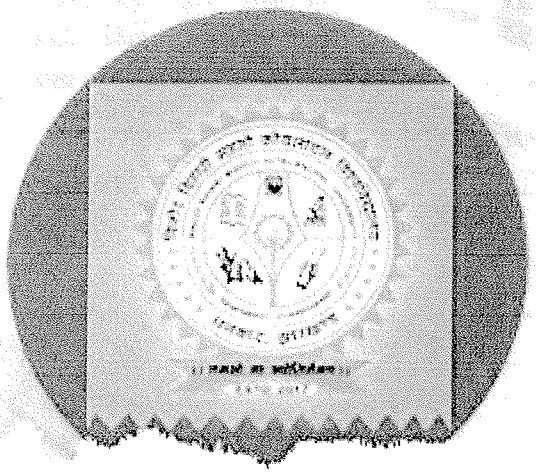
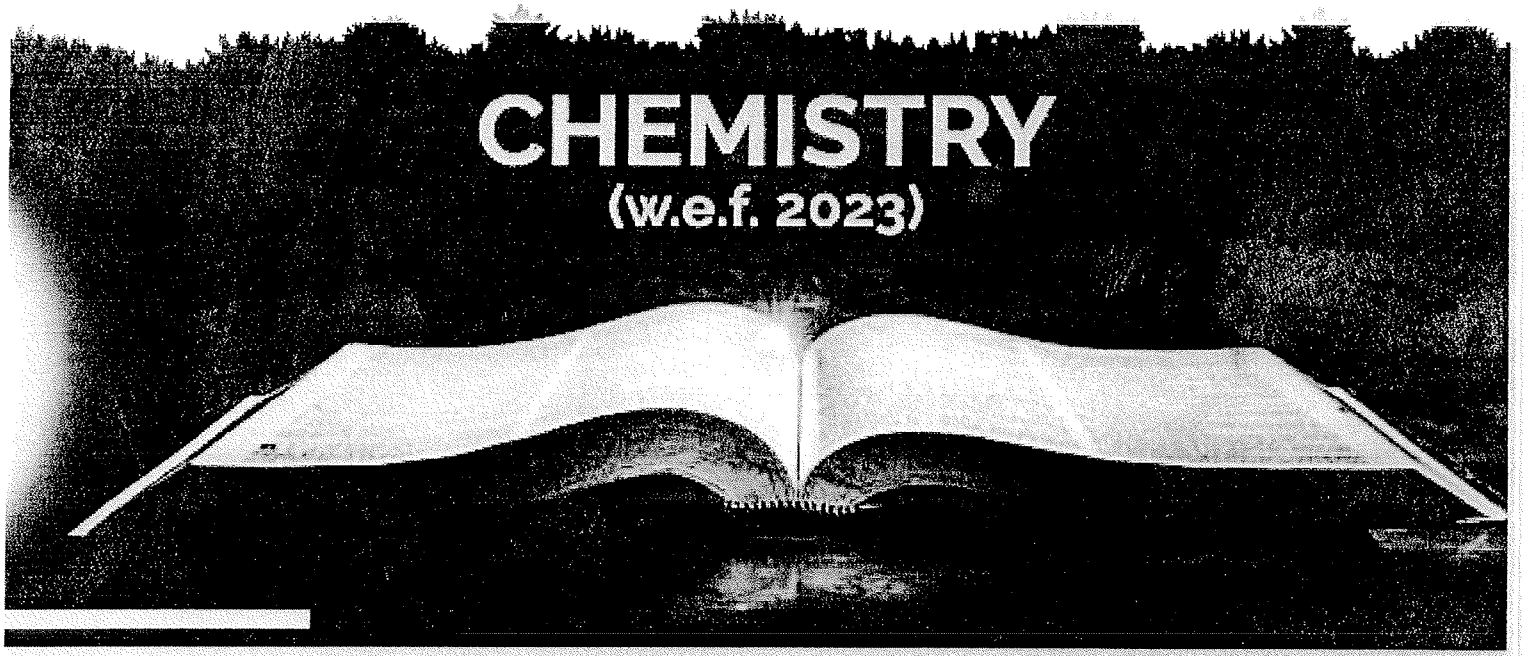
Curriculum Framework and Credit System for the Four Year Undergraduate Programme (FYUGP)



CHEMISTRY

(w.e.f. 2023)



BINOD BIHARI MAHTO KOYALANCHAL UNIVERSITY, DHANBAD

DEPARTMENT OF CHEMISTRY

BINOD BIHARI MAHTO KOYALANCHAL UNIVERSITY, DHANBAD

Members of Board of Studies for Undergraduate Syllabus

1	Dr. Leelawati Kumari, Head, University Department of Chemistry, BBMKU	CHAIRPERSON	
2	Dr. Y. JHA, Retired Head, Department of Chemistry, P.K.R.M. College, Dhanbad	EXTERNAL EXPERT	
3	Sri Rajendra Prasad Singh, UNIVERSITY DEPARTMENT of CHEMISTRY, BBMKU	MEMBER	
4	Dr. Dharmendra Kumar Singh, University Department of Chemistry, BBMKU	MEMBER	
5	Dr. Rajeev Pradhan, Head Department of Chemistry, P.K.R.M. College, Dhanbad	MEMBER	
6			

