UNIVERSITY OF NORTH BENGAL

Raja Rammohunpur, Dist. Darjeeling
Pin: 734 013, West Bengal, India

FYUGP syllabus

B.Sc. 4-YEAR UNDER GRADUATE PROGRAM (FYUGP) WITH CHEMISTRY AS **MAJOR** SUBJECT UNDER THE NEW CURRICULUM AND CREDIT FRAMEWORK, **2024**

WITH EFFECT FROM THE ACADEMIC SESSION

2024-2025

LAYOUT OF SYLLABUS FOR CHEMISTRY AS MAJOR SUBJECT

SEMESTER	*COURSE TYPE*	*PAPER DESCRIPTION*
1	MAJOR-1	ORGANIC CHEMISTRY-I
	MAJOR-2	INORGANIC CHEMISTRY-I
2	MAJOR-3	PHYSICAL CHEMISTRY-I
	MAJOR-4	ORGANIC CHEMISTRY-II
3	MAJOR-5	INORGANIC CHEMISTRY-II
	MAJOR-6	PHYSICAL CHEMISTRY-II
3	SEC	PHARMACEUTICAL CHEMISTRY
4	MAJOR-7	ORGANIC CHEMISTRY-III
	MAJOR-8	INORGANIC CHEMISTRY-III
5	MAJOR-9	PHYSICAL CHEMISTRY-III
	MAJOR-10	ORGANIC CHEMISTRY-IV
	MAJOR-11	INORGANIC CHEMISTRY-IV
	MAJOR-12	PHYSICAL CHEMISTRY-IV
6	MAJOR-13	ORGANIC CHEMISTRY-V
	MAJOR-14	INORGANIC CHEMISTRY-V
	MAJOR-15	PHYSICAL CHEMISTRY-V
	MAJOR-16	SPECTROSCOPY
7	MAJOR-17	RESEARCH METHODOLOGY
	MAJOR-18 (HONS. WITHOUT RESEARCH)	GREEN CHEMISTRY
	MAJOR-18 (HONS. WITH RESEARCH)	PROJECT/ DISSERTATION/ LITERATURE SURVEY
	MAJOR-19	PHYSICAL CHEMISTRY-VI
8	MAJOR-20	ORGANIC CHEMISTRY-VI
	MAJOR-21	INORGANIC CHEMISTRY-VI
	MAJOR-22 (HONS. WITHOUT RESEARCH)	BIOCHEMISTRY
	MAJOR-23 (HONS. WITHOUT RESEARCH)	POLYMER CHEMISTRY & ANALYTICAL CHEMISTRY
	MAJOR-22 (HONS. WITH RESEARCH)	PROJECT WORK
	MAJOR-23 (HONS. WITH RESEARCH)	PROJECT WORK

Semester-1

COURSE TYPE: MAJOR-1

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ101	ORGANIC CHEMISTRY-I
Credit	Paper Type
4	L
Paper Levels	Full Marks
100	80

COURSE TYPE: MAJOR-2

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ102	INORGANIC CHEMISTRY-I
Credit	Paper Type
4	L
Paper Levels	Full Marks
100	80

UNIVERSITY OF NORTH BENGAL

CHEMISTRY

Semester-I

MAJOR-1

Paper Code: CHEMMAJ101

Paper Description: ORGANIC CHEMISTRY-I

Paper Type: L (Credits: Theory-03, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

ORGANIC CHEMISTRY-I

UNIT I: Basics of Organic Chemistry

Hybridization of Organic compounds.

***Electronic Displacements*:** Inductive, electromeric, resonance and mesomeric effects, hyperconjugation; Organic acids and bases: their relative strength.

Homolytic and Heterolytic fission; Electrophiles and Nucleophiles; Types, shape and the relative stability of Carbocations, Carbanions, Free radicals, Carbenes and Nitrenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions (definition with examples). **(12 Lectures)**

UNIT II: Chemistry of Hydrocarbons

***Carbon-Carbon sigma bonds*:** Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation-relative reactivity and selectivity.

***Carbon-Carbon pi-bonds*:** Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions, Saytzeff and Hofmann eliminations.

***Reactions of alkenes*:** Electrophilic additions, their mechanisms (Markownikov/*Anti*-Markownikov addition), hydroboration-oxidation, ozonolysis, catalytic reduction, *syn*- and *anti*-hydroxylation (oxidation), addition reactions in conjugated dienes; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethylbenzene.

***Reactions of alkynes*:** Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes and Reduction reactions. **(21 Lectures)**

UNIT III: Aromatic Hydrocarbons

Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions, polynuclear hydrocarbons and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/ acylation with their mechanism. Directing effects of the groups. **(12 Lectures)**

Reference Books:

- Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry (Volume1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- McMurry, J. E. *Fundamentals of Organic Chemistry*, 7thEd. Cengage Learning India Edition, 2013.
- Claiden, J.; Warren, S. & Greeves, N. *Organic Chemistry*, 2nd Ed., Oxford University Press, 2012.
- Carruthers, W. *Some Modern Methods of Organic Synthesis*, 4th Ed., Cambridge University Press, 2004.
- Loudon, M. *Organic Chemistry*, Oxford University Press, 2002.
- Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, 6th Ed., Harlow, 1961.

PRACTICAL

ORGANIC CHEMISTRY-I **(30 HOURS)**

1. Checking the calibration of the thermometer.
2. Purification of organic compounds by crystallization using the following solvents:
   (a) Water; (b) Alcohol; (c) Alcohol-Water
3. Determination of the melting points of organic compounds.
4. Effect of impurities on the melting point-mixed melting point of Organic compounds.
5. (a) Preliminary characterization of aliphatic and aromatic compounds by ignition.
   (b) Detection of active unsaturation in organic compound.
   (c) Classification of acidic and alkaline compounds.

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Mann, F. G. & Saunders, B. C. *Practical Organic Chemistry*, Pearson Education, 2009.
- Furniss, B. S.; Hannaford, A. J.; Smith, P. W. G. & Tatchell, A. R. *Practical Organic Chemistry*, 5th Ed., Pearson, 2012.
- Vogel, A. *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson India, 2003.

Semester-I

MAJOR-2

Paper Code: CHEMMAJ102

Paper Description: INORGANIC CHEMISTRY-I

Paper Type: L (Credits: Theory-03, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

INORGANIC CHEMISTRY-I

UNIT I: Atomic Structure

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. 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 orbital energy with atomic number. **(14 Lectures)**

UNIT II: Periodicity of Elements

s, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block:

a. Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table
b. Atomic radii (van der Waals)
c. Ionic and crystal radii
d. Covalent radii (octahedral and tetrahedral)
e. Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy
f. Electron gain enthalpy, trends of electron gain enthalpy
g. Electronegativity, Pauling's /Mulliken's /Allred Rachow's /and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity **(16 Lectures)**

UNIT III: Chemical Bonding

(i) *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

(ii) *Covalent bond:* Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals, Bent's rule.

Molecular orbital theory. Molecular orbital diagrams of diatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions (idea of s-p mixing and orbital interaction to be given). 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) and bond lengths.

Fajan's rule of Ionic distortion and its application. **(15 Lectures)**

Reference Books:

- Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
- Douglas, B.E. and McDaniel, D.H. C*oncepts & Models of Inorganic Chemistry* Oxford, 1970.
- Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
- Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
- Huheey, J.E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry*, 4th Ed., Harper Collins College Publishers, 1993.
- Shriver and Atkins' *Inorganic Chemistry*, 5th Ed., Oxford University Press, 2009.
- Cotton, F.A.; Wilkinson, G.; Murillo, C.A. & Bachmann, M. *Advanced Inorganic Chemistry*, 6th Ed., Wiley-Interscience, New York, 1999.

PRACTICAL

INORGANIC CHEMISTRY-I: **(30 HOURS)**

1. Qualitative analysis of **water-soluble** mixtures-**four ionic species** (two cations and two anions), out of the following:
   Cations: Pb^{2+}, Cu^{2+}, Fe^{3+}, Al^{3+}, Ni^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Na^{+}, K^{+}, NH_4^{+}
   Anions: S^{2-}, SO_4^{2-}, NO_2^{-}, NO_3^{-}, Cl^{-}, Br^{-}, I^{-}
   Group analysis can be carried out but Cations can also be confirmed by special tests wherever feasible. (**Group analysis is not mandatory**)

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Mendham, J., A. I. *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson, 2009.
- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.

Semester-II

COURSE TYPE: MAJOR-3

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ203	PHYSICAL CHEMISTRY-I
Credit	Paper Type
4	L
Paper Levels	Full Marks
100	80

COURSE TYPE: MAJOR-4

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ204	ORGANIC CHEMISTRY-II
Credit	Paper Type
4	L
Paper Levels	Full Marks
100	80

Semester-II

MAJOR-3

Paper Code: CHEMMAJ203

Paper Description: PHYSICAL CHEMISTRY-I

Paper Type: L (Credits: Theory-03, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

PHYSICAL CHEMISTRY-I

UNIT I: Gaseous state

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation, Concept of temperature and Gas Laws from KTG. Collision Number, Collision frequency, Collision diameter, Mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η, variation of viscosity with temperature and pressure.

Maxwell distribution of speeds in one, two and three dimensions 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 and heat capacity from equipartition principle.

Behavior of real gases: Deviations from ideal gas behavior, compressibility factor, *Z*, and its variation with pressure for different gases. Causes of deviation from ideal behavior, van der Waals equation of state, its derivation and application in explaining real gas behavior, mention of other equations of state (Berthelot, Dietirici), virial equation of state, van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with Van der Waals isotherms, continuity of states, critical state, relation between critical constants and Van der Waals constants, law of corresponding states. **(22 Lectures)**

UNIT II: Liquid state

Physical properties of liquids, vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases, Liquid crystal (Preliminary Idea), Classification, phases, Properties and Applications. **(5 Lectures)**

UNIT III: Solid state

Nature of the solid state, 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, Bragg's law, a simple account of rotating crystal method and powder pattern method.

Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals. **(18 Lectures)**

Reference Books:

- Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry*, 10th Ed. Oxford University Press, 2014.
- Ball, D. W. *Physical Chemistry*, Thomson Press, India, 2007.
- Castellan, G. W. *Physical Chemistry*, 4th Ed. Narosa, 2004.
- Mortimer, R. G. *Physical Chemistry*, 3rd Ed. Elsevier, NOIDA, UP, 2009.
- Engel, T. & Reid, P. *Physical Chemistry*, 3rd Ed. Pearson, 2013.

PRACTICAL

PHYSICAL CHEMISTRY-I: *(any two)* **(30 HOURS)**

1. **Surface tension measurements:**

a. Determination of the surface tension of a liquid/ ethanol solution by Drop number method.

b. Determination of composition of an unknown solution by Drop Number Method using solutions of known composition (solutions of ethanol may be used).

2. **Viscosity measurement using Ostwald's viscometer:**

a. Determination of viscosity of aqueous solutions of polymer / ethanol / sugar at room temperature.

b. Determination of composition of an unknown solution by Ostwald Viscometer using solutions of known composition (solutions of ethanol, Sucrose may be used).

3. **Indexing of a given powder diffraction pattern of a cubic crystalline system.**

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Khosla, B. D., Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co. New Delhi, 2011.
- Garland, C. W., Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry*, 8th Ed. McGraw-Hill, New York, 2003.
- Halpern, A. M. & Mc Bane, G. C. *Experimental Physical Chemistry*, 3rd Ed. W.H. Freeman & Co. New York, 2003.

Semester-II

MAJOR-4

Paper Code: CHEMMAJ204

Paper Description: ORGANIC CHEMISTRY-II

Paper Type: L (Credits: Theory-03, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

ORGANIC CHEMISTRY-II

UNIT I: Stereochemistry

Tetrahedral carbon, chirality, Fischer Projection, Newman and Sawhorse Projection formulae, and their interconversions; Geometrical isomerism: *cis–trans* and *syn-anti* isomerism *E/Z* notations with C.I.P rules. *Re/Si* face, topicity: Homotopic, Heterotopic, Enantiotopic, Diasterotopic group. Optical activity, specific rotation, Chirality. Asymmetry/Disymmetry, Enantiomers, Molecules with two or more chiral centres, Distereoisomers, Meso compounds, Racemic modification and resolution. Relative and absolute configuration: D/L and *R/S* designations, *threo-erythro* form, Atropisomerism. **(12 Lectures)**

UNIT II: Cycloalkanes and Conformational Analysis

Conformation and physical properties, conformation of ethane, propane, and butane (including substituted variety). Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of cycloalkanes (cyclobutane, cyclopentane, cyclohexane, and mono and di-substituted cyclohexanes): Relative stability: Energy diagrams: Chair, Boat and Twist boat forms of cyclohexane and decalin. **(12 Lectures)**

UNIT III: Dynamic Stereochemistry

Introduction (Stereo-selective and stereo-specific reaction), dynamic stereochemistry of acyclic and cyclic molecules, nucleophilic substitution, elimination reactions and addition reactions. **(6 Lectures)**

UNIT IV: Chemistry of Halogenated Hydrocarbons

Alkyl halides: Naming and structure of alkyl halides, methods of preparation, allylic bromination of alkenes, nucleophilic substitution reactions–SN1, SN2, and *SNi* mechanisms with stereochemical aspects and effect of solvent; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts, nucleophilic aromatic substitution; SNAr, cine Substitution.

Relative reactivity of alkyl, allyl/benzyl, vinyl, and aryl halides towards nucleophilic substitution reactions. **(15 Lectures)**

Reference Books:

- Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*, Wiley: London, 1994.
- Kalsi, P. S. *Stereochemistry Conformation and Mechanism*, New Age International, 2005.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Clayden J, Greeves N & Warren S, *Organic Chemistry*, 2nd Ed. Oxford University Press Inc, New York, 2001.
- Carruthers, W. *Some Modern Methods of Organic Synthesis*, 4th Ed., Cambridge University Press, 2004

PRACTICAL

ORGANIC CHEMISTRY-II: (any three) **(30 HOURS)**

1. Detection of special elements in solid or liquid organic compounds.
2. Perform an Iodoform reaction with ethanol/Isopropanol/acetone/any suitable compound.
3. Preparation of Aryl halide involving diazonium salt.
4. Bromination of acetanilide by conventional method.
5. Bromination of acetanilide by green method (Bromate-bromide method).
6. Preparation of 1,3,5-tribromo benzene.

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Furniss, B.S. Hannaford, A.J. Smith, P.W.G. Tatchell, A.R. *Practical Organic Chemistry*, 5th Ed. Pearson, 2012.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education, 2009.

Semester-III

COURSE TYPE: MAJOR-5

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ305	INORGANIC CHEMISTRY-II
Credit	Paper Type
4	L
Paper Levels	Full Marks
200	80

COURSE TYPE: MAJOR-6

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ306	PHYSICAL CHEMISTRY-II
Credit	Paper Type
4	L
Paper Levels	Full Marks
200	80

COURSE TYPE: SKILL ENHANCEMENT COURSE

PAPER CODE	PAPER DESCRIPTION
POOCSEC339	PHARMACEUTICAL CHEMISTRY
Credit	Paper Type
4	L
Paper Levels	Full Marks
100	60

Semester-III

MAJOR-5

Paper Code: CHEMMAJ305

Paper Description: INORGANIC CHEMISTRY-II

Paper Type: L (Credits: Theory-02, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

INORGANIC CHEMISTRY-II

UNIT I: Chemical Bonding

Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment). Effects of chemical force, melting and boiling points, solubility energetics of dissolution process. **(15 Lectures)**

UNIT II: General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining. **(15 Lectures)**

UNIT III: Acids and Bases

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept. Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB). Application of HSAB principle. **(10 Lectures)**

UNIT IV: Oxidation-Reduction

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Principles involved in volumetric analysis to be carried out in class. **(5 Lectures)**

Reference Books:

- Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
- Douglas, B.E. & McDaniel, D.H. *Concepts & Models of Inorganic Chemistry*, Oxford, 1970.

- Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
- Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
- Douglas, B.E, McDaniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry*, 3rd Ed., John Wiley Sons, N.Y. 1994.
- Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.
- Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
- Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry*, 4th Ed., Pearson, 2010.
- Atkin, P. Shriver & Atkins' *Inorganic Chemistry*, 5th Ed. Oxford University Press, 2010.

PRACTICAL

INORGANIC CHEMISTRY-II: **(30 HOURS)**

1. Titrimetric Analysis:

(a) Calibration and use of apparatus

(b) Preparation of solutions of different Molarity/Normality of titrants

2. Acid-Base Titrations: (*any two*)

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

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

(c) Estimation of free alkali present in different soaps/detergents

3. Oxidation-Reduction Titrimetry: (*any one*)

(a) Estimation of Fe (II) and oxalic acid using standardized $KMnO_4$ solution.

(b) Estimation of oxalic acid and sodium oxalate in a given mixture.

(c) Estimation of Fe (II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Book:

- Mendham, J., A. I. *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson, 2009.

Semester-III

MAJOR-6

Paper Code: CHEMMAJ306

Paper Description: PHYSICAL CHEMISTRY-II

Paper Type: L (Credits: Theory-03, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

PHYSICAL CHEMISTRY-II

UNIT I: Chemical Thermodynamics

Objectives and limitations of thermodynamics, Some common thermodynamic terms – System, Surroundings, Boundary, Intensive and extensive variables, Thermodynamic equilibrium, Thermodynamic processes, partial derivatives, exact and inexact differential, state and path functions, isolated, closed and open systems, Zeroth law of thermodynamics.

First law: Concept of heat, q, work, w, internal energy, U, and statement of first law, enthalpy, H, the relation between heat capacities, 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. Joule's law and Joule-Thomson effect, Joule-Thomson coefficient, inversion temperature, relation between Joule-Thomson coefficient and other thermodynamic parameters, Comparison of isothermal and adiabatic expansion of an ideal gas.

Thermochemistry: 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, and resonance energy from thermodynamics data, Hess's law, the effect of temperature (Kirchhoff's equation) and pressure on enthalpy of reactions.

Second law: Limitations of first law – The need for second law, Concept of entropy, thermodynamics or Kelvin scale of temperature, statement of the second law of thermodynamics. Carnot's cycle, Efficiency of a heat engine, Carnot's theorem, Calculation of entropy change for reversible and irreversible processes (Clausius inequality), Entropy changes of an ideal gas, Entropy changes in physical change and adiabatic process, Clausius inequality applied to an isolated system, Clausius inequality applied to system and surroundings (entropy of universe), statement of the second law of thermodynamics in terms of entropy change, entropy of mixture of ideal gases.

Free Energy Functions: Gibbs and Helmholtz energy, variation of S, G, A with T, V, P, Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters, inversion temperature, Joule-Thomson coefficient for a van der Waals gas, Gibbs-Helmholtz equation, Maxwell relations, thermodynamic equation of state, Nernst heat theorem.

Third law: Statement of the third law, the concept of residual entropy, calculation of absolute entropy of molecules. **(25 Lectures)**

UNIT II: Systems of Variable Composition

Partial molar quantities, the dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, the chemical potential of ideal mixtures, change in thermodynamic functions in the mixing of ideal gases, concept of fugacity. **(7 Lectures)**

UNIT III: Solutions and Colligative Properties

Dilute solutions, lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions.

Thermodynamic derivation using the chemical potential to derive relations between the four colligative properties: (i) relative lowering of vapor pressure, (ii) elevation of boiling point, (iii) depression of freezing point, (iv) osmotic pressure and amount of solute. Applications in calculating molar masses of normal, dissociated, and associated solutes in solution. **(13 Lectures)**

Reference Books:

- Peter, A. & Paula, J. de. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
- Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa, 2004.
- Engel, T. & Reid, P. *Physical Chemistry*, 3rd Ed. Prentice-Hall, 2012.
- McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics*, Viva Books Pvt. Ltd. New Delhi, 2004.
- Assael, M. J., Goodwin, A. R. H., Stamatoudis, M., Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics*, CRC Press, NY, 2011.
- Levine, I .N. *Physical Chemistry*, 6th Ed., Tata Mc Graw Hill, 2010.
- Metz, C.R. *Solved problems in Chemistry*, Schaum Series, 2006.

