

ANDHRAKESARI UNIVERSITY:: ONGOLE

M.Sc. ORGANIC CHEMISTRY/ SYLLABUS

Course Structure as per National Education Policy-2020 under CBCS

(*For the students admitted from the academic year 2026-2027 onwards (Regulation-R26)*)

COURSE STRUCTURE & SCHEME OF MARKS

Semester	Components of Study	Course Code	Title of the Course	Credits	Hr/Week	Internal Assessment	SemEnd Exams	Total
SEMESTER - I	Mandatory Core	R26CH11	Inorganic Chemistry-I	4	4	30	70	100
		R26CH12	Organic Chemistry-I	4	4	30	70	100
	Foundation Course	R26CH13	Essential Analytical Techniques for Industry	4	4	30	70	100
	FoundationElective (Opt' 1)	R26CH14A	Physical Chemistry-I	4	4	30	70	100
		R26CH14B	Polymer Science					
		R26CH14C	Nuclear Chemistry and Applications					
	Core Practical-I(SOC)	R26CH15	Inorganic & Physical Chemistry	4	6	30	70	100
	Core Practical-II(SOC)	R26CH16	Organic Chemistry	4	6	30	70	100
	Audit course	*R26CH17*	*Human Values and Professional Ethics*	*2*	*2*	*50*	-	-
	Sub-Total-I			**24**				**600**
SEMESTER - II	Mandatory Core	R26CH21	Physical Chemistry-II	4	4	30	70	100
		R26CH22	Organic Chemistry-II	4	4	30	70	100
	ResearchFoundation	R26CH23	Research Methodology, Ethics & Scientific Writing	4	4	30	70	100
	Elective Foundation (Opt' 1)	R26CH24A	Inorganic Chemistry-II	4	4	30	70	100
		R26CH24B	Nano Science & Technology					
		R26CH24C	Material Science					
	Core Practical-I(SOC)	R26CH25	Inorganic &Physical Chemistry	4	6	30	70	100
	Core Practical-II(SOC)	R26CH26	Organic Chemistry	4	6	30	70	100
	Skill Development	R26CH27	*MOOCS(https://swayam.gov.in/;https://swayam-plus.swayam2.ac.in/)*	*2*	--	*50*	--	--
	Sub-Total-II			**24**				**600**
SEMESTER - III	Mandatory Core	R26OC31	Organic Spectroscopy-I	4	4	30	70	100
		R26OC32	Organic Synthesis & Reaction Mechanisms-I	4	4	30	70	100
	Generic Elective-I (Opt' 1)	R26OC33A	Alkaloids, Terpenoids, Quinones & Phenothiazines	4	4	30	70	100
		R26OC33B	Chemistry of Aerospace Materials					
		R26OC33C	Drug Discovery, Design and Development					
	Open Elective-II (Opt' 1)	R26OC34A	Chemistry of Natural Products	4	4	30	70	100
		R26OC34B	Chemistry of High Energy Materials					
		R26OC34C	Applications of Synthetic Products					
	Core Practical-I(SOC)	R26OC35	Multistage Organic Synthesis	4	6	30	70	100
	Core Practical-II(SOC)	R26OC36	Industry Internship/Mini Research Project	4	6	30	70	100
	Skill Enhancement	R26OC37	*MOOC's (https://swayam-plus.swayam2.ac.in/)/AI in Chemistry*	*2*	--	*50*	--	--
	Sub-Total-III			**24**				**600**
SEMESTER - IV	Mandatory Core	R26OC41	Organic Spectroscopy-II	4	4	30	70	100
		R26OC42	Organic Synthesis & Reaction Mechanisms-II	4	4	30	70	100
	Core Elective-I (Opt' 1)	R26OC43A	Advanced Organic Chemistry	4	4	30	70	100
		R26OC43B	Engineering Chemistry					
		R26OC43C	Quality Control and Quality Assurance in Pharma Industry					
	Open Elective-II (Opt' 1)	R26OC44A	Chemistry of Antibiotics and Drugs	4	4	30	70	100
		R26OC44B	Forensic Science in Solving Crime					
		R26OC44C	Air, Water, Noise & Thermal Pollution					
	Core Practical-I(SOC)	R26OC45	Analysis of Binary Organic Mixture& Organic Estimations	4	6	30	70	100
	Core Practical-II (Multi-Disciplinary)	R26OC46	Research Project (Dissertation+ +Seminar+Viva-voce)	4	6	--	100 (50+20 +30)	100
	Sub-Total-IV			**24**				**600**
	Grand Total			**96**				**2400**

Note: Pass in Audit course, skill development and skill enhancement courses are mandatory; SOC-Skill Orientation Course.



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DEPARTMENT OF CHEMISTRY
SYLLABUS FOR M.Sc. ORGANIC CHEMISTRY
(*For the students admitted from the academic year 2026-2027 onwards)*
SEMESTER–I

PAPER–I: INORGANIC CHEMISTRY-I (R26CH11)

Max. Marks: 100 **(Internal-30M & External-70M)**

Learning Objectives:

- ✓ To know the fundamentals of VSEPR theory.
- ✓ To know the Crystal field theory.
- ✓ To know the Molecular Orbital Theory.
- ✓ To know the Hard and Soft Acids and Bases and macrocyclic complexes.
- ✓ To know the higher boranes, Isopoly and heteropoly anions.

UNIT-I **12H**

Structure and Bonding: VSEPR theory and its role in explaining the structures of inorganicmolecules. Walsh diagrams for linear molecule (BeH_2) and bent molecule (H_2O). Molecular Orbital theory - Symmetry of Molecular orbitals, Molecular orbitals in triatomic (BeH_2) molecules and ions (NO_2^-) and energy level diagrams.

Participation of p and d orbitals in pπ - dπ bonding- Evidences from both non-transition and transition metal compounds.

Non-valence cohesive forces, Hydrogen bonding - Symmetric and unsymmetric hydrogen bonds in inorganic molecules.

UNIT-II **12H**

Metal-Ligand Bonding: Crystal Field Theory of bonding in transition metal complexes Splitting of d-orbitals in octahedral, tetrahedral, trigonal bipyramidal and square pyramidal fields and energy order of orbitals.

Tetragonal distortions - Jahn-Teller effect. Static and dynamic Jahn -Teller effects. Chelates and Jahn - Teller effect

Spectrochemical series. Nephelauxetic effect. Calculation of crystal field stabilization energies. Factors affecting crystal field splitting energies. Applications and limitations of CFT.

UNIT-III **12H**

Molecular Orbital Theory: Evidence for covalence in complexes - Experimental evidence from both σ- and π-bonded complexes.

Molecular Orbital Theory of bonding for octahedral, tetrahedral and square planar complexes. π-bonding and MOT - Effect of π-donor and π-acceptor ligands on Δ_o. Experimental evidence for π-bonding in complexes.

MOT and Resonance. Resonance in homoatomic molecules (H_2) and hetero atomic ions.
Molecular Orbital Theory and Hybridization. Bents Rule and energetic of Hybridization.



UNIT-IV **12H**

Metal-Ligand Equilibria in Solutions: Stepwise and overall formation constants. Trends in step-wise constants, statistical effect and statistical ratio. Determination of formation constants by Spectrophotometric method (Job's method) and limitations ofJob's method. Determination of formation constants by pH metric method (Bjerrum's method).

Stability correlations and Irving-Williams series for transition metal ions.

Hard and soft acids and bases (HSAB) – Acid-base strength and HSAB, electronegativity and HSAB.

Macrocyclic complexes - Crown ethers and Cryptates.

UNIT-V **12H**

Non-Metal Cages and Ring Compounds: Preparation and structures of higher boranes, Electron counting rules in boranes- Wade's rules and Polyhedral skeletal electron pair theory. Heterocyclic inorganic ring systems: Boron-Nitrogen (B-N), Phosphorus–Nitrogen (P-N) and Sulphur-Nitrogen (S-N) cyclic compounds.

Cage compounds of Phosphorus-Oxygen (P-O) and Phosphorus-Sulphur (P-S).

Preparation and structures of Isopoly and heteropoly anions and their salts.

Reference Books:

1) Inorganic Chemistry, Huheey, Harper and Row.
2) Physical Methods in Inorganic Chemistry, R.S. Drago. Affiliated East-West Pvt. Ltd.
3) Concise Inorganic Chemistry, J. D. Lee, ELBS.
4) Modern Inorganic Chemistry, W. L. Jolly, McGraw-Hill.
5) Inorganic Chemistry, K. F. Purcell and J. C. Kotz Holt Saunders international.
6) Concepts and methods of inorganic chemistry, B.E. Douglas and D.H.M.C. Daniel.
7) Introductory Quantum mechanics, A. K. Chandra.
8) Quantum Chemistry, R. K. Prasad.
9) Inorganic Chemistry, Atkins, ELBS.
10) Advanced Inorganic Chemistry, Cotton and Wilkinson, Wiley Eastern.
11) Quantum Chemistry, R. K. Prasad.
12) Concise Coordination Chemistry, R.Gopalan and V.Ramalingam.