SEMESTER-WISE TITLE OF THE PAPERS IN CHEMISTRY MAJOR

Year	Semester	Course Code	Paper Title	Credits	Page No.
I	I	MJ-01 Theory	Inorganic Chemistry – 1	04	6-8
	II	MJ-02 Theory	Physical Chemistry – 1	04	9-11
		MJ-03 Practical	Practical (Physical Chemistry) - 1	04	12-13
EXIT POINT: UNDERGRADUATE CERTIFICATE					
II	III	MJ-04 Theory	Organic Chemistry – 1	04	14-16
		MJ-05 Practical	Practical (Organic Chemistry) - 2	04	17-18
	IV	MJ-06 Theory	Inorganic Chemistry – 2	04	19-21
		MJ-07 Theory	Organic Chemistry – 2	04	22-24
		MJ-08 Practical	Practical (Inorganic Chemistry) – 3	04	25-26
EXIT POINT: UNDERGRADUATE DIPLOMA					
III	V	MJ-09 Theory	Physical Chemistry – 2	04	27-29
		MJ-10 Theory	Inorganic Chemistry – 3	04	30-32
		MJ-11 Practical	Practical (Organic + Inorganic)	04	33-34
	VI	MJ-12 Theory	Organic Chemistry – 3	04	35-37
		MJ-13 Theory	Physical Chemistry – 3	04	38-40
		MJ-14 Theory	Analytical Chemistry	04	41-42
		MJ-15 Practical	Practical (Analytical Chemistry) - 4	04	43-44
EXIT POINT: BACHELOR'S DEGREE					
IV	VII	AMJ-01 Theory		04	
		AMJ-02 Theory		04	
		AMJ-03 Theory		04	
		AMJ-04 practical		04	
	VIII	AMJ-05 Theory		04	
EXIT POINT: BACHELOR'S DEGREE WITH Hons./ Hons. With Research					

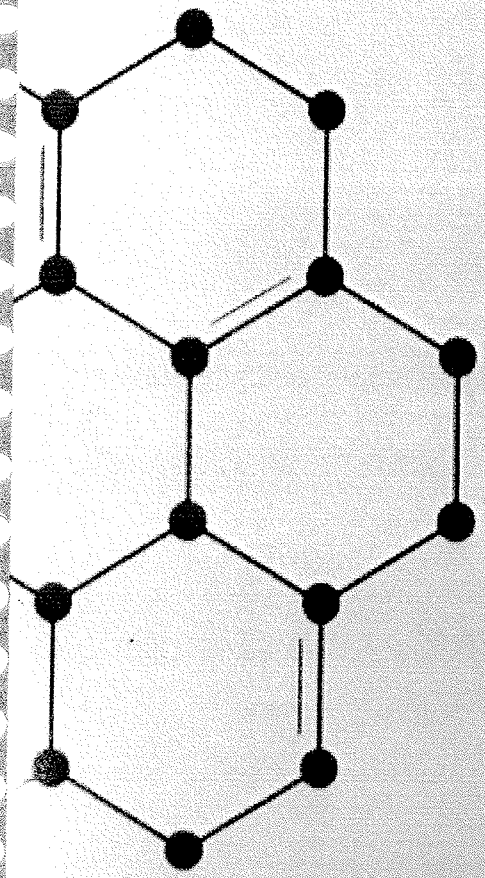
SEMESTER-WISE TITLE OF THE PAPERS IN CHEMISTRY MINOR

Year	Semester	Course Code	Paper Title	Credits	Page No.
I	I	MN-1A Theory	Inorganic 1 + Organic 1	03	46-48
		MN-1A Practical	Practical (Inorganic + Organic)	01	49
II	III	MN-1B Theory	Physical 1 + Organic 2	03	50-52
		MN-1B Practical	Practical (Physical + Organic)	01	53
III	V	MN-1C Theory	Physical 2 + Organic 3	03	54-56
		MN-1C Practical	Practical (Physical + Organic)	01	57
IV	VII	MN-1D Theory	Inorganic 2 + Physical 3	03	58-60
		MN-1D Practical	Practical (Inorganic + Physical)	01	61

SEMESTER-WISE TITLE OF THE PAPERS IN CHEMISTRY MULTIDISCIPLINARY COURSE (MDC)

Year	Semester	Course Code	Paper Title	Credits	Page No.
I / II	I / II / III	MDC	MULTIDISCIPLINARY COURSE – CHEMISTRY	03	63-65

Curriculum Framework and Credit System for the Four Year Undergraduate Programme (FYUGP)



CHEMISTRY MAJOR

BINOD BIHARI MAHTO KOYALANCHAL UNIVERSITY, DHANBAD

SEMESTER -I

PAPER: MJ-01 (Inorganic Chemistry – 01)

	Mid Semester Exam	End Semester Exam	Total
Full Marks	25	75	100
Pass Marks	10	30	40
Time	1 hours	3 hours	

Credits: 04

Duration of Course: 60 hours

Instructions for Question Setter

Mid Semester Examination (MSE): 1 Hrs.

The Mid Semester Examination shall have two components.

(a) One Semester Internal Assessment Test (SIA): 20 Marks.

There will be three questions of 10 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts

(b) Class Attendance Score (CAS) & Day to day activities (DDA): 5 marks.

