Structure of Chemistry (major) Syllabus under NEP-2020 (Semester I to VI)

Yr	Sem	Theory Paper		Practical paper			Total Credits
		Paper Code	**Units**	**Paper Code**	**Units**	**Project**	
1	I	CH101C (Th) Credit: 4	Group –A: Inorganic Group –B: Physical	Nil	NA	Nil	6 (Theory) 2 (Practical)
		CH102C (Th) Credit: 2	Group A: Organic	CH102C (Pr) Credit: 2	Group B: Inorg & Org		
	II	CH201C (Th) Credit: 4	Group-A: Organic Group-B: Inorganic	Nil	NA	Nil	6 (Theory) 2 (Practical)
		CH202C (Th) Credit: 2	Group –A: Physical	CH202C (Pr) Credit: 2	Group-B: Phys, Org & Inorg		
2	III	CH301C (Th) Credit: 4	Group-A: Organic Group –B: Physical	Nil	NA	Nil	6 (Theory) 2 (Practical)
		CH302C (Th) Credit: 2	Group-A: Inorganic	CH302C (Pr) Credit: 2	Group-B: Org & Inorg		
	IV	CH401C (Th) Credit: 4	Group-A: Inorganic Group –B: Physical	Nil	NA	Nil	6 (Theory) 2 (Practical)
		CH402C (Th) Credit: 2	Group A: Organic	CH402C (Pr) Credit: 2	Group-B: Phys & Green Chem		
3	V	CH501C (Th) Credit: 4	Group-A: Inorganic Group –B: Organic	Nil	NA	Nil	12(Theory) 4 (Practical)
		CH502C (Th) Credit: 2	Group –A: Physical	CH502C(Pr) Credit: 2	Group-B: Phys Practical		
		CH503C (Th) Credit: 4	Group-A: Inorganic Group-B: Physical	Nil	NA		
		CH504C (Th) Credit: 2	.Group-A: Organic	CH504C (Pr) Credit: 2	Group-B: Org Chem Pract		
	VI	CH601C (Th) Credit: 4	Group-A: Organic Group-B: Physical	Nil	NA	Nil	12(Theory) 4 (Practical)
		CH602C(Th) Credit: 2	Group A: Inorganic	CH602C(Pr) Credit: 2	Group B: Inorg Chem Pract		
		CH603C (Th) Credit: 4	Group A : Environ & Green Chemistry Group B: Analytical Method in Chemistry	Nil	NA		
		CH604C (Th) Credit: 2	Group A: Industrial Chemistry	CH604C (Pr) Credit: 2	Group B: Industrial Chem		
Total		**16 Papers**					**Total 64 48(Theory) 16 (Practical)**

Major

SEMESTER-I
Paper Code: CH101C (Th)
Credit: 04, Total Marks: 100
Name of Paper: Chemistry-1

Group-A: Inorganic Chemistry, 02 Credits, Marks: 50

UNIT- I: Atomic Structure **(15 L× 45 minutes)**

Bohr's atomic model, Bohr-Sommerfeld model, their limitations, photo electric effect, de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation (1 electron system). Normalized and orthogonal wave functions, significance of ψ and ψ^2. Radial and angular wave functions and distribution curves (H-atom). Quantum numbers and their significance, shapes of s, p, d and f orbitals. Pauli's exclusion principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, variation of atomic orbital energy

UNIT- II: Periodic Properties **(15 L× 45 minutes)**

Periodic classification of elements; Classification of elements on the basis of electronic configuration, discussion of the following properties of the elements, effective nuclear charge, shielding or screening effect, Slater's rule, variation of effective nuclear charge, Atomic radii (van der Waals), ionic radii, covalent radii, ionization enthalpy, successive ionization enthalpies and factors affecting ionization energy, applications of ionization enthalpy, electron gain enthalpy, trends of electron gain enthalpy, electronegativity, Pauling's/ Mulliken's/ Allred Rachow's electronegativity scales, group electronegativity, diagonal relationship.

Theoretical Principles in Qualitative Analysis

Basic principles involved in analysis of cations and anions and solubility, solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents.

Group –B: Physical Chemistry, 02 Credits, Marks: 50

UNIT-I: Kinetic Theory of Gas **(15 L× 45 minutes)**

Postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of Equipartition of energy, degrees of freedom Heat capacities of gas.

Deviations from ideal gas behaviour, compressibility factor, Z, Causes of deviation from ideal behaviour. van der Waals equation of state, Isotherms of real gases and their comparison with van der Waals isotherms, Boyle Temperature, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

UNIT-II: Thermodynamics-I **(15 L× 45 minutes)**

First law: Concept of heat (q) work (w) internal energy (U) and statement of first law; enthalpy (H); relation between heat capacities, adiabatic relations, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions. Relationship between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature.

Thermochemistry: Hess's Law, Heats of reactions: standard states; enthalpy of formation of molecules and ions, enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy, enthalpy of neutralization, enthalpy of solution and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions.

Recommended Books:

1. *J.D. Lee, Concise Inorganic Chemistry, 5th Edition (ELBS)*
2. *James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edition (Pearson Education)*
3. *K Das, Fundamental Concepts of Inorganic Chemistry, Vol.1-4 (CBS Publishers & Distributors)*
4. *S. K. Basu , R. D. Madan , Satya Prakash and G. D. Tuli,Advanced Inorganic Chemistry, Vol. 1-2 (S Chand & Co Ltd)*
5. *Malik, Tuli, Madan, Selected Topics in Inorganic Chemistry, Revised Edition (S Chand & Co Ltd)*
6. *S. P. Banerjee, Advanced Inorganic Chemistry, 2nd Edition (Books & Allied (P) Ltd)*
7. *R. L. Dutta, Inorganic Chemistry Vol-1 & 2 (New Book Stall)*
8. *Puri, Sharma and Kalia, Principles of Inorganic Chemistry (Vishal Publishing Co.)*
9. *R. Sarkar, General and Inorganic Chemisty (Part I & II), New Central Book Agency Ltd.*
10. *P. C Rakhit, . Physical Chemistry, 7th edition*
11. *P. W. Atkins & Paula, J. de Atkin' Physical Chemistry Ed., Oxford University Press 13(2006).*
12. *D. W. Ball, Physical Chemistry Thomson Press, India (2007).*
13. *A. S. Negi, S. C. Anand, Text book of Physical Chemistry*
14. *G. W. Castellan, Physical Chemistry 4th Ed. Narosa (2004).*
15. *M. J Assael, A. R. H,Goodwin, M. Stamatoudis, W. A. Wakeham, & S. Will, Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).*
16. *C.R. Metz, 2000 solved problems in Chemistry, Schaum Series (2006).*

SEMESTER-I
Paper Code: CH102C (Th+ Pr)
Credit: 04, Total Marks: 100
Name of Paper: Chemistry-2

Major

Group-A: Organic Chemistry, 02 Credits, Marks: 50

UNIT- I: Structure, bonding & Fundamentals of Organic reactions (15 L× 45 minutes)

General Introduction: Organic compounds and their classification, nomenclature (trivial and IUPAC), molecular formula, double bond equivalent (DBE), idea of framing constitution from molecular formula.

Bonding Features: Nature of bonds and its orbital representation, atomic and molecular orbitals - bonding, nonbonding and anti-bonding, hybridization (sp^3, sp^2, sp) of C,N,O and halogens; bond lengths, bond angles, bond energy, bond polarity, bond polarizability, formation of σ and π bonds, localized and delocalized chemical bonds, van der Waals interaction, conjugation (resonance), resonance energy, steric inhibition of resonance, hyperconjugation, inductive and field effects, tautomerism, H-bonding, dipole moment- bond moment and group moment, physical properties (mp, bp, solubility) related to molecular structures.

Fundamentals of Organic Reactions: Energy of bond cleavage and bond formation, homolytic and heterolytic bond cleavages. Structure, stability, formation and reactions of electrophilies, nucleophiles and free radicals. Reaction intermediates: carbocations, carbanions, carbenes (electrophilic and

nucleophilic), arynes, free radicals and nitrenes. Study of a) Electrophilic and free radical addition at C=C, b) Nucleophilic addition at the C=O group of aldehydes and ketones; c) Nucleophilic substitution reactions - S_N^1, S_N^2, S_N^i; d) Electrophilic substitution in the aromatic system; Elimination reactions - α and β –eliminations, *syn* – and *anti*-elimination; E_1 and E_2- mechanism.

UNIT- II: Stereochemistry of Organic Compounds: (15 L× 45 minutes)

Stereoisomerism: Different types of stereoisomerism; conformation and configuration. Optical isomerism-optical activity, specific rotation and specific rotation of mixtures, asymmetry and dissymmetry, chirality, elements of symmetry, enantiomers and diastereomers, threo, erythro and meso compounds, representation of molecules in Fischer, flying-wedge, Sawhorse and Newman formulae and their inter conversion. Resolution of racemic mixture, racemisation, asymmetric synthesis-Cram's rule ande Prelog's rule. Relative and absolute configurations, sequence rules, D/L and R/S systems of nomenclature. Geometrical isomerism-determination of configuration of geometrical isomers; E/Z and *syn* /*anti* nomenclature, geometrical isomerism in oximes and alicyclic compounds.

Conformation: Conformational nomenclature; eclipsed, staggered, gauche and anti; dihedral angle, energy barrier of rotation, relative stability of conformers on the basis of steric effects, conformational analysis of ethane, n-butane.

Group-B: Practical, Credit: 02, Marks: 50

Inorganic Qualitative analysis

Qualitative analysis of mixtures of inorganic salts containing not more than **three** radicals **(water soluble)** from the following lists. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested: NO_2^-, SO_4^{2-}, Cl^-, Br^-, I^-, NO_3^-, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Bi^{3+}, Sb^{3+}, Fe^{3+}, Cr^{3+}, Al^{3+}, Zn^{2+}, Mn^{2+}, Ni^{2+}, Co^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}. **Spot tests as well as green methods may be followed if possible.**

Organic Qualitative analysis

Identification of special elements (nitrogen, sulphur, halogens) and functional groups viz. >C=C<, phenolic-OH, -COOH, -CHO, >CO, $-NH_2$, $-CONH_2$, $-NO_2$, in a pure solid organic compound.

Recommended Books:

1. *Sachin Kumar Ghosh, Advance General Organic Chemistry, A Modern Approach,Part-I & II, NCBA*
2. *Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).*
3. *Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).*
4. *Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).*
5. *Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.*
6. *Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.*
7. *Vogel's Qualitative Inorganic Analysis, Revised by G. Shelva, 7th Edition (Prentice Hall)*
8. *Ghoshal, Mahapatra, Nad, An advanced course in Practical Chemistry (NCBA)*
9. *S. C. Das, Advanced Practical Chemistry, The World Press Private Limited*
10. *Qualitative Organic Analysis, CHE-08L, Chemistry Lab-III, IGNOU*
11. *N.K. Vishnoi, Advanced Practical Organic Chemistry, Vikas Publishing House*
12. *M. M. Nandi, Essentials of Chemistry (New Age International)*
13. *Puri, Sharma and Kalia, Principles of Inorganic Chemistry (Vishal Publishing Co.)*

Major

SEMESTER-II
Paper Code: CH201C (Th)
Credit: 04, Total Marks: 100
Name of Paper: Chemistry-3

Group-A: Organic Chemistry, 02 Credits, Marks: 50

UNIT-I: Aliphatic Compounds -I **(15 L× 45 minutes)**

Alkanes, alkenes and alkynes: Synthesis of alkanes; Synthesis and properties of alkenes, alkynes and alkadienes. Inter conversion of constitutional isomers of alkenes and alkynes; inter conversion of E & Z isomers of alkenes.

Reactions with mechanism: Markownikoff's addition to alkenes, peroxide effects, ozonolysis, hydroboration-oxidation, oxy-mercuration-demercuration of alkenes, electrophilic and free radical addition to conjucated dienes; 1,2 Vs 1,4- additions; Birch reduction of alkadienes and alkynes; catalytic hydrogenation of alkenes and alkynes; use of Lindler catalyst.

UNIT-II: Alicyclic compounds: **(15 L× 45 minutes)**

Alicyclic compounds: Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Alcohols: Preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, distinguish 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$.

Group-B: Inorganic Chemistry, 02 Credits, Marks: 50

UNIT-I : Chemical bonding-I **(15 L× 45 minutes)**

Ionic bond: General characteristics,radiusratio rule and its limitations. Born-Lande equation with derivation, Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application. Solvation energy, solubility of ionic solids, ionic potential. Covalent character in ionic compounds: polarizing power, polarizability of ions, partial charge, Fajan's rule and consequences.

Covalent bond: General Characteristics, Resonance and resonance energy, Valence Bond theory (Heitler-London approach), Concept of hybridization, hybrid orbitals using s, p and d orbitals, equivalent and non-equivalent hybrid orbitals, energetic of hybridization, Formal charge. Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach). Bent's rule.

UNIT-II **(15 L× 45 minutes)**

Acid-Base Concepts: Arrhenius and Bronsted-Lowry concept, the Solvent-System concept (Franklin) and their limitations; Lewis concept; SHAB principle, Application of SHAB principle; relative

strengths of acids and bases (pK_a and pK_bconcept), leveling effect; pH and pH scale, acid-base indicators.

Statistical Data Analysis:

Types of errors, Accuracy and Precision, Standard Deviation, Rejection of Data: F-test, Q-test and t-test.

Recommended Books:

1. *S.N. Sanyal, Reactions, Rearrangements and Reagents, Bharati Bhawan*
2. *Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.*
3. *Richard O.C. Norman, James M. Coxon, Principles of Organic Synthesis, CRC Press*
4. *Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).*
5. *Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).*
6. *T. W. Graham Solomons: Organic Chemistry, John Wiley and Sons.*
7. *Sachin Kumar Ghosh, Advance General Organic Chemistry, A Modern Approach,Part-I & II, NCBA*
8. *J.D. Lee, ConciseInorganic Chemistry, 5th Edition (ELBS)*
9. *James E.Huheey, Ellen A. Keiter, Richard L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edition (Pearson Education)*
10. *S. K. Basu , R. D. Madan , Satya Prakash and G. D. Tuli, Advanced Inorganic Chemistry – Vol. 1-2 (S Chand & Co Ltd)*
11. *Malik, Tuli, Madan, Selected Topics in Inorganic Chemistry, Revised Edition, (S Chand & Co Ltd)*
12. *S. P. Banerjee, Advanced Inorganic Chemistry, 2nd Edition (Books & Allied (P) Ltd)*
13. *R. L. Dutta, Inorganic Chemistry Vol-1 & 2 (New Book Stall)*
14. *Puri, Sharma and Kalia, Principles of Inorganic Chemistry (Vishal Publishing Co.)*
15. *Hibbert, D. B. & Gooding, J. J, Data analysis for chemistry (Oxford University Press, 2006)*

SEMESTER-II
Paper Code: CH202C (Th + Pr)
Credit: 04, Total Marks: 100
Name of Paper: Chemistry-4

Major

Group –A: Physical Chemistry, 02 Credits, Marks: 50

UNIT-I: Colligative Properties of solutions (15 L× 45 minutes)

Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient. Dilute solution, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular weight determination, Osmosis, law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure, Elevation of boiling point and depression of freezing, Thermodynamic derivation using chemical potential to derive relations between the four colligative properties (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure. Inter relationship between different colligative properties, Abnormal molar mass, Van't Hoff factor, Colligative properties of degree of dissociation and association of solutes.

UNIT-II: (15 L× 45 minutes)

Solid States: Unit cell and Space lattice, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative

idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Laue equation, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Structure of Different Ionic Crystal (NaCl, CsCl and KCl.,) Different Stoichiometric & nonstoichiometric defects in crystals. Electrical and magnetic properties of solid.& Superconductivity.

Liquid States: surface tension, Surface energy, Contact angle, Determination of surface tension, derivations of coefficient of viscosity, and their determination. Effect of temperature on surface tension, Applications of Surface tension, Viscosity & Viscosity coefficient, Measurement of viscosity, Effect of addition of various solutes on surface tension and viscosity. Temperature variation on viscosity of liquids, Qualitative discussion of structure of Liquid.

Group –B: Practical, 02 Credits, (01+01), Marks: 50

A. Physical Chemistry: Surface tension and Viscosity measurements

1. Determine the surface tension by drop number method
2. Study the variation of surface tension of detergent solutions with concentration.
3. Determination of concentration of a given solution by measuring the surface tension of the solution.
4. Determination of Coefficient of viscosity of given liquid/solution by Ostwald Viscometer at room temperature.
5. Determination of concentration of a given solution by measuring the viscosity of the solution.

B. Organic quantitative analysis

1. Estimation of aniline using brominating mixture
2. Estimation of Oxalic acid by standardized NaOH
3. Estimation of vinegar by using standardized NaOH
4. Estimation of glycine by formal titration method (Soronsen's Method)

C. Inorganic Quantitative analysis:

1. Oxidation-ReductionTitrations
   a.Estimation of Fe(II)/Fe(III) by $KMnO_4$ solution.
   b. Estimation of Fe(II)/Fe(III) by $K_2Cr_2O_7$ solution
2. IodometricTitrations
   a. Estimation of Cu(II) by sodium thiosulphate solution.

Recommended Books:

1. *P. W. Atkins, & Paula, J. de Atkin' Physical Chemistry Ed., Oxford University Press 13(2006).*
2. *D. W. Ball, Physical Chemistry Thomson Press, India (2007).*
3. *G. W. Castellan, Physical Chemistry 4th Ed. Narosa (2004).*
4. *A. S. Negi, S. C. Anand,. A Textbook of Physical Chemistry*
5. *P.C. Rakhit. Physical Chemistry, 7th edition*
6. *A. Peter, & J. de. Paula, Physical Chemistry 10th Ed., Oxford University Press (2014).*
7. *T. Engel, & P. Reid, Physical Chemistry 3rd Ed., Prentice-Hall (2012).*
8. *D. A. McQuarrie, & J. D. Simon, Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).*
9. *I.N. Levine, Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010).*
10. *Mendham, J., A. I. Vogel's Quantitative Chemical Analysis, 6th Edition (Pearson)*
11. *S. C. Das, Advanced Practical Chemistry, 3rd Edition, The World Press Private Limited*

10.G N Mukherjee, Advanced Experiments in Inorganic Chemistry (U. N. Dhur& Sons Pvt. Ltd)
11.N.K. Vishnoi, Advanced Practical Organic Chemistry, Vikas Publishing House
12.Chemistry Lab-V, CHE-12L, IGNOU
13.Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.

SEMESTER-III
Paper Code: CH301C (Th)
Credit: 04, Total Marks: 100
Name of Paper: Chemistry-5

Major

Group –A: Organic Chemistry, 02 Credits, Marks: 50

UNIT-I : Aliphatic Compounds - II **(15 L× 45 minutes)**

Carbonyl Compounds: Structure, reactivity & preparation: Nucloophilic addition – eliminations of ammonia derivatives with mechanism; mechanisms of Aldol and benzoin Condensation, Knoevenagel condensation, Claisen Schmidt, Cnnizaero, Tischenko reactions, Wittig reaction, Benzil-benzellic acid rearrangement, haloform reaction, Baeyer Villigar Oxidation, Alpha Substitution reactions, Oxidations and Reductions (Clemmensen, Wolff Kishner). Addition reactions of unsaturated carbonyls compounds; Michael addition.

Carboxylic Acids and their Derivatives: Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Hoffmann Bromamide Reaction.

UNIT- II: Aromatic Compounds **(15 L× 45 minutes)**

Aromatic hydrocarbon and aromaticity: Sources, nomenclature and isomerisation of aromatic compounds, structure of benzene, stability of benzene ring, molecular orbital picture of benzene, aromaticity, Huckel's (4n+2) rule and its simple applications. Electrophilic substitution reactions in aromatic compounds. General mechanism of aromatic electrophilic substitution, effect of substituent groups, directive influence, orientation, isotope effect, nitration, sulphonation, halogenation, Friedel-Craft's alkylation and acylation, energy profile diagram, nuclear and side chain halogenation.
Aromatic halogen compounds: Introduction, method of synthesis, physical properties, chemical reactivity, nucleophilic aromatic substitution and its mechanism.
Aromatic compounds containing nitrogen: Introduction, methods of synthesis and physical properties, mechanism of nitration, reduction products of nitro compounds. Introduction, methods of synthesis of aromatic amines, basicity and effect of substituents, chemical reactivity. Diazotization and reactions of diazonium salts.
Phenols: Synthesis, physical properties, acidic character, chemical reactions, Kolbe reaction, Reimer – Tiemann reaction, Fries rearrangement, Claisen rearrangement. Houben – Hoesch reaction, phenol – formaldehyde resin, cresols, nitro and amino phenols, dihydric and trihydric phenols.
Aromatic alcohols, aldehydes, ketones: Introduction, methods of synthesis, physical properties, chemical reactivity of aromatic alcohols, aldehydes and ketones, Perkin reaction, phenolic aldehydes.