Learning Outcomes:

- ✓ The student will understand the VSEPR theory, symmetric and asymmetric hydrogen bonds in inorganic molecules.
- ✓ Understanding the Crystal field theory and Jahn-Teller effects.
- ✓ The students are able to understand the basics of molecular orbital theory and energy of hybridization.
- ✓ The students are able to understand the Jobs method, hard and soft acids and bases.
- ✓ The students are able to understand the study of age compounds of oxygen, phosphorus and sulphur compounds and also isopoly and heteropoly anions.



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SEMESTER–I
PAPER-II: ORGANIC CHEMISTRY-I (R26CH12)
Max. Marks: 100 **(Internal-30M & External-70M)**

Learning Objectives:

- ✓ To know about Aromaticity in Benzenoid compounds and Non-Benzenoid compounds.
- ✓ To know about the basics on heterocyclic compounds, their synthesis, and to know the importance of natural products, their medicinal use, along with the synthesis of some terpenoids.
- ✓ To discuss stereochemistry of organic molecules more elaborately.
- ✓ To know about the conformations of acyclic substituted alkenes.
- ✓ To know the conformations of monocyclic, unsaturated acyclic and fused ring systems.

UNIT-I **12H**

Aromaticity Benzenoid & Non-Benzenoid: Concept of aromaticity, Huckel's rule for aromaticity in benzenoid compounds, Aromaticity of five membered, six membered rings and fused systems.

Non-benzenoid aromatic compounds: Cyclopropenyl cation, cyclobutadienyldication, cyclopentadienyl anion, tropylium cation and cyclooctatetraenyl dianion. Ferrocene. Azulenes, Fulvenes, Annulenes, Fullerenes. Homoaromaticity and antiaromaticity.

UNIT-II **12H**

Heterocyclic Compounds and Natural Products:

a) Synthesis, Properties and Reactions of furan, thiophene, pyrrole, pyridine, quinoline, isoquinoline and indole; Skraup synthesis, Fischer indole synthesis.
b) Heterocyclic compounds with more than one hetero atom: synthesis, properties and reactions of Pyrazole, Imidazole, oxazole, iso-oxazole, Thiazole.

Natural Products: Importance of natural products as drugs.

Terpenoids: General methods in the structure determination of terpenes. Isoprene rule. Structure determination and synthesis of α-terpeniol, β-carotene, and camphor.

UNIT-III **12H**

Stereochemistry

a) *Molecular representations of organic molecules* –Wedge, Fischer, Newman and Saw-horse formulae, their description and interconversion. Stereoisomerism-Definition, classification.
b) *Concept of Chirality and Molecular Symmetry*: Symmetry operations, Recognition of symmetry elements (Cn, Ci and Sn), Dissymmetric and asymmetric molecules. Chiral structures (one and more than one chiral centre); D-L and R–S nomenclature, diastereoisomerism; Threo and Erythro isomers, racemic mixture, racemization and methods of resolution, stereospecific and stereoselective synthesis. Stereochemistry of compounds containing nitrogen, sulphur and phosphorus.
c) *Geometrical isomerism*–E,Z- nomenclature–Spectral and chemical methods of determining the configuration of geometrical isomers. Determination of configuration in aldoximes and ketoximes.



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SEMESTER–I
PAPER-II: ORGANIC CHEMISTRY-I (R26CH12)
Max. Marks: 100 **(Internal-30M & External-70M)**

UNIT-IV **12H**

Conformational Analysis-I

a) Conformation of acyclic molecules –alkanes and substituted alkanes (Ethane and 1,2-disubstituted ethane derivatives like butane, di-halobutane, halohydrin, ethylene glycol, butane-2,3-diol, amino alcohols and 1,1,2,2-tetrahalobutanes). Klyne-Prelog terminology for conformers and torsion angles.

b) Factors affecting the conformational stability and conformation equilibrium-Attractive and Repulsive interactions. Use of Physical and Spectral methods in conformational analysis.

c) Conformational effects on the stability and reactivity of diastereomers in cyclic molecules-steric and stereoelectronic factors- examples.

UNIT-V **12H**

Conformational Analysis-II

a) *Conformations of monocyclic compounds*–cyclohexane: chair, boat and twist boat cyclohexanes, energy profile diagram–mono-and di-substituted cyclohexanes–conformations. Effect of conformation on stability and reactivity in mono and disubstituted cyclohexane derivatives.

b) *Conformations of unsaturated acyclic compounds*: Propylene and 1-Butene

c) *Elementary treatment of fused and bridged ring systems* –Decalines and Bornanes. Conformation of sugars. Steric strain due to unavoidable crowding.

Reference Books:

1) Advanced organic chemistry – reaction, mechanism and structure, Jerry March, John Wiley.
2) Advanced organic chemistry, F.A. Carey and R.J. Sundberg, Plenum.
3) A guidebook to Mechanism in organic chemistry, Peter Sykes, Longman.
4) Organic chemistry, I.L.Finar, Vol. I & II, Fifth ed. ELBS, 1975.
5) Organic chemistry, Hendrickson, Cram and Hammond (McGraw–Hill).
6) Stereochemistry of carbon compounds – E.L. Eliel.
7) Modern Organic Reactions, H.O. House, Benjamin.
8) An introduction to chemistry of Heterocyclic compounds, R.M.Acheson.
9) Structure and mechanism in organic chemistry, C.K.Ingold, Cornell University Press.
10) Principles of organic synthesis, R.O.C.Norman and J.M.Coxon, Blakie Academic & Professional.
11) Reaction Mechanism in Organic Chemistry, S.M.Mukherji and S.P.Singh, Macmillan.
12) Basic Principles of Organic Chemistry by J. B. Roberts and M. Caserio.
13) Stereochemistry of Organic compounds, P. S. Kalsi, New Age International pubs.

Learning Outcomes:

- ✓ Students can able to understand aromaticity in Benzenoid compounds and Non-Benzenoid compounds.
- ✓ Students are able to understand the formation of various heterocyclic compounds and their synthesis and the basics on importance of natural compounds formation of terpenoids in medicinal chemistry
- ✓ Students can able to write the stereochemical forms for different organic molecules.
- ✓ Understand the conformations of acyclic and substituted alkanes.
- ✓ Students can able to understand the conformations of monocyclic, unsaturated acyclic and fused ring systems and apply them to organic molecules.



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SEMESTER–I
PAPER–III: ESSENTIAL ANALYTICAL TECHNIQUES FOR INDUSTRY (R26CH13)
Max. Marks: 100 **(Internal-30M & External-70M)**

Learning Objectives:

- ✓ To know the fundamentals of separation analysis using various chromatographic techniques.
- ✓ To know the techniques involving reliable separation by HPLC & applications and purification by ion exchange chromatography.
- ✓ To know the instrumentation and applications of AAS &ICP-OES.
- ✓ To know the basic principles, instrumentation and advantages of UV, IR, NMR, ESR, TEM, SEM- techniques in structural analysis.

UNIT-I **14H**

Chromatography–Adsorption and Partition

1) **Introduction to Chromatography:**Different types of Chromatography. Adsorption chromatography: adsorbents, solvents, solutes, apparatus. Column Chromatography: stationary phase, Mobile phase, packing of column, advantages and disadvantages.
2) **Paper Chromatography:** Basic Principles. Ascending and descending types. Selection of mobile phase, Development of chromatograms, Visualization methods. Application of paper chromatography in the identification of sugars and amino acids. One- and two-dimensional paper chromatography.
3) **Thin Layer Chromatography:** Basic Principles. Common stationary phases, Methods of preparing TLC plates, Selection of mobile phase, Development of TLC plates, Visualization methods, R_f value. Application of TLC in monitoring organic reactions.

UNIT-II **14H**

High Performance Liquid Chromatography (HPLC): Basic Principles. Normal and reversed Phases. Selection of column and mobile phase. Instrumentation. Detectors; RT values. Applications in the separation, identification and quantitative estimation of organic compounds. Concepts on HPLC method development.

UNIT-III **12H**

Gas Chromatography: Basic Principles. Different types of GC techniques. Selection of columns and carrier gases. Instrumentation. Detectors; RT values. Applications in the separation, identification and quantitative analysis of organic compounds.

Ion Exchange Chromatography: Basic Principles. Preparation of cross-linked polystyrene resins. Different types of cation and anion exchange resins. Application in the purification of carboxylic acids and amines.



