Mass and 2-D NMR spectroscopic techniques

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

Web resources:

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

M.Sc. (Chemistry) Second Year Semester- IV [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 403	**Separation Techniques (DSC–III.4)**	**60 hrs (4 hrs/week)**

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

1. Describe the fundamental principles and techniques used in extraction and separation methods.
2. Compare various separation techniques and evaluate their efficiency for specific applications.
3. Identify the components and steps involved in performing paper and TLC.
4. Identify suitable adsorbents and conditions for column chromatography.
5. Evaluate the advantages and limitations of these chromatography methods in various contexts.
6. Identify the types of columns, detectors, and solvents used in HPLC.
7. Evaluate the application of gas chromatography in various industries and research areas.
8. Explain the principles of electrophoresis and its different types (e.g., gel electrophoresis, capillary electrophoresis).
9. Interpret and evaluate analytical data obtained from these techniques to draw meaningful conclusions about the composition and purity of samples.

Unit-I: Extraction and Separation Methods 10L

A) Solvent Extraction and Solid Phase Extraction: Basic concepts of solvent extraction. Mechanism of extraction Liquid anion and cation exchangers. Synergetic Extraction. Solvent Extraction by crown ether, cryptands, calixarenes. Solid phase extraction, Solid phase micro extraction (SPME), Advantage and application of SPME.

B) Chromatography: Introduction, General classification of chromatographic methods. Concept of plate and rate theories: efficiency, resolution, selectivity and separation capability. Broadening of chromatographic peak and van Deemter equation

Unit-II: Paper and Thin layer Chromatography 10L

A) Paper Chromatography: Chromatography Paper, Sample Preparation, Sample Cleanup, Derivatization, Mobile Phases and Stationary Phases, Development of Chromatograms, Detection, Quantitation.

B) Thin layer Chromatography: Stationary Phases for TLC, TLC of Enantiomeric Compounds, Sample Application, Mobile Phases, Development of Chromatograms, Detection and Quantitation, Applications of TLC

Unit-III: Adsorption and Column Chromatography 10L

A) Adsorption Chromatography: Introduction, Theory, Adsorbent, Solvent, Procedure, Difference between Adsorption and Gas- liquid chromatography

B) Column Chromatography: Introduction, Principle, Experimental details, theory of developments, Column efficiency, Factors affecting column efficiency, Applications of Column Chromatography.

C) Gel Chromatography: Introduction, Principle, Materials, Gel Preparation, Column Packing and Detector, Applications, Advantage of Gel Chromatography.

Unit-IV: High Performance Liquid Chromatography: (HPLC) 10L

HPLC theory and instrumentation; mobile phase reservoir and solvent treatment systems, pumping systems, sample introduction systems, columns, Detectors: Ultra Voilet, Refractive Index, Electron Capture and diode array, Adsorption chromatography, Liquid-Liquid partition techniques, Microbore and capillary chromatography, Applications and problems.

Unit-V: Gas Chromatography 10L

Gas chromatography Principle of GLC and GSC; Instrumentation: carrier gas supply Column types, Solid/ Liquid Stationary Phases, Column Switching techniques, Basic and Specialized detectors, elemental detection, chiral separations, pyrolysis gas chromatography, High temperature techniques. Applications.

Unit-VI: Electrophoresis 10L

A) Theory of electrophoresis, Paper and Capillary Electrophoresis, Instrumentation of Capillary Electrophoresis (CE), Separation of amino acid by capillary zone electrophoresis, Applications of Capillary Electrophoresis.

B) Electrophoresis Techniques: Continuous Electrophoresis, Density Gradient Electrophoresis, Micellar Electrokinetic Capillary Chromatography, Immuno Electrophoresis, Preparative Electrophoresis, Electrophoresis in Powder, Capillary Electrochromatography.

Course Material/Learning Resources:

Text books:

1. Fundamentals of Analytical Chemistry", D.A. Skoog, D.M. West, F.J. Holler, S. R. Crouch 8th, edn.
2. Instrumental Method of Chemical Analysis, Gurdeep R. Chatwal, Sham K. Anand, Himalaya Publication
3. Instrumental method of chemical analysis, H. Kaur, Pragati edition
4. Instrumental Methods of Analysis H. H. Willard, L. L. Merritt Jr, J.A. Dean, F.A.Settle (CBS Publisher) 7the edn.
5. Analytical Chemistry: G. D. Christian, Wiley, 6th edn.