PRACTICAL

PHYSICAL CHEMISTRY-II: (30 HOURS)

1. Thermochemistry: (*any three*)

a. Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
b. Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
c. Calculation of the enthalpy of ionization of ethanoic acid.
d. Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
e. Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
f. Determination of enthalpy of hydration of copper sulphate.
g. Study of the solubility of benzoic acid in water and determination of ΔH.

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Khosla, B. D., Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry*, R. Chand & Co., New Delhi, 2011.
- Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry*, New Age International, New Delhi, 2001.

Semester-III

SKILL ENHANCEMENT COURSE

Paper Code: POOCSEC339

Paper Description: PHARMACEUTICAL CHEMISTRY

Paper Type: L (Credits: Theory-02, Practical-01)

Total Marks: 60 [Theory (ESE – 40); Practical (ESE – 20)]

Theory: 30 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

PHARMACEUTICAL CHEMISTRY

UNIT I: Introduction

Drugs and medicines, classification of drugs, importance of drugs, working principle of drugs. Drug targets, binding with the targets, protein and nucleic acid as drug targets. **(4 Lectures)**

UNIT II: Drug Development

Screening of natural products, structure-activity relationship [The binding role of hydroxyl, amino groups, aromatic rings, and double bonds]; synthetic analogs, isosteres. **(6 Lectures)**

UNIT III: Synthesis and Applications of the Representative Classes of Drugs

Analgesic [Paracetamol, Aspirin], Antipyretic [Naproxen, Ibuprofen], Antidiabetic [Metformin], Antihypertensive [Captopril, Atenolol], Antibacterial [Sulfonamides, Penicillin, Chloramphenicol], Antimalarial [Chloroquine], Antiulcer [Pantoprazole], Antiviral agents [HIV

drugs], Cardiovascular (Glyceryl trinitrate), Anti-leprosy (Dapsone), Central Nervous System agents (Diazepam, L-DOPA). **(15 Lectures)**

UNIT IV: Vitamins

Biological importance of Vitamins (A, D, E, K, B, C, H). **(5 Lectures)**

Reference Books:

- Patrick, G. L. *Introduction to Medicinal Chemistry, Oxford University* Press, UK, 2013.
- Wermuth, C. G.; Aldous, D.; Raboisson, P.; Rognan, D. *The Practice of Medicinal Chemistry*, 4th Ed. Academic Press.
- Singh, H. & Kapoor, V.K. *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan, Pitampura, New Delhi, 2012.
- Foye, W.O., Lemke, T.L. & William, D.A.: *Principles of Medicinal Chemistry*, 4th ed., B.I. Waverly Pvt. Ltd. New Delhi.

PRACTICAL

PHARMACEUTICAL CHEMISTRY: (30 HOURS)

A. Practical: (*any two*)

1. Preparation of Aspirin and its analysis.
2. Preparation of magnesium bisilicate (Antacid).
3. Preparation of Milk of magnesia.
4. Preparation of methyl salicylate (oil of wintergreen).
5. Estimation of Ascorbic acid.
6. Assay of Ibuprofen by alkalimetry.

B. Field visit and Project Report Submission.

End Semester Examination (ESE):

At the end of the semester, a practical examination will be conducted as per the following guidelines.

Marks distribution

Experiment	10 marks
Project Work	05 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Beckett, A.H. & Stenlake, J.B. *Practical Pharmaceutical Chemistry*, Part 1, 4th Ed., CBS Publishers, 2005.
- Jenkins, G.L.; Knevel, A.M. & Digangi, F.E. *Quantitative Pharmaceutical Chemistry*, 6th Ed., CBS Publication, 2008.

Semester-IV

COURSE TYPE: MAJOR-7

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ407	ORGANIC CHEMISTRY-III
Credit	Paper Type
4	L
Paper Levels	Full Marks
200	80

COURSE TYPE: MAJOR-8

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ408	INORGANIC CHEMISTRY-III
Credit	Paper Type
4	L
Paper Levels	Full Marks
200	80

Semester-IV

MAJOR-7

Paper Code: CHEMMAJ407

Paper Description: ORGANIC CHEMISTRY-III

Paper Type: L (Credits: Theory-03, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

ORGANIC CHEMISTRY-III

UNIT I: Alcohols, Phenols, Ethers and Epoxides

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

Phenols: Preparation and properties; Acidity and factors affecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.

Ethers and Epoxides*:* Preparation [Ether: Williamson synthesis, Epoxidation (mCPBA, Darzens reaction, Corey-Chaykovsky Reaction, Sharpless epoxidation)] and reactions with acids and base. Reactions of epoxides with alcohols, ammonia derivatives, and $LiAlH_4$. **(15 Lectures)**

UNIT II: Carbonyl Compounds

Structure, reactivity and preparation of carbonyl compounds.

Nucleophilic additions, Grignard Reagents, Organo-Lithium, Nucleophilic addition-elimination reactions, ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Robinson annulation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, Swarn oxidation, Pinnick oxidation, use of PDC, PGC, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, MPV, Selective reduction using metal hydrides ($LiAlH_4$, $NaBH_4$, $NaCNBH_3$, DIBALH) Umpolung of reactivity. Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate. **(20 Lectures)**

UNIT III: Carboxylic Acids and their Derivatives

Preparation, physical properties and reactions of monocarboxylic acids. Basic structures 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,

Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann-bromamide degradation and Curtius rearrangement. **(10 Lectures)**

Reference Books:

- Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Clayden J, Greeves N & Warren S, *Organic Chemistry*, 2nd Ed. Oxford University Press Inc, New York, 2001.
- Graham Solomons, T.W *Organic Chemistry*, John Wiley & Sons, Inc.

PRACTICAL

ORGANIC CHEMISTRY-III: (any *three*) **(30 HOURS)**

1. Functional group tests: Alcoholic-OH, Phenolic-OH, carbonyl group and carboxylic acid group.
2. Identification of compounds by chemical reactions: Oxalic acid, Succinic acid, Tartaric acid, Citric acid, Cane sugar.
3. Qualitative analysis of unknown organic compounds containing Alcoholic-OH, Phenolic-OH, carbonyl group and carboxylic acid group.
4. Organic Preparation:(**any *three***)
   a) Acetylation of Salicylic acid, 2-Napthol / Benzoylation of 2-Napthol, Resorcinol, 4-Cresol etc.
   b) Synthesis of Benzillic acid from Benzil.
   c) Aldol condensation either by Conventional or by Green method.
   d) Perform Hydrolysis of an amides / ester into carboxylic acid.
   e) Preparation of S-Benzylisothiouronium salts of following carboxylic acids;
   a. Oxalic acid, Benzoic acid, Phenyl acetic acid, Phthalic acid.
   f) Preparation of Semicarbazone derivative of the following compounds;
   Acetone, Ethyl methyl ketone, Cyclohexanone, Benzaldehyde.

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education, 2009.

- Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry*, 5th Ed. Pearson, 2012.
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press, 2000.
- Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press, 2000.

Semester-IV

MAJOR-8

Paper Code: CHEMMAJ408

Paper Description: INORGANIC CHEMISTRY-III

Paper Type: L (Credits: Theory-03, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

INORGANIC CHEMISTRY-III

UNIT I: Chemistry of *s* and *p* Block Elements

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behavior of first member of each group. Allotropy and Catenation. Complex formation tendency of *s* and *p* block elements.

Hydrides and their classification, ionic, covalent and interstitial. Basic beryllium acetate and nitrate.

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses: Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, oxides and oxoacids of nitrogen, phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens. **(28 Lectures)**

UNIT II: Noble Gases

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6. Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2, XeF_4 and XeF_6). Molecular shapes of noble gas compounds (VSEPR theory). **(9 Lectures)**

UNIT III: Inorganic Polymers

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates, phosphazenes, and polysulphates.

(8 Lectures)

Reference Books:

- Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
- Douglas, B.E. & McDaniel, D.H. *Concepts & Models of Inorganic Chemistry*, Oxford, 1970.
- Day, M.C. & Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
- Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
- Douglas, B.E, McDaniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry*, 3rd Ed., John Wiley Sons, N.Y. 1994.
- Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.
- Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
- Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry*, 4th Ed., Pearson, 2010.
- Atkin, P. Shriver & Atkins' *Inorganic Chemistry*, 5th Ed. Oxford University Press, 2010.

PRACTICAL

INORGANIC CHEMISTRY-III: (30 HOURS)

1. **Qualitative Inorganic Analysis of mixtures containing *four* radicals:**
   Emphasis should be given to the understanding of the chemistry of different reactions.
   The following radicals are suggested:
   NO_3^-, NO_2^-, S^{2-}, $S_2O_3^{2-}$, Cl^-, Br^-, I^-, H_3BO_3, BO_3^{3-}, PO_4^{3-}
   Pb^{2+}, Cu^{2+}, Cd^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, NH_4^+, K^+, Na^+, Mg^{2+}
   Mixtures should preferably contain one interfering anion, **or** insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$ 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 or special tests should be done wherever feasible)

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- *Vogel's Qualitative Inorganic Analysis*, Revised by G. Svehla, Pearson Education,
  - 2002.
- Marr & Rockett, *Practical Inorganic Chemistry*, John Wiley & Sons, 1972.

Semester-V

COURSE TYPE: MAJOR-9

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ509	PHYSICAL CHEMISTRY-III
Credit	Paper Type
4	L
Paper Levels	Full Marks
300	80

COURSE TYPE: MAJOR-10

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ510	ORGANIC CHEMISTRY-IV
Credit	Paper Type
4	L
Paper Levels	Full Marks
300	80

COURSE TYPE: MAJOR-11

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ511	INORGANIC CHEMISTRY-IV
Credit	Paper Type
4	L
Paper Levels	Full Marks
300	80

COURSE TYPE: MAJOR-12

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ512	PHYSICAL CHEMISTRY-IV
Credit	Paper Type
4	L
Paper Levels	Full Marks
300	80

Semester-V

MAJOR-9

Paper Code: CHEMMAJ509

Paper Description: PHYSICAL CHEMISTRY-III

Paper Type: L (Credits: Theory-03, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

PHYSICAL CHEMISTRY-III

UNIT I: Ionic Equilibria

Arrhenius theory of electrolytic dissociation, 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, Multistage equilibria in acids and bases.

