

**UNDERGRADUATE SYLLABUS (TDC) IN CHEMISTRY  
FOR SIX SEMESTER COURSES (THREE YEARS) –  
UNDER SEMESTER PROGRAMME IN COLLEGES**



***DIBRUGARH UNIVERSITY***

**CHEMISTRY**

**(Non-Major & Major)**

**(2011-2012)**

**(APPROVED BY BOS CHEMISTRY HELD ON 26-11-2010)**

## DIBRUGARH UNIVERSITY

### Scheme of Examination and Course of Study for B.Sc. (General) Chemistry under Semester Programme

Semesters	Paper No.	Title	Marks	
Semester-I	NM 101	<u>General Chemistry I</u> Inorganic Organic Physical	(27+7 Int.)=34 (27+7 Int.)=34 (26+6 Int.)=32	100
Semester-II	NM 201 NM202	Inorganic Chemistry-I Inorganic Lab	(48+12 Int.)=60 (32+8Int.)=40	100
Semester-III	NM 301 NM 302	Organic Chemistry- I Organic Lab	60 (48+12 Int.) 40 (32+8 Int.)	100
Semester-IV	NM 401 NM 402	Physical Chemistry I Physical Lab	60 (48+12 Int.) 40 (32+8 Int.)	100
Semester-V	NM 501 NM 502	Physical Chemistry- II Inorganic Chemistry- II Inorganic Lab	40 (32+8 Int.) 40 (32+8 Int.) 20 (16+4 Int.)	100
Semester-VI	NM 601 NM 602	Organic Chemistry- II Organic Lab Physical Lab Inorganic Lab	40 (32+8 Int.) 25 (20+5Int.) 25 (20+5 Int.) 10 (8+2 Int.)	100

Duration of Examinations (Theory)--- 3 hours per paper

Duration of Examination (Practical)—6 hours per paper

**Course of Study for B.Sc. [Major (MM)] in Chemistry**  
**(Semester course for the session 2011-2012)**

Semesters	Paper No.	Title	Marks	
Semester-I	MM 101	<b>Chemistry I</b> Physical Inorganic Organic	(26+6 Int.)=32 (27+7 Int.)=34 (27+7 Int.)=34	100
Semester-II	MM 201	<b>Chemistry II</b> Physical Inorganic Organic	(26+6 Int.)=32 (27+7 Int.)=34 (27+7 Int.)=34	100
Semester-III	MM 301 MM 302 MM 303 MM 304	Inorganic Chemistry- I Inorganic Lab Organic Chemistry- I Organic Lab	60 (48+12 Int.) 40 (32+8 Int.) 60 (48+12 Int.) 40 (32+8 Int.)	200
Semester-IV	MM 401 MM 402 MM 403 MM 404	Physical Chemistry I Physical Lab Organic Chemistry- II Organic Lab	60 (48+12 Int.) 40 (32+8 Int.) 60 (48+12 Int.) 40 (32+8 Int.)	200
Semester-V	MM 501 MM 502 MM 503 MM 504 MM 505 MM506 MM 507 MM 508	Physical Chemistry- II Physical Lab Inorganic Chemistry- II Inorganic Lab Organic Chemistry- III Organic Lab Symmetry & Quantum Chemistry Inorganic Lab	60 (48+12 Int.) 40 (32+8 Int.) 60 (48+12 Int.) 40 (32+8 Int.) 60 (48+12 Int.) 40 (32+8 Int.) 60 (48+12 Int.) 40 (32+8 Int.)	400
Semester-VI	MM 601 MM 602 MM 603 MM 604 MM 605 MM606 MM 607 MM 608	Physical Chemistry- III Physical Lab Inorganic Chemistry- III Inorganic Lab Organic Chemistry- IV Organic Lab Spectroscopy Project Work	60 (48+12 Int.) 40 (32+8 Int.) 60 (48+12 Int.) 40 (32+8 Int.) 60 (48+12 Int.) 40 (32+8 Int.) 60 (48+12 Int.) 40 (32+8 Int.)	400

Int. = Internal Assessment

**Duration of Examination (Theory) – 3 hours per paper**  
**Duration of Examination (Practical)—6 hours per paper**

# **SEMESTER I**

## **Paper NM-101**

**General Chemistry I Total Marks 100**

**Inorganic (27+7 Int.)**

**Physical (26+6 Int.)**

**Organic (27+7 Int.)**

**(Student will use separate Answer Script for Inorganic, Organic and Physical Chemistry)**

**Objective: To understand chemistry in different fields of specialization. To make the learners to have depth in each branch like Inorganic, Organic and Physical Chemistry**

### **Section A: Inorganic Chemistry-I**

**Unit -I** : Atomic Structure: (Recapitulation of Bohr's Theory, de Broglie, Theory, Heisenberg Uncertainty Principle- a new approach to Atomic Structure)

Time independent Schrödinger wave equation ( $H\psi=E\psi$ ). Significance of  $\Psi$  and  $\Psi^2$

Schrodinger equation for Hydrogen atom (qualitative treatment only). Quantum numbers, Radial and angular wave functions, probability distribution curves, shapes of s,p, and d orbitals. Aufbau and Pauli exclusion principles, Hund's multiplicity rule. Electronic configuration of elements based upon electronic configuration in the periodic table, periodic properties-effective nuclear charge ionization energy, electron affinity, electronegativity, Redox potential.

L-10 Marks: 12

### **Unit -II Chemical Bonding and Molecular Structure:**

**Ionic Bonding:** Energy consideration in ionic bonding, lattice Energy, and Solvation Energy and their importance in the context of Stability and Solubility of ionic compounds. Born-lande equation for calculation of lattice energy. Born - Haber cycle and its application, polarizing power and polarizability. Fajan's rule, Bond moment, dipole moment and percentage ionic character. Hydrogen Bonding.

**Covalent Bonding:** VB Approach-Concept of hybridization, SP, SP<sup>2</sup>, SP<sup>3</sup>, SP<sup>3</sup>d, SP<sup>3</sup>d<sup>2</sup> and dsp<sup>2</sup> VSEPR Theory. Resonance and Resonance energy: Study of some inorganic and organic compounds (O<sub>3</sub>, NO<sub>3</sub><sup>-</sup>, CO<sub>3</sub><sup>2-</sup>, SO<sub>4</sub><sup>2-</sup>, RCOO<sup>-</sup>, C<sub>6</sub>H<sub>6</sub>). Co-ordinate or Dative Bond.

**Molecular Orbital Approach:** LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combination of atomic orbitals non-bonding combination of orbitals, MO treatment of homonuclear diatomic molecules and heteronuclear diatomic molecules such as CO, NO and NO+

L-8 Marks: 15

### **Section B: Physical Chemistry**

#### **Unit-III : Kinetic Theory of gases**

Derivation of Kinetic gas equation., deduction of simple problems on – root mean square speed ,most probable speed ,collision frequency ,collision diameter ,mean free path heat capacity of gases, Maxwell distribution of molecular speed (Derivation not required). Deviation from ideal behavior, Vander Waals equation, Vander Waals constant, critical state of gas, critical constants, continuity of states, law of corresponding states, degree of freedom, law of equipartition of energy (derivation not required), viscosity of gases and effect of temperature and pressure on coefficient of viscosity).

L-8 Marks: 14

**Unit – IV: Liquid state:**

Qualitative treatment of the structure of liquids, Physical properties of liquids vapour pressure. Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald Viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment)

Parachor - determination and application

L-4 Marks: 6

**Unit-V: Solids**

Forms of solids, preliminary idea of symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of crystallography-Law of constancy of interfacial angles. Law of rational indices. Miller indices X-Ray diffraction by crystals. Bragg's law. Structure of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals.

liquid crystal .