SEMESTER–I

PAPER–III: ESSENTIAL LAB TECHNIQUES FOR INDUSTRY (R26CH13)

Max. Marks: 100 **(Internal-30M & External-70M)**

UNIT-IV **10H**

AAS: Principle, instrumentation and applications

ICP-OES: Principle, instrumentation, applications and advantages over AAS

UNIT-V **10H**

UV, IR, NMR, ESR, TEM, SEM-Basic principles, instrumentation and advantages.

Reference Books:

1) Principles of Instrumental Analysis by D. A. Skoog, F. J. Holler and T. A. Nieman, Harcourt College Pub.
2) Separation Techniques by M. N. Sastri, Himalaya Publishing House (HPH), Mumbai.
3) Biophysical Chemistry by A. Upadhyay, K. Upadhyay and N. Nath, (HPH), Mumbai.
4) A Handbook of Instrumental Techniques for Analytical Chemistry- Ed-F. A. Settle, Pearson Edn.,
5) Delhi. Introduction to Organic Laboratory Techniques-D. L. Pavia, G. M. Lampman, G. S. Kriz and R. G. Engel, Saunders College Pub. (NY).
6) Instrumental Methods of Chemical Analysis by B. K. Sharma, Goel Publish House, Meerut.
7) Instrumental Methods of Chemical Analysis by H. Kaur, Pragati Prakashan, Meerut.

Learning Outcomes:

- ✓ The student will understand the advantages of chromatographic separation and its application in various reactions.
- ✓ The student will understand the advantages of HPLC &the technique over conventional separation techniques.
- ✓ The student will know the GC technique for separation and exchange of ions taking place in ion exchange chromatography.
- ✓ The student will know the procedure of analysing the elements using AAS & ICP-OES.
- ✓ The students understand the working principles and advantages of the UV, IR, NMR, ESR, TEM, SEM- techniques.



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SEMESTER–I

PAPER-IV(Elective–A): PHYSICAL CHEMISTRY-I (R26CH14A)

Max. Marks: 100 **(Internal-30M & External-70M)**

Learning Objectives:

- ✓ To know the first and second law of thermodynamics.
- ✓ To know the surface tension, Gibbs-Adsorption, X-ray fluorescence and Augar electron spectroscopy.
- ✓ To know the micelles-Hydrophobic interaction.
- ✓ To know the Nernst equation and Debye Huckel-Onsagar equation.
- ✓ To know the complex reactions, Collision theory and chain reactions.

UNIT-I **12H**

Thermodynamics-I: Classical thermodynamics-Brief review of first and second laws of thermodynamics - Entropy change in reversible and irreversible processes-Entropy of mixing of ideal gases-Entropy and disorder-Free energy functions-Gibbs-Helmoboltz equation - Maxwell partial relations-Conditions of equilibrium and spontaneity-Free energy changes in chemical reactions: Van't Hoff reaction isotherm- Van't Hoff equation-Classiuss Clapeyron equation-partial molar quantities-Chemical potential- Gibbs-Duhem equation-partial molar volume-determination of partial molar quantities – Fugacity- Determination of fugacity-Thermodynamic derivation of Raoult's law.

UNIT-II **12H**

Surface Phenomena and Phase Equilibria: Surface tension-capillary action-pressure difference across curved surface (Young-Laplace equation)-Vapour pressure of small droplets (Kelvin equation)- Gibbs-Adsorption equation - BET equation-Estimation of surface area-catalytic activity of surfaces-ESCA, X-ray fluorescence and Auger electron spectroscopy.

UNIT-III **12H**

Surface Active Agents: Classification of surface active agents-Micellization-critical Micelle concentration (CMC)-factors affecting the CMC of surfactants, microemulsions-reverse micelles- Hydrophobic interaction.

UNIT-IV **12H**

Electrochemistry-I: Electrochemical Cells-Measurement of EMF-Nernst Equation-Equilibrium constant from EMF Data-pH and EMF data-concentration cells with and without transference-Liquid junction potential and its determination-Activity and activity coefficients-Determination by EMF method-Determination of solubility product from EMF measurements. Debye-Hückel limiting law and its verification. Effect of dilution on equivalent conductance of electrolytes-Anomalous behaviour of strong electrolytes. Debye-Hückel-Onsager equation-verification and limitations-Bjerrum treatment of electrolytes-conductometric titrations.



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SEMESTER–I

PAPER-IV(Elective–A): PHYSICAL CHEMISTRY-I (R26CH14A)

Max. Marks: 100 **(Internal-30M & External-70M)**

UNIT-V **12H**

Chemical Kinetics: Methods of deriving rate laws - complex reactions - Rate expressions for opposing, parallel and consecutive reactions involving unimolecular steps. Theories of reaction rates - collision theory - Steric factor - Activated complex theory - Thermodynamic aspects - Unimolecular reactions - Lindemann's theory - Lindemann-Hinshelwood theory. Reactions in solution - Influence of solvent - Primary and secondary salt effects - Elementary account of linear free energy relationships - Hammett - Taft equation - Chain reactions - Rate laws of H_2-Br_2, photochemical reaction of H2 - Cl2 Decomposition of acetaldehyde and ethane - Rice-Hinshelwood mechanism.

Reference Books:

1) Physical Chemistry P.W. Atkins, ELBS
2) Chemical Kinetics - K.J.Laidler, McGraw Hill Pub.
3) Text Book of Physical Chemistry. Samuel Glasstone, Macmillan Pub.
4) Physical Chemistry, G.W.Castellan. Narosa Publishing House
5) Thermodynamic for Chemists. Samuel Glasstone
6) Electrochemistry, Samuel Glasstone, Affiliated East West
7) Physical Chemistry, W.J. Moore, Prentice Hall
8) Atomic Structure and chemical bond. Manas Chanda. Tata McGraw Hill Company Limited.

Learning Outcomes:

- ✓ Students can able to understand the classical thermo dynamics, fugacity.
- ✓ Students are able to understand Kelvin equation, Gibbs-Adsorption equation - BET equation.
- ✓ Students are able to understand the Classification of surface active agents in detail.
- ✓ Students are able to understand the Electrochemical cells, Liquid junction potential.
- ✓ Understand the kinetics of complex reactions, chain reactions.



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SEMESTER–I

PAPER-IV (Elective–B): POLYMER SCIENCE (R26CH14B)

Max. Marks: 100 **(Internal-30M & External-70M)**

Learning Objectives:

- ✓ To learn basic types of polymerization processes and techniques.
- ✓ To learn how to characterize polymers.
- ✓ To learn the rheological characteristics of polymers.
- ✓ To learn how the processing and testing of polymers are done.
- ✓ To learn about high-temperature polymers, polymer blends and composites.

UNIT-I **12H**

Introduction to Polymer Science: Monomers, functionality, degree of polymerizations; classification of polymers, polymerization methods: addition and condensation; new techniques of polymerization; copolymerization, monomer reactivity and its significance; azeotropic copolymerization, block and graft copolymers; techniques for copolymerization: bulk, solution, suspension and emulsion.

UNIT-II **12H**

Polymer Synthesis and Characterization: Synthesis of thermoplastics,Fluoropolymers, Thermosetting polymers and Unsaturated polyesters. Polymer Solubility and swelling, concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights. Polymer crystallinity, analysis of polymers using optical and thermal techniques: Infrared spectroscopy, X-Ray diffraction, DSC, DMTA and TGA.

UNIT-III **12H**

Polymer Rheology: The flow of Newtonian and non-Newtonian fluids and flow equations. Measurements of rheological parameters by capillary rotating, parallel plate and cone-plate rheometer. Mechanical models, control of rheological characteristics through compounding, rubber curing in parallel plate viscometer, Oscillating Disc Rheometer (ODR) and Moving die Rheometer (MDR).

UNIT-IV **12H**

Processing and Testing of Polymers: Types of mouldings: Compression moulding, transfer moulding, injection moulding, blow moulding,reaction injection moulding, extrusion, pultrusion, calendaring, rotational moulding and rubber processing. Testing for Mechanical-static and dynamic tensile, compressive, abrasion, hardness, tear, impact and toughness. Testing for thermal and electrical conductivity, dielectric constant, electrical resistance, swelling, ageing and resistance and environmental resistance.

UNIT-V **12H**

Polymer Applications: *High temperature polymers:* synthesis,processing and applicationsof Aromatic liquid crystalline polyesters, Phenolics, polyimide and polyether ketones.
*Polymer blends and Composites:*Difference between blends and composites, their significance, miscible and immiscible blends, polymer alloys, polymer eutectics, plastic-plastic, rubber-plastic and rubber-rubber blends. Fibre Reinforced Polymers (FRP), particulate, long and short fibre-reinforced composites.