Group –B: Physical Chemistry, Credit 2, Marks: 50

UNIT-I: Equilibrium **(15 L× 45 minutes)**

Chemical Equilibrium: Law of mass action, thermodynamic derivation of law of mass action. Equilibrium constant & its significance, Van't Hoff equation, Van't Hoff reaction isochore, calculations of ΔG^0, ΔH^0 & ΔS^0 from equilibrium constant, factors influencing an equilibrium state, Le-Chatelier's principle, its application in different chemical & physical equilibrium.

Ionic Equilibrium: Ionization of weak acids and bases, pH scale, Calculation of pH, Use of pH, dissociation constants of mono-, di-and triprotic acids (exact treatment).Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations.

UNIT-II: Thermodynamics-II **(15 L× 45 minutes)**

Need of Second Law of Thermodynamics, Second Law, Carnot Theorem, Application of Carnot cycle, Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Feature of Entropy Change, Calculations of entropy change for reversible and irreversible processes, during phase change. Entropy & probability. Variation of S, G, A with T, V, P; Free energy change and spontaneity. Gibbs and Helmholtz energy; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

Third Law: Statement of third law, Nernst Heat theorem, concept of residual entropy, calculation of absolute entropy of molecules.

Recommended Books:

1. *R. N Morrison,. & R. N. Boyd, Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Edu).*
2. *I. L. Finar, Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).*
3. *Sachin Kumar Ghosh, Advance General Organic Chemistry, A Modern Approach,Part-I & II, NCBA*
4. *Subrata Sengupta, Organic Chemistry, Book Syndicate PVT. LTD*
5. *P. W. Atkins, & Paula, J. de Atkin' Physical Chemistry Ed., Oxford University Press 13(2006).*
6. *D. W. Ball, Physical Chemistry Thomson Press, India (2007)*
7. *G. W. Castellan, Physical Chemistry 4th Ed. Narosa (2004).*

A. S. Negi, S. C Anand, A Textbook of Physical Chemistry

8. *P. C. Rakhit. Physical Chemistry, 7th edition*

Major

SEMESTER-III
Paper Code: CH302C (Th + Pr)
Credit: 04, Total Marks: 100
Name of Paper: Chemistry-6

Group –A: Inorganic Chemistry, 02 Credits, Marks: 50

UNIT- Chemical Bonding-II **(15 L× 45 minutes)**

a) MOT: Molecular orbital theory, Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO and their ions; HF, BeF_2, $BeCl_2$ (idea of s-p mixing and orbital interactions).

b) Weak Chemical Forces: Van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Ionic character in covalent compounds: Bond moment and dipole moment, percentage ionic character. Repulsive forces, Hydrogen bonding, significance and effect on structure of compounds.
c**) Metallic Bond**: Qualitative idea of valence bond and band theories. Conductors, semiconductors and insulators, defects in solids.

UNIT-II: Coordination Chemistry-I (15 L× 45 minutes)
Introduction of Coordination compound, classification of ligands, coordination number and stereochemistry, IUPAC nomenclature of coordination compounds, Werner's coordination theory, chelation, chelate effect and its application, isomerism in coordination compounds, stereochemistry of complexes with 4 and 6 coordination numbers, innermetalllic complexes and their applications in Analytical Chemistry.
Bonding in coordination compounds:
(a) EAN rule (Sidwick concept)
(b) Valence bond theory (inner and outer orbital complexes), low spin, high spin complexes, explanation of magnetic moment of coordination compounds and imitations of VBT.
Magnetism: Types, electron spin angular moment and orbital angular moment, magnetic susceptibility and magnetic moment; Curie law, Curie-Weiss law, explanation of magnetic behaviour of coordination compounds taking examples of $[Co(NH_3)_6]^{3+}$, $[Fe(CN)_6]^{4-}$,$[Fe(CN)_6]^{3-}$, $[FeF_6]^{3-}$, $[CoF_6]^{3-}$, $[Ni(CN)_4]^{2-}$,$[NiCl_4]^{2-}$, $[Mn(NH_3)_6]^{2+}$

Group –B: Practical, 02 Credits (01+01), Marks: 50

Organic Compound Preparation: List of compounds to be prepared in pure state is:
Phthalimide, Benzil, Iodoform, Benzilic acid
(Any of the above compounds is to be set in the examination)
Preparation of the following coordination compounds:
Tris(thiourea)copper(I)sulphate, Tetra ammine copper(II) sulphate, Potash alum/ Chrome alum Bis(dimethylglyoximinato)nickel(II), Tris(acetylacetanoto)iron(III), Potassium tri(oxalate)chromate (III)

Recommended Books:

1. *J.D. Lee, Concise Inorganic Chemistry, 5th Edition (ELBS)*
2. *James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edition (Pearson Education)*
3. *S. K. Basu , R. D. Madan , Satya Prakash and G. D. Tuli, Advanced Inorganic Chemistry – Vol. 1-2 (S Chand & Co Ltd)*
4. *S. P. Banerjee, Advanced Inorganic Chemistry, 2nd Edition (Books & Allied (P) Ltd)*
5. *R. L. Dutta, Inorganic Chemistry Vol-1 & 2 (New Book Stall)*
6. *Puri, Sharma and Kalia, Principles of Inorganic Chemistry (Vishal Publishing Co.)*
7. *Malik, Tuli, Madan, Selected Topics in Inorganic Chemistry, Revised Edition, (S Chand & Co Ltd)*
8. *B.R. Puri, L.R. Sharma, Kalia, Kaushal, S & P-block elements, Transition Metals & Co-Ordination Chemistry(Vishal Publishing Co.)*
9. *Shriver and Atkins, Inorganic Chemistry, 5th Edition, (Oxford University Press)*
10. *Sharpe, Inorganic Chemistry, 3rd Edition (Pearson Education)*
11. *R. L. Dutta and A Shyamal, Elements of Magneto chemistry, 2nd Edition (Affiliated East-West Press)*
12. *R. Sarkar, General and Inorganic Chemistry (Part I & II)< New Central Book Agency Ltd*
13. *S. C. Das, Advanced Practical Chemistry, 3rd Edition (Kolkata S.C,Das)*

14. G. N. Mukherjee, Advanced Experiments in Inorganic Chemistry (U. N. Dhur & Sons Pvt. Ltd)
15. M. M. Nandi, Essentials of Chemistry, New Age International Publication
16. R.K. Sharma, Indu Tucker Sidhwani & Mihir K. Chaudhuri, Green Chemistry Experiments
17. N.K. Vishnoi, Advanced Practical Organic Chemistry, Vikas Publishing House
18.

Major

SEMESTER-IV
Paper Code: CH401C (Th)
Credit: 04, Total Marks: 100
Name of Paper: Chemistry-7

Group –A: Inorganic Chemistry, 02 Credit, Marks: 50

UNIT-I: Coordination Chemistry-II **(15 L× 45 minutes)**

Crystal field theory, splitting of d-orbitals in octahedral, tetrahedral and square planar complexes, crystal field splitting parameter (Δ), weak and strong field ligands, pairing energy and CFSE, factors affecting the magnitude of Δ, spectrochemical series. Explanation of magnetic and optical properties of coordination complexes on the basis of CFT.

Tetragonal distortions,Jahn-Teller distortion. Elementary idea of Ligand Field Theory, nephelauxetic effect. Stability of metal complexes-Thermodynamic and Kinetic stability of complexes.

UNIT-II: Redox Reactions **(15 L× 45 minutes)**

Balancing of redox reactions by Ion electron method, calculation of equivalent weights of oxidants & reductants. Standard electrode potential, formal potential, electrochemical series and their application. Redox indicators and their choice in redox titrations. Importance of redox potential in volumetric analysis.

S-block elements:

(i) Group discussion of the elements with respect to position in the periodic table: electronic configuration, atomic and ionic radii, ionization enthalpy, electron affinity (electron gain enthalpy), electronegativity, oxidation states, variation in properties of oxides and hydroxide, solvation and complexation tendencies of alkali and alkaline earth metals.

(ii) Synthesis, structure and properties, uses of Lithium aluminium hydride, sodium thiosulphate, lithopone, potassium iodide, basic beryllium acetate, calcium cyanamide.

Group –B: Physical Chemistry, 02 Credit, Marks: 50

UNIT-I: Chemical Kinetics **(15 L× 45 minutes)**

Rate of a reaction, molecularity and order of reaction, concentration dependence of rates, mathematical characteristic of simple chemical reactions – zero order, first order, second order, pseudo order, half-life and mean life. Determination of the order of reaction – differential method, method of integration, half-life method and isolation method. Effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy. Theories of reaction rates, Simple collision theory based on hard sphere model, transition state theory for bi molecular reactions, kinetics of parallel reactions, consecutive reactions, reversible reactions & chain reactions.

UNIT-II: Surface chemistry **(15 L× 45 minutes)**

Adsorption: Physical and chemical adsorption; Freundlich and Langmuir adsorption isotherms; multilayer adsorption and BET isotherm (no derivation required); Gibbs adsorption isotherm and surface excess; Heterogenous catalysis (single reactant);

Colloids: Classifications of Coloids, Lyophobic and lyophilic sols, preparation & purifications of colloids, Origin of charge and stability of lyophobic colloids, properties of colloids, Coagulation and Schultz-Hardy rule, Zeta potential and Stern double layer (qualitative idea), Tyndall effect; Electrokinetic phenomena (qualitative idea only); Stability of colloids and zeta potential; Micelle formation, Gold Number, Iso-electric point, Emulsion, Types and properties of emulsion, Gels, Classification and properties of Gels. Applications of colloid.

Catalysis: Characteristics of catalysis, theory of catalysis, acid-base catalysis, enzyme catalysis, kinetics of enzyme catalysis (Michaelis –Menten equation).

Recommended Books:

1. *J.D. Lee, Concise Inorganic Chemistry, 5th Edition (ELBS)*
2. *James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edition (Pearson Education)*
3. *Puri, Sharma and Kalia, Principles of Inorganic Chemistry (Vishal Publishing Co.)*
4. *F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann, Advanced Inorganic Chemistry, An Indian Adaptation, (WileyIndia Pvt. Ltd)*
5. *Malik, Tuli, Madan, Selected Topics in Inorganic Chemistry, Revised Edition, (S Chand & Co Ltd)*
6. *R. L. Dutta, Inorganic Chemistry Vol-1 & 2 (New Book Stall)*
7. *S. P. Banerjee, Advanced Inorganic Chemistry, 2nd Edition (Books & Allied (P) Ltd)*
8. *B. C. Ray and S. N. Das, General and Inorganic Chemistry, 1st Edition (NCBA)*
9. *B.R. Puri, L.R. Sharma, Kalia, Kaushal, S&P-block elements, Transition Metals & Co-ordination Chemistry(Vishal Publishing Co.)*
10. *S. K. Basu , R. D. Madan , Satya Prakash and G. D. Tuli, Advanced Inorganic Chemistry – Vol. 1-2 (S Chand & Co Ltd)*
11. *R. D. Madan, Mordern Inorganic Chemistry(S Chand & Co Ltd)*
12. *A. K. Das, Fundamental Concepts of Inorganic Chemistry, Vol.1-4 (CBS Publishers & Distributors)*
13. *R. Sarkar, General & Inorganic Chemistry, Part-II (Vol. I & II) (New Central Agency)*
14. *Peter Atkins & Julio De Paula, Physical Chemistry 10th Ed., Oxford University Press (2014).*
15. *Castellan, G. W. Physical Chemistry, 4th Ed., Narosa (2004).*
16. *McQuarrie, D. A. & Simon, J. D., Molecular Thermodynamics, Viva Books Pvt. Ltd.: New Delhi (2004).*
17. *Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).*
18. *Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).*
19. *Zundhal, S.S. Chemistry concepts and applications Cengage India (2011).*
20. *Ball, D. W. Physical Chemistry Cengage India (2012).*
21. *Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).*
22. *Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).*
23. *Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009).*
24. P.C.Rakhit, *A Textbook of Physical Chemistry. Volume 3.*

Major

SEMESTER-IV
Paper Code: CH402C (Th + Pr)
Credit: 04, Total Marks: 100
Name of Paper: Chemistry-8

Group –A: Organic Chemistry, 02 Credits, Marks: 50

UNIT – I: Nitrogen Containing compounds (15 L× 45 minutes)

Preparation and important reactions of nitro, nitriles and isonitriles. Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction and separation between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.

Heterocyclic Compounds:

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner- Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction Derivatives of furan: Furfural and furoic acid.

UNIT-II: Polynuclear aromatic hydrocarbons (15 L× 45 minutes)

Polynuclear aromatic hydrocarbons (naphthalene, anthracene, phenanthrene); Aromatic heterocycles with one heteroatom: Introduction, five and six membered heterocycles, aromatic characteristic of heterocyclic compounds, structure, synthesis and reactions of furan, thiophene, pyrrole and pyridine, basicity of pyridine and piperidine.

Quinones: Benzoquinones and naphthoquinones – preparations, properties, structures and reactions

Group –B: Practical, 02 Credits, Marks: 50

Physical Chemistry Practical

1. Determination of rate constant of hydrolysis of ester by HCl/NaOH at room temperature.
2. Study of kinetics of saponification of ethyl acetate and determination of rate contant.
3. To determine the specific reaction rates of hydrolysis of ethyl/methyl ester catalyzed by hydrogen ion at room temperature.
4. To study the effect of acid strength on hydrolysis of ester
5. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Green Chemistry

1. Preparation of acetanilide by using AcOH
2. Bromination of acetanilide using green approach (Bromate-bromide method).
3. Nitration of salicylic acid by green approach (using ceric ammonium nitrate)
4. Synthesis of azomethines from vanillin and 4-amino toluene
5. Preparation of Tris(acetylacetonato)manganese(III) by green method
6. Prepration of Tris(acetylacetonato)iron(III) by green method
7. Prepration of bis(acetylacetonato)copper(II) by green method

Recommended Books:

1. *Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).*
2. *Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).*
3. *Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).*
4. *Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons (1976).*
5. *Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.*
6. *McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition,2013.*
7. *Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.*
8. *Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.*
9. *Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Parakashan (2010).*
10. *B. D.Khosla, V. C. Garg & A. Gulati, Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).*
11. *C. W.Garland, J. W. Nibler, & D. P. Shoemaker, Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).*
12. *A. M.Halpern, & G. C. McBane, Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).*
13. *Green Chemistry Task Force Committee, DST, Monograph on Green Chemistry Laboratory Experiments*
14. *Green Chemistry Experiments, Rakesh K. Sharma, Indu Tucker Sidhwani & Mihir K. Chaudhuri, Tucker Prakashan*

SEMESTER-V
Paper Code: CH501C (Th)
Credit: 04, Total Marks: 100
Major
Name of Paper: Chemistry-9

Group –A: Inorganic Chemistry, 02 Credits, Marks: 50

UNIT-I: P-block elements & Noble gases (15 L× 45 minutes)

i) Group discussion of the elements with respect to position in the periodic table: electronic configuration, atomic and ionic radii, ionization enthalpy, electron affinity (electron gain enthalpy), electronegativity, oxidation states, variation of acidic and basic properties of their oxides and oxy-acids, inert pair effect, Catenation.

ii) Synthesis, structure and properties of diborane, borazine, silicone, carbides; oxoacids of phosphorus, sulphur and chlorine; Interhalogen compounds, Pseudo-halogens, polyhalides, basic properties of Iodine.

iii) Occurrence, isolation and uses, rationalization of inertness of noble gases, Clathrates; Synthesis, structure and reactions of xenon oxides , fluorides and oxiflourides.

UNIT-II: Radioactivity and Nuclear Chemistry (15 L× 45 minutes)

Stability of nucleus and nuclear forces; nuclear binding energy; mass defect and packing fraction; natural and artificial radioactivity; first order rate equation of radioactive disintegration; radioactive equilibrium; radioactive disintegration series; half-life, average life period, group displacement law, unit of radioactivity; carbon-14 dating, types of nuclear reactions, concepts of fusion and fission, Q value.

Group –B: Organic Chemistry, 02 Credits, Marks: 50

UNIT-I: Chemistry of Biomolecules- I **(15 L× 45 minutes)**

Carbohydrates: Introduction, occurrence, classification, nomenclature, inter-relationship amongst monosaccharides, constitution of glucose and fructose, ribose and arabinose, reactions of glucose and fructose, osazone formation, mutarotation and its mechanism, cyclic structures, pyranose and furanose forms, determination of ring size. Haworth projection formula, configurations and conformational analysis of monosaccharides, epimerisation, ascending and descending of sugars, inter conversion of aldoses and ketoses.

Introduction to disaccharides: maltose, lactose and sucrose. Introduction to polysaccharides – starch and cellulose.

Amino Acids, Peptides and Proteins: Amino acids, Peptides and their classification. α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, p*K*a values, isoelectric point and electrophoresis; Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis

UNIT-II: Chemistry of Biomolecules–II **(15 L× 45 minutes)**

Nucleic Acids: Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

Enzymes: Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

Lipids: Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenntion of fats and oils, Saponification value, acid value, iodine number, reversion and rancidity.

Recommended Books:

1. *J.D. Lee, Concise Inorganic Chemistry, 5th Edition (ELBS)*
2. *James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edition (Pearson Education)*
3. *S. K. Basu , R. D. Madan , Satya Prakash and G. D. Tuli, Advanced Inorganic Chemistry – Vol. 1-2 (S Chand & Co Ltd)*
4. *R L Dutta, Inorganic Chemistry Vol-1 & 2 (New Book Stall)*
5. *B.R. Puri, L.R. Sharma, Kalia, Kaushal, S & P-block elements, Transition Metals & Co-Ordination Chemistry(Vishal Publishing Co.)*
6. *Puri, Sharma and Kalia, Principles of Inorganic Chemistry (Vishal Publishing Co.)*
7. *Malik, Tuli, Madan, Selected Topics in Inorganic Chemistry, Revised Edition, (S Chand & Co Ltd)*
8. *Puri, Sharma Kalia and Kaushal, A Text Book of Inorganic Chemistry (Vishal Publishing Co.)*
9. *Shriver and Atkins, Inorganic Chemistry, 5th Edition, (Oxford University Press)*
10. *H. J. Arnikar and N. S. Rajurkar, Nuclear Chemistry (New Age Int. Publishers)*
11. *Berg, J.M., Tymoczko, J.L. & Stryer, L. (2006) Biochemistry. 6th Ed. W.H. Freeman and Co.*
12. *Nelson, D.L., Cox, M.M. & Lehninger, A.L. (2009) Principles of Biochemistry. IV Edition. W.H. Freeman and Co.*
13. *Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange Medical Books/ McGraw-Hill.*
14. *Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).*

15. *Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).*

SEMESTER-V
Paper Code: CH502C (Th + Pr)
Credit: 04, Total Marks: 100
Major **Name of Paper: Chemistry-10**

Group –A: Physical Chemistry, 02 Credits, Marks: 50

UNIT-I: Electrochemistry (15 L× 45 minutes)

Electrical transport: Conductance, specific conductance molar and equivalent conductance, measurement of equivalent conductance, variation of molar, equivalent and specific conductances with dilution. Migration of ions and Kohlrausch law, activity & activity coefficient coefficient, ionic strength, Debye-Huckel-Onsager equation for strong electrolytes (elementary treatment only), Asymmetric effect, Electrophoretic effect, Wien effect, Debye-Falkenhagen effect, Walden's rules,. Transport number, definition and determination by Hittorf method and moving boundary method. Ionic mobility. Application of conductance measurement- determination of solubility, dissociation constant & conductometric Titrations

Electrochemical cell: Single electrode potential,. Nernst equation and its thermodynamic derivation; Relation between emf and free energy & Cell thermodynamics, Reference Electrodes (Hydrogen electrode, Calomel electrode, Quinhydrone electrode, glass electrode), Electrode potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i, equilibrium constants, and (ii) pH values, using hydrogen, calomel, Quinone-hydroquinone, glass electrodes.(iii) determination of activity coefficients (iv) solubility product (v)dissociation constant of weak acid (vi) Potentiometric titrations (acid-base, redox, precipitation).; Concept and types of Concentration cells with and without transference, liquid junction potential;. Elementary ideas of polarizations and overvoltage-related theories, Tafel equation, Corrosion – types, theories, factors and prevention. Different types of commercial cells -Lead and alkali accumulators, fuel cell.