Reference Books:

1. Solvent Extraction in Analytical Chemistry, G. H. Morrison and H. Freiser, John Wiley & Sons
2. Basic concept of Analytical Chemistry, S. M. Khopkar, 3 rd edn., Age International Publisher
3. High Performance Liquid Chromatography, Analytical Chemistry by open learning, John Wiley & Sons.
4. Chromatography and Separation Science, Satinder Ahuja, Volume 4, Academic Press.
5. Solid phase Extraction- Principles, Techniques and Applications, N. J. K. Simpson, Marcel Dekker.
6. Analytical Chemistry: A modern Approach to Analytical Science, R. Kellner, J.M. Mermet, M. Oto, M.
7. Valcarcel, H. M. Widmer 2nd edn. Wiley
8. Quantitative Analysis, R. A. Day, Jr. and A.L Underwood 6 th ed., Prentice Hall of India Pvt. Ltd.
9. Introduction to Instrumental Analysis, R. D. Braun, McGraw Hill.
10. Vogel's Textbook of Quantitative Chemical Analysis, G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denney, 6th edn., ELBS, Longman Scientific & Technical.
11. Analytical Separation Science, Jared L. Anderson, Alain Berthod, Veronica Pino, and Apryll M. Stalcup (ed), (Volume 1-5). Wiley

Web resources:

1. Analytical Chemistry: https://onlinecourses.nptel.ac.in/noc22_cy61/preview
2. Solvent Extraction: https://youtu.be/1tmqUVSVPo4?si=If91etolAqWdG957
3. Gas chromatography: https://www.youtube.com/watch?v=08YWhLTjlfo
4. HPLC:https://youtu.be/kz_egMtdnL4?si=ENzntYRkHWKVczr

M.Sc. (Chemistry) Second Year Semester- IV [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 404 (i)	**Material Chemistry (DSE-IV (i))**	**45 hrs (3 hrs/week)**

Course Outcomes: At the end of the course, students will 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 and Ceramics 8L

Glass: Glassy state and its properties, classification (silicate and non-silicateglasses).Manufacture and processing of glass. Glassy state, glass formers and glass modifiers.

Ceramics: Ceramic structure.Mechanical properties. High technology ceramics and their applications.

Clays: Classification, structure and modifications of clays. Properties and applications of clays.

Refractories materials: Classification, properties and applications. Microscopic composites..

Unit-II: Composite materials and Bio materials 7L

A) Composite materials: Definition, glass transition temperature, fibres, concrete and asphaltmaterials, polymer composites, application Ceramic & Refractory: Introduction, classification, properties, raw materials, manufacturing and applications.

B) **Bio-materials:** Biomineralization, controlled formation of biological composites, bone & other mineralised tissues, materials of construction, applications (General aspect only)

Unit-III: Liquid Crystals 8L

Mesomorphic behaviour, thermotropic liquid crystals, positional order, bond orientational order, nematics & smectic mesophases; smectic-Nematic transition clearing temperature-homeotropic, planer & schlieren textures twisted nematics, chiral nematics, molecular arrangement in smectic A &smectic C phases, optical properties of liquid crystals. Dielectric susceptibility & dielectric constants. Lyotropic phases & their description of ordering in liquid crystals.

Unit-IV: Nano Chemistry 7L

Introduction: Definition of nanoscale materials, different types, different physical and chemical synthetic routes, characterization of nanoscale materials by modern instrumental techniques.

Physical and Chemical Properties of Nanoscale Materials: Electrical properties, magnetic properties, 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 metal oxides with different sizes and shapes, useful chemical conversions using nanoparticles.

Nanoscale Materials in Emerging Technologies: Useful properties that can be exploited for applications, applications in the areas such as environmental remediation, adsorption, drug delivery, medical imaging, future prospects, precautions in using nanoparticles.

Unit-V: Nanoporous Materials and Catalysis 8L

Nanoporous Materials: Introduction, Zeolites & molecular sieves, Classifications, fundamental properties of zeolites, Qualitative & quantitative determination of surface acidity, Hydrothermal synthesis of zeolites factors affecting the zeolite preparations, modification, methods of characterizations, & catalytic applications.

Catalysis: Basic principles, types, industrial requirements, classification, theories of catalysis, Types of homogeneous and heterogeneous catalysts, Advantages and disadvantages, thermodynamic and kinetic aspects .Essential properties of catalysts. Characterization of catalysts.