L-4 Marks: 6

**Section C: Organic Chemistry**

**Unit – VI: Introduction to Organic Chemistry**

a) Importance of Organic Chemistry & organic systems to human beings & society. structure and Bonding- Hybridisation, bond lengths, bond angles, bond energy, localized and delocalized –  $\pi$  electrons related to simple organic molecules. Electronic displacements: Inductive effect, Electrometric effect, Resonance and hyper conjugation.

b) Mechanism of organic reactions Cleavage of Bonds: Homolysis and Heterolysis, Structure, Shape and reactivity of organic molecules- Nucleophiles and electrophils. Reactive Intermediates-Carbocation, Carbanions, free radicals, carbenes & nitrenes.

Strength of organic acids and bases: comparative study with emphasis on factors affecting pka values

L-4 Marks: 6

**Unit-VII Stereochemistry:**

**Conformations** w.r.t. ethane, butane and cyclohexane (axial and equatorial bonds) Interconversion of wedge formula, Newman, Sawhorse and Fischer projection representation.

**Concept of symmetry:** Elements of symmetry (Centre of inversion, axis of rotation plane of reflection and improper axis of rotation) applied to organic molecules.

**Optical isomerism:** Concept of chirality (with two stereogenic centres) diastereomers, threo and erythro, meso compounds, enantiomerism CIP Rules: R/S Nomenclature (up-to two chiral carbon atoms) Resolution of enantiomers and Racemisation.

**Geometrical isomerism:**  $\pi$ -diastereoisomerism, Determination of configuration of geometric isomers. E&Z system of Nomenclature.

L-4 Marks: 6

**Unit-VIII Aliphatic Hydrocarbons - Alkanes, Alkenes**

**Alkanes (upto 5 carbons)** Preparation:- Catalytic hydrogenation, wurtz reaction, Kolbe's Synthesis, from Grignard reagent. Corey House Synthesis.

Reactions:- Free radical Substitution : Halogenations

**Alkenes (upto 5 carbons)** Preparation- Elimination reaction- Mechanism of  $E^1$ ,  $E^2$ ,  $E^1cB$ . Dehydration of alcohols and dehydrohalogenation of alkyl halides – Saytzeff's & Hoffmann's rule.

**Reactions:** cis-addition (alk.  $\text{KMnO}_4$ ) and trans addition (bromine). Addition of HX (Markownikoff's and anti-Markownikoff's addition). Hydration, Hydroxylation by Osmium tetroxide, Hydroxylation via epoxydation, Ozonolysis.

Oxymercuration-demercuration, hydroboration-oxidation.

L-4 Marks: 8

**Unit-IX: Alkynes & Aromatic Hydrocarbons**

L-4 Marks: 7

**Alkynes (up-to 5 carbons) Preparation:** Acetylene from  $\text{CaC}_2$  and conversion into higher alkynes: by dehydrohalogenation of tetra halides, dehydrohalogenation of vicinal-dihalides.

**Reactions-**formation of metal acetylides, addition of bromine and alkaline  $\text{KMnO}_4$  ozonolysis and oxidation with hot alk.  $\text{KMnO}_4$ .

**Aromatic Hydrocarbons:**

Preparation (only benzene) from phenol by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions- Electrophitic substitution in benzene- nitration, halogenations, sulphonation, Fridel Craft alkylation and acylation with mechanism.

**Text Books**

**Inorganic Chemistry**

- 1) Advanced Inorganic Chemistry – Satyaprakash, Basu, Tuli
- 2) Inorganic Chemistry – Puri, Sharma and Kalia
- 3) Inorganic Chemistry – J.D. Lee

**Ref. Books:**

- 1) General and Inorganic Chemistry (Part-I & II) R. Sarkar
- 2) Basic Inorganic chemistry – Cotton and Wilkinson
- 3) Inorganic Chemistry – Huhey

**Text Books:**

**Organic Chemistry**

- 1) Organic Chemistry – B.S. Bahl and A. Bahl (Vol. I & II)
- 2) Organic Chemistry – M.K. Jain, S.Chand & Co.
- 3) A Text Book of Organic Chemistry (Vol. I & II) – B.K. Sharma, G.P. Pokhriji and S.K. sharma, (S. Chand & Co.)

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- 2) Organic Chemistry, R.I. Morrison & R.N. Boyd, S.K. Bhattacharyya
- 3) Organic Chemistry – Vol. I & II, Mukherjee and Kapoor

**Text Books:**

- 1) A Text Book of Physical Chemistry – Negi & S.C. Anand, Wiley Eastern
- 2) Physical Chemistry, Castellan G. W., Narosa Publishing
- 3) Principles of Physical Chemistry, Puri, Sharma, Pathania, Shoban Lal, (S. Chand & Co.)

**Ref. Books:**

- 1) Physical Chemistry – P.W. Atkins, Oxford University Press
- 2) Physical Chemistry – Barrow G.M. , Tata-Mc Graw Hill
- 3) Advanced Physical Chemistry – J.N. Gurta & H. Snehi, Pragati Prakashan

**SEMESTER- II**  
**Paper NM-201- Inorganic Chemistry- 60 (48+12 Int.)**

**Objective:** To understand Inorganic Chemistry in the form of materials science.

**Unit-I**     **Coordination Chemistry and Inorganic material chemistry**

Review of werner's theory. Types of ligands, monodentate, bidentate ambidentate and polydentate ligands (including  $\pi$  Acceptor and macrocyclic ligands. IUPAC (post 2005). Nomenclature of Co-ordination compounds.

Isomerism of 4-and 6- coordinate compounds. Introduction to valence bond and crystal field theory.

Application of dimethyl glyoxime, EDTA, 8-hydroxy quinoline, 2,2' bipyridyl, and ethylene diamine in analysis. L-15 Marks: 14

**Unit-II**     **Chemistry of non-metals**

**Boron:** Preparation, structure and bonding of diborane

**Silicon:** Structure, properties and use of silicon carbide and silicon polymers (linear).

**Nitrogen:** Hydroxylamine, Hydrazine, Hydrazoic acid preparation properties, uses and electronic structure.

Rare gases- Xenon compounds

Phosphorous: Structures of oxides and oxyacids. L-15 Marks: 14

**Unit-III**     **Inorganic Material Chemistry**

Zeolites, Ceramics, Glass, Silicates, and their uses.

Cement – composition, raw materials, manufacture, and setting of cement. Inorganic metal oxides, Superconductor. Synthesis, Structure and Application of Fullerenes.

L-10 Marks: 10

**Unit-IV**     **General principles of metallurgy**

Physico-Chemical methods involved in metallurgy (concentration, calcinations, reduction, roasting, zone refining, solvent extraction, hydrometallurgy and electrochemical methods) with reference to gold, nickel, thorium uranium and manganese (which ever is applicable).

L-10 Marks: 10

**Text Books**

**Inorganic Chemistry**

- 4) Advanced Inorganic Chemistry – Satyaprakash, Basu, Tuli
- 5) Inorganic Chemistry – Puri, Sharma and Kalia
- 6) Inorganic Chemistry – J.D. Lee

**Ref. Books:**

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- 5) Basic Inorganic chemistry – Cotton and Wilkinson
- 6) Inorganic Chemistry – Huhey

## **Paper NM-202- Inorganic Lab - 40 (32+8 Int.)**

### **Practical      Marks – 32**

#### **1) Inorganic Qualitative Analysis**

Analysis of samples containing 4 radicals including interfering radicals, phosphate, borate and fluoride. (Marks-18)

2) **Inorganic Preparation** – Chrome alum, Potash alum, Mohr's Salt, Potassium -trioxalato Chromate, Hexammine Cobalt Chloride, Cu-Thiourea Complex, Potassium trialuminato oxalate. (Marks-10)

3) Viva (Marks:4)

4) Internal (Marks:8)

## **SEMESTER- III**

### **Paper NM-301- Organic Chemistry- 60 (48+12 Int.)**

***Objective:*** To understand Organic Chemistry in the light of different types of reaction – to go for the study of broad field of Organic Chemistry.