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SEMESTER–I

PAPER-IV (Elective–B): POLYMER SCIENCE(R26CH14B)

Max. Marks: 100 **(Internal-30M & External-70M)**

Recommended Books:

1) Text Book of Polymer Science, 3rd Ed. (1984), F. W. Billmayer, Jr., Wiley-Interscience.
2) Principles of Polymer Chemistry, P. J. Flory, Cornell Press (recent edition).
3) Principles of Polymerization, G. Odian, 3rd Edition (1991), John Wiley, Singapore
4) Principles of Polymer Sciences, P. Bahadur and N.V. Sastry, Narosa Publishing House, NewDelhi (2002)
5) Polymer Sciences, V.R. Gowarikar, N.V. Vishwanathan, J. Shreedhar, Wiley Eastern, NewDelhi (1986)
6) The Elements of Polymer Science and Engineering, Alfred Rudin, 3rd Ed. Academic Press, New York (2012).
7) Experiments in Polymer Science, E. A. Coolins, J. Bares and E. W. Billmeyer, WileyInterscience, New York (1973).
8) High performance materials in Aerospace, H.M.Flower, Ist Ed., Chapman & Hall (1995).
9) Advanced Aerospace materials, B.Horst, B.Ilschner, K.C.Russel, Springer-verlag, Berlin (1992).
10) Applications of high temperature Polymers, R.R.Luise, 1sted., CRC Press (1996).

Learning Outcomes:

- ✓ The student is provided with a basic theoretical background on polymers.
- ✓ Understands various synthetic techniques used for the preparation of polymers.
- ✓ Equipped with the necessary knowledge to develop new polymers and new techniques.
- ✓ Familiarised with high-temperature polymer uses.
- ✓ Understands various important and diverse applications of polymers in most fields of science.



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SEMESTER–I

PAPER-IV(Elective–C): NUCLEAR CHEMISTRY AND APPLICATIONS(R26CH14C)

Max. Marks: 100 **(Internal-30M & External-70M)**

Learning Objectives:

- ✓ To learn the principles and importance of Nuclear chemistry.
- ✓ To learn about the detection of radiation from radioactive sources.
- ✓ To learn about the radioisotope tracers and their numerous applications.
- ✓ To learn about the nuclear reactors and their working methods.
- ✓ To learn about the handling, safety and protection from radiation.

UNIT-I **12H**

Nuclear Theory and Nuclear Reactions: Radioactive decay processes, natural radioactive series, Determination of half - lives of short and long -lived isotopes. α-β-γ-decays and K-capture Nuclear Reactions(NR): NR induced by neutrons and charged particles. Nuclear fission and fusion, Interaction of radiation and particles with matter. Determination of energies of α-β-γ particles.

UNIT-II **12H**

Detection of Radiations: Types and principles of measuring instruments, GM tubes and GM counter- their characteristics. Ionization chambers: Scintillation counters and solid-state detectors. Neutron detection methods.Energy production in stars, Stellar evolution and Genesis of chemical elements.

UNIT-III **12H**

Radioisotope tracers: Radiometric analysis, various types of dilution techniques. Applications of radio isotopes in the study of isotopic exchange and electron transfer reactions.Applications of radionuclides in therapeutic and diagnostic purposes. Radiocarbon dating and age of earth and minerals by various dating techniques. Radiolysis of water and aqueous solutions. Identification reactions and properties of solvated electrons.

UNIT-IV **12H**

Nuclear reactors: Homogeneous and heterogeneous reactors: Power reactors, Boiling water reactors, Pressurised water reactors, Fast breeder reactors, Research reactors and Reactors for special purposes. Neutron sources and moderation, Criticality factors, moderators, coolants, Cladding and structural materials.



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SEMESTER–I

PAPER-IV(Elective–C):NUCLEAR CHEMISTRY AND APPLICATIONS(R26CH14C)

Max. Marks: 100 **(Internal-30M & External-70M)**

UNIT-V **12H**

Radioactivity in the Environment, Safety and Protection: Natural radioactive nuclides and their distribution in the environment, nuclear processes in the atmosphere, radioactivity contributions to the environment from nuclear tests, nuclear reactors, nuclear fuel reprocessing plants and waste management of radioactive isotopes like Cs-137,I-131,H-3 and Ra-226. Plutonium isotopes in the environment. Hazards associated with radiations, Biological effects of radiations, Radioactive waste handling, disposal and treatment.

Reference Books:

1) Principles of Radiochemistry, H.A.C. McKay, Butterworths, London (1971).
2) Essentials of Nuclear Chemistry, H.J.Arnikar, 4th ed., New Age International, New Delhi, (1997).
3) Nuclear Chemistry and its Applications, M.Haissinsky, Wesley Publishing Co.Inc., London(1964).
4) Radiochemistry,An.N.Nesmeyanov, Mir Publishers, Moscow (1974).
5) Nuclear and Radiochemistry, G. Friedlander, J.W.Kennedy, Wiley-Inter. NY, (1981).
6) Nuclear Radiation Detection, W.J.Price, 2nd ed., McGraw-Hill, NY, (1968).

Learning Outcomes:

- ✓ Student understands the basic principles and importance of Nuclear chemistry.
- ✓ Familiarized with the methods of detection of radiation from radioactive sources.
- ✓ Essential knowledge is imparted on radioisotope tracers and their numerous applications.
- ✓ Understands the importance of nuclear reactors and their working modes.
- ✓ Understands how the environment is affected by radioactive sources, either natural or waste produced from reactors, and knows safety methods to handle radioactive materials. Chemicals to protect from radiation.



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SEMESTER–I

PRACTICAL–I: INORGANIC & PHYSICAL CHEMISTRY (R26CH15)

Max. Marks: 100 **(Internal-30M & External-70M)**

A total Six (6)Experiments must be carryout taking minimum of '3' in each section

LIST OF EXPERIMENTS:

SECTION-I: INORGANIC CHEMISTRY

1) Determination of Zn^{2+} with potassium ferrocyanide (Volumetric).
2) Complexomatric titrations: Determination of Mg^{2+}, Ni^{2+} and hardness of water using EDTA.
3) Determination of Fe^{3+} by photochemical reduction.
4) Argentometry: Determination of chloride by argentometric titration using.
   a) K_2CrO_4 (b) Fluorescein as indicator.

SECTION-II: PHYSICAL CHEMISTRY

1) Relative strengths of acids by studying the hydrolysis of ethylacetate/methyl acetate.
2) Determination of the equilibrium constant of KI3 ↔ KI + I2 by partition coefficient method and determination of unknown concentration of potassium iodide.
3) Distribution coefficient of Benzoic acid between Benzene and water.
4) Determination of critical solution temperature of phenol-water system. Study of the effect of electrolyte on the miscibility of phenol-water system.

Reference Books:

1) Vogel's Textbooks of Quantitative Analysis, Revised. J. Asset, R.C. Denny, G.H. Jeffery and J. Mendhan. ELBS.
2) Synthesis and Characterisation of Inorganic Compounds, W.L. Jolly. Prentice Hall.
3) Practical Inorganic Chemistry by G. Pass and H. Sutcliffe Chapman and Hall.
4) Practical Inorganic Chemistry by. K. Somasekhar Rao and K.N.K. Vani.



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SEMESTER–I

PRACTICAL–II: ORGANIC CHEMISTRY (R26CH16)

Max. Marks: 100 **(Internal-30M & External-70M)**

(Minimum Five Experiments must be carried out)

LIST OF EXPERIMENTS:

1) One-step& Two-step organic compound preparation–Yield of crude and crystallized samples and reporting of the melting point/Boiling points.
   Preparations: i) Iodoform ii) n-Dinitroderivative iii) Aspirin iv) p-Nitroaniline
   v) Benzophenone vi) Benzoic acid vii) p-Bromo Acetanilide
   viii) Acetanilide ix) any other organic compound.
2) Purification of organic compound-The student has to do recrystallisation ofthe final compound(s) (for both steps) and submit the sample.
3) Distillation of Alcohol, Toluene.
4) Chromatography: The student has to submit the purity of the final product with TLC
5) Chromatographic separation of impurities by TLC.
6) Student should practice solvent extraction methods.

Note: Apart from (1) & (2), each student must practice S.No. (3) to (6).



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SEMESTER–I

PAPER-VII: HUMAN VALUES AND PROFESSIONAL ETHICS(R26CH17)

Audit Course **Max. Marks: 50M (Internal)**

Learning Objectives:

- ✓ To know the nature of ethics and goals.
- ✓ To know the basic moral concepts.
- ✓ To know the non-violence of non-possession.
- ✓ To know the crime and theories of punishment.
- ✓ To know the Bhagavad Gita, Buddhism, Jainism.

Unit-I: **6H**

Definition and Nature of Ethics – Is relation to Religion, Politics, Business, Law, Medicine and Environment. Need and Importance of Professional Ethics – Goals – Ethical Values in Various Professions.