Unit-VI: Fertilizers and Coordination Polymers 7L

A) Fertilizers: Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; olyphosphate, 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 substituted phosphazenes and their applications. Polysilanes: sigma bond delocalization in polysilanes and its implications, synthesis and characterization of polysilanes. Polysiloxanes: synthetic routes via anionic and cationic polymerization, properties and environmental aspects.

Course Material/Learning Resources:

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.
9. Shriver & Atkins. Inorganic Chemistry, Peter Alkins, Tina Overton, Jonathan Rourke, Mark Weller
10. Fraser Armstrong, 5th Edition, Oxford University Press (2011-2012)
11. Adam, D.M. Inorganic Solids: An introduction to concepts in solid-state structural chemistry. John Wiley& Sons, 1974.
12. Poole, C.P. & Owens, F.J. Introduction to Nanotechnology John Wiley & Sons, 2003.
13. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.

Web resources:

M.Sc. (Chemistry) Second Year Semester- IV [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 404 (ii)	**Natural Products and Medicinal Chemistry (DSE-IV (iii))**	**45 hrs (3 hrs/week)**

Course Outcomes: At the end of the course, students will 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. Develop the ability to critically evaluate scientific literature and research findings related to natural compounds
9. Analyze the role of medicinal chemistry in drug design, including the design and synthesis of small molecules as drug candidates.
10. 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: Carbohydrates 8L

Carbohydrates: Types of naturally occurring sugars, Deoxy sugars, Amino sugars, Branched chain sugars, Types of glycosidic linkage Configuration of monosaccharides, General methods of structure determination, Ring structure of monosaccharides, Disaccharides, Specific carbohydrates to study: Maltose, Lactose, Sucrose, Starch, Cellulose, chitin and heparin.

Unit-II: Amino acids, peptides and Peptides 7L

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

B) 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

Unit-III: Alkaloids and Steroids 8L

A) **Alkaloids**: Classification of alkaloids, Nomenclature of alkaloids, Occurrence of alkaloids in natural sources, General methods of structure determination Specific alkaloids to study: Papaverine, Reserpine. Biosynthesis of alkaloids. Woodward synthesis of Reserpine from benzoquinone

B) **Steroids and Hormones:** Occurrence of steroids and hormones, Nomenclature of steroids, Basic steroid skeleton, Diel's hydrocarbon and stereochemistry, Structure determination and synthesis of Cholesterol. Synthesis of sex hormones (Testosterone, Oestrone, Progesterone) from cholesterol

Unit-IV: Terpenoids and Enzymes: 7L

A) **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, and Abietic acid .Biosynthesis of terpenes.

B) **Enzymes:** Identification of active sites: Use of inhibitors. Mechanism of enzyme action: Orientation and steric effects. Examples: ribonuclease and carboxypeptidase

Unit-V: Classes of Drugs-I 8L

A) **Antibiotics:** Introduction to antibiotics, Synthesis, mode of action, pharmacokinetics, pharmacodynamic data, and secondary metabolism of: 1. Penicillin V and G 2. Streptomycin

B) **Antimalarial Drugs**: Chemotherapy of malaria, Synthesis, mode of action, pharmacokinetics, pharmacodynamic data, and secondary metabolism of: 1. Aminoquinolines 2. Pamaquine

C) **Antipyretic and Analgesic Drugs**: Synthesis, mode of action, pharmacokinetics, pharmacodynamic data, and secondary metabolism of: 1. Aspirin 2. Salol

D) **Anti-inflammatory Drugs:** Synthesis, mode of action, pharmacokinetics, pharmacodynamic data, and secondary metabolism of: 1. Ibuprofen 2. Oxyphenylbutazone .

Unit-VI: Classes of Drugs- II 7L

A) **Antitubercular and Antileprotic Drugs**: Synthesis, mode of action, pharmacokinetics, pharmacodynamic data, and secondary metabolism of: 1. Ethambutol 2. Isoniazid

B) **Anesthetics**: 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) **Sedatives and Hypnotics**: Barbiturates: mode of action, Synthesis, mode of action, pharmacokinetics, pharmacodynamic data, and secondary metabolism of: 1. Diazepam 2. Caffeine

Course Material/Learning Resources:

1. "Carbohydrates: The Essential Molecules of Life" by Robert V. Stick
2. "Lipids: Structure, Physical Properties and Functionality" by Peter J. Barnes
3. "Principles of Biochemistry" by Albert L. Lehninger, David L. Nelson, and Michael M. Cox
4. "Proteins: Structures and Molecular Properties" by Thomas E. Creighton
5. "Peptide Chemistry and Drug Design" by Ben M. Dunn and Tony J. Ripka
6. "The Organic Chemistry of Biological Pathways" by John McMurry
7. "Steroid Chemistry at a Glance" by Daniel Lednicer
8. "Plant Hormones: Biosynthesis, Signal Transduction, Action!" edited by Peter J. Davies
9. "Alkaloids: Biochemistry, Ecology, and Medicinal Applications" edited by Margaret F. Roberts and Michael Wink
10. "Introduction to Terpenes: Nature's Most Diverse Source of Chemicals" by E. J. Corey
11. "The Biosynthesis of Natural Products" edited by Jonathan B. Spencer
12. "Biosynthesis: Aromatic Polyketides, Isoprenoids, Alkaloids" edited by K. G. Ramawat and Jean-Michel Merillon
13. "Basic & Clinical Pharmacology" by Bertram G. Katzung.
14. "Goodman & Gilman's The Pharmacological Basis of Therapeutics" by Laurence L. Brunton, Bjorn C. Knollmann, and Randa Hilal-Dandan.
15. "Pharmacology: Principles and Practice" by Miles Hacker, William S. Messer Jr., and Kenneth A. Bachmann.
16. "Pharmacology" by Rang, Dale, Ritter, Flower, and Henderson.
17. "Basic Concepts in Pharmacology: What You Need to Know for Each Drug Class" by Janet L. Stringer.
18. "Principles of Pharmacology: The Pathophysiologic Basis of Drug Therapy" by David E. Golan, Armen H. Tashjian Jr., Ehrin J. Armstrong, and April W. Armstrong.
19. "Drug-like Properties: Concepts, Structure Design and Methods" by Li Di and Edward H. Kerns.
20. "Drug Design: Structure- and Ligand-Based Approaches" by Kenneth M. Merz Jr. and Dagmar Ringe.
21. "Computer-Aided Drug Design: Methods and Applications" edited by Jürgen Bajorath.
22. "Principles of Drug Design and Drug Discovery" by Dike G. Mba.
23. "Drug Discovery: A Casebook and Analysis" by Walter Cabri and Gérard Dijoux.
24. "The Art of Drug Discovery: From Nature to the Lab" by Oleg Ursu, Tudor I. Oprea, and Alexey Lagunin.
25. "Classification and Nomenclature of Drugs" by David E. Golan and Armen H. Tashjian Jr.
26. "Goodman & Gilman's The Pharmacological Basis of Therapeutics" by Laurence L. Brunton, Bjorn C. Knollmann, and Randa Hilal-Dandan.
27. "Pharmacology" by Rang, Dale, Ritter, Flower, and Henderson.
28. "Lippincott Illustrated Reviews: Pharmacology" by Karen Whalen and Richard A. Harvey.
29. "The Top 100 Drugs: Clinical Pharmacology and Practical Prescribing" by Andrew Hitchings, Dagan Lonsdale, and Daniel Burrage.

Web Resources:

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.
6. 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/
7. 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/
8. 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
9. 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/
10. 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/
11. 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
12. 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

M.Sc. (Chemistry) Second Year Semester- IV [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 404 (iii)	**Physical Chemistry IV (DSE-IV (iv))**	**45 hrs (3 hrs/week)**

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

1. Understand, the Advanced Understanding of Photochemical Processes:
2. Understand the principle involved in fundamental physical chemistry
3. Understand the concept of photochemistry, Liquid State and Liquid Crystals, Solid-state chemistry, Electronic property of material, Property of multiphase material, Superconductivity.
4. Solve numerical problems associated with photochemistry, Liquid State and Liquid Crystals, Solid state chemistry, Electronic property of material, Property of multiphase material, Superconductivity.

Unit-I: Photochemistry-II 8L

Introduction, Laws of photochemistry, interaction of light with matter, theory of photoluminescence, General features of photochemical and photophysical process, prompt fluorescence, delayed fluorescence and phosphorescence, Critical energy transfer distances, energy transfer efficiency, examples and analytical significance, bimolecular collisions, photoreduction, photooxidation, photodimerization, photochemical substitution, photoisomerization, photosensitisation, chemiluminescence, Numericals.

Unit-II: Liquid State and Liquid Crystals 7L

Liquid State: The Vacancy theory of liquid, free volume of liquid, kelvin equation for volume pressure of droplet, Laplace equation and Young Laplace equation, effect of temperature on viscosity and Reynolds Number.