UNIT-II: Phase Equilibrium (15 L× 45 minutes)

Clausius-Clapeyron equation and its applications to solid-liquid,Distribution Law, Solvent Extraction, Equilibrium constant from Distribution Law, Nernst distribution law Statement and meaning of the terms-phase, component and degree of freedom, derivation of Gibbs phase rule, phase equilibria of one component system– water, CO_2 and sulpher systems.

Binary alloy: solid solutions (Au-Ag system), (Pb-Ag system), (Cu-Ni system), (Mn-Cu system), (Cu-Ag system), (Pb-Sn system).

Binary solutions: Liquid-Liquid phase system (Phenol- water, Water- Trimethyl amine, Water- nicotine system etc.) Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Three component systems, water-chloroform-acetic acid system, Pb-Bi-Sn System, Triangular plots & its application.

Group –B: Practical, 02 Credits, Marks: 50

1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
2. Distribution of distribution co-efficient of ammonia between between water and chloroform.
3. Determination of partition coefficient of benzoic acid between water and nonpolar organic solvent.
4. Determination of cell constant.
5. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
6. Perform the following conductometric titrations: Strong acid vs. strong base and determine the strength of acid solution.
7. Perform the following conductometric titrations: weak acid vs. strong base and determine the strength of weak acid solution.
8. Perform the following conductometric titrations: acetic acid & hydrochloric acid mixture vs. strong base and determine the strength of unknown acid solution.
9. Perform the following conductometric titrations: Na_2SO_4/K_2SO_4 solution vs. strong base and determine the strength of salt solution.
10. Perform the following potentiometric titrations: Strong acid vs. strong base & find out the strength of acid solution
11. Perform the following potentiometric titrations: weak acid vs. strong base & find out the strength of acid solution
12. Perform the following potentiometric titrations: Potassium dichromate vs. Mohr's salt& find out the concentration of Fe^{+2}

Recommended Books:

1. *S, Glasstone, An Introduction to Electrochemistry.*
2. *V. S Bagotsky,Handbook of Electrochemistry... Fundamentals of electrochemistry /—2nd ed.*
3. *P.C.Rakhit, A Textbook of Physical Chemistry. Volume 3.*
4. *K.L.Kapoor, Physical Chemistry, 7th edition..*
5. *A. S.Negi, S. C. Anand, A Textbook of Physical Chemistry*
6. *B. D. Khosla, V. C. Garg, & A. Gulati, Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).*
7. *C. W.Garland, J. W. Nibler, & D. P. Shoemaker, Experiments in Physical Chemistry, 8th Ed.; McGraw-Hill: New York (2003).*
8. *A. M. Halpern, & G. C. McBane, Experimental Physical Chemistry, 3rd Ed.; W.H. Freeman & Co.: New York (2003).*

Major

SEMESTER-V
Paper Code: CH503C (Th)
Credit: 04, Total Marks: 100
Name of Paper: Chemistry-11

Group –A: Inorganic Chemistry, 02 Credits, Marks: 50

UNIT-I: Transition Metals (d-block) **(15 L× 45 minutes)**

Electronic configuration of d-block elements, general properties, oxidation states, complex formation, spectral & magnetic properties;

Preparation, important reactions, structure and uses of the nickel tetracarbonyl, Sodium nitroprusside, sodium cobaltinitrite, hexaammine cobalt(III) chloride, potassium ferrocyanide, potassium ferricyanide, Prussian and turnbull's blue, potassium dichromate, potassium permanganate, manganese dioxide, cupric acetate, chromyl chloride.

UNIT-II: Inner Transition Elements (f-block) **(15 L× 45 minutes)**

Electronic configurations, oxidation states, complex formation, spectral & magnetic properties of lanthanides and actinides; lanthanide and actinide contraction and its consequences, separation of lanthanides by ion exchange method. Preparation, important reactions, structures and uses of cerium(IV) sulphate, uranyl nitrate hexahydrate, zinc uranyl acetate and uranium hexafluoride.

Group –B: Physical Chemistry, 02 Credits, Marks: 50

UNIT-I: Fundamentals of Quantum Chemistry **(15 L× 45 minutes)**

Black-body radiation, Planck's radiation law, photoelectric effect, heat capacity of solids. Atomic spectra, wave particle duality, de-Broglie hypothesis. Heisenberg uncertainty principle. Theory of wave motion, Schrödinger wave equation (time dependent and time independent) and its importance, physical interpretation of the wave function, properties of wave function, condition of normalization and orthogonality, Operators, eigen value & eigen function,different quantum mechanical operators and properties of operators, commutators, postulates of quantum mechanics, particle in a box. Harmonic oscillators, The electronic Schrödinger wave equation for H-atom, equation in spherical coordinates, solving the equation, splitting of the equations in to radial & angular part & their significance.

UNIT-II: Physical properties & Molecular structure **(15 L× 45 minutes)**

Additive and constitutive properties, molar refraction (Lorenz-Laurentz equation) Optical activity, Specific and molar rotation, Optical rotator dispersion, (ORD) and circular dichroism(CD) Basic ideas of electrostatics, Electrostatics of dielectric media, dielectric constant, induced and orientation polarization, Clausius-Mosotti equation, Debye equation,, Dipole moment and molecular polarizabilities and their measurements (Temperature and refractivity method). Magnetic rotation, Magnetic properties-diamagnetism, paramagnetism and ferromagnetism, origin of magnetism, magnetic moment, magnetic susceptibility and its measurement, Ascertaining the structure of different molecules and ions using above properties.

Recommended Books:

1. *J.D. Lee, Concise Inorganic Chemistry, 5th Edition (ELBS)*
2. *James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edition (Pearson Education)*
3. *S. K. Basu , R. D. Madan , Satya Prakash and G. D. Tuli, Advanced Inorganic Chemistry – Vol. 1-2 (S Chand & Co Ltd)*
4. *R. Sarkar, General & Inorganic Chemistry, Part-II (Vol. I & II) (New Central Agency)*
5. *R. L. Dutta, Inorganic Chemistry Vol-1 & 2 (New Book Stall)*
6. *B. R. Puri, L.R. Sharma, Kalia, Kaushal, S & P-block elements, Transition Metals & Co-Ordination Chemistry(Vishal Publishing Co.)*
7. *Puri, Sharma and Kalia, Principles of Inorganic Chemistry (Vishal Publishing Co.)*
8. *Malik, Tuli, Madan, Selected Topics in Inorganic Chemistry, Revised Edition, (S Chand & Co Ltd)*
9. *Shriver and Atkins, Inorganic Chemistry, 5th Edition, (Oxford University Press)*
10. *H. J. Arnikar and N. S. Rajurkar, Nuclear Chemistry (New Age Int. Publishers)*
11. *Kapoor, K. L., A Textbook of Physical Chemistry - Quantum Chemistry and Molecular Spectroscopy | Volume 4, 6th Edition..*
12. *Prasad, R.K., Quantum Chemistry;, New Age International, 2001*
13. *Donald A. McQuarrie. Quantum Chemistry Paperback – 1 December 2016*
14. *Chandra, A. K., Introductory Quantum Chemistry; Author,; Publisher, Tata McGraw-Hill Education, 1994.*
15. *Banwell, C. N., Fundamentals of. Molecular Spectroscopy. THIRD EDITION.. Lecturer in Chemistry. University of Sussex. MCGRAW-HILL BOOK COMPANY.*
16. *Colin N. Banwell & Elaine M. McCash, Fundamentals of Molecular Spectroscopy,.*
17. *Sindhu, P. S.,Fundamentals of Molecular Spectroscopy, New Age International.*

SEMESTER-V
Paper Code: CH504C (Th + Pr)
Credit: 04, Total Marks: 100
Name of Paper: Chemistry-12

Major

Group –A: Organic Chemistry, 02 Credits, Marks: 50

UNIT-I: Reaction Mechanism (15 L× 45 minutes)

Molecular rearrangements: Dienone-phenol, Wagner-Meerwein, Beckmann, Wolf, Lossen, Hoffman, Curtius, Schmidt, Fries, Demjanov and Favorskii reannangement.

Introduction to organic synthesis: Formation of C – C bonds, base catalysed and acid catalysed reactions with special reference to Dieckmann, Michael, Darzens and Mannich reactions.

Active methylene Compounds: Active methylene group, synthesis and applications of ethyl acetoacetate and diethyl malonate in organic synthesis, tautomerism.

UNIT-II: Selective reagents in Organic transformations (15 L× 45 minutes)

Lithium aluminum hydride, Sodium borohydride, Diisobutylaluminium hydride (DIBAL), Lthiumdiisopropylamide (LDA), PCC, DCC, DDQ, Baker's yeast, Selinium oxide, NBS, NCS, periodic acid and periodate, 9-BBN, mCPBA, peracids, I_2/AgOAc (aq. and anhydrous condition), $KMnO_4$ and OsO_4.Preparation and synthetic applications of Grignard reagents, Organolithium, Organocopper, organozinc compounds.

Group –B: Practical, 02 Credits, Marks: 50

A. Organic Qualitative analysis: Identification of the following organic compounds through systematic analysis (determination of mp, solubility test, detection of special elements, detection of functional groups, preparation of suitable derivative, determination of R_f value on TLC and survey of literature)

List of compounds to be identified: Cinnamic acid, succinic acid, salicylic acid, p-hydroxy benzoic acid, ß-naphthol, resorcinol, o-chlorobenzoic acid, phthalic acid, benzamide, phthalimide, benzanilide, acetanilide, benzil, benzophenone, glucose, vaniline, antharacene, diphenyl, urea.

Recommended Books:

1. *Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Edu).*
2. *Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).*
3. *Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).*
4. *Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons (1976).*
5. *Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.*
6. *McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition,2013.*
7. *Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.*
8. *Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press*
9. *S. C. Das, Advanced Practical Chemistry, 3rd Edition (Kolkata S.C,Das)*
10. *N.K. Vishnoi, Advanced Practical Organic Chemistry, Vikas Publishing House*
11. *Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).*
12. *Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. Practical Organic Chemistry, 5th Ed. Pearson (2012).*
13. *Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).*

SEMESTER-VI
Paper Code: CH601C (Th)
Credit: 04, Total Marks: 100
Name of Paper: Chemistry-13

Major

Group –A: Organic Chemistry, 02 Credits, Marks: 50

UNIT-I: Spectroscopy (15 L× 45 minutes)

UV Spectroscopy: Types of electronic transitions, λmax, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λmax for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.

Proton NMR spectroscopy: Introduction, theory, sample handling, chemical shift and factors influencing it, spin-spin coupling, charactersistic chemical values of different kind of protons, application of UV, IR and NMR in structure elucidation of organic molecules.

UNIT-II: Natural Products **(15 L× 45 minutes)**

Terpenoids: Introduction, Natural occurrence, General structural features, classification, isoprene rule, isolation, structure elucidation and synthesis of citral, terpeneol, geraniol and limolene.

Alkaloids: Introduction, classification, isolation, structure elucidation and synthesis of nicotine, piperine, Morphine, Reserpine, Hygrine, Cocaine and Coniine.

Anthocyanins: Introduction, general characteristics, methods of isolations, structure elucidations and synthesis. Structure elucidation of cyanin, pelargonin, delphinin, peonin, malvin, and hirsutin.

Group –B: Physical Chemistry, 02 Credits, Marks: 50

UNIT-I: Spectroscopy **(15 L× 45 minutes)**

Electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born-Oppenheimer approximation, degrees of freedom.

Rotational Spectrum:Diatomic molecules. Energy levels of a rigid rotor (semi-classical principles), selection rules, spectral intensity, distribution using population distribution (Maxwell Boltzmann distribution) determination of bond length, qualitative description of non-rigid rotor, isotope effect.

Vibrational Spectrum: Infrared spectrum: Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant and qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different functional groups.

Raman spectrum: Concept of polarizability, pure rotational and pure vibrational, Raman spectra of diatomic molecules, selection rules.

Electronic Spectrum: Concept of potential energy curves for bonding and antibonding molecular orbitals, qualitative description of selection rules.

UNIT-II: Photochemistry **(15 L× 45 minutes)**

Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry: Grothus- Drapper law, Stark-Einstein law, absorbance & molar absorptivity, consequence of light absorption by molecules, electronic transitions in molecules, potential energy curves for primary photochemical process, Jablonski diagram depicting various processes occurring in the excited state, Luminescence, qualitative description of fluorescence, types of fluorescence, phosphorescence, Chemiluminescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions – energy transfer processes (simple examples), quenching. Role of photochemical reactions in biochemical processes, kinetics of photochemical reaction.

Recommended Books:

1. *Y R Sharma, Elementary Organic Spectroscopy, S. Chand Limited*
2. *William Kemp, Organic Spectroscopy, Palgrave*
3. *Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Prakashan (2010).*
4. *Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).*
5. *Banwell, C. N., Fundamentals of. Molecular Spectroscopy. THIRD EDITION. Lecturer in Chemistry.*
6. *University of Sussex. MCGRAW-HILL BOOK COMPANY.*
7. *Colin N. Banwell & Elaine M. McCash, Fundamentals of Molecular Spectroscopy,.*
8. *Sindhu, P. S.,Fundamentals of Molecular Spectroscopy, New Age International.*
9. *K.K. Rahatgi Mukherjee, Photochemistry, New Age International Publisher.*

SEMESTER-VI **Major**
Paper Code: CH602C (Th + Pr)
Credit: 04, Total Marks: 100
Name of Paper: Chemistry-14

Group –A: Inorganic Chemistry, 02 Credits, Marks: 50

UNIT-I: Bio-inorganic Chemistry (15 L× 45 minutes)

(i) Essentials and trace elements of life, ionophores and siderophores, membrane transport (active and passive transport process); sodium / potassium-pump. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, deficiency of Fe, Ca and iodine and consequences; use of chelating agents in medicine (chelation therapy), platinum complexes as anti-cancer drugs.

(ii) Active site structure and functions of haemoglobin, myoglobin and role of iron and globin chain in haemoglobin, active site structure of chlorophyll and role of magnesium and phytyl group in chlorophyll, role of Co in vitamin B_{12}. Metalloenzymes-Carbonicanhydrase, Carboxypeptidase, hemocyanin-active site structures and functions.

UNIT-II: Organometallic Chemistry (15 L× 45 minutes)

Definition and classification of organometallic compounds, concept of hapticity. 18 & 16 electron rule, electron counts scheme. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and explanation of π -back bonding

Zeise's salt: Preparation and structure

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation), structure and aromaticity.

Study of the following catalytic processes and their mechanism:

1. Alkene hydrogenation (Wilkinson's Catalyst)
2. Polymerisation of alkene (Ziegler–Natta Catalyst)
2. Hydroformylation (Co salts)
3. Wacker Process ($PdCl_2$)
4. Synthetic gasoline (Fischer Tropsch reaction)

Group –B: Practical, 02 Credits, Marks: 50

Qualitative analysis of mixtures of inorganic salts containing **five** radicals (at least one interfering radical) from the following lists. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested: NO_2^-, NO_3^-,S^{2-}, SO_4^{2-}, $Cr_2O_7^{2-}$, CrO_4^{2-}, F^-, Cl^-, Br^-, I^-, BO_3^{3-}, PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Sn^{2+},Bi^{3+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}.

Mixtures should preferably contain one interfering anion **or** insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) **or** combination of anions e.g. NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, Br^- and I^-, NO_3^- and Br^-, NO_3^- and I^-. **Spot tests and green methods may be followed if possible.**

Quantitative Inorganic estimation

Volumetric titrations:

i. Estimation of Fe^{+2}/Ca^{+2} by EDTA
ii. Estimation of Cu^{+2}/Fe^{+2} by iodometric method
iii. Estimation of Cu^{+2}/Zn^{+2} by EDTA
iv. Estimation of CO_3^{2-} + HCO_3^- in a mixture

Complexometric Titrations

i. Estimation of Ca^{2+} in milk powder by EDTA.
ii. Determination of total hardness of water.

Recommended Books:

1. *Asim K Das, Bioinorganic Chemistry (New Central)*
2. *G. N. Mukherjee and A. Das, Elements of Bio-Inorganic Chemistry (U. N. Dhur& Sons Pvt. Ltd)*
3. *ROSETTE M, ROAT-MALONE, Bioinorganic Chemistry: A short course, 3rd Edition (WileyIndia Pvt. Ltd)*
4. *Indrajit Kumar, Organometallic Compounds (Pragati Prakashan)*
5. *F.A. Cotton, G. Wilkinson and Paul L Gaus, Basic Inorganic Chemistry, 3rd Edition (Wiley India Pvt. Ltd)*
6. *B C Ray and S N Das, General and Inorganic Chemistry, 1st Edition (NCBA)*
7. *F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann, Advanced Inorganic Chemistry, An Indian Adaptation, (Wiley India Pvt. Ltd)*
8. *Powell, P, Principles of Organometallic Chemistry, (Chapman and Hall, 1988)*
9. *J.D. Lee, Concise Inorganic Chemistry, 5th Edition (ELBS)*
10. *James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edition (Pearson Education)*
11. *Puri, Sharma and Kalia, Principles of Inorganic Chemistry (Vishal Publishing Co.)*
12. *M. M. Nandi, Essentials of Chemistry (New Age International)*
13. *Vogel's Qualitative Inorganic Analysis, Revised by G. Shelva, 7th Edition (Prentice Hall)*
14. *Ghoshal, Mahapatra, Nad, An advanced course in practical Chemistry (NCBA)*
15. *S. C. Das, Advanced Practical Chemistry 3rd Edition*

SEMESTER-VI **Major**
Paper Code: CH603C (Th)
Credit: 04, Total Marks: 100
Name of Paper: Chemistry-15

Group –A: Environment and Green Chemistry, 02 Credits, Marks: 50

UNIT-I: Environment Pollution (15 L× 45 minutes)

***Air Pollution*:** Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution. Pollution by SO_2, CO_2, CO, NO_x, H_2S and other foul smelling gases. Methods of estimation of CO, NOx, SOx and control procedures.

Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates.

***Water Pollution*:** Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and

ecosystems. Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal. Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

UNIT-II: (15 L× 45 minutes)

Drugs and pesticides: Introduction, classification of drugs, preparation and uses of aspirin,paracetamol, ibuprofen, phenacetin, sulphanilamide, sulphaguanidine, diazepam, ranitidine. Introduction and Classification of pesticides, natural and synthetic pesticides, preparation and uses of DDT, endrin, melathion, parathion and baygon.

Green Chemistry: Principles of green chemistry, atom economy, Environmental factor. Green: synthesis, chemicals, catalysts and recyclability, reaction conditions. Green methods for removal of pollutants. Use of green reagents, green catalysts (Zeolites, enzymes etc.) and green solvents; applications of green chemistry (from laboratory to industries).

Group –B: Analytical Methods in Chemistry, 02 Credits, Marks: 50

UNIT-I: Chromatography (15 L× 45 minutes)

Basic concept of chromatographic separation – adsorption and partition chromatography, theory and handling of different chromatographic techniques – column, thin-layer, and paper chromatography. Gas chromatography: Basic principle, basic equipment; types of column and their selection; detectors (FID, TCD, ECD, NPD); sample separation and applications. High performance liquid chromatography (HPLC): Instrumentation - basic equipment; pumping and injection system, column and its packing, normal and reverse phases; detectors, sample separation and application. Gel permeable (filtration) chromatography, Size exclusion chromatography, gel electrophoresis**,** Starch-gel, polyacrylamide gel (native and SDS-PAGE), agarose gel electrophoresis, pulse field gel electrophoresis, immuno-electrophoresis, isoelectric focusing, Western blotting.

UNIT- II: Spectroscopy & Microscopy (15 L× 45 minutes)

Flame Atomic Absorption Spectroscopy: Principles of atomic absorption spectroscopy, Radiation sources, Flame and electrothermal atomization, Limitations in atomic absorption, Interferences, Comparison of absorption spectrometry techniques-flame and graphite furnace, Quantitative Analysis, inductively coupled plasma-mass spectroscopy (ICP-MS).