#### **Unit – I**

#### **Alkyl and Aryl halides**

**Alkyl halides**- Nucleophilic Substitution Reactions ( $SN_2$ ,  $SN_1$ , &  $SN_i$ )

**Preparation:** from alkenes and alcohols

**Reactions::** Hydrolysis, nitrite and nitro formation, nitrile and isonitrile formation.

Williamson's Synthesis: elimination vs Substitution

**Aryl halides** Preparation (chloro, bromo, iodo benzene only): from phenol, Sand meyer & Gattermann reaction

Reactions (chlorobenzene) Aromatic nucleophilic substitution (replacement by  $-OH$ ) and effect of nitro substituent.

Reactivity and relative strength of C-halogen bond in alkyl, allyl, benzyl, and vinyl and Aryl halide. L-12 Marks: 12

#### **Unit – II**

#### **Alcohols, phenols and ether**

**Alcohol:** Preparation of  $1^0$ ,  $2^0$  and  $3^0$  alcohols: using Grignard reagent, Ester hydrolysis, Reduction of Aldehyde, ketones, carboxylic acid and ester, amines, Reactions – With sodium, HX (Lucas test) esterification, Oxidation (alk.  $KMnO_4$ , acid dichromate, conc.  $HNO_3$ ) Oppeneaur oxidation.

**Glycol** - Oxidation of glycol, pina col - pinacolone rearrangement.

**Glyceroal** : Preparation & reactions.



**Phenols**- Preparation-cumene hydroperoxide method, from diazonium salts  
Reactions – Electrophilic substitution-Nitration, halogenation. Sulphonation,  
Reimer – Tiemann Reaction, Gattermann-Koch reaction, Houben-Hoesch reaction- Schotten-  
Baumann Reaction (Mechanisms are not required)  
Preparation, properties and reactions of other Aromatic hydroxyl compds-nitrophanols, Picric  
acid, amino phenols, benzyl alcohol. L-12 Marks: 12

**Unit – III Aliphatic & aromatic carbonyl compounds, carboxylic acids and their derivatives.**

Study of the following reactions (Mechanisms are not required) – Rosenmund reduction, Stephen's reduction, Aldol condensation, claisen condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation, Clemmensen reduction and Wolf Kishner reduction, Meerwein – Pondorf – Verly reduction and Haloform reaction.

**Aromatic aldehydes & Ketones** – Preparation and reactions, Benzaldehyde, Salicyladehyde, Cinnamal- dehyde, acetophenone, benzophenone.

**Aliphatic carboxylic Acids** – Relative reactivity, Strength of acids, general methods of preparation & properties. Hell volhard-Zelinsky Reaction.

**Carboxylic acid derivatives** – preparation of Acid chloride, Anhydrides, Esters & Amides from acids and their interconversions Reactions – Reformatsky reaction & Perkin condensation. Aromatic Carboxylic acid – Benzoic Acid, Cinnamic Acid, Phthalic Acid.

L-15 Marks: 14

**Unit –IV Amines and Diazonium Salts**

**Amines (Aliphatic & Aromatic)** Preparation – from alkyl halides, Gabriel's phthalimide synthesis, Hofmann Bromamide reaction.

Reactions: Carbylamine test, Hinsberg test, with HNO<sub>2</sub>, Electrophilic substitution (in case of aniline) –Nitration, bromination, sulphonation.

**Diazonium Salts** – Preparation from aromatic amines. Synthetic uses of benzene diazonium chloride including preparation of dyes – coupling reaction.

L-10 Marks: 10

**Text Books:**

Organic Chemistry

- 4) Organic Chemistry – B.S. Bahl and A. Bahl (Vol. I & II)
- 5) Organic Chemistry – M.K. Jain, S.Chand & Co.
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- 6) Organic Chemistry – Vol. I & II, Mukherjee and Kapoor

## **Paper NM-302- Organic Lab - 40 (32+8 Int.)**

### **Organic Chemistry practicals: 32**

#### **a) Organic Qualitative analysis**

Detection of elements (Nitrogen, Sulphur and halogens) and functional groups of Organic compounds containing one functional group.

**Marks 20**

#### **b) Purification of Organic Compounds by crystallization (from water and alcohol) and distillation .**

**Marks: 4**

#### **c) Criteria of purity: Determination of melting points.**

**Marks: 4**

#### **d) Viva**

**Marks: 4**

#### **e) Internal**

**Marks: 8**

## **SEMESTER- IV**

### **Paper NM-401 Physical Chemistry- 60 (48+12 Int.)**

***Objective:*** To understand Physical Chemistry in the form of Physical forces which govern our surroundings.

#### **Unit –I : Solution**

Types of solutions, concentration units, Solution of gases in liquids-Henry's law. Solution of liquids in liquids-Ideal solution-Raoult's law- Non ideal solution. Distillation of solutions, Lever rule, Azeotropes, Partial miscibility of liquids. Critical solution temperature. Solutions of solids in liquids, the solubility curves. Immiscibility of liquids. Principle of steam distillation. The Nernst distribution law and its applications. Solvent extraction.

**L-10 Marks -8**

#### **Unit – II Ionic Equilibrium**

Strong and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water.

Ionization of weak acids and weak bases. pH and its determination, pH scale, common ion effect. Salt hydrolysis – calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts- applications of solubility product (stress to be given to numerical problems).

**L-10 Marks -8**

#### **Unit – III Chemical Kinetics**

Elementary and complex reaction. Rate of a reaction, Order and molecularity of a reaction. Examples of 1<sup>st</sup>, 2<sup>nd</sup> and zero order reactions. Differential and integral forms of zero order, 1<sup>st</sup> order, 2<sup>nd</sup> order rate equation. Half life period of zero order, first order and 2<sup>nd</sup> order reaction, determination of order of a reaction by method of half life period and isolation method. Concept of activation energy and its calculation from Arrhenius equation, theories of reaction rates- collision theory and activated complex theory of bimolecular reaction, comparison of two theories. (qualitative treatment only)

**L-10 Marks-10**

**Unit - IV     a) Chemical Thermodynamics & First law**

Thermal equilibrium and zeroth law of thermodynamics- concept of temperature, Mechanical work, SI sign convention. 1<sup>st</sup> law of thermodynamics, internal energy, enthalpy, reversible and irreversible processes, calculation of W, Q,  $\Delta U$ ,  $\Delta H$  for expansion of ideal gas, isothermal work and enthalpy, relation between enthalpy change, and entropy change, molar heat capacities, relation between  $C_p$  and  $C_v$ , adiabatic processes- relation between P, V and T, Joule-Thomson effect, liquefaction of gases, conversion of heat into work, efficiency of heat engine. Enthalpy of reaction, thermo dynamical equation, variation of enthalpy of reaction with temperature- Kirchhoff's equation, enthalpy of different processes. Hess law, Bond dissociation energy, Born-Haber cycle, calculations based on Hess law.

**L-15 Marks: 12**

**b) Second law of thermodynamics**

Second law of thermodynamics, Spontaneous and Non-Spontaneous processes cyclic process- Carnot cycle, Carnot Theorem related problems. Entropy, Entropy change in reversible and irreversible processes and for ideal gas work function and free energy function. Variation of free energy with temperature and pressure. Gibb's Helmholtz equation, Chemical potential – partial molar free energy.

**L -5 ,Marks -10**

**Text Books:**

- 4) A Text Book of Physical Chemistry – Negi & S.C. Anand, Wiley Eastern
- 5) Physical Chemistry, Castellan G. W., Narosa Publishing
- 6) Principles of Physical Chemistry, Puri, Sharma, Pathania, Shoban Lal, (S. Chand & Co.)

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- 6) Advanced Physical Chemistry – J.N. Gurta & H. Snehi, Pragati Prakashan

**Paper NM-402- Physical Lab - 40 (32+8 Int.)**

- i) Surface Tension measurement
  - a) Surface tension of Solutions by stalogrameter
  - b) Study of the variation of surface tension of a detergent solution with concentration.

**Marks -14**

- ii) Viscosity measurement
  - a) Viscosity of solution by Ostwald s viscometer.