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.

Solubility and solubility product of sparingly soluble salts–applications of solubility product principle. Qualitative treatment of acid–base titration curves (calculation of pH at various stages). Theory of acid–base indicators, selection of indicators and their limitations. **(15 Lectures)**

UNIT II: Chemical Equilibrium

Criteria of thermodynamic equilibrium, Degree of advancement, Variation of free energy with advancement of reaction, chemical equilibria in ideal gases. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Thermodynamic derivation of relations between the various equilibrium constants, *Kp*, *Kc* and *Kx*. Le Chatelier principle (quantitative treatment), equilibrium between ideal gases.

(15 Lectures)

UNIT III: Phase Equilibria

Concept of phases, components and degrees of freedom, criteria for phase equilibrium, true and metastable equilibrium, derivation of Gibbs Phase Rule for nonreactive and reactive systems, Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour, and solid-vapour equilibria, phase transitions : first-order and second-order, the phase diagram for one component systems with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions.

Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes. Nernst distribution law: its derivation and application. **(15 Lectures)**

Reference Books:

- Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
- Ball, D. W. *Physical Chemistry*, Thomson Press, India, 2007.
- Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa, 2004.
- Mortimer, R. G. *Physical Chemistry*, 3rd Ed., Elsevier, NOIDA, UP, 2009.
- Engel, T. & Reid, P. *Physical Chemistry*, 3rd Ed., Pearson, 2013.
- Peter, A. & Paula, J. de. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
- McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics*, Viva Books *Pvt. Ltd*., New Delhi, 2004.
- Assael, M. J., Goodwin, A. R. H., Stamatoudis, M., Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics*, CRC Press, NY, 2011.
- Levine, I. N. *Physical Chemistry*, 6th Ed., Tata Mc Graw Hill, 2010.
- Peter Atkins & Julio De Paula, *Physical Chemistry*,10th Ed., Oxford University Press, 2014.
- Zundhal, S. S. *Chemistry Concepts and Applications*, Cengage India, 2011.
- Ball, D. W. *Physical Chemistry*, Cengage India, 2012.

PRACTICAL

PHYSICAL CHEMISTRY-III: **(30 HOURS)**

1. pH metry:(*any three*)

(a) Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.

(b) Preparation of buffer solutions of different pH

i. Sodium acetate-acetic acid **or**

ii. Ammonium chloride-ammonium hydroxide

(c) pH metric titration of

i. strong acid vs. strong base **or**

ii. weak acid vs. strong base.

(d) Determination of dissociation constant of a weak acid.

(e) Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.

(f) Distribution of acetic / benzoic acid between water and cyclohexane.

(h) Study the equilibrium of at least one of the following reactions by the distribution method:

(i) $I_2(aq) + I^- \rightarrow I_3^-(aq)^{2+}$

(ii) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n$

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment 15 marks

Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Khosla, B. D., Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand &Co., New Delhi, 2011.
- Garland, C. W., Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry*, 8thEd., McGraw-Hill, New York, 2003.
- Halpern, A. M. & Mc Bane, G. C. *Experimental Physical Chemistry*, 3rd Ed., W.H. Freeman & Co., New York, 2003.

Semester-V

MAJOR-10

Paper Code: CHEMMAJ510

Paper Description: ORGANIC CHEMISTRY-IV

Paper Type: L (Credits: Theory-03, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

ORGANIC CHEMISTRY-IV

UNIT I: Nitrogen-Containing Functional Groups

Preparation and important reactions of nitro, nitriles, isonitriles, and amides.

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 between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.

Chemistry of diazomethane and diazo acetic ester.

***Diazonium Salts*:** Preparation and their synthetic applications, **(10 Lectures)**

UNIT II: Heterocyclic Compounds

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one and more heteroatom(s); 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, Bischler-Napieralski reaction. **(20 Lectures)**

UNIT III: Amino Acids

Preparation of Amino Acids: Strecker synthesis, Gabriel's phthalimide synthesis.
Zwitterion, Isoelectric point, and Electrophoresis. Reactions of Amino acids: esterification of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

(7 Lectures)

UNIT IV: Nucleic Acids

Components of nucleic acids, Nucleosides and nucleotides; Structure of nucleic acid, base pairing in DNA, nucleic acids and heredity; Structure, synthesis, and reactions of Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides; protein biosynthesis. **(8 Lectures)**

Reference Books:

- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds*, John Wiley & Sons, 1976.
- Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Clayden, J.; Greeves, N.; Warren, S. & Wothers, P. *Organic Chemistry*, Oxford University Press.
- Joule, J.A. & Mill, K. *Heterocyclic Chemistry*, 5th Ed. John Wiley & Sons, Inc.

PRACTICAL

ORGANIC CHEMISTRY-IV: (*any three*) **(30 HOURS)**

1. Functional group tests: Amino, Nitro, amido/imido group.
2. Estimation of glycine by Sorenson's formalin method.
3. Study of titration curve of glycine.
4. Qualitative analysis of unknown organic compounds containing Amino, Nitro, amido/imido group. Bifunctional compounds may also be taken for analysis.
5. Organic Preparation: (*any two*)
   (a) Nitration of acetanilide/nitro benzene by conventional method.
   (b) Nitration of Salicylic acid by Green method (using CAN).
   (c) Selective reduction of m-Dinitrobenzene to m-Nitro aniline.
   (d) Reduction of p-Nitro benzaldehyde by sodium borohydride.
   (e) Synthesis of N-Heterocyclic compounds.

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education, 2009.
- Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry*, 5th Ed. Pearson, 2012.
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press, 2000.
- Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press, 2000.

Semester-V

MAJOR-11

Paper Code: CHEMMAJ511

Paper Description: INORGANIC CHEMISTRY-IV

Paper Type: L (Credits: Theory-03, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

INORGANIC CHEMISTRY-IV

UNIT I: Coordination Chemistry

Werner's theory, Valence bond theory (inner and outer orbital complexes), electro-neutrality principle and back bonding. Crystal field theory, measurement of 10 Dq (o), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (o, t). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry. Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes. **(21 Lectures)**

UNIT II: Transition Elements

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states

and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excluding their metallurgy). **(18 Lectures)**

UNIT III: Lanthanoids and Actinoids

Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only). **(6 Lectures)**

Reference Books:

- Purcell, K.F. & Kotz, J.C. *Inorganic Chemistry*, W.B. Saunders Co, 1977.
- Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.
- Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry*, Panima Publishing Company, 1994.
- Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley-VCH, 1999.
- Basolo, F, & Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
- Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.

PRACTICAL

INORGANIC CHEMISTRY-IV: (*any two*) (30 HOURS)

1. Iodo / Iodimetry Titrations:

a) Estimation of Cu (II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).

b) Estimation of available chlorine in bleaching powder iodometrically.

2. Permanganometry/Dichrometry Titration:

a) Estimation of Fe(II) and Fe(III) in a mixture by $KMnO_4$.

b) Estimation of Fe(II) and Fe(III) in a mixture by $K_2Cr_2O_7$.

3. Quantitative Estimation of:

a) Fe^{3+} and Cu^{2+}

b) Fe^{3+} and Cr^{3+}

4. Complexometric Titration:

a) Estimation of Copper in Chalcopyrites using standard EDTA solution.

b) Estimation of Calcium in milk using standard EDTA solution.

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Book:

- Mendham, J., A. I. *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson, 2009.

Semester-5

MAJOR-12

Paper Code: CHEMMAJ512

Paper Description: PHYSICAL CHEMISTRY-IV

Paper Type: L (Credits: Theory-03, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

PHYSICAL CHEMISTRY-IV

UNIT I: Quantum Chemistry

Brief description of Classical or Newtonian mechanics and failure of classical theory; Black-body radiation and classical theories of explanation; Planck's quantum concept and Planck's radiation law; Photoelectric and Compton effect; Wave-particle duality and de Broglie's hypothesis; Heisenberg's uncertainty principle; Theory of wave motion; Stationary waves; Origin of Quantum mechanics – Schrodinger equation (time independent), significance of wavefunction 'Ψ' and conditions of acceptable 'Ψ'; Operators; Eigenvalues and eigenfunctions – Hermitian property of operators and Properties of Hermitian operators; Important theorems; Normalised eigen functions; orthogonal and orthonormal wavefunctions; Basic postulates of Quantum mechanics.

Translational motion of a particle: Free particle system and 'particle in a one dimensional box' (rigorous treatment), quantisation of energy levels, zero-point energy and wavefunctions, probability distributions functions, nodal properties; Extension to two and three dimensional boxes, separation of variables and degeneracy.

Vibrational motion of a particle: Classical and Quantum mechanical treatment of simple harmonic oscillator model of vibrational motion (Qualitative treatment): Setting up of Schrödinger equation and discussion of solution and wave functions. Vibrational energy of diatomic molecules and zero-point energy. Physical interpretation of Ψ and Ψ^2. Comparison of Classical and Quantum mechanical results.

Rotational motion of a particle: Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.

Multielectronic Atoms: Setting up of Schrödinger equation for many-electron atoms (He, Li).

Approximation Methods: Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

Theory of Chemical Bonding: Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules. **(30 Lectures)**

UNIT II: Photochemistry

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, the physical significance of absorption coefficients.

Laws of photochemistry, quantum yield, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Fluorescence and Phosphorescence. Jablonski diagram. Stern-Volmer equation (Quenching of fluorescence) Role of photochemical reactions in biochemical processes, photo stationary states, chemiluminescence. **(15 Lectures)**

Reference Books:

- Chandra, A. K. *Introductory Quantum Chemistry*, Tata McGraw-Hill, 2001.
- House, J. E. *Fundamentals of Quantum Chemistry*, 2nd Ed. Elsevier, USA, 2004.
- Kakkar, R. *Atomic & Molecular Spectroscopy, Concepts & Applications*, Cambridge University Press, 2015.
- Lowe, J. P. & Peterson, K. *Quantum Chemistry*, Academic Press, 2005.
- Albini, A. *Photochemistry*, RSC, 44, 2016.