(Attendance: Upto75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)

End Semester Examination (ESE): 3 Hrs.

There will be **two** groups of questions.
Group A is compulsory and will contain two questions. Q. No. 1 will be multiple/fill in the blank/very short type five questions of 1 mark each. Q. No. 2 & 3 will contain two short answer type questions each of 5 marks.
Group B will contain descriptive type six (Q. No. 4 to 9) questions of 15 marks each, out of which any four are to be answered.

UNIT I: Atomic Structure: 18 hours

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 $\psi 2$. 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. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

UNIT II: Periodicity of Elements: 18 hours

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.

1 Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

2 Atomic radii (van'der Waals)

3 Ionic and crystal radii.

4 Covalent radii (octahedral and tetrahedral)

5 Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.

6 Electron gain enthalpy, trends of electron gain enthalpy.

7 Electronegativity, Pauling, Mullikan, Allred Rachow scales, electronegativity and bond order, partial charge, hybridization, group electronegativity.

UNIT III: Chemical Bonding: 16 hours

(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, expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

(ii) *Covalent bond:* Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone-and bond-pairs of electrons multiple bonding, sigma and pi-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid orbitals, Bents rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of simple homonuclear and heteronuclear diatomic molecules, MO diagrams of simple tri and tetra-atomic molecules, e.g., N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, HCHO, (idea of s-p mixing and orbital interaction to be given). Covalent character in ionic compounds, polarizing power and polarizability. Fajan rules, polarization. Ionic character in covalent compounds: Bond moment and dipole moment. ionic character from dipole moment and electronegativities.

UNIT IV: Metallic bonding and Weak chemical forces: 8 hours

(iii) *Metallic Bond:* Qualitative idea of free electron model, Semiconductors, Insulators.

(iv) *Weak Chemical Forces:* van'der Waals, ion-dipole, dipole-dipole, induced dipole dipole-induced dipole interactions, Lenard-Jones 6-12 formula, hydrogen bond, effects of hydrogen bonding on melting and boiling points, solubility, dissolution.

Recommended Books/References:

1. Lee, J. D. *Concise Inorganic Chemistry,* Wiley, 5th Edn.

2. Douglas, B.E., McDaniel, D.H., Alexander J.J., *Concepts & Models of Inorganic Chemistry, (Third Edition)* John Wiley & Sons,1999.

3. Atkins, P. W. and DePaula, J. *Physical Chemistry*, Tenth Edition, Oxford University Press, 2014.

4. Rodger, G. E. *Inorganic and Solid State Chemistry*, Cengage Learning, 2002.

SEMESTER -II

PAPER: MJ-02 (Physical Chemistry – 01)

	Mid Semester Exam	End Semester Exam	Total
Full Marks	25	75	100
Pass Marks	10	30	40
Time	1 hours	3 hours	

Credits: 04

Duration of Course: 60 hours

Instructions for Question Setter

Mid Semester Examination (MSE): 1 Hrs.

The Mid Semester Examination shall have two components.

(a) One Semester Internal Assessment Test (SIA): 20 Marks.

There will be three questions of 10 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts

(b) Class Attendance Score (CAS) & Day to day activities (DDA): 5 marks.

(Attendance: Upto75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)

End Semester Examination (ESE): 3 Hrs.

There will be **two** groups of questions.
Group A is compulsory and will contain two questions. Q. No. 1 will be multiple/fill in the blank/very short type five questions of 1 mark each. Q. No. 2 & 3 will contain two short answer type questions each of 5 marks.
Group B will contain descriptive type six (Q. No. 4 to 9) questions of 15 marks each, out of which any four are to be answered.

UNIT I: Gaseous State: 16 hours

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

Behavior of real gases: Deviations from ideal gas behavior, compressibility factor, 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 behaviour; van der Waals equation expressed in virial form, Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, critical and van der

Waals constants, law of corresponding states.

UNIT II: Liquid State: 08 hours

Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature, Effect of addition of various solutes on surface tension, cleansing action of detergents. Structure of water.

UNIT III: Introduction to thermodynamics: 10 hours

Intensive and extensive variables; 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, 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.

UNIT IV: Chemical Equilibria: 14 hours

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants Kp, *Kc* and *Kx*. Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

UNIT V: Ionic Equilibria: 12 hours

Arrhenius Theory, 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. 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; dissociation constants of mono-, di- and tri-protic acids. Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH for different salts. Buffer solutions; Henderson

equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry, Solubility and solubility product.

Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolytes.

Recommended Text books/references:

1. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).
2. Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
3. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
4. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009).
5. G. M. Barrow, Tata McGraw Hill (Fifth Edition) (2007)

SEMESTER -II

PAPER: MJ-03 (Practical Physical Chemistry – 01)

	Mid Semester Practical	End Semester Practical	Total
Full Marks		100	100
Pass Marks		40	40
Time		3 hours	

Credits: 04

Duration of Course: 120 hours

UNIT I: Surface tension measurements: 12 hours

1. Determine the surface tension by (i) drop number (ii) drop weight method.
2. Study the variation of surface tension of detergent solutions with concentration.

UNIT II: Viscosity measurements using Ostwald's viscometer: 12 hours

1. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
2. Viscosity of sucrose solution with the concentration of solute.