Liquid Crystals: VPT diagram, thermography, LCD and Seven segment cell, classification of thermotropic crystals: Smectic, Nematic, Cholesteric, Disc shaped and polymer liquid crystals. Polymorphism in thermotropic liquid crystal, Numericals.

Unit-III: Solid State Chemistry II 8L

General principle and experimental procedures of solid-state reaction of single solids and their kinetic characteristics, gas-solid, solid-solid, addition and double decomposition reactions, photographic process co-precipitation as a precursor to solid state reactions, other precursor methods, kinetics of solid-state reactions, Crystal Defects. Non-Stoichiometry: Intrinsic and extrinsic defects-point defects, line and plane defects, vacancies- Schottky defects and Frenkel defects. Numericals

Unit-IV: Electronic properties and Band Theory 7L

Metals, insulators and semiconductors, electronic structure of solids- band theory, band structure of metals, insulators and semiconductors. Intrinsic and extrinsic semiconductors, doping semiconductors, semiconductor p-n junctions. Optical properties, photoconductivity of crystals. Color in inorganic solids, Numericals.

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Unit-V: Glass, Ceramics and Multiphase materials 8L

Factors influencing glass formation, kinetics and thermodynamics of glass formation, electrical (ionic) Conductivity of glasses, metallic glasses. Composition, properties and applications of glass-ceramics. Phase diagram of iron-carbon system. Ceramic Matrix composites, carbon and hybrid composites. Numericals.

Unit-VI: Superconductivity 7L

High Tc Materials: Superconductivity in cuprates, preparation and characterization of 1-2-3 and 2-1-4 materials. Normal and Superconducting state of cuprates. The BCS theory. Applications of Low-temperature and High temperature Superconductors. Numericals.

Course Material/Learning Resources:

1. "Photochemistry" by James F. Norris and Geoffrey F. Weiss
2. "Physical Chemistry: Principles and Applications in Biological Sciences" by Ignacio Tinoco Jr., Kenneth Sauer, and James C. Wang
3. "Introduction to Modern Liquid State Theory" by Jean-Pierre Hansen and Ian R. McDonald
4. "The Molecular Theory of Capillarity" by J.S. Rowlinson and B. Widom.
5. "Liquid Crystals" by S. Chandrasekhar.
6. "Liquid Crystals: Nature's Delicate Phase of Matter" by Peter J. Collings.
7. "Introduction to Solid State Chemistry" by Richard C. Ropp

8. "Solid State Chemistry: Techniques" by Anthony R. West
9. "Solid State Chemistry" by S.O. Pillai
10. Electronic structure and Chemistry of Solids by P.A.Cox, Oxford University Press. 1991.
11. Solid State Chemistry by D.K.Chakraburti, New Edge Internation Publication 1996.
12. Principles of Solid State by. H.V.Kirr, Wiley Estern Publication.
13. "Introduction to Solid State Physics" by Charles Kittel
14. "Semiconductor Physics and Devices: Basic Principles" by Donald A. Neamen
15. "Fundamentals of Semiconductors: Physics and Materials Properties" by Peter Y. Yu and Manuel Cardona
16. "Glass Science" by Ivan S. Butler
17. "Introduction to Ceramics" by W.D. Kingery, H.K. Bowen, and D.R. Uhlmann
18. "Metallic Glasses: Formation and Properties" by Kazuo Watanabe and Akihisa Inoue
19. "Superconductivity: Fundamentals and Applications" by Wulf Wulfhekel and Eckhart Schachinger
20. Superconductivity: Properties, Preparation, and Applications" by Dr. K. D. Joshi
21. "Superconductivity: Concepts, Materials, and Applications" by Dr. R. Prasad
22. "Superconductivity and Its Applications" by Dr. S. K. Malik
23. "Introduction to High-Temperature Superconductivity" by Dr. A. K. Bandyopadhyay
24. "Superconductors: Fundamentals and Applications" by Dr. M. S. Narayana
25. Solid State Physics authored by M. A. Wahab.