Unit-II: **6H**

Nature of Values-Good and Bad, Ends and Means, Actual and Potential Values, Objective and Subjective Values, Analysis of Basic Moral Concepts-Right, Ought, Duty, Obligation, Justice, Responsibility and Freedom, Good Behaviour and Respect for Elders, Character and Conduct.

Unit-III: **6H**

Individual and Society: Ahimsa (Non-Violence), Satya (Truth), Brahmacharya (Celibacy), Asteya (Non-Possession) and Aparigraha (Non-stealing). Purusharthas (Cardinal virtues) - Dharma (Righteousness), Artha (Wealth), Kama (Fulfilment of Bodily Desires), Moksha (Liberation).

Unit-IV: **6H**

Crime and Theories of Punishment – (a) Reformative, Retributive and Deterrent, (b) Views on Manu and Yajnavalkya.

Unit-V: **6H**

Bhagavad Gita – (a) Niskama Karma, (b) Buddhism – The Four Noble Truths – Arya astangamarga, (c) Jainism - Mahavratas and Anuvratas. Values Embedded in Various Religions, Religious Tolerance, Gandhian Ethics.



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SEMESTER–I

PAPER-VII: HUMAN VALUES AND PROFESSIONAL ETHICS(R26CH17)

Max. Marks: 50(Internal)

Reference Books:

1) Johns S Mackenjie: A Manual of ethics
2) "The Ethics of Management" by Larue Tone Hosmer, Richard D. Irwin Inc.
3) Management Ethics – Integrity at work by Joseph A. Petrick and John F. Quinn, Response Books, New Delhi.
4) "Ethics in Management" by S.A. Shelekar, Himalaya Publishing House.
5) Harold H. Titus: Ethics for Today
6) Maitra, S.K: Hindu Ethics
7) William Lilly: Introduction to Ethics
8) Sinha: A Manual of Ethics
9) Manu: Manava Dharma Sastra or the Institute of Manu: Comprising the Indian System of Duties: Religious and Civil (ed.) G.C. Haughton.
10) Sasruta Samhita: Tr. Kaviraj Kunjanlal, Kunjanlal Brishagratha, Chowkamba Sanskrit Series, Vol I,II and III, Varanasi, Vol I PP, 16-20, 21-32 and 74-77 only.
11) Charaka Samhita: Tr. Dr. Ram Karan Sarma and Vaidya Bhagavan Dash, Chowkambha Sanskrit Series Office. Varanasi I, II, III Vol I, pp. 183-191.
12) Ethics, Theory and Contemporary Issues. Barbara Mackinnon, Wadsworth/Thomson Learning, 2001.
13) Analyzing Moral Issues, Judith A. Boss, Mayfield Publishing Company, 1999.
14) An Introduction to Applied Ethics (Ed.,), John H. Piet and Ayodya Prasad, Cosmo Publications.
15) Text Book for Intermediate First Year Ethics and Human Values, Board of Intermediate Education – Telugu Academy, Hyderabad.
16) I.C. Sharma, Ethical Philosophy of India. Nagin& Co.,Julundhar.

Learning Outcomes:

- ✓ Students are able to understand relation to religion & ethical values.
- ✓ Students are able to understand to character & conduct.
- ✓ Students are able to understand to crime & theories of punishment.
- ✓ Students are able to understand to Gand
- ✓ hian ethics & values embedded in various religions.
- ✓ Studetns are able to understand various individuals of society.



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SEMESTER–II
PAPER–I: PHYSICAL CHEMISTRY-II(R26CH21)

Max. Marks: 100 **(Internal-30M & External-70M)**

Learning Objectives:

- ✓ To know the Third Law and Statistical thermodynamics and Nernst Heat theorem, entropy, and probability.
- ✓ To know the classification of polymers and molecular weight determination.
- ✓ To know the Butler-Volmer equation, polarography and Amperometric titrations.
- ✓ To know the Hydrogen-oxygen reaction, Quantum yield and Stern - Volmer equation.
- ✓ To know the hydrolysis of ATP, thermodynamics of biopolymer solutions.

UNIT-I **12H**

Thermodynamics II: Third law and statistical thermodynamics- Nernst heat theorem - Third law of thermodynamics - Its limitations - Determination of absolute entropy - Concept of distribution - Thermodynamic probability and most probable distribution - Ensemble-ensemble averaging - Maxwell-Boltzmann distribution law - Partition function - Fermi-Dirac statistics - Bose-Einstein statistics - Entropy and probability - Boltzmann-Planck equation - Calculation of thermodynamic properties in terms of partition function - Application of partition function - Chemical equilibrium and partition function - Translational, rotational and electronic partition function - Entropy of Monoatomic gases (Sackur - Tetrode equation).

UNIT-II **12H**

Polymer Chemistry: Classification of polymers - Free radical, ionic and Ziegler-NattaPolymerisation - kinetics of free radical polymerisation - Techniques of polymerisation - Glass transition temperature - Factors influencing the glass transition temperature - Number average and Weight average, Molecular weights - molecular weights determination - End group analysis - Osmometry - Light scattering and ultra centrifugation methods.

UNIT-III **12H**

Electrochemistry II: Electrode potentials - Double layer at the interface - rate of charge transfer - Decomposition potential - Overpotential - Tafel plots - Derivation of Butler - Volmer equation for one-electron transfer - electrochemical potential. Electrocatalysis - Fuel Cells-Theory of polarography - Diffusion current - Ilkovic equation - Equation for half- wave potential – Applications of polarography - Amperometric titrations -Corrosion - Forms of corrosion - prevention methods.

UNIT-IV **12H**

Chemical Kinetics: Branching Chain Reactions - Hydrogen-oxygen reaction - lower and upper explosion limits - Fast reactions - Study of kinetics by flow methods - Relaxation methods - Flash photolysis - Acid-base catalysis - protolytic and prototropic mechanism - Enzyme catalysis.

Photochemistry: Quantum yield and its determination - Actinometry - Reactions with low and high quantum yields-Photosensitisation-Exciplexes and Excimers -Photochemical equilibrium – Chemiluminescence - Kinetics of collisional quenching-Stern-Volmer equation - Photogalvanic cells.



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SEMESTER–II
PAPER–I: PHYSICAL CHEMISTRY-II(R26CH21)
Max. Marks: 100 **(Internal-30M & External-70M)**

UNIT-V **12H**

Biophysical Chemistry: Standard free energy change in biochemical reactions, exergonic and endergonic reactions, hydrolysis of ATP, thermodynamics of biopolymer solutions, chain configuration of biopolymers, calculation of average dimensions. Membrane equilibrium, ion transport through cell membrane, dialosis and its function. Structure and functions of proteins, enzymes, DNA and RNA in living systems, forces involved in biopolymer interactions, electrostatic forces, hydrophobic forces, molecular expansion and dispersion forces.

Reference Books:

1) Physical Chemistry, G.K. Vemulapalli (Prentice Hall of India).
2) Physical Chemistry, P.W. Atkins. ELBS
3) Chemical kinetics - K.J. Laidler, McGraw-Hill Pub.
4) Text book of Physical Chemistry, Samuel Glasstone, Macmillan pub.
5) Statistical Thermodynamics - M.C. Gupta.
6) Polymer Science, Gowriker, Viswanadham, Sreedhar
7) Elements of Nuclear Science, H.J. Arniker, Wiley Eastern Limited.
8) Quantitative Analysis, A.I. Vogel, Addison-Wesley Longman Inc.
9) Physical Chemistry, G.W. Castellan, Narosa Publishing House, Prentice Hall
10) Physical Chemistry, W.J. Moore, Prentice Hall
11) Polymer Chemistry - Billmeyer
12) Fundamentals of Physical Chemistry, K K. Rohatgi-Mukherjee. Wiley Eastern Limited Publications.
13) Statistical Thermodynamics - M.Dole.
14) M.N. Hughes, The Inorganic Chemistry of Biological Processes, John Wiley and Sons, New York, 2nd Edition, 1981.
15) A text book of Biochemistry, AV.S.S. Rama Rao.
16) Physical Chemistry by Atkenes.

Learning Outcomes:

- ✓ Students understand the Third Law of thermodynamics, Maxwell-Boltzmann distribution law and Sackur - Tetrode equation.
- ✓ Students understand the Free radical, ionic and Ziegler-Natta polymerisation.
- ✓ Students understand the Butler - Volmer equation and Ilkovic equation.
- ✓ Students understand the Branching Chain Reactions, Enzyme catalysis and Photochemical equilibrium.
- ✓ Students understand the free energy change in biochemical reactions, exergonic and endergonic reactions, DNA and RNA in living systems in biopolymer interactions.