Flame Atomic Emission Spectroscopy: Atomic emission, Principles of flame emission photometry, Limitations of flame emission photometry, Interference, Qualitative Analysis, Quantitative Analysis, Comparison of flame atomic emission and absorption spectroscopy. Excitation sources in atomic emission spectroscopy, ICP-AES spectroscopy. Principle and law of absorption fluorimetry, colorimetry, spectrophotometry (visible, UV, infrared, centrifugation, cell fractionation techniques, isolation of sub-cellular organelles and particles. Simple microscopy, phase contrast microscopy, florescence and electron microscopy (TEM and SEM),

Recommended books:

1. *K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.*
2. *S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.*
3. *S.E. Manahan, Environmental Chemistry, CRC Press (2005).*
4. *G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).*

A. *Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).*
5. *V K Ahluwalia "Green Chemistry: Environmentally Benign Reactions"*
6. *V K Ahluwalia and M Kidwai, "New Trends in Green Chemistry"*
7. *Cremlyn, R. Pesticides. Preparation and Modes of Action, John Wiley & Sons, New*
8. *York, 1978.*
9. *Singh, H. & Kapoor, V.K. Medicinal and Pharmaceutical Chemistry, Vallabh*
10. *Prakashan, Pitampura, New Delhi, 2012.*
11. *Foye, W.O., Lemke, T.L. & William, D.A.: Principles of Medicinal Chemistry, 4th*
12. *ed., B.I. Waverly Pvt. Ltd. New Delhi.*
13. *Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley& Sons. Inc.*
14. *De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.*
15. *Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.*
16. *Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009 The World of the Cell.7th edition.Pearson Benjamin Cummings Publishing, San Francisco.*
17. *Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.*
18. *Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.*
19. *Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.*
20. *Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.*

SEMESTER-VI
Paper Code: CH604C (Th + Pr) **Major**
Credit: 04, Total Marks: 100
Name of Paper: Chemistry-16

Group –A: Industrial Chemistry, 02 Credits, Marks: 50

UNIT-I: Industrial chemistry – I (15 L× 45 minutes)

Enzymes in industries: Production of alcohol by fermentation of starch and sugar(reaction conditions, nature of enzymes used, structural transformation during reaction). Preparation and use of cellulose.

Oils, Fats and Detergents: Catalytic hydrogenation of vegetable oil and fat for production of soap, synthesis of detergents. Principles of cleansing action.

Coal and Petroleum: Cracking of petroleum, knocking and octane number. Synthetic petrol, LPG and CNG, Biodiesel.

UNIT-II: Industrial chemistry – 2 (15 L× 45 minutes)

Fertilisers: Different types of N and P fertilizers, manufacture of ammonia, ammonium nitrate, urea phosphates and superphosphates. Nitrogen fixation by plants.

Glass: Various types of glass fibers, optical glass, glazing and vitrification, glass ceramics.

Cement: Various types of cement, their composition and manufacture. Portland cement, setting of cement.

Paints: Constituents of different paints, Role of binder and solvent, Lead and Zinc containing paints, common use of paints.

Group –B: Practical, 02 Credits, Marks: 50

Organic Preparation

Acid and Base catalyzed aldol condensation (Synthesis of dibenzalpropanone),7-hydroxy-4-methylcoumarin from resorcinol and ethylacetoacetate (Pechmann condensation).

Quantitative Analysis

i. Estimation of total hardness of a supplied water sample.
ii. Estimation of the amount of iron present in a supplied cement sample.
iii. Determination of saponification value of a supplied vegetable oil/ester.
iv. Determination of iodine value of a supplied vegetable oil/unsaturated ester.
v. Determination of chemical oxygen demand(COD) of a supplied water sample
vi. Determination of available chlorine in supplied bleaching powder.
vii. Extraction of caffeine from tea leaves
viii. Preparation of Biodiesel from vegetable oil.

Recommended Books:

1. *Asim K Das, Bioinorganic Chemistry (New Central)*
2. *G. N. Mukherjee and A. Das, Elements of Bio-Inorganic Chemistry (U. N. Dhur& Sons Pvt. Ltd)*
3. *ROSETTE M, ROAT-MALONE, Bioinorganic Chemistry: A short course, 3rd Edition (WileyIndia Pvt. Ltd)*
4. *Indrajit Kumar, Organometallic Compounds (Pragati Prakashan)*
5. *F.A. Cotton, G. Wilkinson and Paul L Gaus, Basic Inorganic Chemistry, 3rd Edition (Wiley India Pvt. Ltd)*
6. *B C Ray and S N Das, General and Inorganic Chemistry, 1st Edition (NCBA)*
7. *F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann, Advanced Inorganic Chemistry, An Indian Adaptation, (Wiley India Pvt. Ltd)*
8. *Powell, P, Principles of Organometallic Chemistry, (Chapman and Hall, 1988)*
9. *J.D. Lee, Concise Inorganic Chemistry, 5th Edition (ELBS)*
10. *James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edition (Pearson Education)*
11. *S C Das, Advanced Practical Chemistry, 3rd Edition (Kolkata S.C,Das)*

B. *C. Ranu, Monograph on Green Chemistry Laboratory Experiments (Green Chemistry Task Force Committee, DST).*

12. *Vogel's Qualitative Inorganic Analysis, Revised by G. Shelva,, 7th Edition (Prentice Hall)*
13. *Ghoshal, Mahapatra, Nad, An advanced course in practical Chemistry (NCBA)*
14. *G N Mukherjee, Advanced Experiments in Inorganic Chemistry (U. N. Dhur& Sons Pvt. Ltd)*
15. *C. K. Sharma, Industrial Chemistry (Part1 &2) (Krishna Prakashan)*
16. *Prakash G. More, Comprehensive Industrial Chemistry*
17. *Vogel's Qualitative Inorganic Analysis, Revised by G. Shelva, 7th Edition (Prentice Hall)*
18. *Ghoshal, Mahapatra, Nad, An advanced course in practical Chemistry (NCBA)*
19. *S. C. Das, Advanced Practical Chemistry 3rd Edition*

Semester-I
Minor course 1 (MC-1): CH 101 M
Fundamentals of Chemistry
Credits: 03, Full Marks: 75

Unit I: Atomic Structure and Periodicity of Elements (Credit-1, 15 L× 45 minutes)

Bohr's atomic structure and its limitations, atomic spectrum of hydrogen atom; de'Broglie equation, Heisenberg's Uncertainty Principle and its significance. Shapes of s, p, d and f orbital's. Pauli's exclusion principle, Hund's rule of maximum multiplicity, Aufbau principle and its limitations.

Periodic classification of elements on the basis of electronic configuration; Periodic properties – atomic radii, ionic radii, covalent radii; ionization potential, electron affinity, electronegativity, ionization enthalpy, factors affecting ionization enthalpy. applications of ionization enthalpy. Pauling's scale of electronegativity, group electronegativity; Mullikan, Allred Rochow scales, electro negativity and bond order, partial charge, group electronegativity.

Unit II: Basics of Organic Chemistry (Credit-1, 15 L× 45 minutes)

Concept of hybridization, hybrid orbitals and molecular geometry, bond lengths and bond angles, bond energy, localized and delocalized chemical bonding, Van der Waals interactions, hyperconjugation, Dipole moment; Electronic Displacements: Inductive effect, resonance, mesomeric effects and their applications; acidity and basicity of organic compounds; Mechanism of Organic Reactions: homolytic and heterolytic bond fission, Types of reagents – electrophiles and nucleophiles, Types of organic reactions, examples of reactive intermediates – Carbocations, carbanions, free radicals, carbenes, arynes and nitrenes.

Unit III: Properties and Kinetic theories of gases (Credit-1, 15 L× 45 minutes)

Gas laws, behaviour of real gases, PV isotherms of real gases, deviation from ideal behavior of gases, van der Waals equation of state; Critical phenomena: continuity of states, the isotherms of van der Waals equation, relationship between critical constants and van der Waals constants, the law of corresponding states, reduced equation of state, postulates of kinetic theory of gases, gas pressure, kinetic theory of gases ($PV = 1/3\ mnc^2$), average kinetic energy of molecules, mean free path, collision diameter, collision number, collision frequency, their dependence on temperature and pressure, heat capacity of gases, atomicity of molecule, viscosity of gases; Maxwell's distribution of molecular velocities.

Minor course 1 (MC – 1): CH 101M (Practical)
Credits: 01, Full Marks: 25

Titrimetric Analysis

(A) Preparation of solutions of different Morality/Normality.

(B) Acid-Base Titrations

(i) Estimation of oxalic acid in a given solution by standard NaOH

(ii) Estimation of percentage of acetic acid in a commercial vinegar sample

(iii) Estimation of carbonate and bicarbonate present together in a mixture.

(C) Oxidation-Reduction Titration

(i) Estimation of Fe (II) using standardized $KMnO_4$ solution.

(ii) Estimation of Fe(II) using standard $K_2Cr_2O_7$

Recommended books:

1. *Lee, J.D. Concise Inorganic Chemistry, Pearson Education 2010.*
2. *Huheey, J.E., Keiter, E.A., Keiter, R.L., Medhi, O.K. Inorganic Chemistry, Principles of Structure andReactivity, Pearson Education 2006.*
3. *Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford*
4. *Atkins, P.W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 2006.*
5. *Ball, D.W. Physical Chemistry Thomson Press 2007.*
6. *Castellan, G.W. Physical Chemistry 4th Ed. Narosa 2004.*
7. *Singh J.,YadavL.D.S.,Advanced Organic Chemistry,Pragati Edition*
8. *Morrison, R.N. & Boyd, R.N. Organic Chemistry, Pearson Education.*
9. *Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003*
10. *Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.*
11. *Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.*

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Semester-II
Minor course 2 (MC-2): CH 201 M
Selected Topics in Chemistry -I
Credits: 03, Full marks: 75

Unit I: Bonding and intermolecular Forces (Credit-1, 15 L× 45 minutes)

Bonding (σ and π bond approach) and bond lengths, the Valence bond theory (VBT), Bent's rule, Valence shell electron pair repulsion theory (VSEPR), shapes of the simple molecules and ions containing lone pairs and bond pairs of electrons; Molecular orbital theory (MOT): Molecular orbital diagrams, bond orders homonuclear and heteronuclear diatomic molecules and their ions (N_2, O_2, C_2, B_2, F_2, CO, NO); Resonance and resonance energy, formal charge, Van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interaction, dipole moment of diatomic and polyatomic molecules, Percentage ionic character from dipole moment, polarizing power and polarizability. Fajan's rules, H- bonding and its consequences. Ionic and metallic bonds.

Unit II: Chemical Kinetics **(Credit-1, 15 L× 45 minutes)**

Rate of a reaction, concentration dependence of rates, and mathematical characteristic of simple chemical reactions, Order and molecularity of a reaction,– zero order, first order, second order, pseudo 1st order, half-life and mean life. Determination of the order of a reactions – differential method, method of integration, half-life method and isolation method.

Theories of chemical kinetics: Effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy. Simple collision theory based on hard sphere model, transition state theory. Expression for the rate constant based on equilibrium constant and thermodynamic aspects (no derivation).

Unit III: Basic Stereochemistry of organic molecules **(Credit-1, 15 L× 45 minutes)**

Concept of isomerism, types of isomerism; optical isomerism – elements of symmetry, molecular chirality, enantiomers, stereogenic center, optical activity, properties of enantiomers, chiral and achiral molecules with two stereo centers, disasteromers, threo and erythro, meso compounds, resolution of enantionmer, inversion, retention and recemization. Relative and absolute configuration, sequence rules, D & L and R & S systems of nomenclature. Newman projection and Sawhorse formulae, Fischer and flying wedge formulae, Difference between configuration and conformation. Geometrical isomerism – determination of configuration of geometric isomers, E & Z system of nomenclature. Conformational analysis of ethane and n-butane; conformations of cyclohexane, axial and equatorial bonds, conformation of mono substituted cyclohexane derivatives.

Minor course 2 (MC – 2): CH 201M (Practical)
Credits: 01, Full Marks: 25

1. Detection of special elements (N, S, Cl) in organic compounds.
2. Purification of organic compounds by crystallization (from water and alcohol) and distillation and determination of melting point to check the purity of the crystallized compound.
3. Preparations: (a) Benzoylation of amines/phenols
   (b) Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone
   (c) Acetylation of aniline
   (d) Preparation of phthalimide

Recommended books:

1. *Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford*
2. *Huheey, J.E., Keiter, E.A., Keiter, R.L., Medhi, O.K. Inorganic Chemistry, Principles of Structure andReactivity, Pearson Education 2006.*
3. *Lee, J.D. Concise Inorganic Chemistry, Pearson Education 2010.*
4. *Atkins, P.W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 2006.*
5. *Ball, D.W. Physical Chemistry Thomson Press 2007.*
6. *Castellan, G.W. Physical Chemistry 4th Ed. Narosa 2004.*
7. *Singh J.,Yadav L.D.S.,Advanced Organic Chemistry,Pragati Edition*
8. *Morrison, R.N. & Boyd, R.N. Organic Chemistry, Pearson Education.*

9. *Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003*
10. *Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.*
11. *Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.*
12. *Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical OrganicChemistry, Prentice-Hall, 5th edition, 1996.*
13. *Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960*

Semester-III
Minor course 3 (MC-3): CH 301 M (Th)
Selected Topics in Chemistry -II
Credits: 03, Full marks: 75

Unit I: Coordination Chemistry (Credit-1, 15 L× 45 minutes)

Werner's theory of coordination complexes, classification of ligands, ambidentate ligands, chelating ligands, coordination numbers, IUPAC nomenclature of coordination complexes (up to two metal centers), Isomerism in coordination compounds, constitutional and stereo isomerism, geometrical and optical isomerism in square planar and octahedral complexes; Metal- ligand bonding in transition metal complexes, limitations of valance bond theory, an elementary idea of crystal field theory. Stability and properties of of metal complexes, factors affecting the stability, stability constants of complexes and their determination.

Unit II: Equilibrium (Credit-1, 15 L× 45 minutes)

Chemical Equilibrium: Equilibrium constant and free energy, thermodynamic derivation of law of mass action. Le-Chatelier's principle, reaction isotherm and reaction isochore– Clapeyron-Clausius equation and its applications.

Phase Equilibrium : Statement and meaning of the terms-phase, component and degrees of freedom, derivation of phase rule, phase equilibria of one component system – water, CO_2 and systems. Phase equilibria of two component systems – Solid – liquid.

Ionic Equilibrium: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis, calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions, solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

Unit III: Basics of organic reaction (Credit-1, 15 L× 45 minutes)

Formation of alkanes, Wurtz reaction, Wurtz-Fittig reaction, Free radical substitutions Mechanism of Halogenation- relative reactivity and selectivity, formation of alkenes and alkynes by elimination reaction. Mechanism of E_1, E_2, E_{1cb} reaction. Saytzeff and Hofmann eliminations. Addition of HBr to propene, Free radical addition of HBr to propene, carbocation and halonium ions. Stereochemistry of halogen addition to alkenes, ozonolysis of propene. Diel's –Alder reaction and mechanism of allylic and benzylic substitutions, bromination mechanism in propene, 1-butene and toluene. Mechanism of S_N1 and S_N2 reactions with suitable examples; Energy profile diagrams, stereochemistry and factors effecting S_N1 and S_N2 reactions. elimination reactions, mechanisms of E_1 and E_2 reactions, elimination vs substitution reactions,

Aromatic Electrophilic substitution reactions (σ and π complexes), halogenation, nitration, sulphonation, Friedel Crafts alkylation and acylation with their mechanism; Activating and deactivating groups; ortho, para direction; aromatic nucleophilic substitution reaction: SNAr and Benzyne mechanism with suitable examples.

Minor course 3 (MC – 3): CH 301M (Practical)
Credit: 01, Full Marks: 25

1. Study of the solubility of benzoic acid in water and determination of ΔH.
2. Measurement of pH of different acidic and basic solutions using pH-meter.
3. Measurement of pH of solutions like aerated drinks, fruit juices, shampoos and soaps
4. Preparation and measurement of the pH of the following buffer solutions and comparison of the values with theoretical values.
   (i) Sodium acetate-acetic acid
   (ii) Ammonium chloride-ammonium hydroxide

Recommended books:

1. *Alberty, R A, Physical Chemistry,4 theditionWiley Eastern Ltd ,2001.*
2. *Atkins,PW,the elements of physical chemistry,Oxford ,1991*
3. *Barrow,G .M,International student Edition .McGraw Hill, McGraw-Hill,1973.*
4. *Cotton,F.A, Wilkinson,G and Gaus,P. L ,Basic Inorganic Chemistry,3rd Edition ,Wiley 1995.*
5. *Lee,J.D, Concise Inorganic Chemistry 4th Edition ELBS,1977*
6. *Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).*
7. *Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd.*
8. *Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.*
9. *Carey, F. A., Guiliano, R. M.Organic Chemistry, Eighth edition, McGraw Hill Education, 2012.*
10. *Clayden, J., Greeves, N. &Warren, S. Organic Chemistry, 2nd edition, Oxford University Press, 2012.*

Semester-IV
Minor course 4 (MC-4): CH 401 M (Th)
Polymer Chemistry
Credits: 03, Full Marks: 75

Unit-I: Basics of polymeric materials (Credit-1, 15 L× 45 minutes)

Classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, texture of polymers, polymerization processes, degrees of polymerization. Bifunctional systems, Poly-functional systems; Polymerization reactions – addition and condensation, step growth, radical, chain growth, and coordination polymerizations. Copolymerization, polymerization techniques, olecular weight of polymers and their determination (Mn, Mw, Mv, Mz) by end group analysis, viscometry and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index. Glass transition temperature (Tg) and outlines of factors affecting glass transition temperature (Tg).

Unit II: Natural Polymers **(Credit-1, 15 L× 45 minutes)**

Introduction, classification, structure and applications of bio-polymers viz. cellulose, cotton, wool, silk, paper, natural rubber, collagen, hyaluroran- melanin, lignin. Monomers and polymers from renewable resource materials *viz*. castor oil, natural gums, oleo chemicals, cashew nut shell liquid, carbohydrates, furfural. Structure of Proteins, nucleic acids and polysaccharides.

UNIT-III: Synthetic polymers **(Credit-1, 15 L× 45 minutes)**

Preparation, structure, properties and applications of the polymers: polyolefins, polystyrene, polyvinyl chloride, polyvinyl acetate, polyacrylamide, fluoro polymers (Teflon), polyamides (nylon-6 and nylon 6,6). Thermosetting polymers - phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, conducting polymers (polyacetylene, polyaniline). Brief outline of biodegradable polymers. Manufacture, general properties and applications of styrene-bitadiene rubber (SBR), Polyisoprene, Polybutadiene, Butyl rubber, Ethylene –propylene rubber, Neoprene rubber, Speciality rubbers: Silicon rubbers, Nitrile rubbers, Polyacrylic rubbers –Polyurethane rubbers –Hypalon –Fluorocarbon elastomers – Thermoplastic elastomer,reclaimedrubber,foam rubber; Synthetic rubber - SBR - manufacturing process - comparison of properties of SBR withNR - compounding of SBR.

Minor course 4 (MC-4): CH 401 M (Practical)
Credit: 01, Full Marks: 25

1. Determination of surface tension by (i) drop number (ii) drop weight method.
2. Studies on the variation of surface tension of detergent solutions with concentration.
3. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugarat room temperature.
4. Studies on the variation of viscosity of sucrose solution with the concentration of solute.
5. Determination of molecular weight of polymer by viscometry.
6. Determination of acid value/saponification value of fats/oils/resin.

Recommended books:

1. *Mark, J.E. AlcockH.R.and Lampe, F.W.Contemporary Polymer Chemistry- Prentice Hall Publishers, 3rd Edition; 2005.*
2. *Charles E.Carroher Jr., Introduction to Polymer Chemistry-by CRC Press, Taylor &Francis, Boca Raton, 2010.*
3. *Lehninger, L., Nelson, D L., Cox, M.M Principles of Bio-Chemistry, 1970*
4. *Awapara, Introduction to Biological Chemistry, Prentice Hall,1968.*
5. *Saunders,K.J. Organic Polymer Chemistry –2nd Edition, Chapman & Hall.1973*
6. *Methven, J.M.Polymeric Materials from Renewable Resources – RAPR Technology Ltd., Pergamon Press, 4 (7) 1991.*
7. *Carrahar E.D. and Sperling, L.H. Polymer Applications of Renewable Resource Materials – by Plenum Press, New York (1981).*
8. *Bahadur, P. Sastry,N.V - Principles of Polymer Science- Narosa Publishing House.2002*

9. *Nayak P.L., Polymer Chemistry, Kalyani Publisher (2017).*
10. *Gowarikar, V. R. Sreedhar, J.; Viswanathan, N. V. Polymer Science 1st Edition,New Age International Publishers, 1986.*
11. *Ghosh, P. Polymer Science and Technology: Plastics, Rubber, Blends andComposites, 3rd Edition, McGraw Hill Education, 2010.*
12. *Hundiwale G.D., Athawale V.D., Kapadi U.R. and Gite V. V., Experiments in PolymerScience, New Age Publications (2009).*
13. *Malcohm P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed.*

Semester-V
Minor course 5 (MC-5): CH 501 M (Th)
Bimolecular chemistry
Credits: 03, Full Marks: 75

Unit I: Carbohydrates (Credit-1, 15 L× 45 minutes)

Classification of carbohydrates; reducing and non-reducing sugars; general properties of glucose and fructose, their open chain structure; epimers, mutarotation and anomers; mechanism of mutarotation, osazone formation; determination of configuration of glucose (Fischer's proof). Cyclic structure (Haworth projections) of glucose, fructose; inter conversions of sugars (ascending and descending of sugar series, conversion of aldoses to ketoses); linkage between monosachharides, structure of disacharrides (sucrose, maltose, lactose); metabolism of glucose.