Web resources:

1. https://ocw.mit.edu/courses/5-43-advanced-organic-chemistry-spring-2007/
2. https://www.sciencedirect.com/topics/chemistry/photoreduction
3. https://en.wikipedia.org/wiki/Young%E2%80%93Laplace_equation
4. https://en.wikipedia.org/wiki/Liquid_crystal#Classification
5. https://www.sciencedirect.com/topics/chemistry/co-precipitation
6. https://ocw.mit.edu/courses/3-091sc-introduction-to-solid-state-chemistry-fall-2010/
7. https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_General_Chemistry_(Petrucci_et_al.)/24%3A_Complex_Ions_and_Coordination_Compounds/24.07%3A_Color_and_the_Colors_of_Complexes
8. https://www.sciencedirect.com/topics/engineering/glass-ceramics
9. https://www.sciencedirect.com/topics/materials-science/superconductor-applications
10. https://en.wikipedia.org/wiki/Cuprate_superconductor

M.Sc. (Chemistry) Second Year Semester- IV [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 404 (iv)	**Applied Analytical Chemistry (DSE-IV (iv))**	**45 hrs (3 hrs/week)**

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

1. Identify the major sources of chemical waste and the methods for minimizing and managing waste in laboratory and industrial settings.
2. Apply environmental chemistry principles to real-world situations and propose solutions to environmental problems.
3. Explain the importance of quality control in food and cosmetic products.
4. Describe the chemical and physical properties of soil and their impact on plant growth
5. Assess the safety and effectiveness of fertilizers and pesticides based on analytical data
6. Identify methods for sampling and analyzing ores.

Unit-I: Green Chemistry and Waste Management 8L

A) Green Chemistry: Introduction, Designing a Green synthesis, Basic Principles of Green Chemistry, Green Chemistry in Day-to-Day life, Green Chemistry in sustainable development.

B) Waste: Production, Problems and Prevention: Sources of waste from chemical industry, waste minimization techniques, on-site waste treatment (Physical treatment, Chemical treatment and bio-treatment plants), and design for degradation: Degradation and surfactants, DDT, Polymers, rules for degradation.

Unit-II: Environmental Chemistry 7L

A) Chemical Toxicology: Toxic chemicals in the environment, biochemical effects and speciation of toxic elements like arsenic, lead, mercury and cadmium; antidotes for the toxic elements. Biochemical effects of fluoride and pesticides.

B) Radiation pollution: Sources and biological implication of radioactive pollutants.

C)Solar energy: Use of solar energy in space heating and water heating; Production of electricity using solar trough collectors, Power tower and solar pond; solar energy for driving vehicles.

Unit-III: Food and Cosmetic Analysis 8L

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. 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.

Unit-IV: Soil Analysis 7L

Importance of soil analysis in agriculture and environmental studies, Soil sampling techniques and sample collection methods, Physical and Chemical Properties of Soil, pH determination and soil acidity Cation exchange capacity (CEC) and nutrient retention , 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, 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, Soil Contaminant Analysis, Heavy metal analysis (Cd, Pb, As, etc.), Soil pollution assessment and remediation strategies.

Unit-V: Fertilizers and Pesticide Analysis 8L

Fertilizer Analysis: Different types of synthetic fertilizers and introduction to organic fertilizers and their analysis and interaction with different components of soil.

Pesticide Analysis: Overview of pesticide analysis techniques, Residue analysis and determination of pesticide concentrations, Pesticide Formulations and Adjuvants, Analysis of pesticide formulation (emulsifiable concentrates, wettable powders, etc.), Pesticide Fate and Environmental Impacts, Pesticide degradation and persistence studies, Environmental risk assessment and monitoring.

Unit-VI: Ore Analysis 7L

Introduction to Ores Analysis, Importance and applications of ores analysis, Sample preparation and handling, Chemical Analysis of Ores, 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), Mineralogical Analysis of Ores, X-ray diffraction (XRD) analysis for phase identification ,Optical microscopy for mineral identification and characterization

Course Material/Learning Resources:

Text books:

1. Fundamentals of Analytical Chemistry", D.A. Skoog, D.M. West, F.J. Holler, S. R. Crouch 8th, edn.
2. Instrumental Method of Chemical Analysis, Gurdeep R. Chatwal, Sham K. Anand, Himalaya Publication
3. Instrumental method of chemical analysis, H. Kaur, Pragati edition
4. Instrumental Methods of Analysis H. H. Willard, L. L. Merritt Jr, J.A. Dean, F.A.Settle (CBS Publisher) 7the edn.
5. Analytical Chemistry: G. D. Christian, Wiley, 6th edn.