PRACTICAL

PHYSICAL CHEMISTRY-IV: (*any three*) (30 HOURS)

1. Verify Lambert-Beer's law and determine the concentration of $KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration.
2. Study the (200-500) nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture in a 0.1 M H_2SO_4 and determine the λmax values. Calculate the energies of the two transitions in different units ($Jmolecule^{-1}$, $kJmol^{-1}$, eV)
3. Study the kinetics of iodination of propanone in acidic medium.
4. Determine the amount of iron present in a sample using 1,10-phenathroline.
5. Determine the dissociation constant of an indicator (phenolphthalein).
6. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
7. Analysis of the given vibration-rotation spectrum of HCl(g).
8. Study the pH dependence of UV-Vis spectrum (200-500)nm of $K_2Cr_2O_7$.

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Linde, C.B.; Meuter, N.; Zeller, D. & Tausch, M.W. *Teaching Photochemistry: Experimental Approaches and Digital Media*, Wiley-VCH, 2021.

Semester-VI

COURSE TYPE: MAJOR-13

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ613	ORGANIC CHEMISTRY-V
Credit	Paper Type
4	L
Paper Levels	Full Marks
300	80

COURSE TYPE: MAJOR-14

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ614	INORGANIC CHEMISTRY-V
Credit	Paper Type
4	L
Paper Levels	Full Marks
300	80

COURSE TYPE: MAJOR-15

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ615	PHYSICAL CHEMISTRY-V
Credit	Paper Type
4	L
Paper Levels	Full Marks
300	80

COURSE TYPE: MAJOR-16

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ616	SPECTROSCOPY
Credit	Paper Type
4	L
Paper Levels	Full Marks
300	80

Semester-VI

MAJOR-13

Paper Code: CHEMMAJ613

Paper Description: ORGANIC CHEMISTRY-IV

Paper Type: L (Credits: Theory-03, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

ORGANIC CHEMISTRY-V

UNIT I: Alkaloids

Natural occurrence, General structural features, Isolation and their physiological action. Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine. **(11 Lectures)**

UNIT II: Terpenoids

Classification, Isoprene rule, Elucidation of structure and synthesis of Citral, Neral and α-terpinol, sesqui-, di- and tri-terpenoids. **(7 Lectures)**

UNIT III: Flavonoids

Synthesis and reactions of coumarin and chromones; Occurrence, Nomenclature and general methods of structure determination, Isolation and synthesis of Apigenin, Luteolin, Quercetin, Myrcetin Quercetin 3-glucoside, Vitexin, Diadzein, Butulin, Aureusin, Cyanidin-7-arabinoside, Cyanidin, Hirsutidin, Biosynthesis of flavonoids-acetate and shikimic pathway. **(12 Lectures)**

UNIT IV: Dyes

Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing; Synthesis and application of: Azo dyes- Methyl Orange and Congo Red (mechanism of Diazo Coupling); Triphenyl Methane dyes- Malachite Green, Rosaniline and Crystal Violet; Phthalein Dyes-Phenolphthalein and Fluorescein; Natural Dyes- Structure Elucidation and Synthesis of Alizarin and Indigotin; Edible dyes with examples. **(10 Lectures)**

UNIT V: Retrosyntheis

A brief introduction to retrosynthesis. **(5 Lectures)**

Reference Books:

- Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Singh, J. Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan, 2010.

PRACTICAL

ORGANIC CHEMISTRY-VI: (*any three*) **(30 HOURS)**

1. Preparation of Methyl orange.
2. Separation of a binary mixture containing an acid and a neutral compound (e.g Benzoic acid & Napthalene or any suitably chosen pair of compounds).
3. Separation of a binary mixture containing a basic and a neutral compound (e.g. Napthalene and 4-Toluidine or any suitably chosen pair of compounds).
4. Separation of a binary mixture containing Urea & Benzophenone.
5. Preparation of 7-Hydroxy-4-methyl coumarin using resorcinol and ethyl acetoacetate.
6. Extraction of Caffeine from tea leaves.
7. Extraction of Betalain from beetroot.
8. Extraction *d*-Limunine from peels of citrous fruit.

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Vogel, A.I. *Quantitative Organic Analysis*, Part 3, Pearson, 2012.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education, 2009.
- Furniss, B.S. Hannaford, A.J. Smith, P.W.G. Tatchell, A.R. *Practical Organic*
- *Chemistry*, 5th Ed., Pearson, 2012.
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press, 2000.
- Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press, 2000.

Semester-VI

MAJOR-14

Paper Code: CHEMMAJ614
Paper Description: INORGANIC CHEMISTRY-V
Paper Type: L (Credits: Theory-03, Practical-01)
Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]
Theory: 45 Lectures [Each Lecture is 1 hour in duration]
Practical: 15 classes [Each class is 2 hours in duration]

INORGANIC CHEMISTRY-V

UNIT I: Organometallic Compounds

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands.

***Metal carbonyls*:** 18 electron rules, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. pi-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain the extent of back bonding.

***Zeise's salt*:** Preparation and structure, evidence of synergic effect and comparison of synergic effect with that in carbonyls.

***Metal Alkyls*:** Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicenter bonding in these compounds. Role of triethylaluminium in polymerization of ethene (Ziegler-Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

***Ferrocene*:** Preparation and reactions (acetylation, alkylation, metalation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene. **(30 Lectures)**

UNIT II: Reaction Kinetics and Mechanism

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans-effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes. **(10 Lectures)**

UNIT III: Catalysis by Organometallic Compounds

Study of the following industrial processes and their mechanism:

1. Alkene hydrogenation (Wilkinsons' Catalyst)
2. Hydroformylation (Co salts)
3. Wacker Process
4. Synthetic gasoline (Fischer Tropsch reaction)
5. Synthesis gas by metal carbonyl complexes **(5 Lectures)**

Reference Books:

- Cotton, F.A.G., Wilkinson & Gaus, P.L. *Basic Inorganic Chemistry*, 3rd Ed. Wiley, India.
- Huheey, J. E., Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles of Structure and Reactivity*, 4th Ed., Harper Collins, 1993, Pearson, 2006.
- Sharpe, A.G. *Inorganic Chemistry*, 4th Indian Reprint, Pearson Education, 2005.
- Douglas, B. E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, 3rd Ed., John Wiley and Sons, NY, 1994.
- Lee, J.D. *Concise Inorganic Chemistry*, 5th Ed., John Wiley and Sons, 2008.
- Powell, P. *Principles of Organometallic Chemistry*, Chapman and Hall, 1988.
- Shriver, D.D. & P. Atkins, *Inorganic Chemistry*, 2nd Ed., Oxford University Press, 1994.
- Basolo, F. & Pearson, R. *Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution*, 2nd Ed., John Wiley & Sons Inc; NY.
- Purcell, K.F. & Kotz, J.C., *Inorganic Chemistry*, W.B. Saunders Co. 1977.
- Collman, J. P. et al. *Principles and Applications of Organotransition Metal Chemistry*, Mill Valley, CA: University Science Books, 1987.
- Crabtree, R. H. *The Organometallic Chemistry of the Transition Metals*, New York, NY: John Wiley, 2000.
- Spessard, G. O. & Miessler, G.L. *Organometallic Chemistry*, Upper Saddle River, NJ: Prentice-Hall, 1996.

PRACTICAL

INORGANIC CHEMISTRY-V: **(30 HOURS)**

1. Gravimetric Analysis: (*any one*)

(a) Estimation of Nickel (II) using Dimethylglyoxime (DMG).
(b) Estimation of Copper as CuSCN.
(c) Estimation of Iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.
(d) Estimation of Al (III) by precipitating with oxine and weighing as $Al(oxine)_3$(aluminium oxinate).

2. Inorganic Preparations:(*any four*)

(a) Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$
(b) *Cis* and *trans* $K[Cr(C_2O_4)_2(H_2O)_2]$ Potassium dioxalatodiaquachromate(III)
(c) Tetraamminecarbonatocobalt (III) ion
(d) Potassium tris(oxalate)ferrate(III)
(e) Cuprous Chloride, Cu_2Cl_2
(f) Preparation of Manganese(III) phosphate, $MnPO_4.H_2O$
(g) Preparation of Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Book:

- Mendham, J., A. I. *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson, 2009.

Semester-VI

MAJOR-15

Paper Code: CHEMMAJ614
Paper Description: INORGANIC CHEMISTRY-V
Paper Type: L (Credits: Theory-03, Practical-01)
Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]
Theory: 45 Lectures [Each Lecture is 1 hour in duration]
Practical: 15 classes [Each class is 2 hours in duration]

PHYSICAL CHEMISTRY-V

UNIT I: Chemical Kinetics

Rate of reaction, Factors influencing the rate of reaction, rate laws in terms of the advancement of a reaction, Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.

Temperature dependence of reaction rates, Arrhenius equation, activation energy. Collision theory of reaction rates, qualitative treatment of the theory of absolute reaction rates. **(20 Lectures)**

UNIT II: Catalysis

General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples), and heterogenous catalysis (catalytic steps and examples) and their industrial applications.

Enzyme catalysis, Michaelis-Menten mechanism, Acid-base catalysis.