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SEMESTER–II
PAPER–II: ORGANIC CHEMISTRY-II(R26CH22)
Max. Marks: 100 **(Internal-30M & External-70M)**

Learning Objectives:

- ✓ To know the general methods of synthesis involving carbon-carbon multiple bonds.
- ✓ To know various mechanisms involved in aliphatic and aromatic Nucleophilic/electrophilic substitution reactions.
- ✓ To know about various elimination mechanisms in different types of substrates.
- ✓ To know the different elimination mechanism and importance of functional group protection in organic synthesis.
- ✓ To know the mechanisms involved in various types of named reactions and their applications in organic synthesis.

UNIT-I **12H**

General Methods for Synthesis: Addition reactions involving electrophiles (Br_2, HBr, HOBr, and H_2O/H_2SO_4); nucleophilic additions (Michael addition, Mannich, and Grignard reactions); Addition to C-C multiple bonds- stereochemistry of addition, formation and reactions of epoxides, syn and anti hydroxylation; hydrogenation (catalytic and non-catalytic).

UNIT-II **12H**

Aliphatic Nucleophilic Substitutions: The SN_2 and SN_1: Mechanisms, energy profile diagram and stereochemistry; SN_1, mixed SN_1& SN_2, and SET mechanisms; Factors influencing nucleophilic substitution reactions: Effect of structure, nucleophile, solvent, and leaving group.

The neighbouring group mechanism: Neighbouring group participation by O, N, S, halogens, in nucleophilic substitution reactions. Concept of classical and non-classical carbocations-participation of Pi and Sigma bonds as neighbouring groups. Anchimeric assistance-steric requirement.

UNIT-III **12H**

Aromatic Nucleophilic Substitutions: The SNAr, SN1 mechanisms and benzyne mechanism. Reactivity: effect of substrate structure, leaving group and attacking nucleophile. The Von-Ritcher, Sommelet-Hauser and Smiles rearrangements.

Aromatic Electrophilic Substitution reactions- Friedel-Crafts Alkylation, Acylation, Halogenations.

UNIT-IV **12H**

Elimination and Protecting Groups:

a) Types of elimination (E1, E1CB, E2) reactions, mechanisms, stereochemistry and orientation, Hofmann and Saytzeff`s rules, Syn elimination versus anti elimination. Competition between elimination and substitution.



b) Dehydration, dehydrogenation, decarboxylative elimination, pyrolytic elimination, molecular rearrangement during elimination.

c)*Importance of functional group protection in organic Synthesis:* Protecting agents for the protection of functional groups- hydroxyl group, Amino group, Carbonyl group and Carboxylic acid group

UNIT-V **12H**

Familiar Named Reactions: Benzoin, Perkin, Cannizaro,Dieckmann and Stobbe condensations; Hofmann, Schmidt, Lossen, Curtius, Claisen, Backmann and Fries rearrangements; Reformatsky, Favorskii, Wittig reaction, Baeyer-Villiger reaction and Chichibabin reaction, Oppenauer oxidation, Clemmensen, Wolff-Kishner, Meerwein–Ponndorf–Verley and Birch reductions..

Reference Books:

1) Advanced organic chemistry – reaction, mechanism and structure, Jerry March, John Wiley.
2) Advanced organic chemistry, F.A.Carey and R.J.Sundberg, Plenum.
3) A guide book to Mechanism in organic chemistry, Peter Sykes, Longman.
4) Organic chemistry, I.L.Finar, Vol. I & II, Fifth ed. ELBS, 1975.
5) Organic chemistry, Hendrickson, Cram and Hammond (McGraw–Hill).
6) Stereochemistry of carbon compounds – E.L. Eliel.
7) Modern organic Reactions, H.O.House, Benjamin.
8) An introduction to chemistry of Heterocyclic compounds, R.M.Acheson.
9) Structure and mechanism in organic chemistry, C.K.Ingold, Cornell University Press.
10) Principles of organic synthesis, R.O.C.Norman and J.M.Coxon, Blakie Academic & Professional.
11) Reaction Mechanism in organic chemistry, S.M.Mukherji and S.P.Singh, Macmillan.

Learning Outcomes:

- ✓ Students understand the mode of addition reactions involving addition by electrophiles and nucleophiles over unsaturated bonds between carbons
- ✓ Students understand and apply the substitution and elimination reaction mechanisms at aliphatic and aromatic substrates for various reactions leading to research
- ✓ Understand how to protect various functional groups in organic synthesis and can apply the same to novel molecules useful for research also.
- ✓ Students understand the mechanisms of studied named reactions and their applications in organic synthesis.
- ✓ To learn the molecular rearrangements.



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SEMESTER–II
PAPER-III:Research Methodology, Ethics & Scientific Writing(R26CH23)
Max. Marks: 100 **(Internal-30M & External-70M)**

Course Objectives
After completing this course, the student will be able to:

- Understand the principles and methodologies of scientific research.
- Develop skills in literature search using scientific databases.
- Learn scientific writing for research papers, dissertations, and technical reports.
- Understand research ethics, plagiarism, intellectual property rights, and publication ethics.
- Apply statistical and digital tools for research planning, data analysis, and reference management.

UNIT–I: Research Methodology **12H**

Introduction to Scientific Research: Meaning, objectives, significance, and characteristics of scientific research; Basic, applied, and interdisciplinary research; Qualitative and quantitative research; Fundamental, exploratory, descriptive, analytical, and experimental research.

Scientific Method: Observation, hypothesis, experimentation, data collection, analysis, and conclusion; Identification and formulation of research problems; Selection of research topics in chemistry.

Research Design: Components of research design; Independent, dependent, and controlled variables; Sampling methods and experimental planning; Laboratory notebooks and proper maintenance of research records.

UNIT–II: Literature Survey and Information Retrieval **12H**

Scientific Information Sources: Primary, secondary, and tertiary literature; Research journals, review articles, books, patents, conference proceedings, and technical reports.

Literature Search Tools: Google Scholar, Scopus, Web of Science, SciFinder, Reaxys, PubChem, ChemSpider.

Literature Review Techniques: Keyword selection and Boolean operators; Citation searching; Evaluating journal quality; Impact Factor, CiteScore, h-index, and i10-index, Identifying research gaps and preparing a literature review.

UNIT–III: Scientific Writing and Communication **12H**

Research Paper Writing

Structure of a research article: Title, Abstract, Keywords, Introduction, Experimental Section, Results and Discussion, Conclusion, References

Technical Writing: Thesis and dissertation writing, Laboratory reports, Project reports, Standard chemical nomenclature, Units, symbols, and abbreviations.

Scientific Communication: Poster preparation, Oral presentation techniques, PowerPoint presentation design, Writing cover letters for journal submission, Responding to reviewers' comments.

UNIT–IV: Research Ethics, Publication Ethics and Intellectual Property Rights 12H

Research Ethics: UGC guidelines on research ethics, Responsible conduct of research, Data integrity and reproducibility.

Publication Ethics: Authorship criteria, Acknowledgements, Conflict of interest, Duplicate publication, Predatory journals, Peer-review process.

Plagiarism: Types of plagiarism, Similarity index, Plagiarism detection software (Turnitin, Ouriginal), Avoiding plagiarism through proper citation.

Intellectual Property Rights: Copyright, Patent fundamentals, Patentability criteria, Indian Patent Act (overview), Technology transfer and commercialisation.

UNIT–V: Data Analysis, Statistics and Digital Research Tools 12H

Statistical Methods: Accuracy and precision, Significant figures, Mean, median, and mode, Standard deviation, Relative standard deviation, Error analysis (absolute and relative error).

Graphical Representation: Tables and charts, Scatter plots, Calibration curves, Trendline interpretation.

Reference Management: Mendeley, Zotero, Citation styles (ACS, APA, Vancouver).

Digital and AI Tools for Research: AI-assisted literature search, AI-assisted scientific writing (ethical use), ChemDraw basics, Chemical structure databases, Best practices for responsible AI use in research.

Course Outcomes

Upon successful completion of the course, the student will be able to:

- Explain research methodologies and scientific approaches used in chemical research.
- Apply literature search techniques using scientific databases to identify research gaps.
- Prepare research papers, technical reports, dissertations, and scientific presentations.
- Analyze issues related to research ethics, plagiarism, publication ethics, and intellectual property rights.
- Apply statistical methods, reference management software, and digital tools for research planning and data analysis.

Recommended Books

1. C.R. Kothari – Research Methodology
2. UGC Research Ethics Manual
3. Day & Gastel – Scientific Writing



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SEMESTER–II

PAPER-IV (Elective–A): INORGANIC CHEMISTRY-II (R26CH24A)

Max. Marks: 100 **(Internal-30M & External-70M)**

Learning Objectives:

- ✓ To know the Classification and Applications of Metal Clusters.
- ✓ To know the reactions of organometallic compounds.
- ✓ To know the Anation Reactions and Trans effects.
- ✓ To know the Selection rules, Correlation diagrams and Orgel diagrams.
- ✓ To know the Cotton effect and Faraday effect, structures of Hemoglobin and Myoglobin, Vitamin B_{12}, Photo Chemical Laws.