**Marks -14**

**Viva**

**Marks - 4**

**Internal Assessment**

**Marks - 8**

## SEMESTER- V

**Paper NM 501 Inorganic + Physical (Theory) 40+40 = 80(64-Th +16-Int.)**  
(Student will use separate Answer Scripts for Inorganic and Physical Chemistry)

**Objective:** In this course/paper, nuclear chemistry, preparative chemistry, Bio-Inorganic as well as the importance of electrochemistry, surface phenomena and photo chemical processes are dealing with.

**First half- Inorganic Chemistry**

**Marks:(32+8 Int.) = 40**

**Unit-I Nuclear Chemistry** : Mass defect and binding energy , packing fraction , stability of nucleus neutron- proton ratio ,Artificial radioactivity ,nuclear fission ,nuclear reactors ,separation of isotopes .Detection and measurement of radioactivity by GM counter .Application of radio isotopes in agriculture medicine and industry .Radio carbon dating.

**L-6, Marks -10**

**Unit-II Preparative Chemistry**

Preparation Properties and uses of the following compounds : Lithium aluminium hydride , potassium ferro and ferricyanide , sodium cobaltinitrite , sodium thiosulphate , Nesler s reagent ,sodiumborohydride ,silica gel ,Pb and Zn containing paints

**L-6 ,Marks -10**

**Unit-III Bioinorganic Chemistry :**

Role of zinc , iron, cobalt, molybdenum, sodium, potassium in biological system Role of Mg<sup>++</sup> in chlorophyll . Role of Ca in blood clotting .

Poisoning due to heavy metal ion – Mercury , Cadmium , Lead and Arsenic .

**L-8 ,Marks -12**

**Second half; Physical Chemistry .**

**Marks (32+8 Int.) = 40**

**Unit – I Conductance**

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Hittorf and Moving boundary method. Ionic mobility, Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conduct metric titrations (only acid-base).

**L-8 ,Marks -5**

**Unit –II                      Electrochemistry**

Reversible and irreversible cells, Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Commercial applications of galvanic cell, dry cell, lead storage battery, fuel cell.

**L-6, Marks -6**

**Unit –III                      Adsorption and Catalyst**

Types of adsorption. Differences between chemisorptions and Physical adsorption; Freundlich adsorption isotherm and Langmuir adsorption isotherm, application of adsorption. Homogeneous heterogeneous catalysis, acid-base catalysis catalytic promoter, poisoning, negative catalysis ,enzyme catalysis characteristics of enzyme catalysis ,Theories of catalysis .

**L-6 ,Marks -5**

**Unit –IV                      Phase Rule:**

Statement of phase rule, definition of phase, components and degrees of freedom with examples .phase diagram of water and sulphur system.

Solid liquid equilibrium – simple eutectic mixture –phase diagram of Pb –Ag.

**L-4, Marks -5**

**Unit –V                      Colloids:**

Lyophilic and Lyophobic colloids, preparation and properties of colloids, stability and coagulation of colloids, Schultz –Hardy rule, protective colloid, gold number, electrophoresis, emulsion.

Surfactants –Definition, micelle formation and critical micelle concentration.

**L-4, Marks -6**

**Unit IV                      Photochemistry**

Adsorption of light Lambert Beer's law, Laws of photochemistry, Quantum yield Quantum efficiency, fluorescence, phosphorescence chemiluminescence .phosphosensitized reaction.

**L-4, Marks -5**

**Text Books**

**Inorganic Chemistry**

- 1) Advanced Inorganic Chemistry – Satyaprakash, Basu, Tuli
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**Ref. Books:**

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**Paper NM 502 Inorganic Lab**

**Marks -20(16 +4 Int.)**

**Inorganic Chemistry Practicals**

**A) Volumetric analysis**

**Marks: 14**

- i) Estimation of  $\text{Na}_2\text{CO}_3$  &  $\text{NaHCO}_3$  present in a mixture
- ii) Estimation of  $\text{C}_2\text{O}_4^{2-}$  / Fe (II) by  $\text{KMnO}_4$
- iii) Estimation of Fe (III) / Cu (II) by iodometric titration
- iv) Estimation of Fe (II) ions by titrating with potassium dichromate using internal indicator.

**B) Viva**

**Marks -02**

**C) Internal Assessment**

**Marks -04**

**SEMESTER-VI**

**Paper NM-601-Organic Chemistry Marks - 40(32-Th +8-Int.)**

***Objective:* To understand the preparative Organic Chemistry as well as the importance of Organic Chemistry in life processes are dealing with.**

**UNIT -I Active Methylene Compounds**

**Synthesis** of ethylacetoacetate (Claisen ester condensation), Diethylmalonate .Synthetic uses of ethylacetoacetate and diethylmalonate.

Keto – enol Tautomerism.

**L-4, Marks -5**

**Unit-II – Preparation, properties and reaction of the following Organic Compounds**

**A) Compounds containing more than one functional group**

**Hydroxy acid** - Lactic and Tartaric acids

**Dicarboxylic acids**- (Oxalic, Malonic, Succinic and Pthalic acid) and Citric acid.

**B) Unsaturated compounds**- Acrolein, Crotonaldehyde, Cinnamaldehyde,

Acrylic acid, Crotonic acid, Maleic acid and Fumaric acid

**L-8, Marks: (3+2)**

**Unit-III- Preparation, properties and reaction of the following Organic Compounds**

**Aromatic Sulphonic acids**- Benzene sulphonic acid, nitro sulphonic acid, amino sulphonic acid, sulphuryl chloride, saccharin, chloramines-T

**Aromatic nitro compounds**- Nitrobenzene, Dinitrobenzene, Nitro toluene, TNT, Reduction of nitro compounds in different conditions.

**Heterocyclic compounds**- - preparation and properties of five and six membered heterocyclic compounds: pyrrole, thiophene, furan, pyridine.

**Polynuclear Hydrocarbon** : preparation and properties of Naphthalene and Anthracene

**L-10, Marks -7**

#### **Unit - IV**

##### **Organic Chemistry of life**

**Amino Acids:** classification, preparation and properties Glycine, Alanine and Phenylalanine (Strecker synthesis and Gabriel phthalimide method).

Zwitter ion, isoelectric point and Electrophoresis. Reactions of amino acids: ester of –COOH group, acetylation of –NH<sub>2</sub> group.

Elementary ideas of peptides and proteins.

**Elementary ideas of nucleic acid: nucleoside, nucleotide, DNA, RNA.**

**Elementary ideas of enzyme and co-enzyme.**

**L-10, Marks -5**

**Unit –V Carbohydrates :** Classification and General properties, Glucose and Fructose (open chain and cyclic structure) epimerization, mutarotation, conversion process --ascending and descending methods conversion of aldose to ketose and vice versa .

**L-8, Marks -5**

#### **Unit – VI Synthetic Polymers :**

Classification of polymers, Addition or chain growth polymerization (free radical vinyl polymerization only). Condensation or step growth polymerization (simple ideas of urea formaldehyde and phenol formaldehyde resins).

**L-8, Marks -5**

#### **Text Books:**

Organic Chemistry

- 7) Organic Chemistry – B.S. Bahl and A. Bahl (Vol. I & II)
- 8) Organic Chemistry – M.K. Jain, S.Chand & Co.
- 9) A Text Book of Organic Chemistry (Vol. I & II) – B.K. Sharma, G.P. Pokhriji and S.K. sharma, (S. Chand & Co.)