UNIT III: pHmetry: 12 hours

1. Effect on pH of addition of HCl/NaOH to solutions of acetic acid sodium acetate and their mixtures.
2. Preparation of buffer solutions of different pH
   i. Sodium acetate-acetic acid
   ii. Ammonium chloride-ammonium hydroxide
3. pH metric titration of
   i. strong acid vs. strong base
   ii. weak acid vs. strong base.
4. Determination of dissociation constant of a weak acid.

UNIT IV: Conductometry: 12 hours

1 Determination of cell constant

2 Equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

3 Conductometric titrations of: (i) Strong acid Vs. strong base (ii) Weak acid vs. strong base, (iii) Mixture of strong acid and (iv)weak acid vs. strong base, Strong acid vs. weak base.

UNIT V: Potentiometry: 12 hours

Potentiometric titrations of:

1 Strong acid vs. strong base

2 Weak acid vs. strong base

3 Dibasic acid vs. strong base

4 Potassium dichromate vs. Mohr's salt.

Recommended text books/references:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).

2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).

3 Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

4 Athawale V. D. amd Mathur P. Experimental Physical Chemistry,, New Age Intenational (2001)

SEMESTER -III

PAPER: MJ-04 (Organic Chemistry – 01)

	Mid Semester Exam	End Semester Exam	Total
Full Marks	25	75	100
Pass Marks	10	30	40
Time	1 hours	3 hours	

Credits: 04

Duration of Course: 60 hours

Instructions for Question Setter

Mid Semester Examination (MSE): 1 Hrs.

The Mid Semester Examination shall have two components.

(a) One Semester Internal Assessment Test (SIA): 20 Marks.

There will be three questions of 10 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts

(b) Class Attendance Score (CAS) & Day to day activities (DDA): 5 marks.

(Attendance: Upto75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)

End Semester Examination (ESE): 3 Hrs.

There will be **two** groups of questions.
Group A is compulsory and will contain two questions. Q. No. 1 will be multiple/fill in the blank/very short type five questions of 1 mark each. Q. No. 2 & 3 will contain two short answer type questions each of 5 marks.
Group B will contain descriptive type six (Q. No. 4 to 9) questions of 15 marks each, out of which any four are to be answered.

UNIT I: Basics of Organic Chemistry: 06 hours

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.

Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

UNIT II: Stereohemistry: 12 hours

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.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

UNIT III: Chemistry of Aliphatic Hydrocarbons: 22 hours

A. Carbon-Carbon sigma bonds

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

B. 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 (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, DielsAlder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.

Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

C. Cycloalkanes and Conformational Analysis

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

UNIT IV: Aromatic Hydrocarbons: 08 hours

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions 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.

UNIT V: Chemistry of Halogenated Hydrocarbons: 12 hours

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – SN1, SN2 and SNi mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. Nucleophilic aromatic substitution; SNAr, Benzyne mechanism.

Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

Reference Books:

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.
5. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.

SEMESTER -III

PAPER: MJ-05 (Practical Organic Chemistry – 02)

	Mid Semester Practical	End Semester Practical	Total
Full Marks		100	100
Pass Marks		40	40
Time		3 hours	

Credits: 04

Duration of Course: 120 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 above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus).
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
5. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100°C by distillation and capillary method)
6. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
7. Organic preparations:
   (i) Acetylation of one of the following compounds: amines (aniline, o-, m-, p- toluidines and o-, m-, panisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method:
      (a) Using conventional method.
      (b) Using green approach
   (ii) Benzolyation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, panisidine) and one of the following phenols (β-naphthol, resorcinol, p- cresol) by Schotten-Baumann reaction.
   (iii) Oxidation of ethanol/ isopropanol (Iodoform reaction).

(iv) Bromination of any one of the following: (a) Acetanilide by conventional methods (b) Acetanilide using green approach (Bromate-bromide method)

8. Nitration of any one of the following:
   (a) Acetanilide/nitrobenzene by conventional method
   (b) Salicylic acid by green approach (using ceric ammonium nitrate).
9. Selective reduction of meta dinitrobenzene to m-nitroaniline.
10. Reduction of p-nitrobenzaldehyde by sodium borohydride.
11. Hydrolysis of amides and esters.
12. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
13. S-Benzylisothiouronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).
14. Aldol condensation using either conventional or green method.

Reference Books:

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

SEMESTER -IV

PAPER: MJ-06 (Inorganic Chemistry – 02)

	Mid Semester Exam	End Semester Exam	Total
Full Marks	25	75	100
Pass Marks	10	30	40
Time	1 hours	3 hours	

Credits: 04

Duration of Course: 60 hours

Instructions for Question Setter

Mid Semester Examination (MSE): 1 Hrs.

The Mid Semester Examination shall have two components.

(a) One Semester Internal Assessment Test (SIA): 20 Marks.

There will be three questions of 10 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts

(b) Class Attendance Score (CAS) & Day to day activities (DDA): 5 marks.

(Attendance: Upto75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)

End Semester Examination (ESE): 3 Hrs.

There will be **two** groups of questions.
Group A is compulsory and will contain two questions. Q. No. 1 will be multiple/fill in the blank/very short type five questions of 1 mark each. Q. No. 2 & 3 will contain two short answer type questions each of 5 marks.
Group B will contain descriptive type six (Q. No. 4 to 9) questions of 15 marks each, out of which any four are to be answered.