Reference Books:

1. New Trends in Green Chemistry (2nd Edition)- V. K. Ahluwalia and M. Kidwai Anamaya Publishers.
2. Green Chemistry, Theory and Practice, Paul T. Anastas and John C. Warner, Oxoford University.
3. Introduction to Green Chemistry, John Andraos & Albert S. Matlack, CRC Press.
4. Textbook of Environmental Chemistry and Pollution Control, S. S. Dara and D. D. Mishra, S. Chand & Company Ltd.
5. Environmental Chemistry, A. K. De, 7th Ed., New Age International Publishers.
6. Fundamental Concepts of Environmental Chemistry, G. S. Sodhi, 3rd Ed., Narosa Publishing House
7. Introduction to Food Analysis, P. S. Belton and R. F. Smith
8. Analytical Methods for Food and Dairy Powders, Amitava Dasgupta and Satinder Ahuja.
9. Handbook of Cosmetic Science and Technology, André O. Barel, Marc Paye, and Howard I. Maibach
10. Methods of Soil Analysis: Chemical Methods D. L. Sparks, (Vol. 5). Soil Science Society of America
11. Environmental Soil Chemistry, R. Sutton, & G. Sposito, Academic Press.
12. Standard methods of Chemical Analysis, Vol. 2, (Part A& B), 5th ed, F. J. Welcher, Von Nostrand & Robert E. Krieger Publishing.
13. Pesticide Analysis: Instrumentation and Techniques, P. M. Downey & R. D Frew, Wiley
14. Analytical Techniques in Materials Conservation, J, Jankowski, & F. L. Traversa, Springer.

Web resources:

Advanced Analytical Course: https://nptel.ac.in/courses/104104066
Green Chemistry: https://youtu.be/SFP0YUAoEOY?si=b2bWoYOA64AQF7nZ
Soil Analysis: https://youtu.be/mrI5A1i5muw?si=ZsseqWYMSYzmr6-2

M.Sc. (Chemistry) Second Year Semester- IV [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 404 (v)	**Polymer, Dyes and Paints (DSE-IV (v))**	**45 hrs (3 hrs/week)**

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

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.
6. The present status of paint and pigment industry.

Unit-I: Polymer Chemistry-I 8L

Basic concepts, nomenclature, 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.

Unit-II: Polymer Chemistry-II 7L

A) Commercial polymers-: Manufacturing process, properties and uses of nylon-66, polyethylene, polypropene, polyvinyl chloride, polystyrene, teflon and polybutene. Effect of stereochemistry on the structure and properties of polymers.

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

Unit-III: Dyes 8L

Introduction, classification of dye on the basis of mode of application and structure, dye intermediates, preparation of dye intermediates, structural features of a dye; preparation and applications of picric acid, methyl orange, methyl red, indigo phthalenes, xanthenes, cyanine, anthraquinone.

Unit-IV: Paper and Pulp 7L

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

B) 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; Fiber recovery: Broke system

Unit-V: Paints and Pigments 8L

Introduction of paints, ingredients and classification, new technologies; Principles of paint formulation, concept of pigment volume concentration, theory of pigment wetting & dispersion, dispersion technology, properties of coatings; solvents, plasticizers, dyes and bioactive additives; paint formulations, testing and evaluation. Pigments: Introduction, classification and general physical properties.

Unit-VI: Corrosion 7L

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.

Course Material/Learning Resources:

1) Textbook of polymer science by F. Bill Mayer, Wiley Inter Science.
2) Polymer Science by V. Govarikar, N. Viswanathan and J Sreedhar, New Age International (P) Ltd. Publishers New Delhi.
3) Plastic materials, J.A. Brydson, Newnes-Butterwarths (London)
4) The Text book of Polymer science, Fred W. Billmeyer Wiely & sons
5) Introduction to plastics, J.H. Briston and C.C. Gosselin, Newnes, London

6) Polymeric Materials, C. C. Winding and G. D. Hiatt McGraw Hill Book Co. Polymer Science by Gowarikar
7) Physical chemistry of polymers by D. D. Deshpande, Tata McGraw Hill.
8) Principles of polymer chemistry By P.J. Flory, Cornell Univ. Press.
9) Introduction to polymer chemistry by R. B. Seymour McGraw Hill.
10) A Practical Course in polymer chemistry by S. J.Panna, Pergamon press.
11) Synthetic dyes by Venkatram (VOL I &II)
12) Fundamental processes of dye chemistry, by FierziDavid.
13) Dyes and Intermediates by Adrahaedt.
14) Paints, coatings and solvents by D. State.
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

Web Resources:

1) Introduction to Polymer: https://nptel.ac.in/courses/104105039
2) Dyes: https://nptel.ac.in/courses/116104044
3) Paints: https://nptel.ac.in/courses/103105222
4) Corrosion: https://nptel.ac.in/courses/113102109

M.Sc. (Chemistry) Second Year Semester- I V [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 405	**Lab 08 (based on DSC–IV.1,2 and 3)**	**60 hrs (4 hrs/week)**

Course Outcomes: At the end of the course 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..