#### **Ref. Books**

- 7) Organic Chemistry – I.L. Finar, Vol. I & II, ELBS
- 8) Organic Chemistry, R.I. Morrison & R.N. Boyd, S.K. Bhattacharyya
- 9) Organic Chemistry – Vol. I & II, Mukherjee and Kapoor

#### **Paper NM 602 1) Organic Lab**

**Marks (20+5 Int.)=25**

##### **A) Organic preparation-**

- 1) **Acctylation-** preparation of aspirin from salicylic and preparation of acetamide from aniline.
- 2) **Bromination** of phenol and aniline
- 3) **Benzoylation** of amines and phenol
- 4) **2, 4 dinitro phenyl hydrazone** of aldehydes and ketones

**Marks: 10**

**B) Separation of mixtures by chromatography:** Determination of R<sub>f</sub> value in each case (combination of two compounds to be given)

- 1) Identify and separate the components of a given mixture of two amino acids (glycine, aspartic acid, glutamic acid, or any other amino acid) by paper chromatography.
- 2) Identify and separate the sugars present in the mixture by paper chromatography

**Marks 07**

c) **Viva**

**Marks 03**

d) **Internal Assessment**

**Marks 05**

**2) Physical Lab.**

**Marks (20+ 5 Int.)=25**

**a) Physical Experiments (any one)**

- i) Partition Co-efficient of a solute between two immiscible solvents.
- ii) Study of rate constant of methyl acetate in presence of  $H^+$  concentration at room temperature.

**Marks: 17**

**b) Viva**

**Marks 03**

**c) Internal Assessment**

**Marks 05**

**3) Food Analysis (Turmeric, mustard oil common salt, milk, sugar, coffee, pulses cereals spices –qualitative aspect only)**

**Marks -10**

**Additional recommended Books:**

**Inorganic Chemistry**

- 1) Advance Inorganic Chemistry – Satyaprakash, Basu, Tuli
- 2) Inorganic Chemistry – Purl, Sharma and Kaila
- 3) Inorganic Chemistry – J.D. Lee
- 4) Inorganic Chemistry: principle, Structure and Reactivity, James E Huberg & Richard keiler, Pearson publication.

**Physical Chemistry**

- 1) Physical Chemistry, Barrow G.M. Tata – Mc Graw Hill (2007)
- 2) A test book of Physical Chemistry, Negi & S.C. Anand – Wiley Eastern
- 3) An Elements of Physical Chemistry, P.W. Atkins, Oxford University press
- 4) New College Chemistry, YR Sharma & KD Sharma, Kalyani Pub.
- 5) Physical Chemistry, Castellan G.W. 4<sup>th</sup> Ed. Narosa publishing (2004)

**Organic Chemistry**

- 1) Organic Chemistry, IL Finar Vol. I & II, ELBS.
- 2) Organic Chemistry, RI Morrison & RN Boyed, S.K. Bhattacharyya Pearson
- 3) Advance Organic Chemistry, Arun Bahl and B.S. Bahl, S. Chand & Co.
- 4) Advance General Organic Chemistry- a modern approach S.K. Ghosh
- 5) Advance Organic Chemistry, Jerry March
- 6) A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Orient Longmann
- 7) Organic Chemistry, TW Graham Solomon, John Wiley and Sons
- 8) General Chemistry 5<sup>th</sup> Ed. Petrucci RH, Macmillan publishing Co. New York
- 9) Organic Reaction mechanism – Mukharjee and Singh.

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## SEMESTER I (Major)

### Paper MM 101

(Students will use separate Answer Scripts for Physical, Inorganic and Organic Chemistry)

Physical + Inorganic + Organic [(26+6 Int.) + (27+7 Int.) + (27+7(Int.))] = 100

*Objective:* To understand Inorganic, Organic and Physical Chemistry in their advanced treatment

### Section I Physical Chemistry (Major) Marks: (26+6 Int.) =32

#### Unit I- Gas

Derivation of kinetic gas equation, Maxwell distribution of molecular speed, different types of average speeds, collision properties, Mean free path, determination of collision diameter, transport phenomenon in gases-viscosity, coefficient of viscosity, law of equipartition of energy, degrees of freedom and average energy of a molecule, molecular basis of heat capacity, barometric formula, and its uses for determination of Avogadro number.

Deviation from ideal behavior, vander Waals and Dieterici's, Virial equation of state, Boyle's temperature, Critical constants, reduced equation of state, co-efficient of compressibility and thermal expansion.

L-8 Marks: 10

#### Unit II- Liquid

Qualitative treatment of structure of liquids, physical properties of liquids, physical properties of liquids, vapour pressure, surface tension, viscosity, parachor-determination and application, Newtonian and non Newtonian liquid, liquid crystals, qualitative discussion of structure of water.

L -4 Marks: 06

#### Unit III – Solids

Basic laws of crystallography, crystal system, crystal lattice, Miller indices, and simple face centered and body centered cubic lattice, number of points in a unit cell.

X-Ray diffraction study of crystals, Bragg's law, determination of crystal structure- Rotating crystal method, powder method, crystal structure of NaCl and KCl, packing of crystals, closed packed structure, crystal defect-point defects, conductors, semiconductors and insulators from band theory.

L-5 Marks: 10

### Section II Inorganic Chemistry Marks: 34= (27+7 Int.)

#### UNIT – I:

**Periodic properties:** - Effective nuclear charge (screening constant – Slater's rule only), ionic and covalent radii, ionization potential, electron affinity and electro negativity (Pauling, Mullikan's and Allred-Rochow scales).

L-4 Marks = 9

**Bonding and structure:** Electrovalent bond, covalent bond, covalent ionic resonance and partial ionic character in covalent bonds, lattice energy, bond length, bond angle and bond energy. VB and MO theories, LCAO and MO diagram of homo and hetero diatomic molecules, VSEPR theory and its applications.

L-10. Marks =18

### Section -III Organic Chemistry-I Marks: 34= (27+7 Int.)

#### Unit-I

##### Basics of Organic chemistry

Importance of Organic Chemistry and Organic systems to human beings and society.

Organic Compounds: Natural Sources, classification and Nomenclature.

Hybridization: Shape of molecules, Influence of hybridization on bond properties.

Electronic displacements: Inductive, Electromeric, Resonance, Mesomeric effects and Hyper conjugation and their applications. Dipole moment.

Organic acids and bases: Their relative strength, hard and soft Acids and Bases.

Homolytic and Heterolytic fission, Electrophiles and Nucleophiles: Nucleophilicity and basicity.

Reactive intermediates: Carbocations, Carbanions, free radicals, Carbenes, nitrenes-Benzynes types, Shape and their relative Stability.

Energy profile diagrams of one step, two steps and three steps reactions, Rate limiting steps. Activation Energy. Kinetically and thermodynamically controlled reactions.

L-12. Marks =15

#### Unit -II

##### **Stereochemistry**

Elements of symmetry and their application in simple organic molecules. Definition and classification of stereoisomerism, Representation of organic molecules in three & two dimension: Fischer Projection, Newman projection, Saw horse and flying wedge projection formula and their interconversions.

**Optical isomerism**: Concepts of asymmetry, dissymmetry, optical activity, Specific rotation, Chirality, enantiomers, Diastereomers, racemic mixture, racemization and Resolution, Threo and Erythro forms, Meso structures & Epimers.

Relative and absolute configuration: D/L and R/S designations.

Walden inversion and asymmetric synthesis.

**Geometrical Isomerism**: Restricted rotation about C=C bonds, physical and chemical properties of diastereoisomers, determination of configuration of geometrical isomers: cis-trans isomerism, syn-anti and E/Z notation with CIP rules.

Geometrical isomerism in oximes and alicyclic compounds.

L-10.Marks 12

#### **Text Books:**

- 1) Basic Inorganic Chemistry – Cotton and Wilkinson
- 2) Inorganic Chemistry – J.D. Lee
- 3) Inorganic Chemistry – Huhey
- 4) General Inorganic Chemistry – (Part-I & Part-II), R. Sarkar
- 5) Advanced Inorganic Chemistry – R.D. Madan

**Ref. Books:**

- 1) Selected Topics in Inorganic chemistry – Malik, Tuli and Madan
- 2) Inorganic Chemistry – Shriver & Alkins
- 3) Greenwood, N.N. Earnshaw, Chemistry of the Elements, Butterworth-Heinemann.
- 4) Basolo F and Pearson R.C., Mechanism of Inorganic chemistry – John Wiley & Sons.