Unit II: Amino acids, peptides and proteins (Credit-1, 15 L× 45 minutes)

Classification *of α-amino acids*, zwitter ion structure and isoelectric point; single and three letters code of amino acids; essential, glucogenic and ketogenic amino acids; introduction on peptides, N-terminal and C-terminal peptide residue, Determination of N-terminal amino acid (by DNFB and Edman method) and C–terminal amino acid (with carboxypeptidase enzyme) residues; total hydrolysis and partial hydrolysis of peptides; overview of primary, secondary, tertiary and quaternary structure of proteins; Protein denaturation/ renaturation; coagulation of proteins.

Unit III: Fats, oils and Lipids (Credit-1, 15 L× 45 minutes)

Introduction to oils, fats and fatty acids; classification of lipids, common fatty acids present in oils and fats, biological importance of fatty acids and lipids, essential fatty acids: ω-3and ω-6 fatty acids; mono and polyunsaturated fatty acids and their significance, trans fatty acids, Hydrogenation of fats and oils, Saponification value, acid value, iodine value; reversion and rancidity; metabolism fatty acids, oxidation of fatty acids (alpha, beta, and omega), ketone bodies and their significance; Structure, sources and functions of prostaglandins, biosynthesis of prostaglandins, inhibition of prostaglandin synthesis.

Minor course 5 (MC-5): CH 501 M (Practical)
Credit: 01, Full Marks: 25

1. Differentiate between a reducing/ non reducing sugar
2. Synthesis of Osazones from glucose and fructose
3. Detection of protein by the Biuret reaction.
4. Estimation of quantity of glycine by Sorensen's formylation method.
5. Determination of iodine value of an oil/fat

Recommended books

1. *Clayden, J.;Greeves, N.; Warren, S.;Wothers, P.Organic Chemistry, (2001) Oxford Univ. Press, Oxford.*
2. *Barrett G. C.and Elmore, D. T. Amino acids and peptides (2004), Cambridge University press.*
3. *Gustone, F. D. Fatty acid and Lipid Chemistry (1996), Wiley*
4. *Bhtani, S. P. Chemistry of Biomolecules (2010), CRC Press*
5. *R. J. Simmonds,Chemistry of Biomolecules : An Introduction, , RSC, 1992.*
6. *Lehninger Principles of Biochemistry, David L. Nelson and Michael M. Cox. 7th Edition. W H Freeman & Co (Sd). 2017.*
7. *Power C.B. and Chatwal. G.R. Biochemistry, Himalayan Publishing House. 4th edition 1999.*
8. *Vance, J.E Vance, D.E Biochemistry of Lipids, Lipoproteins and Membranes. Amsterdam: Elsevier (2002).*

Semester-VI
Minor course 6 (MC-6): CH 601 M (Th)
Chemistry of life process
Credits: 03, Full Marks: 75

Unit I: Bioinorganic Chemistry (Credit-1, 15 L× 45 minutes)

Essential metal ions present in biological systems and their role, classification of elements according to their action in biological system, basic bioenergetics, Structure and function of biological membranes, active transport of cations across membrane, Crown either complexes of Na and K, ionophores, Sodium /Potassium pump; carbonic anhydrase and carboxypeptidase. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, use of chelating agents in medicine; Pt-complexes as anticancer drugs, Iron and Haemoglobin.

Unit II: Enzyme Chemistry (Credit-1, 15 L× 45 minutes)

Enzymes and Mechanism of Enzyme Action: General aspects of enzymes; nomenclature, classification and specificity, isolation, purification and function of enzymes. enzyme specificity, active sites. Mechanism of enzyme action, factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, Kinetics of enzyme action – Michaeli's-Menten equation, Different plots for determination of K_m and V_{max} and their physiological significance; Enzyme regulation & drug design, Fischer's lock and key and Koshland's induced fit hypothesis.

Enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition). Enzymatic hydrolysis of peptides (carboxy peptidase, trypsin, chrymotrypsin and Lys C).

Unit III: Medicinal Chemistry (Credit-1, 15 L× 45 minutes)

Concepts of drugs, classification, Drug discovery, drug design and drug development; analogues and pro-drugs, soft drugs, Structure Activity Relationships (SAR) of drug molecules, Quantitative Structure Activity Relationship (QSAR); ADME; Synthesis and applications of aspirin, paracetamol, Chloramphenicol, Sulphonamides, Sulphanethoxazol, Sulphacetamide, acyclovir, Phenobarbital, Diazepam, Glyceryl trinitrate; an elementary concept on antibiotics; broad spectrum and narrow spectrum antibiotics. Medicinal values of curcumin (haldi), azadirachtin (neem), piperine (black pepper), vitamin C and essential oils.

Minor course 6 (MC-6): CH 601 M (Practical)
Credit: 01, Full Marks: 25

1. Preparation of Ni-DMG complex
2. Preparation of potash alum
3. Estimation of proteins by Lowry's method.
4. Preparation of Aspirin and its analysis.

Recommended books:

1. *Das, A. K., Bioinorganic Chemistry, Books & Allied Ltd, 2013*
2. *Bertini, Ivano G, Harry B, Lippard, S. J, Valentine, J.S. Bioinorganic Chemistry, University Science Books, CA, 1994.*
3. *Cowan, J.A. Inorganic Biochemistry: An Introduction, 2nd Edition, Wiley-VCH , 1997*
4. *Hanzlik, R. P. Inorganic Aspects of Biological and Organic Chemistry,, Academic Press, New York, 1976*
5. *Lehninger Principles of Biochemistry, David L. Nelson and Michael M. Cox. 7th Edition.* W H Freeman & Co (Sd). 2017.
6. *Bioorganic and Bioinorganic and Supramilecular Chemistry. P.S. Kalsi, New Age International (Pvt. Ltd.) 2nd edition 2010.*
7. *A. Kar, Medicinal Chemistry, New Age publication*

Semester-I

Interdisciplinary Course 1 (ID-1):
Fundamentals of Chemistry
Credits: 03
Full Marks: 100 (IA = 40 +ESE = 60)

Unit I: Atomic Structure and Periodicity of Elements (Credit-1, 15 L× 45 minutes)

Bohr's theory of atomic structure and its limitations, spectrum of hydrogen atom; de'Broglie equation, Heisenberg's Uncertainty Principle and its significance. Shapes of s, p, d and f orbital's. Pauli's exclusion principle, Hund's rule of maximum multiplicity, Aufbau principle and its limitations.

Periodic classification of elements on the basis of electronic configuration; Periodic properties – atomic radii, ionic radii, covalent radii; electron affinity, electronegativity, ionization enthalpy, factors affecting electron affinity and ionization enthalpy, applications of ionization enthalpy.

Unit II: Basics of Organic Chemistry (Credit-1, 15 L× 45 minutes)

Concept of hybridization, hybrid orbitals and molecular geometry, bond lengths, bond angles, bond energy, localized and delocalized chemical bonding, van der Waals interactions, Dipole moment; Electronic displacements: Inductive effect, resonance, mesomeric effects, hyper conjugation and their applications; acidity and basicity of organic compounds; Mechanism of Organic Reactions: homolytic and heterolytic bond fission, Types of reagents – electrophiles and nucleophiles, Types of organic reactions, examples of reactive intermediates – carbocations, carbanions, free radicals.

Unit II: Equilibrium (Credit-1, 15 L× 45 minutes)

Chemical Equilibrium: Equilibrium constant and free energy, thermodynamic derivation of law of mass action. Le-Chatelier's principle, reaction isotherm and reaction isochore– Clapeyron-Clausius equation and its applications.

Ionic Equilibrium: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis, Buffer solutions applications of buffer solutions.

Recommended books:

1. *Lee, J.D. Concise Inorganic Chemistry, Pearson Education 2010.*
2. *Selected Topics in inorganic Chemistry, Madan, Tuli*
3. *Singh J., YadavL. D.S., Advanced Organic Chemistry, Pragati Edition*
4. *Morrison, R.N. & Boyd, R.N. Organic Chemistry, Pearson Education.*
5. *Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003*
6. *P.C. Rakshit, Physical Chemistry*

Semester-III

Interdisciplinary Course 1 (ID-2):
Bimolecular Chemistry
Credits: 03
Full Marks: 100 (IA = 40 +ESE = 60);

Unit I: Biomolecules I (Credit-1, 15 L× 45 minutes)

Carbohydrates: Introduction, classification of carbohydrates; general properties of glucose and fructose, their open chain and cyclic structure; epimers and anomers; mutarotation, structure of disacharrides (sucrose, maltose, lactose); metabolism of glucose. Detection of carbohydrates.

Fats, oils and lipids: Introduction to oils, fats and fatty acids; classification of lipids, common fatty acids present in oils and fats, biological importance of fatty acids and lipids, essential fatty acids: ω-3 and ω-6 fatty acids; mono and polyunsaturated fatty acids and their significance.

Unit II: Biomolecules II (Credit-1, 15 L× 45 minutes)

Amino acids & Proteins: Introduction, classification *of* α-*amino acids,* Zwitter ion structure and isoelectric point; single and three letters code of amino acids; essential and non-essential amino acids; introduction on peptides, hydrolysis of peptides; overview of primary, secondary, tertiary and quaternary structure of proteins; protein denaturation/renaturation.

Enzymes: General aspects of enzymes, nomenclature, classification and specificity, function of enzymes. factors affecting enzyme action, co-enzymes and cofactors and their role in biological reactions, enzyme regulation & drug design, Fischer's lock and key hypothesis of enzymes activity. Some common digestive enzymes, intra-cellualar and extracellular enzymes. Enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

Unit III: Bioinorganic Chemistry (Credit-1, 15 L× 45 minutes)

Essential metal ions present in biological systems and their role, classification of elements according to their action in biological system, structure and function of biological membranes, active transport of cations across membrane, crown ether complexes of Na and K, ionophores, Sodium/Potassium pump; carbonic anhydrase and carboxypeptidase. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, use of chelating agents in medicine; Pt-complexes as anticancer drugs, Iron and Haemoglobin.

Recommended books:

1. Advanced General Organic Chemistry by Sachin Kumar Ghosh
2. Nelson, D.L. & Cox, M.M. Lehninger Principles of Biochemistry, W.H.Freeman,2013.
3. Organometallic and Bioinorganic Chemistry by Ajay Kumar

Semester-IV

Interdisciplinary Course 1 (ID-3)
Bimolecular Chemistry
Credits: 03
Full Marks: 100 (IA = 40 +ESE = 60);

Unit I: Polymers **(Credit-1, 15 L× 45 minutes)**

Introduction, classification of polymers (based on source and structure): cellulose, cotton, wool, silk, paper, thermosetting polymers and thermoplastic polymers. polythene, polystyrene, PAN, PVC, PTFE, synthetic rubber, Buna-S, Buna-N, Tyrelene, Glyptal, Nylon-66, Nylon-6,10, melamine, bakelite – their momoners and uses. Bio-degradable polymers, PHBV, Polyglycolic acid-Polylactic acid, Nylon2,6. Recycling of polymers and recycle codes.

Unit II: Medicinal Chemistry **(Credit-1, 15 L× 45 minutes)**

Concepts of drugs, classification of drugs, drug discovery, drug design and drug development; analogues and pro-drugs, soft drugs, ADME; drugs and medicines, Synthesis and applications of aspirin, paracetamol, chloramphenicol, sulphonamides, elementary concept on antibiotics; broad spectrum and narrow spectrum antibiotics. Medicinal values of curcumin (haldi), azadirachtin (neem), piperine (black pepper), vitamin C and essential oils.

Unit III: Chemistry in everyday life **(Credit-1, 15 L× 45 minutes)**

Cosmetics and perfumes:

A general study including uses of the following: Hair dye, hair spray, shampoo, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams).

Soap and detergents:

Soaps, detergents, properties of soap, soaps for different purposes- laundry soaps, toilet soaps, liquid soaps, transparent soaps, baby soaps, shaving soaps, medicated soaps. biodegradability of detergents, green detergents.

Shampoos: Ingredients and functions, different kinds of shampoos, Anti-dandruff, antilice, herbal and baby shampoos. Health effects of shampoos.

Food preservatives and additives: Classification, chemical composition and food preservation and processing. Permitted food additives and their role; antioxidants, colouring agents, sweeteners and dyes as food additives.

Fertilizer: General principles of plant nutrition: essential plant nutrients, functions of the essential elements, classification of commercial nitrogenous fertilizers viz. ammonium sulphate, urea, ammonia nitrate; phosphatic fertilizers viz. single super phosphate, triple superphosphate.

Recommended books:

1. K. J. Saunders, Organic Polymer Chemistry, An Introduction to the Organic Chemistry of Adhesives, Fibres, Paints, Plastics and Rubbers
2. Singh, H. & Kapoor, V.K. Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi, 2012
3. B. K. Sharma, Engineering chemistry, Krishna Prakashan Media.
4. M. Ash, I. Ash, Formulary of Detergents and Other Cleaning Agents, Chemical Publishing, 1999.
5. Jain, P.C. & Jain, M. Engineering Chemistry Dhanpat Rai & Sons, Delhi.
6. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut, *1996*

त्रिपुरा विश्वविद्यालय
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27.07.26
Dr. Amitava Saha
Member, BUGS, Chemistry

27-07-2026
Prof. Sudhan Debnath
Member , BUGS, Chemistry

Surajit Biswas
27/07/26
Dr. Surajit Biswas
BUGS, Chemistry

27.07.26
Dr. Kanti Rn Nath Bhowmik
BUGS, Chemistry

27.07.26
Dr. Samhita Bhowmik
BUGS, Chemistry

27/07/26
Prof. Utpal Ch. De
Chairman
BUGS & BPGS, Chemistry

27/07/26
Prof. Swapan Majumdar
Member
BUGS & BPGS, Chemistry

SYLLABUS FOR
FOURTH YEAR UNDERGRADUATE PROGRAMME
UNDER NEP – 2020
ACADEMIC SESSION 2026-27

27.07.26
Dr. Arghya Bhattacharyya
Member
BUGS & BPGS, Chemistry

27/7/26
Dr. Swapan Kr. Biswas
Member
BUGS & BPGS, Chemistry

27/07/2026
Dr. Anirban Chandra
Member
BUGS & BPGS, Chemistry

SYLLABUS

Fourth Year Course Structure as per NEP-2020

For Four Years B.Sc.Chemistry Honours

Chemistry Honours with/without Research

HONOURS WITH COURSE WORK ONLY (HONS WITHOUT RESEARCH)

Sem.	Courses	Course Code	Name of the Courses	Credits	Nature of Course*
VII	Major 17	CH701C	Advanced Inorganic Chemistry-I	4	Four major courses 16C (4x4C); One minor course of 4C Total Semester Credit = 20
	Major 18	CH702C	Advanced Organic Chemistry-I	4	
	Major 19	CH703C	Advanced Physical Chemistry-I	4	
	Major 20	CH704C	Chemistry Lab course - I	4	
		CH701M	Sustainable and Environmental Chemistry		

Sem.	Courses	Course Code	Name of the Courses	Credits	Nature of Course*
VIII	Major 21	CH801C	Selected Topics in Chemistry	4	Four major courses 16C (4x4C); One minor course of 4C Total Semester Credit = 20
	Major 22	CH802C	Application of Advanced Spectroscopic methods in Chemistry	4	
	Major 23	CH803C	Advanced organometallics and metal clusters	4	
	Major 24	CH804C	Chemistry Lab course - II	4	
	Minor 8	CH801M	Medicinal and Basic Forensic Chemistry	4	
		CH802M	Summer internship	4	

Course Structure under NEP-2020

4-Years B.Sc.-Chemistry Honours

Fourth Year

HONOURS WITH COURSE WORK & RESEARCH

Sem.	Courses	Course Code	Name of the Courses	Credits	Nature of Course*
VII	Major 17	CH701C	Advanced Inorganic Chemistry-I	4	Four major courses 16C (4x4C); One minor course of 4C Total Semester Credit = 20
	Major 18	CH702C	Advanced Organic Chemistry-I	4	
	Major 19	CH703C	Advanced Physical Chemistry-I	4	
	Major 20	CH704C	Chemistry Lab course - I	4	
		CH701M	Sustainable and Environmental Chemistry		

Sem.	Courses	Course Code	Name of the Courses	Credits	Nature of Course*
VIII	Major 21	CH 801C	Selected Topics in Chemistry	4	One major course (4C) + one minor course (4C); One Research Paper of 12C Total Semester Credit = 20
	Minor 8	CH 801C	Medicinal and Basic Forensic Chemistry	4	
		CH802M	Summer internship	4	
	Major 22 Research Project & Dissertation	CH805C	Research Paper	12	

N.B: For each 4 credit papers, the total marks are of 100 divided into 60 marks for End Semester Examination and 40 marks of In-Semester (Internal Assessment) Examination.

7th SEMESTER

Course Name: Advanced Inorganic Chemistry-I
Course Code: CH 701C
Nature of the Course: Chemistry Major-17
Total Credits: 4
Distribution of Marks: 60 (End Sem) + 40 (In-Sem)

Course Objectives

a) To develop a comprehensive understanding of the electronic structure, spectroscopy, and reaction mechanisms of coordination compounds.
b) To introduce the principles of inorganic photochemistry and bioinorganic chemistry, emphasizing their roles in energy, catalysis, and biological systems.
c) To enhance the ability to analyse the structure, properties, and applications of inorganic compounds using modern theoretical concepts.

Course Outcomes

After successful completion of the course, students will be able to:

1) Explain the electronic spectra, bonding, and magnetic properties of transition metal complexes using crystal field theory and related models.
2) Analyse ligand substitution, isomerization, and electron transfer reactions in coordination compounds based on mechanistic principles.
3) Describe the photophysical and photochemical behaviour of inorganic complexes and their applications in catalysis, sensing, and solar energy conversion.
4) Interpret the roles of metal ions in biological systems, including metalloproteins, metalloenzymes, metal-based drugs, and biomimetic complexes.

UNIT-I : Advanced Coordination Chemistry 15L

Metal-centered electronic spectra of transition metal complexes: microstates, determination of ground and excited state terms of dn ions, splitting of dn terms in octahedral and tetrahedral fields. Electronic absorption spectra of octahedral and tetrahedral complexes, Orgel diagrams (qualitative approach), Tanabe- Sugano diagrams (qualitative approach), Charge transfer spectra, calculation of Dq, B and ß values, selection rules, band intensities and band widths, spectra of high spin octahedral and tetrahedral complexes of d1 to d9 systems, Spectrochemical series; Adjusted crystal field theory, Nephelauxetic series, Application of Tetragonal distortion, Jahn-Teller effect in transition metal complexes.

UNIT-II: Inorganic Reaction Mechanism 15L

Thermodynamic and kinetic stability of metal complexes; labile and inert complexes; factors influencing the rates of ligand substitution reactions and energy profiles. Mechanisms of ligand substitution reactions: solvent exchange, aquation, anation and pseudo-substitution; dissociative (D), associative (A), interchange dissociative (Id) and interchange associative (Ia) mechanisms with experimental identification. Ligand substitution reactions in octahedral and square planar complexes; trans effect; acid and base hydrolysis reactions. Mechanisms of isomerization reactions: linkage isomerism, cis–trans isomerism, intramolecular and intermolecular racemization, Ray-Dutta and Bailar twist mechanisms. Electron transfer reactions: general characteristics, inner-sphere and outer-sphere mechanisms, self-exchange reactions and elementary aspects of Marcus theory.

UNIT-III: Inorganic Photochemistry 15L

Introduction to inorganic photochemistry; photophysical and photochemical processes; electronic excitation in transition metal complexes; ligand-field and charge-transfer excited states; characteristics and fate of electronically excited states; excitation modes, vibrational relaxation, internal conversion, intersystem crossing, excited-state lifetimes, quenching processes and intramolecular energy transfer. Selection rules, Jablonski diagram, fluorescence, phosphorescence, delayed fluorescence, photochromism, photosensitization and quantum yield. Photochemical reactions of coordination compounds including photosubstitution, photoinduced electron transfer and photoredox reactions of Cr(III), Co(III), Rh(III) and Ru(II)/Ru(III) complexes. Introduction to flash photolysis and time-resolved spectroscopic techniques.Luminescent transition metal complexes and factors affecting luminescence.Applications of inorganic photochemistry in molecular recognition, chemical sensing, photocatalysis, photochemical water splitting, CO_2 photoreduction and dye-sensitized solar cells.