Deactivation or regeneration of catalysts. Phase transfer catalysts, application of zeolites as catalysts. **(10 Lectures)**

UNIT III: Surface Chemistry

Physical adsorption, chemisorption, adsorption isotherms, nature of adsorbed state: Freundlich adsorption isotherm. Langmuir theory of adsorption. BET isotherm. Nature of adsorbed state. Gibbs adsorption isotherm and its application. **(5 Lectures)**

UNIT IV: Colloids

Classification, Preparation, Purification, Stability of colloids, Properties of colloids (optical, kinetic and electrical properties), Schulze Hardy Rule, Gold Number, Colloidal electrolytes and their properties, Iso-electric Point, Electrical double layer and Zeta Potential, Preliminary concept of Micelles, Emulsion and Gel. **(10 Lectures)**

Reference Books:

- Peter Atkins & Julio De Paula, *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
- Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa, 2004.
- Engel, T. & Reid, P. *Physical Chemistry*, 3rd Ed., Prentice-Hall, 2012.
- Zundhal, S.S. *Chemistry Concepts and Applications*, Cengage, India, 2011.
- Ball, D. W. *Physical Chemistry*, Cengage, India, 2012.
- Mortimer, R. G. *Physical Chemistry*, 3rd Ed., Elsevier, NOIDA, UP, 2009.
- Levine, I. N. *Physical Chemistry*, 6th Ed., Tata McGraw-Hill, 2011.
- Metz, C. R. *Physical Chemistry*, 2nd Ed., Tata McGraw-Hill, 2009.

PRACTICAL

PHYSICAL CHEMISTRY-V: (30 HOURS)

1. **Study the kinetics of the following reactions:(*any one*)**
   (a) Initial rate method: Iodide-persulphate reaction
   (b) Integrated rate method:
      i. Acid hydrolysis of methyl acetate with hydrochloric acid.
      ii. Saponification of ethyl acetate.
   (c) Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.
2. **Adsorption**
   Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Khosla, B. D., Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand &Co., New Delhi, 2011.
- Garland, C. W., Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry*, 8thEd., McGraw-Hill, New York, 2003.
- Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry*, 3rd Ed., W.H. Freeman & Co., New York, 2003.

Semester-VI

MAJOR-16

Paper Code: CHEMMAJ615

Paper Description: PHYSICAL CHEMISTRY-V

Paper Type: L (Credits: Theory-03, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

SPECTROSCOPY

UNIT I: Molecular Spectroscopy

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.

***Rotation spectroscopy*:** Rotational spectrum of rigid and non-rigid rotor, Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

***Vibrational spectroscopy*:** Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, selection rules for vibrational spectra, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

***Raman spectroscopy*:** Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

***Electronic spectroscopy*:** Franck-Condon principle, electronic transitions, singlet and triplet states, Jablonsky diagram, fluorescence and phosphorescence, dissociation and pre-dissociation, calculation of electronic transitions of polyenes using free electron model. **(23 Lectures)**

UNIT II: Organic Spectroscopy

General principles, Introduction to absorption and emission spectroscopy.

UV Spectroscopy: Types of electronic transitions, λmax, Chromophores and Autochromes, 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.

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin–Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds. Applications of IR, UV and NMR for identification of simple organic molecules.

***Electron Spin Resonance (ESR) spectroscopy*:** principle, hyperfine structure, ESR of simple radicals. **(22 Lectures)**

Reference Books:

- Kemp, W. *Organic Spectroscopy*, Palgrave.
- Pavia, D. L. et al. *Introduction to Spectroscopy*, *5th* Ed. Cengage Learning India Ed. 2015.
- Silverstein, R.M.; Webster, F. & Kiemle**.** D. *Spectrometric Identification of Organic Compounds*.
- Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. TataMcGraw-Hill: New Delhi, 2006.
- Kakkar, R. *Atomic & Molecular Spectroscopy*: *Concepts & Applications*, Cambridge University Press, 2015.

PRACTICAL

SPECTROSCOPY: **(30 HOURS)**

1. Identification of simple organic compounds by UV, IR, NMR spectroscopy. (At least spectral analysis of five compounds are recommended to consider).
2. Determination of absorbance of beet extract/ carotene/ butterfly pea extract /Hibiscus extract.

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Robinson, J.W. *Practical Handbook of Chemistry*, 1st Edition, CRC Press, 1991.
- Harrison, G.R. *Practical Spectroscopy*, Read Books, 2011.

Semester-VII

COURSE TYPE: MAJOR-17

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ717	RESEARCH METHODOLOGY
Credit	Paper Type
4	L
Paper Levels	Full Marks
400	80

COURSE TYPE: MAJOR-18
[FOR HONOURS WITHOUT RESEARCH]

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ718	GREEN CHEMISTRY
Credit	Paper Type
4	L
Paper Levels	Full Marks
400	80

COURSE TYPE: MAJOR-18
[FOR HONOURS WITH RESEARCH]

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ718	PROJECT/ DISSERTATION/ LITERATURE SURVEY
Credit	Paper Type
4	L
Paper Levels	Full Marks
400	80

COURSE TYPE: MAJOR-19

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ719	PHYSICAL CHEMISTRY-VI
Credit	Paper Type
4	L
Paper Levels	Full Marks
400	80

Semester-VII

MAJOR-17

Paper Code: CHEMMAJ717

Paper Description: RESEARCH METHODOLOGY

Paper Type: L (Credits: Theory-03, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

RESEARCH METHODOLOGY

UNIT I: Objectives of Research

Definition, objectives, types of research, classification, various phases of research. **(4 Lectures)**

UNIT II: Research Proposals and Literature Survey

Research proposal and aspects, Review of literature using appropriate sources – reviews, patents, research papers, books and e-resources. **(4 Lectures)**

UNIT III: Basic Principles of Research Design

Types of research designs – exploratory, descriptive, experimental, survey and case study. **(6 Lectures)**

UNIT IV: Laboratory & Chemical Safety

Introduction, Hazards in chemical laboratory: explosion and fire hazards, reactive reagents, toxic chemicals, electrical safety. Storage of samples, chemical waste disposal. **(5 Lectures)**

UNIT V: Experimental, Sampling Design and Data Collection

Purification: Filtration, recrystallization, sublimation, distillation (atmospheric pressure, vacuum, and steam), Chromatography: Theory and application of TLC, Column Chromatography, GC and HPLC, Reverse Phase Chromatography.

Sample - types, criteria, characteristics and steps.

Tools and techniques to execute experiments including working principle of UV, IR, NMR, HRMS, ESR, SEM, XRD, DSC, TGA, Viscometer, Pycnometer, Stalagmometer.

Observation, and data interpretation. **(18 Lectures)**

UNIT V: Interpretation, Report writing and the Art of Oral presentation

Report writing, format of publications in research journals, how to present papers and research findings. **(4 Lectures)**

UNIT VI: Ethics and Plagiarism in Research

Ethics - compliance and concerns;

Plagiarism; Introduction to Intellectual Property Rights; Citation and acknowledgement. **(4 Lectures)**

Reference Books:

- Cresswell, J. *Research Design: Qualitative and quantitative Approaches*, Thousand Oaks CA, 3rd Ed., Sage Publications, 2009.
- Kothari, C.R. *Research Methodology: Methods and Techniques*, 2nd Ed., New Age International Publishers, 2004.

- Kumar, R. *Research Methodology: A Step-by-Step Guide for Beginners*, 5th Ed., SAGE Publisher, 2011.
- Walliman, N. *Research Methods: The Basics*, 2nd Ed., London, New York: Routledge, 2017.
- WHO *Health Research Methodology – A Guide for Training in Research Methods*, 2001.
- Kemp, W. *Organic Spectroscopy*.
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G. & Tatchell, A.R. *Vogel's Textbook of Practical Organic Chemistry*.

PRACTICAL

RESEARCH METHODOLOGY: **(30 HOURS)**

1. Writing of a mini-review paper **or**
   Design of a research survey on a specific problem.
2. Idea presentations in small groups.
3. Spectral analysis and working area of different instruments mentioned in UNIT-V.

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Review paper or Research Design	05 marks
Oral Presentation	12 marks
Practical record notebook	03 marks

Reference Books:

- Cresswell, J. *Research Design: Qualitative and quantitative Approaches*, Thousand Oaks CA, 3rd Ed., Sage Publications, 2009.
- Kumar, R. *Research Methodology: A Step-by-Step Guide for Beginners*, 5th Ed., SAGE Publisher, 2011.
- Walliman, N. *Research Methods: The Basics*, 2nd Ed., London, New York: Routledge, 2017.
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G. & Tatchell, A.R. *Vogel's Textbook of Practical Organic Chemistry*.

Semester-VII

MAJOR-18

Paper Code: CHEMMAJ718
[FOR HONOURS WITHOUT RESEARCH]
Paper Description: GREEN CHEMISTRY
Paper Type: L (Credits: Theory-03, Practical-01)
Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]
Theory: 45 Lectures [Each Lecture is 1 hour in duration]
Practical: 15 classes [Each class is 2 hours in duration]

GREEN CHEMISTRY

Green Chemistry – Overview, Set of principles of green chemistry, Green synthetic methods, Green chemistry metrics: atom economy, percent yield, reaction mass efficiency, environmental factor, organic synthesis in aqueous media, Ionic liquids, Supercritical liquids, microwave-assisted organic reactions, Principle of sonochemistry, Solvent-free organic reactions, Solid phase organic synthesis, Merrifield synthesis. The art of catalysis, metal-catalyzed organic reactions, and characteristics of transition metals make them suitable as catalysts, as well as homogeneous and heterogeneous catalysis. Catalyst and molecular activation, Catalytic reaction and the 16 electron rule, Catalysts for fine chemical synthesis, transition metal ion catalysts for organic transformations involving catalytic reductions, oxidations, carbon-carbon bond formation, hydrolysis, and their applications in epoxidation of alkenes, isomerization of unsaturated molecules, Alkene Metathesis, Oligomerisation and polymerization (Zeigler Natta polymerization), olefin oxidation (Wacker Process), Hydroformylation (oxoreaction), Fischer-Tropsch Reaction, Monsanto Acetic Acid Process, and Reppe Carbonylation. **(45 Lectures)**

Reference Books:

- Lancaster, M. *Green Chemistry, An Introductory Text*, 3rd Edition, RSC, 2016.
- Anastas, P.T. & Warner, J.C. *Green Chemistry Theory and Practice*, Oxford University Press, 1998.
- Anastas, P. *Handbook of Green Chemistry*, Wiley-VCH, New York, 2010.
- James, C. & MacQuarrie, D. *Handbook of Green Chemistry and Technology*, Blackwell Science, Malden, MA, 2002.
- Horvath, I.T. & Anastas, P.T. *Innovations and Green Chemistry*, *Chemical Reviews*, **107**, 2169-2173, 2007.
- Lancaster, M. *Green Chemistry*, Royal Society of Chemistry, London, 2002.
- Matlack, A. *Introduction to Green Chemistry*, 2nd ed., CRC Press, Boca Raton, FL, 2010.