UNIT I: Oxidation Reduction and General Principal of Metallurgy: 08 hours

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon or 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.

UNIT II: Chemistry of *s* and *p* Block Elements: 16 hours

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.

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. Per-oxo acids of Sulphur inter-halogen compounds, poly- halide ions, pseudo-halogens, properties of halogens.

UNIT III: Transition Elements: 10 hours

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and 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)

UNIT IV: Lanthanoid and Actinides: 10 hours

Electronic configuration, oxidation states, color, spectra and magnetic behavior, lanthanide contraction, separation of lanthanides (ion-exchange method only).

UNIT V: Noble Gases: 08 hours

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Bonding in noble gas compounds (Valence bond and MO treatment for XeF_2), Shapes of noble gas compounds (VSEPR theory).

UNIT VI: Inorganic Polymers: 08 hours

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

Recommended books/references:

1) Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.

2) Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. 1994.

3) Greenwood, N.N., Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann. 1997.

4) Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.

5) Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.

6) Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* Fourth Ed., Pearson, 2010

7) Atkins, P. W and Shriver D. N. *Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

SEMESTER -IV

PAPER: MJ-07 (Organic Chemistry – 02)

	Mid Semester Exam	End Semester Exam	Total
Full Marks	25	75	100
Pass Marks	10	30	40
Time	1 hours	3 hours	

Credits: 04

Duration of Course: 60 hours

Instructions for Question Setter

Mid Semester Examination (MSE): 1 Hrs.

The Mid Semester Examination shall have two components.

(a) One Semester Internal Assessment Test (SIA): 20 Marks.

There will be three questions of 10 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts

(b) Class Attendance Score (CAS) & Day to day activities (DDA): 5 marks.

(Attendance: Upto75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)

End Semester Examination (ESE): 3 Hrs.

There will be **two** groups of questions.
Group A is compulsory and will contain two questions. Q. No. 1 will be multiple/fill in the blank/very short type five questions of 1 mark each. Q. No. 2 & 3 will contain two short answer type questions each of 5 marks.
Group B will contain descriptive type six (Q. No. 4 to 9) questions of 15 marks each, out of which any four are to be answered.

UNIT I: Alcohols, Phenols, Ethers and Epoxides: 14 hours

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 effecting acidity, Ring substitution reactions,

Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism;

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

Sulphur containing compounds: Preparation and reactions of thiols and thioethers

UNIT II: Carbonyl Compounds: 12 hours

Structure, reactivity and preparation: Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisan-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, LiAlH4, NaBH4, MPV, PDC and PGC).

Addition reactions of unsaturated carbonyl compounds: Michael addition.

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

UNIT III: Carboxylic Acids and their derivatives: 10 hours

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic, phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids;

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann- bromamide degradation and Curtius rearrangement.

UNIT IV: Polynuclear Hydrocarbons: 06 hours

Reactions of naphthalene, phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.

UNIT V: Carbohydrates: 10 hours

Occurrence, classification and their biological importance.

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani- Fischer synthesis and Ruff degradation; Disaccharides: Structure elucidation of maltose, lactose and sucrose.

UNIT VI: Enzymes: 08 hours

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

Reference Books:

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
4. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VIth Edition. W.H. Freeman and Co.
5. Nelson, D.L., Cox, M.M. and Lehninger, A.L. (2009) Principles of Biochemistry. IV Edition. W.H. Freeman and Co.

SEMESTER -IV

PAPER: MJ-08 (Practical Inorganic Chemistry – 03)

	Mid Semester Practical	End Semester Practical	Total
Full Marks		100	100
Pass Marks		40	40
Time		3 hours	

Credits: 04

Duration of Course: 120 hours

UNIT I: Titrimetric Analysis: 10 hours

(i) Calibration and use of apparatus.

(ii) Preparation of solutions of different Molarity/Normality of titrants.

(iii) Use of primary and secondary standard solutions.

UNIT II: Acid-Base Titrations: 10 hours

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

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

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

UNIT III: Oxidation-Reduction Titrimetry: 10 hours

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

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

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

UNIT IV: Qualitative analysis of Salt Mixture: 30 hours

Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-},$S_2O_3^{2-}$, CH_3COO^-, F^-,Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+},Sr^{2+}, Ca^{2+}, Mg^{2+}

Mixtures should preferably contain one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$,

CaF_2 or Al_2O_3) or combination of anions e.g. $CO_3^{2-}$and SO_3^{2-}, NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, $Br^-$and I^-, NO_3^- and Br^-, NO_3^- and I^-.

Spot tests should be done whenever possible.

Recommended Books/References:

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

SEMESTER -V

PAPER: MJ-09 (Physical Chemistry – 02)

	Mid Semester Exam	End Semester Exam	Total
Full Marks	25	75	100
Pass Marks	10	30	40
Time	1 hours	3 hours	

Credits: 04

Duration of Course: 60 hours

Instructions for Question Setter

Mid Semester Examination (MSE): 1 Hrs.

The Mid Semester Examination shall have two components.

(a) One Semester Internal Assessment Test (SIA): 20 Marks.

There will be three questions of 10 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts

(b) Class Attendance Score (CAS) & Day to day activities (DDA): 5 marks.

(Attendance: Upto75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)

End Semester Examination (ESE): 3 Hrs.