UNIT-I **12H**

Metal Clusters Classification: LNCs and HNCs**,** Isoelectronic and Iso lobal relationships, electron counting rules: Wade's and Lauher's rules. M-M multiple bonding; Preparation, structure and bonding in dinuclear $[Re_2Cl_8]^{2-}$, trinuclear $[Re_3Cl_9]$, tetranuclear $[W_4OR_{16}]$and hexanuclear $[Mo_6Cl_8]^{4+}$, $[Nb_6Cl_{12}]^{2+}$ cluster molecules and ions.

Polyatomic Zintl ions and Chevrel phases. Applications of clusters

Metal π-Complexes Preparation, structure and bonding in Nitrosyl, Dinitrogen and Dioxygen complexes.

UNIT-II **12H**

Organometallic Complexes of Transition Metals: Classification and electron counting rules. Metallocenes with four, five, six, seven and eight ($\square^4$ - $\square^8$) membered rings. Synthesis, structure and bonding of Ferrocene. Cyclopentadienyl, Arene, cycloheptatriene and Tropylium complexes of transition metals.

Reactions of organometallic compounds-oxidative addition, reductive elimination, insertion and elimination.

Applications of organometallic compounds-Catalytic hydrogenation, hydroformylation, and polymerization of olefins using Ziegler-Natta catalyst.

UNIT-III **12H**

Reaction Mechanism in Transition Metal Complexes: Kinetics of octahedral substitution, acid hydrolysis, base hydrolysis-conjugate base (CB) mechanism. Direct and indirect evidence in favour of CB mechanism.

Anation Reactions: Reactions without metal-ligand bond cleavage. Factors affecting the substitution reactions in octahedral complexes. Trans effect on substitution reactions in square planar complexes.

Mechanism of redox reactions, outer sphere mechanism, cross reactions and Marcus –Hush equation, inner sphere mechanism, complementary and non - complementary reactions.



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SEMESTER–II

PAPER-IV (Elective–A): INORGANIC CHEMISTRY-II (R26CH24A)

Max. Marks: 100 **(Internal-30M & External-70M)**

UNIT-IV **12H**

Electronic Spectra of Transition Metal Complexes: Electronic configurations of metal ions and Spectroscopic terms. Selection rules, Breakdown of selection rules, Slator – Condon repulsion parameters, Racah parameters, Term separation energies for d^n electronic configurations.

Correlation diagrams and Orgel diagrams. Tanabe-Sugano diagrams for configurations from d^1 to d^9 in octahedral and tetrahedral transition metal complexes of 3d series.

Calculations of Dq, B and β parameters. Charge transfer spectra.

UNIT-V **12H**

Magnetic Properties of Transition Complexes: Types of magnetism, anomalous magnetic moments - Orbital and spin contribution, spin - orbit coupling and magnetic moments. Chiroptical properties, Cotton effect and Faraday effect.

Biochemical Aspects of Iron and Cobalt: Binding, storage and transport of dioxygen by Hemoglobin and Myoglobin, Vitamin B_{12} and its importance.

Photo Inorganic Chemistry: Introduction, Photochemical laws, photo redox reactions and photo anation reactions. Photochemical decomposition of water.

Reference Books:

1) Inorganic Chemistry, Huheey. Harper and Row.
2) Concise Inorganic Chemistry, J. D. Lee, ELBS.
3) Inorganic chemistry,K.F. Purcell and J.C. Kotz, Holt Saunders international
4) Organometallic Chemistry, R.C. Mehrotra and A. Singh. New Age International.
5) Advanced Inorganic Chemistry, Cotton and Wilkinson, Wiley Eastern
6) Inorganic Reaction Mechanism, Basolo and Pearson, Wiley Eastern
7) Bioinorganic Chemistry, K. Hussan Reddy
8) Biological Aspects of Inorganic Chemistry, A. W. Addiso, W. R. Cullen, D. Dorphin and G. J. James. Wiley-Interscience.
9) Photochemistry of coordination compounds, V.BalzaniandV.Carassiti. Academic Press.

Learning Outcomes:

- ✓ The student will understand the various metal clusters and metal $\boldsymbol{\pi}$ complexes.
- ✓ Understanding the reactions of organometallic compounds and its applications.
- ✓ The students canunderstand the reaction mechanism in transition metal complexes, anation reactions, and complementary reactions.
- ✓ The students are able to understand the orgel diagrams and electronic spectra of transition metal complexes.
- ✓ The study of magnetic properties and anomalous magnetic moments of transition complexes.
- ✓ The students are able to understand the structure and functions of hemoglobin, myoglobin and vitamin B12, and photochemical laws.



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SEMESTER–II
PAPER-IV (Elective–B): NANOSCIENCE AND TECHNOLOGY(R26CH24B)
Max. Marks: 100 **(Internal-30M & External-70M)**

Learning Objectives:

- ✓ To learn the types of nano structures and the binding forces.
- ✓ To learn the synthetic and characterization techniques for nanostructures.
- ✓ To learn the chemistry involved in various functional nanostructures.
- ✓ To learn about the role of nanostructures in improving energy efficiency.
- ✓ To learn about the various types of nanosensor devises for biomedical applications.

UNIT -I **12H**

Introduction to Nanoscience: Definition of Nano, emergence and challenges of nanoscience, influence of nano over micro/macro, Types of nanostructures: One dimensional, Two dimensional and Three dimensional nanostructured materials, Quantum Dots structures, metal oxides, semiconductors and composites. Nanoscience and Interface: Intermolecular Forces, Van der Waals forces. Keesom, Debye, and London Interactions. Surface nanoscience and surface active agents.

UNIT-II **12H**

Synthesis and Characterization of Nanostructures: Fabrication techniques: Self-assembly, self-replication, sol- gels, Langmuir-Blodgett thin films, Nanolithography, bio-inspired synthesis, and chemical vapour deposition. Characterization techniques: Electron microscopy, Scanning probe microscopy, near-field microscopy, Micro- and near-field Raman spectroscopy, surface-enhanced Raman spectroscopy and X-ray photoelectron spectroscopy.

UNIT-III **12H**

Chemistry of Nanostructures: Carbon nanotubes (CNT): Structure of carbon nanotubes, synthesis and functionalization of Carbon nanotubes, electronic, vibrational, mechanical and optical properties of carbon nanotubes; Graphene nanostructures. Carbon-based nanomaterials in environment and biological systems. Biological aspects of Carbon Nanostructures, Fullerene and its derivatives. Environmental effects of nanostructures.

UNIT-IV **12H**

Applications of Nanostructured Materials: Nanostructures in Ferroelectric materials and coatings, polymer-based applications, hydrophilic-hydrophobic surface-cleaning materials, nanostructures in energy conversion and storage for renewable energy, semiconductor materials, solar cells, fuel cells, Carbon nanotubes for energy storage and hydrogen storage, as nanoscale catalysts to save energy. Nanostructures in waste reduction and improved energy efficiency, in water purification, sensors for biomedical applications and Carbon nano-adsorbents for environmental purification.



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SEMESTER–II

PAPER-IV (Elective–B): NANOSCIENCE AND TECHNOLOGY(R26CH24B)

Max. Marks: 100 **(Internal-30M & External-70M)**

UNIT-V **12H**

Nanotechnology in Sensor Devices: Nanosensors: Introduction to sensors, fundamentals and terminology ofsensors, static and dynamic characteristics and characterization of sensors. Micro and nano-sensors, biosensors and micro fluids and organic and inorganic nanosensors. Nanotechnology-based devices: nanomaterials, nanostructured films, nanoscale electronic and ionic transport devices. Sensors for biomedical applications. Biosensors: generation of biosensors and nanomaterial-based biosensors.

Recommended Books:

1) Nanomaterials: Synthesis, Properties and Applications, Edited by A.S.Adelstein.
2) Nanostructured carbon for advanced Applications, Edited by G.Benedek, Kluwer Academic Publishers, 1996.
3) Chemistry of nanomaterials: Synthesis, properties and applications, CNR Rao et.al.
4) Nanoparticles: From theory to applications G. Schmidt, Wiley Weinheim (2004).
5) Processing & properties of structural nanomaterials - Leon L. Shaw
6) Nanochemistry: A Chemical Approach to Nanomaterials, Royal Soc. of Chemistry, Cambridge, UK (2005).
7) Environmental Chemistry for a Sustainable World, Volume -1: Nanotechnology and
8) Health Risk Editors: Lichtfouse, Schwarzbauer, Robert
9) Advances in Nanotechnology and the Environment, Juyoung Kim, CRC Press, Taylor and Francis Group.
10) Nanomaterials for Biosensors, Cs. Kumar, Wiley–VCH (2007).
11) Nanostructures and Nanomaterials: Synthesis, properties and applications, G.Cao, Imperial College Press (2004).
12) The chemistry of nanomaterials: Synthesis, properties and applications, C.N.R.Rao, A.Muller, A.K.Cheetham (Eds), Wiley VCH Verlag Gmbh&Co, Weinheim, 2004.
13) Carbon Nanotubes: Properties and Applications- Michael J. O'Connell.
14) Nanotubes and Nanowires-CNR Rao and A. Govindaraj,RCS Publishing.
15) Carbon Nanomaterials for Environmental and Biological Applications, Bergmann andMachado., Springer.