PRACTICAL

GREEN CHEMISTRY: (*any four*) **(30 HOURS)**

1. The Grignard reaction
2. The Esterification reaction
3. The Alcohol Dehydration reaction-Zaitsev Elimination
4. The Oxidation reaction
5. The Polymerization reaction
6. The Aldol Condensation reaction
7. The Friedal Crafts Alkylation and Acylation reaction
8. The Diels Alder reaction
9. The Wittig reaction
10. The Substitution (S_N2) reaction.
11. Michael Addition

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Roesky, H.W., Kennepohl, D. & Lehn, J.M. *Experiments in Green and Sustainable Chemistry*, Wiley-VCH, Weinheim, Germany, 2009.
- Anastas, P.T. & Warner, J.K. *Green Chemistry-Theory and Practical*, Oxford University Press, 1998.

Semester-VII

MAJOR-18

Paper Code: CHEMMAJ718

[FOR HONOURS WITH RESEARCH]
Paper Description: PROJECT/ DISSERTATION/ LITERATURE SURVEY

Paper Type: L (Credits: 04)

Total Marks: 80

PROJECT/ DISSERTATION/LITERATURE SURVEY

Literature review, identification of a problem, designing/planning of research work, expected outcome.

A detailed report is to be submitted.

At the end of the semester, the paper will be evaluated on the basis of his/her presentation and interaction with external(s).

Semester-VII

MAJOR-19

Paper Code: CHEMMAJ719

Paper Description: PHYSICAL CHEMISTRY-VI

Paper Type: L (Credits: Theory-03, Practical-01)

Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]

Theory: 45 Lectures [Each Lecture is 1 hour in duration]

Practical: 15 classes [Each class is 2 hours in duration]

PHYSICAL CHEMISTRY-VI

UNIT I: Electrochemical Cells

Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation, Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants and (iii) pH values, using hydrogen, quinone-hydroquinone, glass electrodes. Concentration cells with and without transference, liquid junction potential, determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation). **(22 Lectures)**

UNIT II: Conductance

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity, and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rule.

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts. **(23 Lectures)**

Reference Books:

- Atkins, P.W & Paula, J.D. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
- Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa, 2004.
- Mortimer, R. G. *Physical Chemistry*, 3rd Ed., Elsevier, NOIDA, UP, 2009.
- Barrow, G. M. *Physical Chemistry*, 5th Ed., Tata McGraw Hill, New Delhi, 2006.
- Engel, T. & Reid, P. *Physical Chemistry*, 3rd Ed., Prentice-Hall, 2012.
- Rogers, D. W. *Concise Physical Chemistry*, Wiley, 2010.
- Silbey, R. J., Alberty, R. A. & Bawendi, M. G. *Physical Chemistry*, 4th Ed., John Wiley & Sons, Inc. 2005.

PRACTICAL

PHYSICAL CHEMISTRY-VI: **(30 HOURS)**

1. Conductometry: (*any two*)

(a) Determination of cell constant

(b) Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

(c) Perform the following conductometric titrations: (***any two***)

i .Strong acid vs. strong base

ii. Weak acid vs. strong base

iii. Mixture of strong acid and weak acid vs. strong base

iv. Strong acid vs. weak base

2. Potentiometry:

Perform the following potentiometric titrations: (***any two***)

a. Strong acid vs. strong base

b. Weak acid vs. strong base

c. Dibasic acid vs. strong base

d. Potassium dichromate vs. Mohr's salt

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Khosla, B. D., Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co., New Delhi, 2011.
- Garland, C. W., Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry*, 8th Ed., McGraw-Hill, New York, 2003.
- Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry*, 3rd Ed., W.H. Freeman & Co., New York, 2003.

Semester-VIII

COURSE TYPE: MAJOR-20

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ820	ORGANIC CHEMISTRY-VI
Credit	Paper Type
4	L
Paper Levels	Full Marks
400	80

COURSE TYPE: MAJOR-21

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ821	INORGANIC CHEMISTRY-VI
Credit	Paper Type
4	L
Paper Levels	Full Marks
400	80

COURSE TYPE: MAJOR-22
[FOR HONOURS WITHOUT RESEARCH]

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ822	BIOCHEMISTRY
Credit	Paper Type
4	L
Paper Levels	Full Marks
400	80

COURSE TYPE: MAJOR-22
[FOR HONOURS WITH RESEARCH]

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ822	PROJECT WORK
Credit	Paper Type
4	L
Paper Levels	Full Marks
400	80

COURSE TYPE: MAJOR-23
[FOR HONOURS WITHOUT RESEARCH]

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ823	POLYMER CHEMISTRY & ANALYTICAL CHEMISTRY
Credit	Paper Type
4	L
Paper Levels	Full Marks
400	80

COURSE TYPE: MAJOR-23
[FOR HONOURS WITH RESEARCH]

PAPER CODE	PAPER DESCRIPTION
CHEMMAJ823	PROJECT WORK
Credit	Paper Type
4	L
Paper Levels	Full Marks
400	80

Semester-VIII

MAJOR-20

Paper Code: CHEMMAJ820
Paper Description: ORGANIC CHEMISTRY-VI
Paper Type: L (Credits: Theory-03, Practical-01)
Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]
Theory: 45 Lectures [Each Lecture is 1 hour in duration]
Practical: 15 classes [Each class is 2 hours in duration]

ORGANIC CHEMISTRY-VI

UNIT I: Photochemistry

Basic principles, Jablonski diagram, photochemistry of olefinic compounds, Cis-trans isomerisation, stereomutation, Paterno-Buchi reaction, Norrish type I and II reactions, photoreduction of ketones, di-pi-methane rearrangement, photochemistry of arenes, Photoreaction in the solid state. Method of generation and detection (ESR) of radicals, radical initiators, reactivity pattern of radicals, substitution and addition reactions involving radicals, cyclization of radicals, allylic halogenation, auto-oxidation. **(20 Lectures)**

UNIT II: Pericyclic Reaction

Pericyclic reactions, Selection rules and stereochemistry of electrocyclic reactions, cycloadditions, sigmatropic rearrangements, carbene addition, cheleotropic reactions. 1,3 dipolar additions, Rationalization based on Frontier M.O. approach, correlation diagrams, Dewer-Zimmermann approach, Sommelet-Hauser, Cope, aza Cope and Claisen rearrangements, Ene Reaction, Wittig rearrangement, suitable examples of [(2π +2 π), (4π +2 π), (4π + 4π), (2π +2 π +2π)] and metal catalysed cycloaddition reactions. **(25 Lectures)**

Reference Books:

- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Clayden, J. Greeves, N. Warren, S. Wothers, P. *Organic Chemistry*, Oxford University Press.
- Robert O Kan. *Organic Photochemistry*, McGraw-Hill, USA
- Albert Padwa. *Organic Photochemistry.*
- John D. Coyel, *Introduction to Organic Photochemistry*.

PRACTICAL

ORGANIC CHEMISTRY-V: (*any three*) **(30 HOURS)**

1. Perform thermal addition reaction involving Anthracene and Maleic anhydride/ cycloaddition reaction with suitable substrates.
2. Preparation of Benzopinacol by Photoreduction of Benzophenone.
3. Experiment on (or Study of) thermal or photochemical electrocyclic reaction covering 4π electron system

4. Experiment on (or Study of) thermal or photochemical electrocyclic reaction covering 6π electron system.
5. Experiment on (or Study of) cyclo addition reaction covering two components having (2π +2 π)/ (4π +2 π)/ (4π + 4π) electron system.
6. Experiment on (or Study of) thermal sigmatropic reaction covering [3,3] shift.
7. Experiment on (or Study of) photoinduced cis-trans isomerization of compounds.

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

References Books:

- Normann R.O.C & Coxon J. M. *Principles of Organic Synthesis*, 3rd Ed, CRC Press New York, 2012.
- Carey F.A. & Sundberg R. J. *Advanced Organic Chemistry*, Springer, India, 2012.

Semester-VIII

MAJOR-21

Paper Code: CHEMMAJ821
Paper Description: INORGANIC CHEMISTRY-VI
Paper Type: L (Credits: Theory-03, Practical-01)
Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]
Theory: 45 Lectures [Each Lecture is 1 hour in duration]
Practical: 15 classes [Each class is 2 hours in duration]

INORGANIC CHEMISTRY-VI

UNIT I: Magnetochemistry

Magnetic properties: paramagnetism, ferro- and antiferro magnetism and diamagnetism, Pascal constants, Russell-Saunder's terms, Microstates: Equivalent and non-equivalent multi-electron systems, Hund's Rule, Spin-orbit coupling constant, Lande interval rule, Determination of magnetic susceptibility: Gouy's balance and Evan's method. Thermal energy and magnetic properties, Currie equation, Curie-Weiss law, 1st order Zeeman effect and 2nd order Zeeman effect, Magnetic properties of first transition series metal ions, lanthanides and actinides, orbital contribution and quenching of orbital magnetic moment by the crystal field, quantitative relation between μ_{eff} and μ_s and its derivation, Spin-Orbit coupling and A, E, T ground terms, Spin pairing and cross-over region. **(30 Lectures)**

UNIT II: Nuclear Chemistry

Nuclear reactions, Nuclear Activation Analyses, Charged Particle Activation Analyses, Radiotracer Methods: Study of Chemical Reactions, Nuclear Medicine, Isotope Dilution Analysis. Radioanalytical techniques: Particle Induced X-ray Emissions. **(15 Lectures)**

Reference Books:

- Carlin, R.L. *Magnetochemistry*, Springer Verlag, 1986.
- Kahn, O. *Molecular Magnetism*, VCH-Verlag, Weinheim, New York, 1993.
- Nicola A. *Magnetic Materials: Fundamentals and Applications*, Hardcover Spaldin, Cambridge University Press, 2010.
- Cullity, B.D. & Graham, C.D. *Introduction to Magnetic Materials*, Second Edition, Wiley.
- Loveland, W.D.; Morrissey, D.J. & Seaborg, G.T. *Modern Nuclear Chemistry*, Second Edition, Wiley, 2017.
- McPherson, P.A.C. *Principles of Nuclear Chemistry*, World Scientific, 2017.
- Choppin, G.R. & Rydberg, J. *Nuclear Chemistry: Theory and Applications*, Pergamon Press, 1980.