There will be **two** groups of questions.
Group A is compulsory and will contain two questions. Q. No. 1 will be multiple/fill in the blank/very short type five questions of 1 mark each. Q. No. 2 & 3 will contain two short answer type questions each of 5 marks.
Group B will contain descriptive type six (Q. No. 4 to 9) questions of 15 marks each, out of which any four are to be answered.

UNIT I: Thermochemistry: 06 hours

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

UNIT II: Second Law of thermodynamics: 06 hours

Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

UNIT III: Third law of thermodynamics: 04 hours

Third Law of thermodynamics, residual entropy, calculation of absolute entropy of molecules.

UNIT IV: Free Energy Functions: 06 hours

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; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

UNIT V: Partial molar quantities: 06 hours

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs- Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

UNIT VI: Dilute solutions: 06 hours

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties: [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

UNIT VII: Solid State: 10 hours

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. Various types of defects in crystals, Glasses and liquid crystals.

UNIT VIII: Catalysis: 08 hours

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

UNIT IX: Surface chemistry: 08 hours

Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Temkin, Derivation of Langmuir adsorption isotherms, surface area determination), BET theory of multilayer adsorption (no derivation), Adsorption in solution.

Recommended Books/References

1) Atkins P. and De Paula, J. *Physical Chemistry* Tenth Ed., OUP, 2014.

2) Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa, 2004.

3) Engel, T. and Reid, P. *Physical Chemistry 3rd Ed.,* Prentice Hall, 2012.

4) McQuarrie, D. A. and Simon, J. D. *Molecular Thermodynamics* Viva Books, 2004.

5) Roy, B. N. Fundamentals of Classical and Statistical Thermodynamics Wiley, 2001

6) *Commonly Asked Questions in Thermodynamics.* CRC Press, 2011.

7) Levine, I .N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill, 2010. 8 Metz, C.R. *2000 solved problems in chemistry,* Schaum Series, 2006.

SEMESTER -V

PAPER: MJ-10 (Inorganic Chemistry – 03)

	Mid Semester Exam	End Semester Exam	Total
Full Marks	25	75	100
Pass Marks	10	30	40
Time	1 hours	3 hours	

Credits: 04

Duration of Course: 60 hours

Instructions for Question Setter

Mid Semester Examination (MSE): 1 Hrs.

The Mid Semester Examination shall have two components.

(a) One Semester Internal Assessment Test (SIA): 20 Marks.

There will be three questions of 10 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts

(b) Class Attendance Score (CAS) & Day to day activities (DDA): 5 marks.

(Attendance: Upto75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)

End Semester Examination (ESE): 3 Hrs.

There will be **two** groups of questions.
Group A is compulsory and will contain two questions. Q. No. 1 will be multiple/fill in the blank/very short type five questions of 1 mark each. Q. No. 2 & 3 will contain two short answer type questions each of 5 marks.
Group B will contain descriptive type six (Q. No. 4 to 9) questions of 15 marks each, out of which any four are to be answered.

UNIT I: Coordination Chemistry: 12 hours

Werner's theory, EAN rule, piano-stool compounds, valence bond theory (inner and outer orbital complexes), Crystal field theory, d-orbital splitting, , weak and strong fields, pairing energies, factors affecting the magnitude of (Δ). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar complexes, d orbital splitting in trigonal bipyramidal, square pyramidal and cubic ligand field environments, CFSE, Variation of lattice energies, enthalpies of hydration and crystal radii variations in halides of first and second row transition metal series, Qualitative aspect of Ligand field theory, MO diagrams of representative coronation complexes, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with the coordination number 4 and 6, Chelate effect.

UNIT II: Organometallic Compounds: 22 hours

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

Metal carbonyls: 18 electron rule, 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. π-acceptor behavior of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

Zeise's salt: Preparation and structure, evidences 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 multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

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

UNIT III: Catalysis by Organometallic Compounds: 06 hours

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

UNIT IV: Reaction Kinetics and Mechanism: 10 hours

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.

UNIT V: Bioinorganic Chemistry: 10 hours

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium/ K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.

Recommended Books/References

1) Purcell, K.F & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co, 1977.

2) Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.

3) Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.

4) Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999

5) Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.

6) Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.

SEMESTER -V

PAPER: MJ-11 (Practical Organic + Inorganic Chemistry – 04)

	Mid Semester Practical	End Semester Practical	Total
Full Marks		100	100
Pass Marks		40	40
Time		3 hours	

Credits: 04

Duration of Course: 120 hours

Group A (Organic Chemistry)

1. Detection of extra elements.
2. Functional group test for nitro, amine and amide groups.
3. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)
4. Saponification value of an oil or a fat.
5. Determination of Iodine number of an oil/ fat.
6. Preparation of urea formaldehyde.
7. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
8. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols etc.
9. Preparation of methyl orange.
10. Estimation of glycine by Sorenson's formalin method.
11. Study of the titration curve of glycine. .
12. Study of the action of salivary amylase on starch at optimum conditions.
13. Effect of temperature on the action of salivary amylase.
14. Saponification value of an oil or a fat.
15. Determination of Iodine number of an oil/ fat.

Group B (Inorganic Chemistry)

Gravimetric Analysis:

i. Estimation of nickel (II) using Dimethylglyoxime (DMG).

ii. Estimation of copper as CuSCN

iii. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.

iv. Estimation of Al (III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminium oxinate).