Exercise -I : 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. Extraction of Limonene from Orange by Steam Distillation
7. Estimation of Phenol by $KBr/KBrO_3$
8. Spectrophotometric/UV estimations of Caffeine
9. Spectrophotometric/UV estimations of Cholesterol
10. Analysis of Lindane in BHC powder
11. Analysis of some common pesticides, insecticides, plastics, and detergents
12. Estimation of Aspirin (Potentiometric/Conductometric)
13. Estimation of Streptomycin (Colorimetric)
14. Estimation of Vitamin B12 (Colorimetric)

Exercise II a (Separation Techniques) (minimum-6)

1. Separation of given mixture of amino acids (any two) using ascending paper chromatography
2. Determination of Rf value of amino acids using paper chromatography.
3. Investigate the composition of inks using simple distillation & paper chromatography.
4. Paper chromatographic separation of following metal ions:
   i. Ni(II) and Co(II) or
   ii. Fe(III) and Al(III)
5. Separation of mixtures by chromatography: Measure the Rf value in each case. (Combination of two ions to be given)
   i. Paper chromatographic separation of Fe^{3+}, $A1^{3+}$ and Cr^{3+} or
   ii. Paper chromatographic separation of Ni^{2+}, Co^{2+}, Mn^{2+} and Zn^{2}
6. Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.
7. Thin layer chromatography: Determination of Rf values and identification of organic compounds in a given mixture by TLC
   (i) Separation of mixture of benzil and 2-nitrophenol
   (ii) Mixture of benzophenone and naphthalene
   (iii) Mixture of 2-nitrophenol and 4-nitrophenol
8. Thin layer chromatography
   (i) Separatation and identification of the given mixture of colourless compounds (Diphenylamine, Benzophenone and Naphthalene)
   (ii) Separation and identification of the given mixture of coloured compounds (azobenzene, hydroxyazobenzene, p-aminoazobenzene).
11. Separation of binary mixture by column chromatography – one polar sample.
12. Separation of mixture of methyl orange and methylene blue by column chromatography.
13. Separation of food dyes using Column Chromatography.

Exercise II b

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

Examination: CHE 405 Lab 08 (based on DSC–IV. 1, 2 and 3)

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

A.	**Exercise-I**	**20**
B.	**Exercise-II a**	**10**
C.	**Exercise II b**	**10**
D.	**Viva (External + Internal)**	**10**
E.	**Internal assessment***	**50**
	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.

Course Material/Learning Resources:

1. Experiments and technique in organic experiments- D. Pasto, C. Johnson and M. Miller prentice Hall.
2. Macro- scale and micro-scale organic experiments-K.L. Williaman, D. C. Heath.
3. Systematic quantitative organic analysis – H. Middleton, Edward Arnold.
4. Vogel's Textbook of practical organic chemistry Fifth Edition-Brain S. Furniss, Antoy J. Hannaford, Peter W,G. Smith, Austin R. Tatchell.
5. Experiment organic chemistry Vol.I&II –P.R. Singh, D. S. Gupta and K.S. Bajpai.
6. The Golden book of chemistry experiments- Robert Brent
7. Quantitative Chemical analysis - A.I. Vogel
8. Vogel's textbook of quantitative analysis (Revised) - J. Bassett, R.C. Denney, G.H. Jeffery, and J.
9. Experiment and technique in Organic chemistry - D. Pasto, C. Johnson, and M. Miller
10. Handbook of organic analysis - qualitative and quantitative - H. Clark, Edward Arnold

Web resources:

1. 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.
2. 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.

M.Sc. (Chemistry) Second Year Semester- I V [Level 6.5]

Code of the Course/ Subject	Title of the Course/Subject	(Total Number of Periods)
CHE 406	**Research Project Phase II (Lab 09)**	**150 hrs (2Tut+8 P= 10 hrs/week)**

Course Outcomes: At the end of the course students will 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 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.

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: CHE 406 Research project Phase II (Lab 09) Max Marks 150

A.	**Internal Assessment***	**75**
B.	**Submission of Research project**	**25**
C.	**VIVA (Internal and External Examiner)**	**50**
	Total	**150**

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