**Text Books,**

**Physical Chemistry:**

- 1) G.W. Castellan, Physical Chemistry, Narosa Publishing House, New Delhi.
- 2) P.C. Rakshit, Physical Chemistry - Science Book Agency, Kolkata
- 3) Physical Chemistry Vols. I, II, III and IV – K.L. Kapoor, MacMillan (India) Ltd., New Delhi
- 4) Advanced Physical Chemistry – J.N. Gurta & H. Snehi, Pragati Prakashan.

**Ref. Books:**

- 1) P.W. Atkins, Physical Chemistry, Oxford University Press
- 2) Physical Chemistry – B.R. Puri, L.R. Sharma, Madan S. Pathania, Shobanlal Nagin, Chand & Co.

**Text Books,**

- 1) Organic Chemistry: I.L. Finers, Vol. I & II ELBS
- 2) Organic Chemistry Morrison and R.N. Boyd
- 3) Advanced Organic Chemistry: Reaction Mechanism & Structure – Jerry March Wiley Eastern.
- 4) P.S. Kalsi Textbook of Organic Chemistry

**Ref. Books:**

- 1) A Guide book to Mechanism in Organic Chemistry, P. Sykes, McGraw Hill
- 2) Advanced Organic Chemistry - B.S. Bahl and A. Bahl
- 3) Organic reaction mechanism – R.K. Bansal, Tata McGraw Hill
- 4) Advanced General Organic Chemistry – S.C. Ghosh

## SEMESTER II

### Paper-MM 201

### Chemistry II

(Students will use separate Answer Scripts for Physical, Inorganic and Organic Chemistry)

**Physical +Inorganic + Organic** [(26+6Int.) + (27+7Int.) + (27+7(Int.))] = 100

*Objective:* Importance of Chemical Thermodynamics, Non-Transition Metals, Metals alongwith different types of organic reaction are dealing with.

**Section-I Semester-II Physical Chemistry (Major)** Marks: (26+6Int.)=32

#### **Unit 1- Chemical Thermodynamics -I**

Extensive and intensive properties of a system, thermodynamic processes: cyclic, reversible, irreversible processes, thermodynamic function, complete differential, Zeroth law of thermodynamics.

First law of thermodynamics-internal energy, enthalpy, molar heat capacities, relation between  $C_p$  and  $C_v$ , work of expansion in reversible and irreversible process, adiabatic process, relation between  $P$ ,  $V$ ,  $T$ .

Variation in internal energy and enthalpy with temperature, Joule Thomson effect, calculation of Joule Thomson co-efficient for ideal and Vander Waal's gas.

Thermo chemistry- Hess's law, Kirchhoff's law relation of reaction enthalpy with internal energy, Bond energy and Bond dissociation energy, calculation from thermo chemical data.

L-10 Marks: 14

#### **Unit II – Chemical Thermodynamics II**

Second law of thermodynamics, Carnot's theorem, Carnot cycle, efficiency of heat engines, thermodynamic scale of temperature, concept of entropy, entropy change in a cyclic, reversible, irreversible processes, calculation of entropy changes of an ideal gas with change in  $P$ ,  $V$ ,  $T$ , entropy change in physical transformation, entropy of mixing.

Helmholtz free energy ( $A$ ) and Gibb's free energy ( $G$ ), variation of  $A$  and  $G$  with  $P$ ,  $V$ ,  $T$ , criteria for spontaneity and equilibrium, Maxwell's relationship, Gibb's –Helmholtz equation.

Nernst heat theorem, consequence of the theorem, third law of thermodynamics, and its verification. Determination of absolute entropies of pure substance

L-10 Marks: 12

**Section II Inorganic Chemistry** Marks : (27+7 Int.)=34

#### **UNIT – I:**

**Non Transition elements:** Electronic structure, general properties and comparative study of group of non transition elements.

- Noble Gas : Compounds of Xenon only
- Boron:** Wade's rule, Nomenclature of closo, nido and arachno boranes, structure of boron hydrides ( $B_2H_6$ ), metaloborane and metallocarboranes.  
Borazine, phosphazine,  $S_4N_4$ ,  $(SN)_x$  – preparation, structure and use.
- Carbon : Fullerenes ( $C_{60}$ )
- Silicon:** Silicones, classifications and structure of silicates. Zeolites, use of Zeolites as catalyst and molecular sieve, aluminosilicates.
- Nitrogen:** Hydrazine, hydroxylamine and hydrazoic acid.
- Phosphorus;** Phosphines, oxy acids of phosphorus, organo phosphorus compounds.

L-8 Marks= 15

## UNIT – II : Metals

Theory of reduction (Thermodynamic approach), role of carbon and other reducing agents, electrolytic reduction, roasting and calcinations.

Method of purification and refining of metals including modern methods like zone refining, vacuum arc process, ion exchange, solvent extraction and electrolytic method, Van – Arkel process and hydrometallurgy.

### Chemistry of the following metals:

Cr, Mn, Mo, Co, Ni, and V.

L-6, Marks= 12

## Section –III Organic Chemistry Marks = (27+7 Int.)= 34

### Unit –I

#### a) Carbon- Carbon sigma bonds

Chemistry of Alkanes: Formation of Alkanes with special emphasis on **Corey House** Synthesis, **Wurtz** Reaction, **Wurtz-Fittig**, Reactions, of Alkanes. Free Radical substitution-Halogenations-relative reactivities and selectivity

L-2.Marks -5

#### b) Carbon-Carbon pi bonds

Formation of alkenes and alkynes by Elimination: Mechanism E1., E2, E1cB reactions. Saytzeff and Hoffmann Elimination, special emphasis on preparation of alkenes by syn elimination-pyrolysis of esters, **Chugaev, Wittig, Heck, Peterson reaction.**

**Reaction of alkenes: Addition Reaction-** Electrophilic and free radical additions, their Mechanisms. (Markonikoff/ Anti Markonikoff addition) regioselectivity (directional selectivity), and stereoselective of addition reactions. Mechanism of oxymercuration – demercuration, Hydroboration-Oxidation, Ozonolysis, reduction (catalytic and chemical) **syn. and Anti hydroxylation** (oxidation), simple effect of stereo selectivity and stereo specificity.

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

**Conjugated Alkenes/Alkynes: 1, 2 and 1, 4 addition reactions, Diels-Alder reaction.**

L-8.Marks -8

### Unit -II

#### Cycloalkanes and conformational analysis:

Synthesis and reactions of three, four, five and six membered Cycloalkanes, Their relative stability, Bayer strain theory. Sacke-Mohr theory.

**Conformational analysis of Alkanes:** (ethane & butane) Relative stability, Energy diagram

**.Cyclohexane:** Chair, Boat and Twist boat forms, Relative stability with energy diagram axial and equatorial bonds including perspective representation and Newman projections.

Conformation & conformational analysis of monosubstituted Cyclohexane derivative

L-6 Marks-6

### Unit-III

#### Aromatic Hydrocarbons

Aromaticity: Huckel's rule, aromatic characters of arenes, benzenoid, non-benzenoid- aromatic compounds and heterocyclic and polynuclear hydrocarbons with suitable examples.

Antiaromaticity and nonaromaticity structure and stability of benzene

Preparation, Properties and reactions of Toluene, Xylene, Mesitylene, Styrene.

**Electrophilic Aromatic Substitution:** Halogenation, nitration, sulphonation and Friedel-craft's alkylation / acylation with their mechanism. Activation / deactivation of aromatic ring and directing effects of groups. Partial rate factor (O/P ratio)

L-4, Marks-8

**Text Books:**

- 1) Basic Inorganic Chemistry – Cotton and Wilkinson
- 2) Inorganic Chemistry – J.D. Lee
- 3) Inorganic Chemistry – Huhey
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- 5) Advanced Inorganic Chemistry – R.D. Madan

**Ref. Books:**

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- 2) Inorganic Chemistry – Shriver & Alkins
- 3) Greenwood, N.N. Earnshwa, Chemistry of the Elements, Butterworth-Heinemann.
- 4) Basolo F and Pearson R.C., Mechanism of Inorganic chemistry – John Wiley & Sons.