Inorganic Preparations:

i. Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$

ii. *Cis* and *trans* $K[Cr(C_2O_4)_2.(H_2O)_2]$ Potassium dioxalatodiaquachromate (III)

iii. Tetraamminecarbonatocobalt (III) ion

iv. Potassium tris(oxalate)ferrate(III)

v. Cuprous Chloride, Cu2Cl2 vi. Preparation of Manganese(III) phosphate, MnPO4.H2O.

vii. Preparation of Aluminium potassium sulphate KAl(SO4)2.12H2O (Potash alum) or Chrome alum.

Chromatography of metal ions

Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

i. Ni (II) and Co (II)

ii. Fe (III) and Al (III)

Reference Books:

1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.
2. Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
3. Arthur, I. V. Quantitative Organic Analysis, Pearson.
4. Vogel, A.I. Quantitative Organic Analysis, Part 3, Pearson (2012).
5. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
6. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5thEd., Pearson (2012).
7. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
8. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS. 1978

SEMESTER -VI

PAPER: MJ-12 (Organic Chemistry – 03)

	Mid Semester Exam	End Semester Exam	Total
Full Marks	25	75	100
Pass Marks	10	30	40
Time	1 hours	3 hours	

Credits: 04

Duration of Course: 60 hours

Instructions for Question Setter

Mid Semester Examination (MSE): 1 Hrs.

The Mid Semester Examination shall have two components.

(a) One Semester Internal Assessment Test (SIA): 20 Marks.

There will be three questions of 10 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts

(b) Class Attendance Score (CAS) & Day to day activities (DDA): 5 marks.

(Attendance: Upto75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)

End Semester Examination (ESE): 3 Hrs.

There will be **two** groups of questions.
Group A is compulsory and will contain two questions. Q. No. 1 will be multiple/fill in the blank/very short type five questions of 1 mark each. Q. No. 2 & 3 will contain two short answer type questions each of 5 marks.
Group B will contain descriptive type six (Q. No. 4 to 9) questions of 15 marks each, out of which any four are to be answered.

UNIT I: Nitrogen Containing Functional Groups: 10 hours

Amines: 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.

Diazonium Salts: Preparation and their synthetic applications.

UNIT II: Amino Acids, Peptides and Proteins: 10 hours

Amino acids, Peptides and their classification.

Alpha Amino Acids – Synthesis, ionic properties and reactions. Zwitterions, pKa values, isoelectric point and electrophoresis.

Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis

UNIT III: Nucleic Acids: 10 hours

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

UNIT IV: Heterocyclic Compounds: 16 hours

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

UNIT V: Lipids: 08 hours

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

UNIT VI: Pharmaceutical Compounds: Structure and Importance: 06 hours

Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarial: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

Reference Books:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VIth Edition. W.H. Freeman and Co.
2. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange Medical Books/ McGraw-Hill.
3. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
7. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
8. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Pragati Prakashan (2010).

SEMESTER -VI

PAPER: MJ-13 (Physical Chemistry – 03)

	Mid Semester Exam	End Semester Exam	Total
Full Marks	25	75	100
Pass Marks	10	30	40
Time	1 hours	3 hours	

Credits: 04

Duration of Course: 60 hours

Instructions for Question Setter

Mid Semester Examination (MSE): 1 Hrs.

The Mid Semester Examination shall have two components.

(a) One Semester Internal Assessment Test (SIA): 20 Marks.

There will be three questions of 10 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts

(b) Class Attendance Score (CAS) & Day to day activities (DDA): 5 marks.

(Attendance: Upto75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)

End Semester Examination (ESE): 3 Hrs.

There will be **two** groups of questions.
Group A is compulsory and will contain two questions. Q. No. 1 will be multiple/fill in the blank/very short type five questions of 1 mark each. Q. No. 2 & 3 will contain two short answer type questions each of 5 marks.
Group B will contain descriptive type six (Q. No. 4 to 9) questions of 15 marks each, out of which any four are to be answered.

UNIT I: Chemical Kinetics: 10 hours

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated rate laws for first, second and fractional order reactions, pseudounimolecular reactions, determination of the order, kinetics of complex reactions (limited to first order): (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, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

UNIT II: Phase Equilibria: 10 hours

Concept of phases, components and degrees of freedom, 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 diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water- chloroform-acetic acid system, triangular plots. *Binary solutions:* Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

UNIT III: Conductance: 06 hours

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 rules.

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.

UNIT IV: Electrochemistry: 12 hours

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.

Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and 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 and SbO/Sb_2O_3 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).

UNIT V: Introduction to Quantum Chemistry I: 12 hours

Introduction to black-body radiation and distribution of energy, photo-electic effect, concept of quantization, wave particle duality (de-Broglie's hypothesis), The uncertainty principle, The wave function: wave function and its interpretation, conditions of normalization and Orthogonality and its significance. Basic idea about operators, eigen function and values, Schrodinger equation and application to free-particle and particle in a box, boundary conditions, wave functions and energies, degeneracy, hydrogen atom, Schrodinger equation in polar coordinates, radial and angular parts of the hydrogenic orbitals, degeneracies, spherical harmonics, representations of hydrogenic orbitals.