UNIT-IV: Advanced Bio-inorganic Chemistry **15L**

Metalloporphyrins and dioxygen transport/storage proteins: structure, bonding, thermodynamics and kinetics of oxygen binding in haemoglobin and myoglobin; structure, thermodynamics and kinetics of oxygenation in hemerythrin and hemocyanin. Electron transport proteins: cytochromes, iron–sulphur proteins, blue copper proteins and other biological electron carriers; respiratory electron transport chain. Metalloenzymes: structure, mechanism and biological functions ofsuperoxide dismutase, catalase and nitrogenase. Photosynthesis and metal-containing photosynthetic systems: chlorophyll, Photosystem-I, Photosystem-II and photosynthetic electron transport chain. Biological nitrogen fixation and the nitrogenase enzyme system. Bioinorganic aspects of metal-based drugs with special reference to platinum and non-platinum anticancer agents. Bioinspired inorganic chemistry: design and applications of biomimetic model complexes.

Recommended books:

1. Inorganic Chemistry-Principles of Structure and Reactivity, 5th Edn. J. Huhee, E.A. Keiter, R.L.Keiter& O.K. Medhi Pearson Education, New Delhi.
2. Shriver & Atkins - Inorganic Chemistry, Atkins, Overton, Rourke, Weller, Armstrong, South Asia Edn. 5th Edn. Oxford University Press, 2010.
3. J. D. Lee, Concise Inorganic Chemistry (5thEdn) John Wiley & Sons (1996).
4. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley & Sons, Inc, New York, 1999.
5. B. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn, John Wiley & Sons, Inc., New York, 2001.
6. J. Huhee, E.A. Keiter, R.L. Keiter& O.K. Medhi-Inorganic Chemistry-Principles of Structure and Reactivity, 5thEdn..Pearson Education, 2007.
7. F. Basolo& R. G. Pearson, Mechanism of Inorganic Reactions, Wiley Eastern (1967)
8. Bioinorganic Chemistry (Bertini, Ivano; Gray, Harry B.; Lippard, Stephen J.; Valentine, JoanSelverstone), University Science Books, CA, 1994.
9. F. Basolo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Edn, Wiley, New York, 1967.
10. D. Katakis and G. Gordon, Mechanisms of Inorganic Reactions, John Wiley & Sons, New York, 1987.
11. R. G. Wilkinns, Kinetics and Mechanism of Reactions of Transition Metal Complexes, 2nd Edn, VCH, Weinheim, 1991.
12. W. Kaim and B. Schwederski, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, Wiley, New York, 1994.

13. I. Bertini, H. B. Gray, S. J. Lipperd and J. S. Valentine, Bioinorganic Chemistry, Viva Books Pvt. Ltd., New Delhi, 1998.
14. V. Balzani and V. Carassiti, Photochemistry of Coordination Compounds, Academic Press, New York, 1970.
15. A. W. Adamson and P. D. Fleischauer (Ed), Concept of Inorganic Photochemistry, Wiley, New York, 1975.
16. G. L. Geoffroy and M. S. Wrighton, Organometallic Photochemistry, Academic Press, New York, 1970.
17. A. R. Hollebone, C. H. Langford and N. Serpone, Inorganic Photochemistry, Coord. Chem. Rev., 1981, 39, 181.
18. D. Rendell and D. Mowthrope, Fluorescence and Phosphorescence Spectroscopy, John Wiley, New York, 1987.
19. C. E. Wayne and R. P. Wayne, Photochemistry, Oxford University Press, 1st Indian Edn, New Delhi, 2005.
20. J. R. Lakowicz, Principles of fluorescence spectroscopy, 3rd Edn, Springer, USA, 2006.

Course Name: Advanced Organic Chemistry-I
Course Code: CH 702C
Nature of the Course: Chemistry Major-18
Total Credits: 4
Distribution of Marks: 60 (End Sem) + 40 (In-Sem)

Course Objectives:

This course aimed to provide knowledge to the learner to

a) understand the advanced organic synthesis using special reagents involving silicon, phosphorous, boron and their applications in organic synthesis.

b) the course also aimed to focus to establish the reaction mechanism based on the formation of active intermediates.

Course Outcomes

After completion of the course students will be competent on the learning about the

1) formation reaction intermediates during the organic transformation
2) to understand and analyze the mechanisms of key name reactions involving
3) to design the synthetic plan of multifunctional molecules
4) understand about stereochemistry and conformational analysis of mono and polycyclic compouds
5) Special reagents in organic synthesis
6) Mechanistic aspects of various name reactions in synthetic organic chemistry.
7) About the stereochemistry non-tetrahedral carbons, fused ring systems, asymmetric synthesis
8) Various strategies adopted in organic synthesis

Unit I: Reactive intermediates **15L**

Structure, reactivity and stability of nonclassical carbocations, α-carbanions (silicon, phosphorous and sulphur stabilized), Rearrangement reactions involving carbocation (Wagner-Meerwein, Pinacol-Pinacolone rearrangement, Demjenov rearrangement, dienone-phenol rearrangement),carbenoids-Simon-Smith reaction;Generation, structure and stability of arynes; reactivity of arynes and synthetic applications;Methods of preparation, structure and stability of enamines; selectivity in the synthetic applications;Generation, structure and stability of radicals, radical- initiator, radical scavenger,type of radials, generation of radicals in unactivated position, tributyl tin hydride mediated radical reactions, exo- and endo cyclisation and applications; reactions involving diradicals.

Unit II: Advanced stereochemistry **15L**

Axial and planar chirality: stereochemistry of allenes, atropisomerism, biphenyls and spiro compounds; conformational analysis of cyclic compounds: mono and disubstitutedcyclohexanes, fused ring systems-decalins, hydrindane, perhydroanthracene, perhydrophenanthrene and cyclophanes; effect of conformation on reactivity, helicity; allylic strains, alkylketone effects, haloketone rule; methods of resolution, principles of asymmetric synthesis: Crams rule, Felkin-Anh model, Prelog's rule, asymmetric induction, enantio and diastereoselective synthesis; stereospecific synthesis, optical purity, determination of enantiomeric and diastereomeric excess.

Unit III: Strategies in organic synthesis **15L**

Protection-deprotection and retro-synthetic analysis; Designing of organic synthesis - Retrosynthetic and Disconnection approach; Synthons and retrons, strategies involving reversal of dipoles (umpolung of reactivity) and it's applications; linear and convergent synthesis, protection and deprotection strategies for common functional groups in organic synthesis; Various strategies for coupling carboxylic acids/amino acids with alcohols/amines; strategies related to solve the solubility issues of organic compounds in water and inorganic reagents in organic solvent; applications of crown ether and phase transfer catalyst in organic synthesis

Unit IV: Selective organic named reaction **15L**

Swern oxidation, Moffat oxidation, Henry reaction, Wittig reaction and Horner-Wordwoth-Emmons reaction (stabilized and non-stabilized ylide); Peterson's synthesis, McMurry olefination, Julia olefination, Nazarov cyclization, Pictet-Sprengler reaction, Passerini reaction, Ugi reaction, Shapiro reaction, Baylis-Hillman Reaction, Staudinger Reaction, Birch reduction, Fries rearrangement, Mitsonobu reaction, Yamaguchi esterification

Recommended books:

1. R. O. C. Norman and J. M. Coxon, Principles of organic synthesis, 3rd Edition, CRC Press.
2. P. A. Sykes, A Guidebook to Mechanism in Organic Chemistry, Longman Scientific, 1986.
3. T. W. Graham Solomons, Craig B. Fryhle, Scott A. Snyder, Organic Chemistry, John Wiley & Sons Inc.
4. W. Carruthers, *Some Modern Methods of Organic Synthesis,* Cambridge University Press
5. T. Laue and A. Plagens, Named OrganicReactions,2nd edition (2005), John Wiley & Sons Ltd**.**
6. H. O. House, Modern Synthetic Reactions, 3rd Edition (1992), Benjamin Publishing Co.
7. S. Warren, Organic Synthesis, Disconnection Approach, 1982, Wiley Interscience, NY
8. Francis A. Carey and Richard J. Sundberg, Advanced Organic Chemistry Part A and Part B.
9. T. Laue and A. Plagens, Named Organic Reactions,2nd edition (2005),John Wiley & Sons Ltd
10. J. March, Organic Chemistry, Structure, Reactions and Mechanisms, 4thedn, J. Willey
11. R.T. Morrison and R.N. Boyd, Organic chemistry, 6thedn, Prentice hall of India, New
12. Michael B. Smith & Jerry March, Advanced Organic Chemistry Reactions, Mechanisms, and Structure. (2013) Wiley-Interscience.
13. D. Nasipuri, Stereochemistry, Conformation and mechanism, 2ndEdn. John Wiley
14. E. L. Eliel, Stereochemistry of Carbon Compounds, Tata McGraw Hill, 2007.

15. S. Sengupta Basic Stereochemistry of Organic Moleclules, Book Syndicate Pvt. Ltd. 2nd Edn
16. P.S. Kalsi, Stereochemistry, Conformation and Mechanism, 8th Edition. New Age Int., 2015.
17. Reinhard Bruckner Advanced Organic Chemistry, Reaction Mechanisms (2002). Elsevier

Course Name: Advanced Physical Chemistry-I
Course Code: CH 703C
Nature of the Course: Chemistry Major-19
Total Credits: 4
Distribution of Marks: 60 (End Sem) + 40 (In-Sem)

Course Objectives:

a) Advanced understanding of chemical kinetics.
b) Understanding advanced electrochemistry.
c) Understanding of bonding phenomenon in light of quantum mechanics.
d) Understanding statistical thermodynamics at a basic level.

Course outcomes:

1) Thorough understanding of chemical kinetics.
2) Understanding electrochemistry of diluted and concentrated solutions at thermodynamic level.
3) Understanding of bonding and spectroscopic selection rules.
4) Understanding statistical mechanics and its application for determining thermodynamic properties.

Unit I: Chemical Kinetics **15L**

Determination of rate constants of very fast reactions: Stopped flow method, Relaxation Methods, Shock Tube Methods, Flash photolysis, steady-state approximation and detailed balance treatment for Composite reactions, Lindemann Hypothesis of unimolecular reactions, Derivation of Arrhenius equation from van't Hoff equation, Deviations from Arrhenius equation, Treatment of the pre-exponential factor in light of Collision theory of reaction rates.

Unit II: Electrochemistry **15 L**

Electrochemistry I: Activity in electrolytic solutions. Freezing point depression and the mean ionic activity coefficient. The Debye-Hückel theory for dilute ionic solutions (complete derivation) and correction for concentrated solutions Equilibrium in ionic solutions. Ion association.
Electrochemistry–II: Electrodics - The basic electrodic equation: Butler-Volmer equation, overpotential, polarizable and non-polarizable interfaces; Faradaic and non -faradaic Currents, Over-potentials, aspects of deviation from equilibrium. Electrical conductance of solutions; The Debye Hückel Önsagar equation for conductance (derivation); Conductance at high fields and high frequencies, Conductance in non-aqueous solvents. Fuel Cells: H_2-O_2 cell.

Unit III: Quantum Mechanics **15L**

Part A: Perturbation theory
Time-dependent treatment of Schrödinger equation, introduction to Bra-Kett formalism, perturbation theory, first order and second order perturbation, implications in the energy correction, origin of selection rules of spectroscopy (rotational, vibrational and Raman)
Part B: Bonding phenomenon in light of quantum chemistry
Born-Oppenheimer approximation, LCAO, Concept of molecular orbitals and hybridization, HOMO and LUMO of Hydrogen molecule.

Unit IV: Statistical Thermodynamics **15L**

Concept of probability, Boltzmann distribution (nondegenerate and degenerate cases). Independent subsystems and distinguishability. Review of partition function: Thermal De Broglie wavelength. Partition functions for electronic, nuclear, rotational and vibrational degrees of freedom. Thermodynamic quantities in terms of partition functions (translational, rotational, vibrational and electronic). Entropy of ideal gas. Gibbs paradox. Equilibrium constants (ideal gas reaction) in terms of partition function. The mathematical proof of the equipartition of energy principle. Specific heats of solids (C_p&C_v). Preliminary idea about Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac Statistics.

Recommended books:

1. G.W. Castellan, *Physical Chemistry*, (3rd volume) 1980. Wiley, New York.
2. D. A. MacQuarrie, *Quantum Chemistry*, (1983) Oxford University press,
3. Ira N. Levine, *Quantum Chemistry*, (1994)Tata McGraw Hill, New Delhi.
4. R. K. Prasad, Quantum Chemistry; New Age International, 2001.
5. K. L. Kapoor, Textbook of Physical Chemistry - Quantum Chemistry and Molecular Spectroscopy, Volume 4, 6th Edition, Macgraw Hill.
6. K. J. Laidler, *Chemical Kinetics*, 3rd edition, Pearson.
7. P.W. Atkins and J. de Paula, *Physical Chemistry*, 8thedition, Oxford University Press.
8. D. A. McQuarrie and J.D. Simon, *Physical Chemistry*, VIVA Students Ed. (2003).
9. J. O'M, Bockris and A. K. N. Reddy, *Modern Electrochemistry*, Vol.1&2 (1998), Plenum Press, New York.
10. S. Glasstone, *An Introduction to Electrochemistry*, East-West Press (Pvt.) Ltd.

Course Name: Chemistry Lab course - I
Course Code: CH 704C
Nature of the Course: Chemistry Major-20
Total Credits: 4
Distribution of Marks: 60 (End Sem) + 40 (In-Sem)

Course Objectives:

This course enables the students to
a) Familiarize themselves with potentiometric experiments.
b) Acquainted to various types of titrations necessary for determining various physical quantities.
c) Correlating theory of kinetics to experimental determination of order of chemical reaction.

Course outcomes:

1) Expertise in determining solubility product.
2)Expertise in determining dissociation constant by potentiometric method.
3) Expertise in determining order of chemical reaction and polarimetric technique.
4) Expertise in polarimetry.

Unit I: Inorganic Chemistry Lab Course-I (20 marks)

A. Quantitative Estimation of Metal Ions in Multicomponent Mixtures, Alloys, and Real Samples by Volumetric, Gravimetric, and Spectrophotometric Methods

Quantitative analysis of metal ions in synthetic mixtures, alloys, and selected real samples using volumetric (redox and complexometric), gravimetric, and spectrophotometric techniques. The experiments include:

1. Determination of Cu(II), Fe(II), and Zn(II) in a synthetic three-component mixture by selective EDTA complexometric titration using suitable masking and demasking agents.
2. Sequential estimation of Ca(II), Mg(II), and Zn(II) in a synthetic three-component mixture by EDTA complexometric titration.
3. Determination of Fe(II) and Cu(II) in a binary alloy mixture by redox titration following selective separation of the constituent metal ions.

B. Synthesis, Purification and Characterization of Selected Coordination Compounds

Preparation of selected coordination compounds by suitable synthetic methods, followed by purification, calculation of percentage yield, and characterization using appropriate physical, chemical, and spectroscopic techniques (Melting Point, IR, UV-Visiblespectroscopy, Molar Conductance &Magnetic susceptibility measurements):

1. Tris(acetylacetonato)manganese(III), $[Mn(acac)_3]$
2. Tris(acetylacetonato)iron(III), $[Fe(acac)_3]$
3. Synthesis of Mohr's salt by crystallization, followed by determination of percentage yield, characterization, and quantitative estimation of Fe^{2+} by permanganate titration

Unit II: Organic chemistry lab course I (20 marks)

The separation and identification of components present in a binary solid mixture of organic compounds. (Determination of physical properties such as melting point, color, odor, solubility and R_f values along with characteristic chemical tests for the identification of functional groups for each component are to be reported by the students in the answer scripts).**The following solid mixtures may be considered*:**

SL. No.	MIXTURE	SL. No.	MIXTURE
1	Benzophenone + D-Mannitol	10	Anthracene + Benzamide
2	Benzophenone + Salicylic acid	11	Anthracene + D-Mannitol
3	Benzophenone + Cinnamic acid	12	Anthracene + Salicyclic Acid
4	Succinic acid + Benzil	13	Biphenyl + Salicyclic Acid
5	Succinic acid + Anthracene	14	Biphenyl + Cinnamic acid
6	Succinic acid + Benzophenone	15	Biphenyl + D-Mannitol
7	Succinic acid + Biphenyl	16	Acenaphthene +4-amino benzoic acid
8	Salicyclic Acid + Benzil	17	Benzil +4-amino benzoic acid
9	Salicyclic Acid + Benzoin	18	4-hydroxy benzoic acid + Benzil

Unit III: Physical chemistry lab course I (20 marks)

a) Determination of the concentration of a sugar solution of unknown strength by polarimetry.
b) Kinetics of reaction between $KBrO_3$ and KI.
c) Determination of stoichiometry of complexation between Cu^{2+} and ammonia by titrimetric method.
d) Determination of rate constant of inversion of cane sugar by polarimetry.
e) Potentiometric titration of acetic acid with NaOH and determination of dissociation constant of acetic acid using quinhydrone electrode.
f) Determination of solubility product of PbI_2.

Recommended books:

1. D. P. Shoemaker, C. W. Garland & J. W. Nibler, *Experiments in Physical Chemistry*, 5thedition McGraw Hill.
2. A. Findlay,*Practical Physical Chemistry*, 9th Ed. (Revised by B.P. Levitt), Longman.
3. V. D. Athawala& P. Mathur,*Experimental Physical Chemistry*, New Age InternationalPublishers (2001).
4. J. Mendham, R. C. Danney, J. D. Barnes & M. Thomas. Vogel'sTextbook of Quanti-tative Chemical Analysis, Peterson Education (2000).
5. G. Marr& B. W. Rockett. Practical Inorganic Chemistry, Van Nostrand (1972).
6. G. Pass& H. Sutcliffe. Practical Inorganic Chemistry (2nd edn.), Chapman & Hill (1974)
7. G. Brauer, Ed., Handbook of preparative Inorganic Chemistry, Academic Press, Vol 2, 1965.
8. A. I. Vogel, A Text Book of Quantitative Inorganic Analysis, 3rd Edn, Longmans, London, 1961.
9. Principles of Instrumental Analysis by Douglas A. Skoog, F. James Holler, Stanley R. Crouch, 7th ed., Cengage Learning, 2018.

Course Name: Sustainable and Environmental Chemistry
Course Code: CH 701M
Nature of the Course: Chemistry Minor 7
Total Credits: 4
Distribution of Marks: 60 (End Sem) + 40 (In-Sem)

Course Objectives:

a) To demonstrate how sustainability considerations can impact on individual community's day to day activities.
b) To focus on the existing sustainable development tools and methods
c) To provide knowledge and understanding the basic concept of Sustainable Development (SD), the environmental, social and economic dimensions.
d) To provide in depth learning and analysis of factors that support to achieve sustainability and resilience in an individual level and in a community
e) To provide idea and concept of renewable sources of materials and its correlation with sustainability enhance critical thinking skills and evaluation of information sources
f) To demonstrate different segments of our environment, environmental pollution and pollution prevention etc.
g) To discuss the various aspects of the principles of green engineering and technology

Course outcomes:

1) Students will be able to discuss the conflicts which are involved in the sustainable development concept on the local, national as well as on the global scale.
2) To be able to identify different stakeholders in a challenge to sustainability, and analyze the political and economic structures that connect them.
3) Ability to assess the sustainable practices of any community based on metrics
4) To understand the principles of green engineering and technology
5) To learn about pollution using hazardous chemicals and solvents

Unit I: Sustainable Development - Society, Environment and Current challenges 15L

Introduction to sustainable development, current practices for sustainable development - its importance, need, impact and implications; evolution of sustainable development perspectives over the years; Brundtland Commission and its outcome; later UN summits (Rio summit, etc.) and outcome. Ecosystem & Sustainability: Fundamentals of ecology - types of ecosystems & interrelationships, factors influencing sustainability of ecosystems, ecosystem restoration - developmental needs. Introduction to sustainability & its factors, requirements for sustainability in food security and agriculture; Dimensions to sustainable development - society, environment, culture and economy; current challenges - natural, political, socio-economic imbalance; sustainable development initiatives and policies of various countries: global, regional, national, local; needs of present and future generation. Critical Perspectives on Sustainable Development: Resource management and implications on sustainable development - implications for valuation, risk assessment; integrated decision-making processes: Sustainable development and impact of climate change; Factors contributing to climate change, Sustainable development Goals (SDGs), Action Plan on Climate Change in Indian perspectives

Unit - II Sustainability and Renewable Resources 15L

Natural Resources- Types, importance, Causes and effects of depletion of natural resources (Forest Resources, Water Resources, Energy Resources, Land resources, Mineral resources; Impact of overexploitation of natural resources on the environment, optimum use of natural resources; Renewable and non-renewable sources of energy - thermal energy, nuclear energy, solar energy, wind energy, geothermal energy, biomass energy, hydropower energy and biofuel; Definition and advantages of advanced solar collectors; Solar water heater and Solar stills and their uses. Biomass: Overview of biomass as energy source; thermal characteristics of biomass as fuel. Wind energy: Current status and future prospects of wind energy. Wind energy in India. Energy Conservation and Management; Carbon Footprint-Sources of Emissions, Carbon Credits, Carbon Footprint Calculators; Global energy demand: historical and current perspective; Current and future energy use patterns in the world and in India; evolution of energy use over time; need for energy efficiency; energy conservation and sustainability; action strategies for sustainable energy mix and management from a future perspective.