**Text Books,**

**Physical Chemistry:**

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- 2) P.C. Rakshit, Physical Chemistry - Science Book Agency, Kolkata
- 3) Physical Chemistry Vols. I, II, III and IV – K.L. Kapoor, MacMillan (India) Ltd., New Delhi
- 4) Advanced Physical Chemistry – J.N. Gurta & H. Snehi, Pragati Prakashan.

**Ref. Books:**

- 1) P.W. Atkins, Physical Chemistry, Oxford University Press
- 2) Physical Chemistry – B.R. Puri, L.R. Sharma, Madan S. Pathania, Shobanlal Nagin, Chand & Co.

## SEMESTER III

**Paper: MM 301**

**Inorganic Chemistry I**

**Total Marks 60[48(Th)+Int.-12]**

Objective: To understand Coordination Chemistry, Mechanism and the importance of d- and f-block elements are dealing with.

### **UNIT – I:**

**Coordination compounds:** Types of ligands: monodentate, bidentate, ambidentate, polydentate and macro cyclic ligand. Nomenclature of complex compounds, Isomerism in 4- and 6-coordinate compounds. Inner complex and chelates.  
Effective atomic number rule, VB, crystal field, MO and introduction to ligand field theories and their applications.  
Spectroscopic terms, RS coupling, Mulliken's symbol (A, B, E, T).  
Spectrochemical and nephelauxetic series, Electronic spectra, selection rules and Orgel diagram ( $d^1$  and  $d^9$  system).  
**Magnetic properties:** Paramagnetism, diamagnetism, magnetic properties of octahedral complexes, Antiferromagnetism.

L-20.Marks = 30

### **UNIT – II:**

#### **Inorganic reaction mechanism:**

Introduction to inorganic reaction mechanism, inert and labile complexes, association, dissociation and concerted paths.  
Acid and base hydrolysis (with reference to cobalt complexes only).  
Substitution reaction in octahedral and square planar complexes. Trans effect, Irving-William series.

L-15.Marks = 12

### **UNIT – III:**

#### **Chemistry of d- and f- block elements:**

Electronic structure, oxidation state, ionic radii, Lanthanide and Actinide contraction and separation of lanthanides

L-10.Marks = 6

### **Text Books:**

- 1) Basic Inorganic Chemistry – Cotton and Wilkinson
- 3) Inorganic Chemistry – J.D. Lee
- 4) Inorganic Chemistry – Huhey
- 5) General Inorganic Chemistry – (Part-I & Part-II), R. Sarkar
- 6) Advanced Inorganic Chemistry – R.D. Madan

### **Ref. Books:**

- 1) Selected Topics in Inorganic chemistry – Malik, Tuli and Madan
- 2) Inorganic Chemistry – Shriver & Alkins
- 3) Greenwood, N.N. Earnshaw, Chemistry of the Elements, Butterworth-Heinemann.
- 4) Basolo F and Pearson R.C., Mechanism of Inorganic chemistry – John Wiley & Sons.

**Paper MM 302 Inorganic Lab. Marks (32+8 Int.)= 40**

- 1) Inorganic Qualitative analysis (5 Radicals, including interfering radicals- $\text{PO}_4^{-3}$ ,  $\text{BO}_3^{-3}$ ,  $\text{F}^-$ ,  $\text{C}_2\text{O}_4^{2-}$ ) Marks = 27  
2) Viva Marks: 5  
3) Internal Marks: 8  
(Spot tests should be carried out wherever feasible)

**Paper-MM 303 Organic Chemistry-I Marks 60[48+12(Int.)]**

*Objective:* Importance of Halogenated Hydrocarbons, Chemistry of Carbonyls along-with sulphur containing compound are discussed in this course.

**Unit-I**

**Chemistry of Halogenated Hydrocarbons**

**Alkyl halides:** Methods of preparation including Hunsdiecker reaction from silver or lead (IV) salts of carboxylic Acid).

**Nuclcophilic substitution Reactions:** SN1, SN2, and SNi; Mechanisms with, stereochemical aspects and effect of solvent. Nuclcophilic substitution vs elimination. Halo form reaction.

**Aryl halides:** Preparation from diazonium salts. Nuclcophilic Aromatic Substitution SN Ar, Benzyne intermediates.

Relative reactivity of Alkyl, Allyl / Benzyl, vinyl and Aryl halides towards Nuclcophilic substitution reactions.

**Organometallic Compounds of Mg and Li** - Use in synthesis of organic compounds.

**L-12.Marks-12**

**Unit-II**

**Chemistry of C-O Bond**

**Alcohols:** Preparation, properties and relative reactivity of 1<sup>o</sup>, 2<sup>o</sup>, 3<sup>o</sup> alcohols.

Bouvaclt Balance Reduction and Baeyer-Villiger Oxidation

Preparation and properties of Glycol: Oxidation by  $\text{OsO}_4$ , alkaline,  $\text{K MnO}_4$ , periodic Acid and lead tetracetate. **Pinacol Pinacolone Rearrangement** with mechanism.

**Trihydric alcohol:** glycerol preparation & properties. **Phenols:** Preparation and properties: Acidity-Comparison with Alcohol. Substitution Reaction, **Reimer- Tiemann and Kolbe's-Schmidt reaction, Fries rearrangement with mechanism.**

**Other aromatic Hydroxy compounds:** Cresol, Nitrophenols, picric acid, Benzl alcohol, dihydric phenols.

**Ethers and Epoxides:** Preparation and Reactions with acids.

**L-12.Marks-12**



### Unit-III

#### Carbonyl Compounds

##### Aldehydes and ketones (aliphatic and Aromatic)

###### Structure, Preparation and Reactions

Relative reactivity of aldehydes, ketones.

Nucleophilic addition- reactions.

**Mechanism of Aldol, Benzoin, Stobbe, Darzen glycidic ester condensation, Perkin, Cannizzaro reaction. Beckmann and Benzil-Benzilic acid Rearrangement** substitution, oxidation and reduction (**Clemmensen, Wolf-Kishner and M P V reduction**)

Addition Reactions of Unsaturated carbonyl Compound: **Michael addition.**

**Unsaturated aldehydes (Acrolein, Crotonaldehyde, Cinnamaldehyde)**

**Unsaturated ketone ( MVK ).**

**L-12.Marks-12**

### Unit-IV

#### Carboxylic acid and their derivatives (aliphatic & aromatic)

Preparation and properties and reactions of, monocarboxylic acids: effect of substituent on acidity, **HVZ Reaction**, and **Schmidt reaction** .Typical reactions and uses of dicarboxylic acids, Hydroxy acids,Unsaturated acids-: Succinic,phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids.

Preparation and reactions of acid chlorides, anhydrides, esters, amides: Mechanism of acidic and alkaline Hydrolysis of Esters.

**Claisen Ester Condensation, Dieckmann and Reformatsky Reaction, Hofmann bromamide degradation, Curtius rearrangement.**

Urea & Urethanes: Preparation and Typical Reactions.

**L-10.Marks-10**

### Unit-V

Sulphur containing compounds

Preparation and reactions of Thiols, Thioethers and sulphonic acids.

**L-3.Marks-2**

### Text Books,

Organic Chemistry: I.L. Finers, Vol. I & II ELBS

Organic Chemistry Morrison and R.N. Boyd

Advanced Organic Chemistry: Reaction Mechanism & Structure – Jerry March  
Wiley Eastern.