UNIT VI: Introduction to Quantum Chemistry II: 10 hours

Quantitative treatment of simple harmonic osciallator model, setting up of Schodinger equation and discussion of solution of wave functions. Rigid rotator model and discussion of application of Schrodinger equation. idea about transformation to spherical polar coordinate, discussion on solution,

Recommended books/References:

1. Atkins P. W. and De Paula J., *Physical Chemistry, (*tenth edition) Oxford University Press, 2014.

2 Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa , 2004.

3 4 Engel, T. & Reid, P. *Physical Chemistry* Third Edition, Prentice-Hall,2012.

5 Zundhal, S.S. *Chemistry concepts and applications* Cengage India, 2011

6 Ball, D. W. *Physical Chemistry* Cengage India, 2012.

7 Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP, 2009.

8.Levine, I. N. *Physical Chemistry 6th Ed.,* Tata McGraw-Hill, 2011.

9.Metz, C. R. *Physical Chemistry 2nd Ed.,* Tata McGraw-Hill, 2009.

10. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition (International)1999

SEMESTER -VI

PAPER: MJ-14 (Analytical Chemistry)

	Mid Semester Exam	End Semester Exam	Total
Full Marks	25	75	100
Pass Marks	10	30	40
Time	1 hours	3 hours	

Credits: 04

Duration of Course: 60 hours

Instructions for Question Setter

Mid Semester Examination (MSE): 1 Hrs.

The Mid Semester Examination shall have two components.

(a) One Semester Internal Assessment Test (SIA): 20 Marks.

There will be three questions of 10 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts

(b) Class Attendance Score (CAS) & Day to day activities (DDA): 5 marks.

(Attendance: Upto75% = 1 mark; 75-80% = 2 marks; 80.-85% = 3 marks; 85-90% = 4 marks; >90% = 5 marks)

End Semester Examination (ESE): 3 Hrs.

There will be **two** groups of questions.
Group A is compulsory and will contain two questions. Q. No. 1 will be multiple/fill in the blank/very short type five questions of 1 mark each. Q. No. 2 & 3 will contain two short answer type questions each of 5 marks.
Group B will contain descriptive type six (Q. No. 4 to 9) questions of 15 marks each, out of which any four are to be answered.

UNIT I: Qualitative and quantitative aspects of analysis: 08 hours

Tools in analytical chemistry and their applications, Sampling, evaluation of analytical data, errors, accuracy and precision, statistical test of data; F, Q and t-test, rejection of data, and confidence intervals.

UNIT II: Spectroscopy: 12 hours

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

Vibration spectroscopy: Basic principles of instrumentation, sampling techniques. Application of IR spectroscopy for characterization through interpretation of data, Effect and importance of isotope substitution. Introduction to Raman spectra

UV-Visible Spectrometry: Basic principles of instrumentation, principles of quantitative

analysis using estimation of metal ions from aqueous solution, Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

UNIT III: Thermal analysis: 08 hours

Theory of thermogravimetry (TG and DTG), instrumentation, estimation of Ca and Mg from their mixture.

UNIT IV: Electroanalytical methods: 12 hours

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. determination of pKa values.

UNIT V: Separation techniques: 20 hours

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current 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.

Chromatography techniques: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis using LC, GLC, TLC and HPLC.

Recommended Books/Reference Books:

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

2) Christian, G.D, *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.

3) Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.

4) Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis, Saunder College Publications, (1998).*

5) Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood John Wiley 1979.

6) Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand, 1974.

7) Khopkar, S. M., Basic Concepts of Analytical Chemistry, New Age (Second edition)1998 9

8) Skoog D.A., Holler F.J., Nieman T.A., Principles of instrumental analysis, 5th Edn., Brooks & Cole (1997).

SEMESTER -VI

PAPER: MJ-15 (Practical Analytical Chemistry – 05)

	Mid Semester Practical	End Semester Practical	Total
Full Marks		100	100
Pass Marks		40	40
Time		3 hours	

Credits: 04

Duration of Course: 120 hours

UNIT I: Chromatography: 16 hours

(i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.

(ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.

iii. Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.

(iv) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

UNIT II: Solvent Extractions: 12 hours

(i) To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry.

ii. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

iii. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.

UNIT III: Analysis of soil: 12 hours

(i) Determination of pH of soil.

(ii) Total soluble salt

(iii) Estimation of calcium, magnesium, phosphate, nitrate

UNIT IV: Ion exchange: 10 hours

(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.

(ii) Separation of metal ions from their binary mixture.

(iii) Separation of amino acids from organic acids by ion exchange chromatography.

UNIT V: Spectrophotometry: 10 hours

(i). Determination of pKa values of indicator using spectrophotometry.

(ii) Structural characterization of compounds by infrared spectroscopy.

(iii) Determination of dissolved oxygen in water.

(iv) Determination of chemical oxygen demand (COD).

(v) Determination of Biological oxygen demand (BOD).

(vi) Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Recommended text books/references:

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

2. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.

3. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.

4. Harris, D.C. *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.

5. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.

6. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Edition.

7. Mikes, O. & Chalmes, R.A. *Laboratory Handbook of Chromatographic & Allied Methods*, Elles Harwood Ltd. London.

8. Ditts, R.V. *Analytical Chemistry: Methods of separation.* Van Nostrand, New York, 1974.