Unit III: Environmental Chemistry 15L

Introduction- concept, terminology and environmental segments, Ozone depletion, the green-house effect and Global warming, El-Nino phenomenon. Micro-organism in aquatic chemical reactions, Eutrophication, Re-cycle of waste-water in process industry, Treatment of sewage and reuse of water in industry and agriculture, microbiologically mediated redox reactions and Nitrogen transformation by bacteria. Water pollutants: Water-quality parameters and standards: physical and chemical parameters (colour, odour, taste and turbidity, DO, BOD, COD etc.); industrial and waste-water treatment; Chemical hazards, chemical disasters, pollution of environment-man made, industrial, natural disasters, environmental biochemistry, toxicological chemistry; analysis of water and waste water, solid wastes and air pollution-Photochemical smog, Auto exhausts, Acid-rains, Air-quality standards. Toxic chemicals in the environments, Impact of toxic chemicals on enzymes, Biochemical effects of arsenic, cadmium, lead, mercury, carbon monoxide, nitrogen oxides, sulphur oxides, ozone, PAN, cyanide, pesticides, insecticides and carcinogens.

Unit – IV: Green Chemistry **15L**

Concepts, need and Principles of Green Chemistry; atom economy, E factor, reaction mass efficiency, and other green chemistry metrics, less hazardous chemical syntheses, designing safer chemicals, safer solvents and auxiliaries, design for energy efficiency, Green synthesis, clean routes, supercritical solvents, ionic liquids, green catalyst, auto-exhaust catalyst and clean technology. Development of new methods for organic synthesis such as Green Synthesis: use of sonochemistry, use of ionic liquids, use of microwaves, use of grind-stone and ball milling process, bio-catalysis. Selection of solvent: i) Aqueous phase reactions ii) Reactions in ionic liquids iii) Solid supported synthesis iv) Solvent free reactions, Green catalysts: i) Phase transfer catalysts (PTC) and ii) Biocatalysts. Microwave and Ultrasound assisted green synthesis: Aldol condensation, Cannizzaro reaction, Diels-Alder reactions, Strecker synthesis, Willaimson synthesis and Dieckmann condensation. Nanomaterials for water treatment, nanotechnology for renewable energy, nanotechnology for environmental remediation and waste management, nanotechnology products as potential substitutes for harmful chemicals, environmental concerns with nanotechnology

Recommended books:

1. D. Elliott, Sustainable Technology. Energy, Society and Environment, 1997 New York, Routledge Press.
2. T. P. Soubbotina, Our Common Journey: A Transition Toward Sustainability. National Academy Press, (2004).
3. J. Elliott, An Introduction to Sustainable Development. 4th Ed. Routledge, London (2012).
4. P. P. Rogers, K. F. Jalal, and J. A. Boyd. "An introduction to sustainable development." (2012).
5. J. D. Sachs, The Age of Sustainable Development. Columbia University Press, New York (2015).
6. J. Kerr, Introduction to energy and climate: Developing a sustainable environment. CRC Press, 2017.
7. Handbook of Environmental chemistry, Springer-Verlag, O. Hutzinger.
8. L.J. Fristschen, & L.W. Gay, Environmental Instrumentation, Springer-Verlag,.
9. P.T. Enastas and T.C. Williamson, Green Chemistry: Designing Chemistry for Environment, ACS,
10. Green separation processes, methods and application, Fonso, National Scientific Book Agency, Delhi-110053.
11. G.W. Vanloon, S.J. Duffer, Environmental Chemistry - A Global Perspective, (2000) Oxford University Press.
12. F.W. Fifield and W.P.J. Hairens, Environmental Analytical Chemistry, 2nd Edition, Black Well Science Ltd.
13. A.K. De, Environmental Chemistry, 4th Edition (2000), New Age International Private Ltd., New Delhi.
14. Peter O. Warner, Analysis of Air Pollutants, 1st Edition (1996), John Wiley, New York.
15. S.M. Khopkar, Environmental Pollution Analysis, 1st Edition (1993), Wiley Estern Ltd., New Delhi.
16. S.K. Banerji, Environmental Chemistry, 1st Edition (1993), Prentice-Hall of India,New Delhi
17. P. T. Anastas, J. Warner, Green Chemistry: Theory and Practice; Oxford University Press: London, 1998.
18. M. Doble, A. K. Kruthiventi, in Green Chemistry and Engineering, 2007
19. V. K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry, Anamalaya Publishers (2005).
20. P. T. Anastes& J. K. Warmer: Oxford Green Chemistry- Theory and Practical, University Press (1998).
21. A. S. Matlack: Introduction to Green Chemistry, Marcel Deckkar (2001).
22. M.C. Cann& M.E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington.
23. M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American Chemical Society, Washington .

8th SEMESTER

Course Name: Selected Topics in Chemistry
Course Code: CH 801C
Nature of the Course: Chemistry Major-21
Total Credits: 4
Distribution of Marks: 60 (End Sem) + 40 (In-Sem)

Course Objectives:

a) To provide the basic concepts of molecular and supramolecular chemistry and familiarize with self-assembly techniques, molecular recognition of various receptors like crown ethers, cyclophanes, cyclodextrins etc.
b) To learn about nano-particles, nano-materials, nano-devices etc.
c) To motivate the students to go for the advanced courses or career related to nanotechnology and nano-medicine.
d) To provide knowledge about the basic group theory and X-ray diffraction studies
e) To focus on thebasic of optical microscopy and electron microscopy; SEM and TEM imaging techniques and their working principle

Course Outcomes:

1) Supramolecular chemistry course provides detailed information about the theories andconcepts of supramolecular chemistry.
2) Students get to learn about the processing of energyand signals by molecular and supramolecular systems, molecular recognition and molecular scale mechanical devices. Thisknowledge is useful for the students to understand and advance in the area of supramolecularchemistry.
3) The students will also get knowledge about the nano-materials that have versatile biomedical applications, development of sensors and devices. The students learn about the synthesis, properties, characterization and bio-functionalization of nano-materials.
4) After completing this course, the learner will also be able know about Crystal system and crystal structure; Symmetry elements in crystals and X-ray diffraction
5) Basic of electron microscopy; SEM and TEM imaging techniques.

Unit I: Supramolecular Chemistry **15L**

Concepts and Languages of supramolecular chemistry - molecular to supramolecular chemistry: Factors leading to strong binding(non-covalent interactions);, Types of supramolecular interactions (Hydrogen bonding, vander Waal's interaction, π-stacking, CH-π, anion-π interaction); molecular receptors – design and principles; supramolecular aggregation; Molecular recognition – factors involved;Types of interactions between host and guest molecules;Thermodynamics of host-guest complexation; Enthalpy and entropy contributions, complexation free energies; Molecular receptors – for alkali metal ions, ammonium ions, anions and neutral molecules;Crown ethers, cryptands, spherands, siderophores and ionophores; Creation of rotaxanes, catenanes and cyclophanes, cyclodextrin and their application in specific recognition processes.; Supramolecular chemistry in inorganic perspective: Inorganic crystal engineering and design principle of metal organic framework (MOF) and inorganic-organic hybrid material. Metal guided self-assembly reactions, molecularknot with double helical complexes, Self-

assembly of polynuclear metal complexes. Application of supramolecular chemistry in catalysis, drug delivery, recognition/sensing and material science; Dendrimers as multi-electron storage devices.

Unit II: X-ray crystallography and Diffraction 15L

Form of solids, Lattice points, Reciprocal Lattice, Bravais Lattices, Unit Cells; Geometry of Crystals;Classification of unit cells, Crystal systems, Herman-Mauguin notation, Distinction between trigonal and hexagonal systems, Crystal planes and indices; Law of rational indices.

Space groups and equivalent positions: Screw axis, Glide planes, Space groups, Relationship between space groups, point groups, Equivalent positions, Special positions,

X-ray diffraction: Principles of X-Ray Diffraction, X-Ray Diffraction Methods, Bragg's law; Crystal systems and symmetry, stereographic projection of 32 point groups and space groups-Hermann–Mauguin notations, Primitive and non-primitive unit cells; Symmetry elements: isogonal symmetry groups and reciprocal lattice.; X-ray-instrumentation- Basics of X-Rays, Production and Detection of X-Rays, Data collection, data reduction, refinement and structure solution, Intensity of Diffracted Beams**;** Determination of Crystal structures, Precise Lattice Parameter Determination, Phase Diagram Determination, Ordered - Disordered Transformation, Qualitative and QuantitativePhase Analysis, Effect of Crystal Size on Diffracted X-Ray, Intensity Determination of Single Crystal.

Unit – III: Microscopy 15L

Introduction to Microscopy: types of microscopes, Optical microscopy- principles, imaging modes, components of optical microscope, concept of resolution, Abbe's equation, -confocal optical microscope, inverted and fluorescence microscope; Comparison between light and electron microscope,

Electron microscope-optical microscope versus electron microscop, brief history of electron microscope, interaction of electrons and matter, elastic and inelastic scattering of electrons; configuration of electron microscopes- electron gun, electron lenses, detectors, vacuum pumps

Atomic Force Microscopy (AFM)- basic principles, instrumentation, operational modes, applications, limitations. Scanning electron microscope (SEM): Instrumentation:, electron source; lenses and lens defects, apertures and resolution, electron detection and display, pumps and sample holders, calibration of imaging system, Energy Dispersive X-ray Analysis (EDX), sample preparation; Fundamentals of Transmission Electron Microscope- Instrumentation, working, forming diffraction patterns and images; principle of image contrast, bright field and dark field imaging, selected area Electron diffraction (SAED) and obtaining SAED, high-resolution TEM, grain boundary, phase boundary, and other imaging techniques; Reciprocal space; diffraction from crystals; diffraction from particles, and dislocation, indexing of diffraction patterns, specimen preparation for TEM

Unit IV: Nano Chemistry 15L

Background to Nano-science and Technology - Classifications of nano-structured materials, nano particles - quantum dots, Nano wires, nano-tubes. Synthesis of nanoparticle: Bottom-up Synthesis, Top-down Approach: Precipitation, Mechanical Milling, Colloidal routes, Self-assembly, sol-gel, electrochemical methods (cathodic and anodic processes), and ball milling, lithography.Characterization of nano particles-X-ray diffraction technique, Scanning Electron Microscopy, Transmission Electron Microscopy, Surface Analysis techniques, Raman XPS and EDAX. Properties and applications of nano materials: Electrical, optical, mechanical, chemical and magnetic properties of nanomaterials; Surface Plasmon resonance –

Fluorescence Resonance energy transfer (FRET). Applications of bio-functionalized nanomaterials – Optical and Electrochemical Sensing; drug delivery, Nanomedicine.

References Books:

1. A. Das, An Introduction To Supramolecular Chemistry, CBS Pub. (2023).
2. A. Katsuhiko and T. Kunitake, Supramolecular Chemistry - Fundamentals and Applications: Springer (2006).
3. S. Jonathan & J. Atwood, Supramolecular Chemistry; 2nd ed,Wiley India Pvt Ltd (2017).
4. G. A. Ozin , A. C. Arsenault, and L. Cademartiri, Nanochemistry: A Chemical Approach to Nanomaterials; RSC.
5. G. A. Ozin, A. C. Arsenault, L. Cademartiri and Jean-Marie Lehn, Concepts of Nanochemistry; 1st Edition, Wiley-Vch (2009).
6. A. R. West: *Solid State Chemistry and Its Applications*, John Wiley & Sons, 1989.
7. L. Smart and E. Moore, *Solid State Chemistry*, Chapman and Hall, 1992.
8. A. K. Cheetham and P. Day: *Solid State Chemistry Compounds*, Clarendon Press, Oxford 1992.
9. C. N. R. Rao and J. Gopalkrishanan: *New Directions in Solid State Chemistry*, Cambridge Univ. Press 1997.
10. D. B. Williams and C. B. Carter: *Transmission Electron Microscopy: A Textbook for Materials Science*, Plenum Press, New York, 1996.
11. B. D. Cullity: *Elements of X-ray Diffraction*, Eds: 2nd, Ad6985dison-Wesley, USA, 1959.
12. W. Zhou & Z. Linwang (editors), *Scanning Microscopy for Nanotechnology: Techniques and Applications.*

Course Name: Applications of Advanced Spectroscopic methods in Chemistry
Course Code: CH 802C
Nature of the Course: Chemistry Major-22
Total Credits: 4
Distribution of Marks: 60 (End Sem) + 40 (In-Sem)

Course Objectives

a) To provide students with a clear understanding of the structure, bonding, and chemical behaviour of metal carbonyls, nitrosyl complexes, and metal cluster compounds.
b) To familiarize students with the fundamental concepts governing boranes, carboranes, and metal–metal bonded systems, and their importance in modern organometallic chemistry.
c) To familiarize students with the fundamental concepts of EPR, multinuclear NMR, and Mössbauer spectroscopy and their significance in modern inorganic chemistry.
d) To enable students to use spectroscopic methods for understanding the structure, bonding, and electronic properties of inorganic and organometallic compounds.

Course Outcomes

Upon completion of the course, students will be able to:

1) Analyze and interpret EPR, NMR, Mass and Mössbauer spectroscopic data to characterize inorganic, Organic and organometallic compounds.
2) Relate spectroscopic observations to the electronic environment, bonding features, and structural characteristics of metal-containing systems.
3) Interpret the bonding, structure, and reactivity of metal carbonyls, nitrosyl complexes, and metal clusters using electron-counting and molecular orbital approaches.
4) Analyze the structures of boranes, carboranes, metalloboranes, and metal–metal bonded compounds by applying Wade–Mingos rules and related bonding concepts.

Unit I: Basics of NMR spectroscopy

15L

Spinning nuclear magnet, angular momentum of atomic nuclei and NMR activity, sensitivity of NMR active nuclei, gyro magnetic ratio and its significance, Larmor equation, precessional frequency, phenomenon of resonance (absorption and relaxation), relaxation phenomenon – magnetic vectors, relaxation process, spin-spin and spin-lattice relaxation, mechanism of spin lattice relaxation, (dipole-dipole, spin-rotation, quadrupolar relaxation, scaler coupling and chemical shift anisotropy), relaxation effects and broadening of signals, electric quadrupole relaxation and signal broadening, types of NMR (CW-NMR and FT-NMR), signal to noise (S/N) ratio – determination and techniques for S/N enhancement.

Unit II: Nuclear magnetic resonance spectroscopy for organic compounds 15L

General introduction of NMR handling, solvent and sample preparation for NMR study.NMR interpretations: chemical shift, internal standards, factors affecting the chemical shift, NMR shift reagents, coupling constant, spin-spin coupling *viz*vicinal and geminal coupling, long range coupling *viz* two bond coupling (2J) three bond coupling (3J), Karplus relationship, multiplicity of splitting and relative intensity of lines, spin decoupling. First order and second order spectra with various spin systems;Nuclear overhauser effect (NOE).

Resolution and multiplicity of 13C NMR, 1H-decoupling, noise decoupling, broadband decoupling; deuterium, fluorine, and phosphorus coupling; NOE signal enhancement, off-resonance, proton decoupling, structural applications of CMR; DEPT and INEPT experiments; introduction to 2D-NMR; COSY, HETCOR, HSQC, HMBC, NOESY, HOESY, ROESY spectra.

Applications of typical ^{1}H and ^{13}C-NMR techniquesin structure determination of different type of compounds. Magnetic resonance imaging (MRI).

Unit-III: Structural Analysis of Inorganic Complexes 15L

EPR: Principle of EPR and spin Hamiltonian (comparison to NMR spectra), instrumentation, representation of EPR spectrum, X-band and Q-band spectra, line width, hyperfine splitting, magnetically equivalent and nonequivalent sets of nuclei, g-anisotropy, spectra of simple organic free radicals: expected number of lines, intensities. Spectra of transition metal complexes(d^1 -d^9 ions), metal hyperfine anisotropic spectra, zerofield splitting, Kramers degeneracy, Application: structural information of organic radicals and inorganic molecules from EPR spectra.

NMR: Applications of multinuclear NMR spectroscopy (1H, 13C, 19F, 31P and 119Sn) in the structural characterization and bonding analysis of inorganic and organometallic compounds.

Mossbauer spectroscopy: Principles of Mössbauer spectroscopy; isomer shift, quadrupole splitting and magnetic hyperfine interactions; applications to iron and tin compounds.

Unit IV: Mass spectroscopy for organic compounds 15L

Introduction – basic theory, instrumentation and sample handling. Important terms: singly, doubly/multiple charged ions, metastable peak, base peak, isotopic mass peaks, relative intensity. Methods of generation of mass ions – electron impact (EI), chemical ionization (CI), electron spray ionization (ESI) and fast atom bombardment (FAB) techniques, TOF-MALDI and SELDI; Tandem mass spectroscopy, General fragmentation rules of various classes of organic molecules, including compounds containing

oxygen, sulphur, nitrogen and halogens; α-, β-, allylic and benzylic cleavage; McLafferty rearrangement, ortho effect etc., Recognition of M+ ion peak; Nitrogen rule; HDI, application of mass spectroscopy alone and in combination with other spectroscopic techniques.

Recommended books:

1. High-Resolution NMR Techniques in Organic Chemistry, Third Edition, 2016, by Timothy D.W. Claridge, Oxford, United Kingdom.
2. Organic Spectroscopy- Principles and Applications, Jag Mohan, Narosa publishing House.
3. Spectroscopic Methods in Organic Chemistry, By D.H. Williams, I. Fleming. Tata McGraw Hill Pub. Co. Ltd.
4. Organic Spectroscopy, 3rd Edn, By William Kemp. Published by Palgrave, NewYork.
5. R. S. Drago, Physical Methods in Inorganic chemistry, Saunders, Philadelphia, 1977.
6. C. J. Ballhausen, Molecular Electronic Structure of Transition Metal Complexes, McGraw-Hill, London.
7. A. B. P Lever, Inorganic Electronic Spectroscopy, Elsevier, New York, 1984.
8. A. Abragam and B. Bleaney, Electron Paramagnetic Resonance of Transition Metal Ions, Clarendon Press, Oxford, 1970.
9. N. M. Atherton, Principles of Electron Spin Resonance, Ellis Horwood/Prentice-Hall, HemelHempsted.
10. V. I. Goldanskii and R. H. Herber, Chemical Applications of Mossbauer Spectroscopoy, Academic Press, New York.
11. N. N. Greenwood and T. C. Gibb, Mossbauer Spectroscopy, Chapman and Hall, London.

Course Name: Advanced Organometallics and Metal Clusters
Course Code: CH 803C
Nature of the Course: Chemistry Major-23
Total Credits: 4
Distribution of Marks: 60 (End Sem) + 40 (In-Sem)

Course Objectives

a) To provide students with a clear understanding of the structure, bonding, and chemical behaviour of metal carbonyls, nitrosyl complexes, and metal cluster compounds.
b) To familiarize students with the fundamental concepts governing boranes, carboranes, and metal–metal bonded systems, and their importance in modern organometallic chemistry.