PRACTICAL

INORGANIC CHEMISTRY-VI: (30 HOURS)

1. **Magnetochemistry:**
   a. Determination of magnetic moment of iron and nickel complexes.
2. **Nuclear Chemistry: (*any two*)**
   a. Determination of the Background Radiation
   b. Determination of the Half-life of a Radioactive Isotope
   c. Determination of the type of radiation from a source
   d. Absorption of Gamma photons (Shielding)
   e. Inverse Square Law
   f. Precipitation reactions
   g. Washing Efficiency
   h. Wear Studies

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- Schuler, R.H. *Laboratory Experiments in Magnetochemistry*, J. Chem. Edu. 27 (11), 591, 1950.

Katz, D.A. *Experiments for Nuclear Chemistry*, Pima Community College, USA, 2004.

Semester-VIII

MAJOR-22

Paper Code: CHEMMAJ822
[FOR HONOURS WITHOUT RESEARCH]
Paper Description: BIOCHEMISTRY
Paper Type: L (Credits: Theory-03, Practical-01)
Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]
Theory: 45 Lectures [Each Lecture is 1 hour in duration]
Practical: 15 classes [Each class is 2 hours in duration]

BIOCHEMISTRY

UNIT I: Bio-organic Chemistry

Carbohydrates: Classification and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disaccharides (sucrose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

Peptides: Determination of Primary structure of Peptides by degradation: Edmann degradation (N-terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (up to dipeptides) by *N*-protection (*t*-butyloxycarbonyl and phthaloyl) and C-activating groups and Merrifield solid-phase synthesis. **(15 Lectures)**

UNIT II: Bioinorganic Chemistry

Metalloproteins-oxygen transporting and electron transporting. Heme proteins: Hemoglobin, Myoglobin, Hemerythrin, Hemocyanin, Cytochrome P450, Cytochrome c oxidase. Non-heme proteins: Copper in cytochrome c oxidase and in respiratory chain, blue copper proteins. *Metalloenzymes*: Zinc enzymes-carboxypeptidase and carbonic anhydrase. Iron enzyme-catalyses, peroxidase and cytochrome P-450. Copper enzyme-superoxide dismutase.

Role of alkali and alkaline earth metals in biological systems. Biological functions and toxicity caused by metal ions. Biological fixation of nitrogen. Chlorophyll-the photosynthetic catalyst, Bio-availability of metal ions. **(15 Lectures)**

UNIT III: Biophysical Chemistry

Primary, Secondary, Tertiary and Quaternary structure of proteins; origin of secondary structures and their stabilization. Protein functions and characterization. Enzyme kinetics and inhibitions. Membrane structures and functions. Nucleic acids and their characterization. Introduction to oils

and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, (transportation value), acid value, iodine number. Reversion and rancidity. **(10 Lectures)**

UNIT IV: Concept of Energy in Biosystems

Introduction to metabolism (catabolism, anabolism).

ATP: The universal currency of cellular energy, Agents for transfer of electrons in biological redox systems: NAD^+, FAD^+.

Conversion of food to energy: Outline of catabolic pathways of carbohydrate- glycolysis, Krebs cycle. Caloric value of food, standard caloric content of food types. **(5 Lectures)**

Reference Books:

- Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, 6th Ed. W.H. Freeman and Co. 2006.
- Nelson, D.L., Cox, M.M. & Lehninger, A.L. *Principles of Biochemistry*, IV Edition, W.H. Freeman and Co. 2009.
- Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. *Harper's Illustrated Biochemistry*, XXVIII Edition, Lange Medical Books/ McGraw-Hill, 2009.
- Lippard, J. & Berg, G.M. *Principles of Bio-Inorganic Chemistry*, Panima Publishing, 1994.
- Allen, J.P. *Biophysical Chemistry*, Wiley-Blackwell, 2008.

PRACTICAL

BIOCHEMISTRY: (*any three*) (30 HOURS)

1. (a) Identify monosaccharides and Polysaccharides (Molisch's Test, Iodine Test).
   (b) Distinguish aldose and ketose (Seliwanoff's Test).
   (c) Differentiate reducing and non-reducing sugar (Tollen's Test, Fehling's Test).
2. Perform Biuret test, Ammonium sulphate half saturation test, Saponification test.
3. Estimation of Protein by Lowry's method.
4. Detection of the optimum temperature for action of salivary amylase on starch.
5. Determine the saponification value of an oil or fat.
6. Determine the Iodine index of an oil or fat.
7. Isolate DNA from onion/peas/cauliflower.

End Semester Examination (ESE)

At the end of the semester, a practical examination will be conducted as per the following guidelines:

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference Books:

- *Manual of Biochemistry Workshop*, Department of Chemistry, University of Delhi, 2012.
- Arthur, I. V. *Quantitative Organic Analysis*, Pearson.

Semester-VIII

MAJOR-23

Paper Code: CHEMMAJ823
[FOR HONOURS WITHOUT RESEARCH]
Paper Description: POLYMER CHEMISTRY & ANALYTICAL CHEMISTRY
Paper Type: L (Credits: Theory-03, Practical-01)
Total Marks: 80 [Theory (ESE – 60); Practical (ESE – 20)]
Theory: 45 Lectures [Each Lecture is 1 hour in duration]
Practical: 15 classes [Each class is 2 hours in duration]

POLYMER CHEMISTRY & ANALYTICAL CHEMISTRY

POLYMER CHEMISTRY

UNIT I:

Functionality and its importance: Addition and Condensation–Mechanism of Cationic, anionic and free radical addition polymerization. Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. **(5 Lectures)**

UNIT II:

Kinetics of Polymerization: Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization.

Crystallization and crystallinity: Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

(10 Lectures)

UNIT III:

Determination of molecular weight of polymers: (*Mn*, *Mw*) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index.

Glass transition temperature (Tg) and determination of Tg: Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg).

Rubbers: natural and synthetic; Buna-S, Chloroprene, and Neoprene; Vulcanization; Biodegradable polymers with examples. **(10 Lectures)**

ANALYTICAL CHEMISTRY

UNIT I: Qualitative and quantitative aspects of analysis

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data, F, Q and test, rejection of data, and confidence intervals. **(8 Lectures)**

UNIT II: Separation techniques

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch and continuous extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media.

Ion-exchange: Principle, Types of ion-exchangers, Quality of resins, Swelling of resins, Action of ion-exchange resin, Ion-exchange equilibrium, Ion-exchange capacity, Deionization of water. **(12 Lectures)**

Reference Books:

- Seymour, R.B. & Carraher, C.E., *Polymer Chemistry: An Introduction*, Marcel Dekker, Inc. New York, 1981.
- Odian, G. *Principles of Polymerization*, 4th Ed., Wiley, 2004.
- Billmeyer, F.W. *Textbook of Polymer Science*, 2nd Ed., Wiley Interscience, 1971.
- Ghosh, P. *Polymer Science & Technology*, Tata McGraw-Hill Education, 1991.
- Mendham, J., A. I. *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson, 2009.
- Willard, H.H. et al. *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, D.C. *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
- Khopkar, S.M. *Basic Concepts of Analytical Chemistry*, New Age International Publisher, 2009.
- Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
- Ditts, R.V. *Analytical Chemistry*, Methods of Separation, van Nostrand, 1974.

PRACTICAL

POLYMER CHEMISTRY: (20 HOURS)

1. **Polymer synthesis: (*any two*)**
   (a) Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
   i. Purification of monomer
   ii. Polymerization using benzoyl peroxide (BPO) / 2,2'-azo-bis-isobutylonitrile (AIBN)
   (b) Preparation of nylon 6,6
   (c) Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and Phenolphthalein.
   i. Preparation of IPC

ii. Purification of IPC

iii. Interfacial polymerization

(d) Redox polymerization of acrylamide

(e) Precipitation polymerization of acrylonitrile

(f) Preparation of urea-formaldehyde resin

(g) Preparations of novalac resin/ resold resin.

(h) Microscale Emulsion Polymerization of Poly(methylacrylate).

2. Polymer characterization: (*any one*)

(a) Determination of molecular weight by viscometry:

i. Polyacrylamide-aq. $NaNO_2$ solution

ii. Poly vinyl proplylidine (PVP) in water

(b) Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.

(c) Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).

(d) Testing of mechanical properties of polymers.

(e) Determination of hydroxyl number of a polymer using colorimetric method.

ANALYTICAL CHEMISTRY: (10 HOURS)

1. Solvent Extraction: (*any one*)

(a) Determination of Nickel as the Dimethylglyoxime complex.

(b) Determination of Iron as the 8-Hydroxy Quinolate.

2. Seperation/Purification

Column or Thin Layer or Paper Chromatography

3. Ion exchange: (*any one*)

a) Determination of the capacity of a cation exchange resin and an anion exchange resin (Column method).

b) Determination of Na^+/K^+ in a given solution by Ion-Exchange method.

End Semester Examination (ESE):

At the end of the semester, a practical examination will be conducted as per the following guidelines.

Marks distribution

Experiment	15 marks
Practical record notebook	03 marks
Viva-voce	02 marks

Reference books:

- Pinner, S.H. *A Practical Course in Polymer Chemistry*, Pergamon Press, 1961.
- *Vogel's Textbook of Quantitative Inorganic Analysis*, Fourth Edition, ELBS, 1986.

FOR HONOURS WITH RESEARCH

Semester-VIII

MAJOR-22

Paper Code: CHEMMAJ822

Paper Description: PROJECT WORK

Paper Type: L (Credits: 04)

Total Marks: 80

Semester-VIII

MAJOR-23

Paper Code: CHEMMAJ823

Paper Description: PROJECT WORK

Paper Type: L (Credits: 04)

Total Marks: 80