Learning Outcomes:

- ✓ The student is provided with basic theoretical background on nanoscience and nanostructures.
- ✓ Understands various synthetic and characterization techniques for nanostructures.
- ✓ Equipped with the necessary chemistry knowledge involved in various functional nanostructures.
- ✓ Student is encouraged to pursue the development of new Nanostructures for energy efficiency.
- ✓ Understands the challenges of Nanoscience and its potential applications in biomedical and environmental fields.



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SEMESTER–II
PAPER-IV (Elective-C): MATERIAL SCIENCE (R26CH24C)
Max. Marks: 100 **(Internal-30M & External-70M)**

Learning Objectives:

- ✓ To learn the basic concepts involved in materials science and material structures.
- ✓ To learn about various types of conducting materials.
- ✓ To learn how testing and characterizations are done for materials.
- ✓ To learn about aerospace materials used in Cryogenic applications.
- ✓ To learn about the materials used in energy production and storage.

UNIT-I **12H**

Materials Science: Introduction, Condensed states of matter- crystalline and amorphous states. Ionic, covalent, metallic and molecular bonding- bond angle, bond length and bond energy. Hybridisation - Delocalised chemical bonding. Basics in crystal morphology, Lattice energy - Madelung constant. Inert gas crystals - van der Waals interaction - Lennard-Jones potential. Simple crystal structures - Sodium Chloride, Cesium Chloride, Diamond and Zinc sulphide structures. Close packed structures - packing efficiency and density of materials.

UNIT-II **12H**

Conducting Materials: Metals, Alloys, Semiconductors-Definition, electrical properties, optical properties, mechanical properties and thermal properties. Specific examples of metals: Copper, Aluminium, Iron, Gold, Silver. Uses of metals. Drawbacks of metals. Alloys-advantages of alloying. Examples: brass, Bronze, Steel, Stainless steel, Gold alloys, silver alloys and their uses. Semiconductors: Elemental semiconductors- Silicon, Germanium. Doping-n-type and p-type semiconductors, p-n junctions. Qualitative ideas of devices- diodes to Integrated circuits (ICs).

UNIT-III **12H**

Materials Testing and Characterization Vacuum Techniques: Vacuum pumps: Rotary, Vapour diffusion, Turbomolecular and Cryogenic pumps. Vacuum measurement: Thermal conductivity gauges and Pirani and thermocouple gauges. Ionisation gauges: Hot and cold cathode ionisation gauges. Non- Destructive Testing of Materials: X-Ray and Neutron Radiography. Mechanical Testing of Materials: Tensile, Compression and Hardness tests, B-V-R hardness numbers. Impact and Fatigue tests. Materials Characterisation: Electron Microscopy,Transmission Microscopy (TEM)-Scanning Microscopy (SEM) - Atomic Absorption, IR, Raman, Low Energy Electron Diffraction (LEED) and X-ray Photoelectron Spectroscopy (XPS).



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SEMESTER–II
PAPER-IV (Elective-C): MATERIAL SCIENCE (R26CH24C)
Max. Marks: 100 **(Internal-30M & External-70M)**

UNIT-IV **12H**

Aerospace Materials, Superalloys and Smart Materials: Aerospace materials-Evaluation of materials for the space environment. Materials for Cryogenic applications: Metals for low-temperature applications, Austenitic stainless steel, nitrogen-containing steel, Al-Li alloys, Titanium alloys and cryoinsulation materials. Materials for space environment: Radiation shielding materials, Space suit materials and materials for life support systems. Metallic materials, superalloys and Smart Materials: Iron based-nickel based–cobalt-based superalloys-applications. Smart materials-shape memory effect (SME). Ti-Ni(SM) alloys, Cu based alloys and applications.

UNIT-V **12H**

Materials in Energy Production: Global Energy Scene, Forms of energy, Conservation of energy, Solar Cells, Types of Solar cells. Solar Cell Fabrication Technology. Hydrogen energy-merits as a fuel; hydrogen storage; sea as a source of deuterium. Fuel cells-components, working and performance of fuel cells; types of fuel cells-Solid oxide fuel cells (SOFC), Molten carbonate fuel cells (MCFC), Phosphoric acid fuel cells (PAFC), Polymer Electrolyte fuel cells and applications. Superconductors: Types - high Tc superconductors - applications of Superconductors.

Recommended Books

1) Elements of Materials Science and Engineering–Lawrence H van Vlack, Addison-Wesley (1975).
2) Materials Science and Engineering, V. Raghavan, Prentice Hall India (1993).
3) The Structure and Properties of Materials, Rose, Shepard and Wulff, Vol.I-IV, Wiley Eastern, (1987).
4) X-Ray Crystallography, M. J. Burger, John Wiley (1942).
5) Introduction to Solids, A J. Dekker, McMillan India (1981).
6) Electronic Processes in Materials, L. V.Azaroff and J.J. Brophy.McGraw-Hill (1963).
7) Materials Science and Technology–A comprehensive treatment, R. W. Cahn, P Haasen & E J. Kramer.
8) Electronic and Magnetic Properties of Metals and Ceramics: Part I. Materials Science and Technology: A Comprehensive Treatment, Vol. 3, R. W. Cahn, P. Haasen, 1991, John Wiley.
9) High performance materials in Aerospace, H.M.Flower, Ist ed, Chapman & Hall (1995).
10) Advanced Aerospace Materials, B.Horst, B.Ilschner, K.C.Russel, Springer-verlag,Berlin (1992).

Learning Outcomes:

- ✓ The student is provided with basic theoretical background on Materials Science and molecular structures.
- ✓ Understands various types of widely used conducting materials.
- ✓ Gains necessary knowledge about material testing and characterization.
- ✓ Understands properties of materials used to protect severe environments and extreme stress levels in spacecraft.
- ✓ Understands global energy scenario and the role played by materials in energy storage and conservation.



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SEMESTER–II

PRACTICAL–I: INORGANIC & PHYSICAL CHEMISTRY(R26CH25)

Max. Marks: 100 **(Internal-30M & External-70M)**

A total Six (6) Experiments must be carried out, taking minimum of '3' in each section

LIST OF EXPERIMENTS:

SECTION-I: INORGANIC CHEMISTRY

Semimicro analysis of six radical mixtures containing one interfering radical and one less familiar cation each.

Interfering Anions : Oxalate, tartrate, phosphate, chromate.

Less familiar Cations : Thallium, molybdenum, thorium, zirconium,vanadium, uranium. (Minimum three Mixtures)

SECTION-II: PHYSICAL CHEMISTRY

1) Potentiometric determination of Fe(II) with Cr(VI)
2) pH-metric determination of strong acid with strong base.
3) Conductometric titration of strong acid with strong base
4) Verification of Beers Law using potassium permanganate.

Reference Books:

1) Vogel's Textbooks of Qualitative Analysis, Revised. J. Asset, R.C. Denny, G.H. Jeffery and J. Mendhan. ELBS.
2) Synthesis and Characterisation of Inorganic Compounds, W.L.Jolly. Prentice Hall.
3) Practical Inorganic Chemistry by G. Pass and H. Sutcliffe, Chapman and Hall.
4) Practical Inorganic Chemistry by K. Somasekhar Rao and K.N.K. Vani.



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SEMESTER–II

PRACTICAL–II: ORGANIC CHEMISTRY(R26CH26)

Max. Marks: 100 **(Internal-30M & External-70M)**

(Minimum Five Experiments must be carried out)

1) **Identification of Functional Groups in Organic Compounds:** Phenol, bases, organic acid, ketone, aldehyde, amide and carbohydrate with preparation of two solid derivatives.
   i) Identification of given two compounds with preparation of two solid derivatives and
   ii) Reporting of the melting points for derivatives.

2) **Purification of Derivatives**: The student has to do recrystallisation ofthe final derivative(s) and submit the sample. If the sample is impure,the liquid must undergo a distillation process.



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SEMESTER–II

Paper-VII: MOOCS (R26CH27)

Max. Marks: 50

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1) The students can choose a course fromSwayam or Swayam plus platform using the below links with not less than 4 weeks course

https://swayam.gov.in/

(or)

https://swayam-plus.swayam2.ac.in/

Note: Finally, the student has to submit the certificate to the University through respective College Principal.