Course Outcomes

1) Synthesis, structure and reactivity of organometallic compounds
2) Application of organometallic reagents in organic and inorganic synthesis
3) Organometallic catalyzed reaction, catalytic cycles etc.
4) Preparations, structures and bonding of metal carbene complexes
5) Catalytic applications of organometallic complexes.
6) Fluxional properties of organometallic compounds.
7) Magnetic properties of inorganic compounds. Magnetic moments and Ground state terms for complexes.
8) Interpret the bonding, structure, and reactivity of metal carbonyls, nitrosyl complexes, and metal clusters using electron-counting and molecular orbital approaches.
9) Analyze the structures of boranes, carboranes, metalloboranes, and metal–metal bonded compounds by applying Wade–Mingos rules and related bonding concepts.

Unit I: Main group Organometallic Chemistry: 15L

Introduction, importance of organometallic compounds as reagents, additive and catalyst; Chemistry of organolithium, magnesium, zinc, copper, aluminium, cadmium and mercury - synthesis, structures and reactivity; selectivity of organocopper agent; higher order cuprate, synthesis of enones, mode of addition of organocopper to cyclohexenone system including effect of substation in cyclohexenones; Applications of main group organometallics in organic synthesis.

Unit II: Transition metal based Organometallics in organic synthesis 15L

Application of 18-electron and 16-electron rules to transition metal organometallic complexes, Ligands in organometallic chemistry; Synthesis, bonding and reactivity of Metal-alkyl, -alkene, -alkyne, -allyl, -carbene, -carbyne and -carbide complexes, Agostic interaction, Stereochemical non-rigidity and fluxional behaviour of organometallic compounds with typical examples; haptonumber-Chemistry of η1 to η8 complexes, sandwich and half-sandwich transition metal complexes; synthesis and reactivity. of organo-transition metal reagents of chromium, cobalt, iron, nickel, rhodium and palladium in organic synthesis; sandwich compounds and their reactivity, Synthesis and reactions of cyclopentadienyl metal carbonyls, cyclopentadienyl metal hydrides, cyclopentadienyl metal halides, arene metal group complexes, η6-arene-chromium tricarbonyl in organic synthesis.

Unit III - Catalysis and metathesis in organometallics: **15L**

Terminology in catalysis -Turnover, Turnover number, Turnover frequency or turnover rate; homogeneous and heterogeneous catalysis; Wilkinson's catalysis; Palladium catalyzed C–C coupling reactions-The Heek reaction, Suzuki-Miyaura coupling, Sonogashira coupling, Stille coupling, Kumadacoupling,Negishi coupling. Olefin Metathesis: Metal carbenes, Tebbe reagent, comparative account between Fischer and Schrock carbenes, synthesis of Grubbs' and Schrock catalysts, Mechanism of olefin metathesis, ring opening metathesis, cross metathesis, ring closing metathesis, ring opening polymerization metathesis, acyclic diene metathesis polymerization, enyne metathesis

Olefin polymerization and oligomerisation reactions: The Ziegler-Natta catalyst, site control and chain end control mechanisms, metallocene based catalysts, post metallocenes catalyst.

Unit IV: Metal carbonyls and metal clustures 15L

Transition metal π-acid complexes: π-acid ligands (CO, NO and tertiary phosphines), synergic bonding, structure, bonding, synthesis and reactivity of metal carbonyls, nitrosyl complexes and metal carbonyl hydrides. Metal carbonyl clusters: low- and high-nuclearity clusters, electron counting and bonding. Borane and carborane chemistry: structure and bonding of boranes, Lipscomb's topology, Wade–Mingos rules and skeletal electron counting; synthesis and structures of carboranes, metalloboranes and metallocarboranes. Metal–metal multiple bonding including quadruple bonds; molecular orbital description, structures and bonding in representative compounds.

Recommended books:

1. The Organometallic Chemistry of The Transition Metals. By Robert H. Crabtree, Yale University, New Haven, Connecticut. Published By John Wiley & Sons, Inc., Hoboken, New Jersey. Isbn 0-471-66256-9.
2. Organometallics in Synthesis - A Manual. Edited by Manfred Schlosser. Published by John Wiley & Sons Ltd.
3. Handbook of Functionalized Organometallics - Applications in Synthesis. Volume -1
   By Paul Knochel.Published by Wiley-VCH Verlag GmbH & Co.

4. Metallo-Organic Chemistry. By A.J. Pearson. John – Wiley & Sons.
5. Organotransition Metal Chemistry : Applications to organic synthesis, Stephen G Davies Pergman Press
6. Organolithiums: Selectivity for synthesis, Jonathan Clayden, Pergamon, 2002
7. R O C Norman and J M Coxon, Principles of organic synthesis, 3rd Edition, CRC Press.
8. Organometallic Chemistry- A Unified Approach, R. C. Mehrotra. And A.Singh,New Age International , Ltd. New, Delhi.
9. Advanced Inorganic Chemistry. F.A.Cotton, G. Wilkinson, C.A.Murillo and M. Bochmann, 5th Edition, Wiley Interscience, NewYork.
10. N. N. Greenwood & A. Earnshaw. Chemistry of the Elements, Pergamon Press (1984.
11. Shriver & Atkins - Inorganic Chemistry, Atkins, Overton, Rourke, Weller, Armstrong, South Asia Edn. 5th Edn. Oxford University Press, 2010.
12. The Organometallic Chemistry of The Transition Metals. By Robert H. Crabtree, Yale University, New Haven, Connecticut. Published By John Wiley & Sons, Inc., Hoboken, New Jersey. Isbn 0-471-66256-9.
13. Organometallics in Synthesis - A Manual. Edited by Manfred Schlosser. Published by John Wiley & Sons Ltd.
14. Handbook of Functionalized Organometallics - Applications in Synthesis. Volume -1
15. By Paul Knochel. Published by Wiley-VCH Verlag GmbH & Co.
16. Metallo-Organic Chemistry. By A.J. Pearson. John – Wiley & Sons.
17. Organotransition Metal Chemistry : Applications to organic synthesis, Stephen G Davies Pergman Press
18. Organolithiums: Selectivity for synthesis, Jonathan Clayden, Pergamon, 2002
19. R O C Norman and J M Coxon, Principles of organic synthesis, 3rd Edition, CRC Press
20. D. F. Shriver, H. D. Kaesz and R. D. Adams (Eds), The Chemistry of Metal Cluster Complexes, VCH, New York, 1990.
21. P. Braunstein, L. A. Oro and P. R. Raithby (Eds), Metal Clusters in Chemistry, Wiley-VCH, Weinheim, 1999.

Course Name: Chemistry Lab course - II
Course Code: CH 804C
Nature of the Course: Chemistry Major-24
Total Credits: 4
Distribution of Marks: 60 (End Sem) + 40 (In-Sem)

Course Objectives: This course enables the students to
a) Familiarize themselves with Quantitative Estimation of metal ions.
b) Acquainted to various synthesis, purification and characterization of selected coordination compounds.
c) Quantitative estimation of organic compounds.

Course outcomes: This course will equip the students to expertise
a) with Quantitative Estimation of metal ions in Multicomponent Mixtures, Alloys, and Real Samples by volumetric, gravimetric, and spectrophotometric methods
.b) in various synthesis, purification and characterization of selected coordination compounds.
c) in quantitative estimation of organic compounds.

Unit I: Inorganic chemistry lab course - II (20 marks)

A. Quantitative Estimation of Metal Ions in Multi component Mixtures, Alloys, and Real Samples by Volumetric, Gravimetric, and Spectrophotometric Methods

Quantitative analysis of metal ions in synthetic mixtures, alloys, and selected real samples using volumetric (redox and complexometric), gravimetric, and spectrophotometric techniques. The experiments include:

1. Estimation of Zn(II) in pharmaceutical formulations by EDTA titration.
2. Determination of iron in pharmaceutical iron tablets by permanganometric or dichromatometric titration.
3. Spectrophotometric determination of Fe(III), Cu(II), or Ni(II) in synthetic mixtures or real samples using suitable chromogenic reagents and calibration curve methods.

B. Synthesis, Purification and Characterization of Selected Coordination Compounds

Preparation of selected coordination compounds by suitable synthetic methods, followed by purification, determination of percentage yield, and characterization using appropriate physical, chemical, and spectroscopic techniques. Following successful synthesis and characterization, students shall quantitatively determine the metal content of the prepared coordination compound using suitable analytical methods, including volumetric (redox or complexometric) and gravimetric methods, wherever applicable. The experiments include:

1. Synthesis of potassium tris(oxalato)ferrate(III) trihydrate, $K_3[Fe(C_2O_4)_3]\cdot 3H_2O$, followed by quantitative determination of iron by redox titration and oxalate by permanganate titration.
2. Synthesis of bis(dimethylglyoximato)nickel(II), $Ni(DMG)_2$, followed by gravimetric determination of nickel.
3. Synthesis of tris(ethylenediamine)nickel(II) chloride, $[Ni(en)_3]Cl_2$, followed by complexometric determination of nickel(II).

Unit II: Organic chemistry Lab course - II (20 marks)

Quantitative estimation of organic compounds:

1. Estimation of glucose by titration using Fehling's solution; 2. Estimation of sucrose by titration using Fehling's solution; 3. Estimation of vitamin-C (reduced); 4. Estimation of saponification value of oil/fat/ester; 5. Estimation of aspirin

Organic preparations: (i) Photoreduction of benzophenone to benzopinacol (ii) pthalic anhydride to anthranilic acid (iii) Benzaldehyde to dibenzalpropanone(iv) Aniline to acetanilide using Zn dust/NaOAc (v) Hydantoin (vi) Benzil to Benzilic acid

Unit III: Physical chemistry lab course II (20 marks):

a. Verification of Lambert-Beer's law by UV-Vis spectrophotometry.
b. Determination of the stoichiometry of complexation between Fe^{3+} and salicylic acid by Job's method.
c. Determination of the equilibrium constant of ethyl acetate in acid catalyzed hydrolysis.
d. Kinetic study of decomposition of $K_2S_2O_8$ by KI & effect of added salts.
e. Potentiometric titration of Co(II) by $K_3[Fe(CN)_6]$ and determination of strength of Co(II) solution.

f. Conductometric titration of a triple mixture containing KCl, NH_4Cl and HCl by $AgNO_3$ and NaOH solution.

Recommended books:

1. D. P. Shoemaker, C. W. Garland & J. W. Nibler. *Experiments in Physical Chemistry* (5^{th}edn.), McGraw Hill (1989)
2. A. Findlay, Practical Physical Chemistry, 9^{th} Ed. (Revised by B.P. Levitt), Longman.
3. V. D. Athawala& P. Mathur,*Experimental Physical Chemistry*, New Age InternationalPublishers (2001).
4. J. Mendham, R. C. Danney, J. D. Barnes & M. Thomas. Vogel'sTextbook of Quanti-tative Chemical Analysis, Peterson Education (2000).
5. G. Marr& B. W. Rockett. Practical Inorganic Chemistry, Van Nostrand (1972).
6. G. Pass& H. Sutcliffe. Practical Inorganic Chemistry (2nd edn.), Chapman & Hill (1974)
7. G. Brauer, Ed., Handbook of preparative Inorganic Chemistry, Academic Press, Vol 2, 1965.
8. A. I. Vogel, A Text Book of Quantitative Inorganic Analysis, 3rd Edn, Longmans, London, 1961.
9. Principles of Instrumental Analysisby Douglas A. Skoog, F. James Holler, Stanley R. Crouch, 7th ed., Cengage Learning, 2018.

Course Name: Medicinal and Basic Forensic Chemistry
Course Code: CH 801M
Nature of the Course: Chemistry Minor 8
Total Credits: 4
Distribution of Marks: 60 (End Sem) + 40 (In-Sem)

Course Objectives:

a) Qualitative and Quantitative Analysis: Identify unknown substances and accurately determine their concentration using standard laboratory protocols.
b) Drug Classification: Understand the chemical makeup, classification, and physiological effects of controlled substances and illicit drugs.
c) Toxicokinetics and Dynamics: Study the absorption, distribution, metabolism, and excretion (ADME) of poisons and drugs in the human body.
d) Drug-Target Interactions: Understand the chemical basis of how drugs bind to receptors and interact with biological systems.
e) Structure-Activity Relationships (SAR): Analyze how slight chemical modifications in a drug's structure alter its efficacy, toxicity, and metabolism.

Course Outcomes:

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

1. Explain the principles, scope, and applications of forensic science and forensic chemistry in criminal investigations.
2. Demonstrate knowledge of crime scene management, evidence collection, preservation, documentation, and maintenance of the chain of custody.
3. Apply chemical principles for the examination of drugs, poisons, pesticides, petroleum products, alcohol, dyes, adulterants, and other forensic evidence.
4. Understand the chemistry, classification, forensic significance, and analytical approaches for explosives, improvised explosive devices (IEDs), post-blast residues, and fire debris.
5. Select and interpret appropriate instrumental analytical techniques for forensic examination of chemical and trace evidence.
6. Evaluate forensic analytical data and prepare scientifically sound reports suitable for legal and judicial proceedings.

Unit I: Medicinal Chemistry-I **15L**

Fundamentals of Medicinal Chemistry, Lipinski's Rule, Basics of Drug Discovery, Heterocyclic compounds as leads, understanding of pharmacokinetics (PK) and pharmacodynamics (PD). Lipinski's Rule of Five significance and Limitations; Disease Identification, Target Identification (Enzymes, Receptors, Ion channels, Nucleic acids, Transport proteins); Target Validation, Hit Identification - High-throughput screening (HTS), Virtual screening, Fragment-based drug discovery, Natural product screening; Lead Optimization- to improve Potency, Selectivity, Solubility, Stability, ADME properties, Safety; Preclinical Studies (Cell culture, Animal models) to evaluate Toxicity, Pharmacokinetics, Pharmacodynamics and Safety; Clinical Trials, Ethical considerations, Regulatory Approval.

Unit II: Medicinal Chemistry-II **15L**

Drugs and drug design -Concepts of drugs, classification, analogues and pro-drugs, theories of drug action, assay and metabolism of drugs; Drug design, theory of drug design, structure activity relationship (SAR), Quantitative structure activity relationship (QSAR); prodrugs and soft drugs; Synthesis and uses of the following drugs of different pharmacological activities: Trimethoprim, Meperidine, methadone, aminopyrine, ibuprofen, diclophenac, indomethacin, ethambutol, lidocaine, thiopental, diphenylhydramine, trimeprazine, dilliazem, methyldopa, atenolol, oxyprenol, isoniazid, 5-fluorouracil, metronidazole, fluconazole, sumatriptan, quinine, chloquine/hydroxychloroquine, albendazole, linezolid, ritonavir, papaverine, methotrexate, mavacoxib/celecoxib, efavirenz, valsartan.

Unit III: Forensic Chemistry-I **15L**

Introduction to Forensic Science, Forensic Chemistry - Definition, scope, objectives, and history of forensic science, Branches of forensic science, Role of forensic chemistry in criminal and civil investigations, Organization and functions of forensic science laboratories, Crime Scene Investigation-documentation, Collection, preservation, packaging, transportation, and storage of forensic evidence. Classification of forensic evidence: biological, chemical, physical, trace, and digital evidence. Forensic Chemistry- Sampling, preservation, and handling of chemical evidence, Principles of qualitative and quantitative forensic chemical analysis, Presumptive and confirmatory tests for chemical evidence, Analysis of Chemical Evidence, Examination of narcotic drugs and psychotropic substances, Analysis of poisons and toxic chemicals, Detection of pesticides and agrochemicals, Examination of dyes, inks, paints, polymers, and petroleum products, analysis of alcohol and volatile organic compounds, Detection of food adulterants and common household adulterants.

Unit IV: Forensic Chemistry-II **15L**

Explosives and Classification of explosives - low explosives, high explosives, primary and secondary explosives, properties, preparation, stability, and forensic significance of common explosive compounds: TNT (2,4,6-Trinitrotoluene), PETN (Pentaerythritol tetranitrate), RDX (Cyclotrimethylenetrinitramine), HMX(Cyclotetramethylenetetranitramine), ANFO (Ammonium Nitrate Fuel Oil), TATP (TriacetoneTriperoxide), Nitroglycerin (NG), Dynamite, Improvised Explosive Devices (IEDs): components, classification, and forensic examination. Fire and Arson Investigation, Chemistry of combustion and fire dynamics. Improvised Explosive Devices (IEDs) - components, classification and

forensic examination. Detection of inorganic explosive residues (common anions and cations) and organic explosive residues. Applications of Instrumental Methods in Forensic Chemistry - UV–Visible Spectroscopy, FTIR-Spectroscopy, TLC and High-Performance Thin Layer Chromatography (HPTLC), GC, GC–MS, HPLC, LC–MS, Atomic Absorption Spectroscopy (AAS), Inductively Coupled Plasma–Optical Emission Spectroscopy (ICP-OES), X-ray Diffraction (XRD), NMRSpectroscopy, Fluorescence Spectroscopy, Electrochemical methods (Potentiometry, Voltammetry, Conductometry), Thermal analytical techniques (TGA, DTA, DSC).

Recommended books:

1. Graham L. Patrick, An Introduction to Medicinal Chemistry, 7th Edition, Oxford University Press.
2. David J. Abraham (Ed.), Burger's Medicinal Chemistry, Drug Discovery and Development, 8th Edition, Wiley.
3. Camille G. Wermuth (Ed.), The Practice of Medicinal Chemistry, 5th Edition, Academic Press.
4. Wilson and Gisvold, Textbook of Organic Medicinal and Pharmaceutical Chemistry, 13th Edition, Lippincott Williams & Wilkins.
5. Foye's Principles of Medicinal Chemistry, 8th Edition, Lippincott Williams & Wilkins.
6. Suzanne Bell, Forensic Chemistry, 3rd Edition, Pearson.
7. Richard Saferstein, Criminalistics: An Introduction to Forensic Science, 13th Edition, Pearson.
8. Max M. Houck and Jay A. Siegel, Fundamentals of Forensic Science, 4th Edition, Academic Press.
9. Jacqueline Akhavan, The Chemistry of Explosives, 4th Edition, Royal Society of Chemistry.
10. Douglas A. Skoog, F. James Holler and Stanley R. Crouch, Principles of Instrumental Analysis, Cengage.

Course Name: Summer Internship
Course Code: CH 802M
Nature of the Course: Chemistry Minor 8
Total Credits: 4
Distribution of Marks: 60 (End Sem) + 40 (In-Sem)

Course Objectives

a) To Test classroom concepts in real-world business or industrial settings.
b) To Understand day-to-day functional operations and industry workflows.
c) To Improve communication, teamwork, and time management.
d) To Connect with industry mentors and professionals.

Course Outcomes

1) Would learn Solve real-world or industry-specific problems using technical skills.
2) Would learn workplace ethics, discipline, and corporate responsibility.
3) Would learn Compile comprehensive logs, project reports, and technical presentations.
4) Would be able to Identify personal strengths and form a focused

Guidelines of the course:

- Internships are to be completed during summer of 4 credits totaling 100 hours of work (minimum 75 hours on-site at the organization and remaining hours for report writing/evaluation). Allowed formats include on-site, virtual/online, or hybrid setups.

- Course may be done in any sector viz. Local government bodies, municipal corporations, panchayats, MSMEs, private firms, NGOs, R&D labs, and recognized artists or craftspeople.
- Students must secure prior written approval from their college principal or department head before starting.
- Submission of a hard and soft copy of the work report within 15 days of completion, along with an attendance/work certificate from the host mentor are to be submitted.
- Assesment may be done via internal or external examiners based on project quality, presentation, problem understanding, and a viva-voce examination.

For Chemistry Honours with Research

Course Name: Project Paper
Course Code: CH 805C
Nature of the course: Major
Total Credits: 12

Course Objectives:

This course enables the students

a) To know about the chemical research,
b) To learns about different techniques of reaction purification and drying of solvents.
c) Spectral interpretation and identification of compounds.
d) How to handling of sophisticated instruments like HPTLC, Rotary evaporator, IR, TGA, UV-Vis.
e) An ability to write project report and its presentation.

Course Outcomes:

At the end of the course, the students will be able to

1) Analyze the problems for which research can provide solutions and select the problem for research
2) Know the various chemical publishers, journals and perform literature survey.
3) Synthesize new chemical compounds through various methods.
4) Characterize the compounds using various analytical and spectroscopic studies

Project topics and process of evaluation

This paper is to be designed as Unit –I (4C): Literature Survey on assigned topic & Submission of Dissertation and Unit-II (8C): Work done on assigned topic & Submission of Dissertation. However, the marks will be as a whole as happened in other core papers comprising four different units. Students will be assigned a topic for a project under the supervision of a guide. The students are expected to complete a substantial literature studies followed by an own work on the assigned topic and submit the study reports in the form of a binding document to the Department through the guide. An open presentation is to be given before the faculties and the students of the department. Thereafter, the department will evaluate the overall write up and presentation of the students and award marks accordingly. .

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