P.S. Kalsi Textbook of Organic Chemistry

### Ref. Books:

A Guide book to Mechanism in Organic Chemistry, P. Sykes, McGraw Hill

Advanced Organic Chemistry - B.S. Bahl and A. Bahl

Organic reaction mechanism – R.K. Bansal, Tata McGraw Hill

Advanced General Organic Chemistry – S.C. Ghosh

**Paper MM 304 Organic Lab. Marks = (32+8 Int.)=40**

**Organic Qualitative analysis**

- A) Detection of elements (N, S, and X) and functional groups;  
Determination of m.p. preparation of the derivative and determination of mp of the derivative and structure of the compounds and **complete identification**).Marks -20
- B) i) **Purification of Organic compounds by crystallization**
- a) Benzoic acid from Hot water
  - b) Naphthalene from alcohol
- Marks :7**
- c) **Viva** **Marks: 5**
  - d) **Internal Assessment** **Marks: 8**

**SEMESTER IV**

**Paper MM401 (Physical Chemistry) -I Marks: (48+12 Int.)=60**

*Objective:* Electrochemistry is one of the Topics that really revolutionized the world now a days. This paper deals with this particular aspect.

**Unit I – 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-Huckel - 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, anomalous transference number, application 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) Hydrolysis constant of aniline hydrochloride, v) Conductometric titration (Acid Base and precipitation).

**L-20.Marks: 20**

**Unit II – Electrochemical cells**

Quantitative aspects of Faraday's laws of electrolysis, concept of oxidation/reduction of half cells potentials, application of electrolysis in metallurgy and industry, electrolytic and galvanic cells, E.M.F of a cell and its measurement, free energy, entropy and enthalpy of cell reactions, Nernst equation, standard electrode potential, types of electrodes- Hydrogen, calomel, quinhydrone and glass electrodes. Concentration cell with and without transference-liquid junction potential, pH determination using hydrogen, SbO/Sb<sub>2</sub>O<sub>3</sub> electrode, glass, quinhydrone electrodes, potentiometric titration (acid, base and redox), storage cells- Lead storage cell- mechanism of charging and discharging, fuel cells- hydrogen-oxygen cell.

**L-15, Marks: 16**

### **Unit III- System of Variable Composition and Chemical Equilibrium**

Partial molar quantities-chemical potential, Gibb's- Duhem equation, effect of temperature and pressure on chemical potential, Duhem-Margules equation, concept of activity and activity coefficient, fugacity, derivation of expression of equilibrium constant, temperature pressure and concentration dependence of equilibrium constant-Van't Hoff equation, Le-Chatelier principle (qualitative treatment) . **L-15, Marks: 12**

#### **Text Books,**

##### **Physical Chemistry:**

G.W. Castellan, Physical Chemistry, Narosa Publishing House, New Delhi.

P.C. Rakshit, Physical Chemistry - Science Book Agency, Kolkata

Physical Chemistry Vols. I, II, III and IV – K.L. Kapoor, MacMillan (India) Ltd., New Delhi

Advanced Physical Chemistry – J.N. Gurta & H. Snehi, Pragati Prakashan.

##### **Ref. Books:**

P.W. Atkins, Physical Chemistry, Oxford University Press

Physical Chemistry – B.R. Puri, L.R. Sharma, Madan S. Pathania, Shobanlal Nagin, Chand & Co.

Physical Chemistry – D.S. Pahari ( Vol. I & II )

#### **Paper MM 402**

#### **Physical Lab.**

**Marks: (32+8 Int.)=40**

Physical Chemistry experiment Group A (any one)

1) To determine the coefficient of viscosity of solutions by Ostwald viscometer.

2) To determine the surface tension of solutions by Stalagmometer.

3) Determination of parachor values. **Marks=12**

Physical Chemistry experiment Group B (any one)

**Marks: 15**

1. Preparation of buffer solutions

(i) Sodium acetate - acetic acid

(ii) Ammonium chloride-ammonium hydroxide

Measurement of pH of buffer solutions and comparison of the values with theoretical values

2. Determination of Molar mass of substance by Rust method.

**Viva –**

**Marks: 5**

**Internal Assessment -**

**Marks: 8**

**Paper MM 403 Organic Chemistry-II Total Marks: 60 [48-Th. + 12-Int.]**

*Objective:* This paper deals with active methylene compounds, aliphatic and aromatic amines and heterocyclic compounds

**Unit-I**

**Active Methylene Compounds: Keto-enol tautomerism, Preparation and properties of Acetoacetic ester and diethyl malonate. Knoevenagel Condensation**

**L-8, Marks- 6**

**Unit-II**

**Nitrogen containing functional groups: (Aliphatic and aromatic) Amines:** Effect of substituent and solvent on basicity. Preparation and properties: Gabriel Phthalimide synthesis and Hoffmann bromamide degradation, carbylamines reaction, Mannich Reaction, Hoffmann's Exhaustive methylation, Hoffmann-Elimination Reaction.

Distinction between 1<sup>o</sup>, 2<sup>o</sup> and 3<sup>o</sup> amines with Hinsberg reagent and nitrous acid.

**Nitro and nitroso compounds**, Nitriles and isonitriles, cyanates and isocyanates: Preparation and important reactions.

Diazomethane and diazoacetic ester with synthetic application

Diazonium salts: Preparation and their synthetic applications.

**L-8, Marks-10**

**Unit-III**

**Amino acids and proteins.**

**Amino Acids** and their classification, synthesis and Ionic properties, Reactions, Zwitter ions, pKa values, isoelectric point & Electrophoresis.

Study of peptides: Determination of their primary structure: end group analysis, Principles of peptide synthesis.

**Proteins:** Their classification and biological importance. Elementary idea on Primary, Secondary, Tertiary and Quaternary structure of proteins,  $\alpha$  helix and  $\beta$  pleated sheet structure, tertiary structure of proteins.

**L-10 Marks- 8**

**Unit-IV Polynuclear Hydrocarbons**

Important methods of synthesis and reactions of polynuclear Aromatic-hydrocarbons: naphthalene, anthracene and phenanthrene. Important derivatives of Naphthalene and Anthracene.

**L-8, Marks-6**

**Unit – V Heterocyclic Compounds**

Classification, Nomenclature, and structure. Aromaticity in 5-membered and 6-membered rings containing one heteroatom. Synthesis, reactions, properties of Furan, Pyrrole. (Paal-Knorr synthesis, Knorr pyrrole synthesis), Thiophene pyridine (Hantzsch synthesis), Quinoline (Skraup synthesis, Friedlander's synthesis, Conrad-Limpach synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Pfitzinger reaction) and Isoquinoline (Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Iritsch reaction)

**L-10, Marks: 10**

**Unit-VI      Alkaloids**

Natural occurrence, General Structural features, Isolation and their Physiological Action. Hoffmann's Exhaustive Methylation, with special reference to connine, nicotine) Emde's modification. Medicinal importance of nicotine, Hygrine, Quinine, Morphine, Cocaine and Reserpine.

**L-5, Marks: 8**

**Text Books,**

- 1) Organic Chemistry: I.L. Finers, Vol. I & II ELBS
- 2) Organic Chemistry Morrison and R.N. Boyd
- 3) Advanced Organic Chemistry: Reaction Mechanism & Structure – Jerry March Wiley Eastern.
- 4) P.S. Kalsi Textbook of Organic Chemistry

**Ref. Books:**

- 1) A Guide book to Mechanism in Organic Chemistry, P. Sykes, McGraw Hill
- 2) Advanced Organic Chemistry - B.S. Bahl and A. Bahl
- 3) Organic reaction mechanism – R.K. Bansal, Tata McGraw Hill
- 4) Advanced General Organic Chemistry – S.C. Ghosh

**Paper MM 404 Organic Lab.      **Marks 40 (32 + 8- Int.)****

**A) Organic preparation**

- i) Acetylation - Preparation of Aspirin from Salicylic acid and Acetanilide from aniline.
- ii) Nitration -Nitration of nitro benzene to meta dinitrobenzene  
Preparation of p-nitro acetanilide from acetanilide.
- iii) Benzoylation – preparation of benzanilide from aniline..
- iv) Oxidation - Oxidation of Benzaldelyde to benzoic Acid  
Benzil from Benzoin.
- v) Hydrolysis of benzanide to benzoic Acid
- vi) Diazocoupling - preparation of methyl orange

**Marks 17**

B) Chromatographic separation of the following mixtures and Rf value calculation of the compounds

- a) Amino acids
- b) Sugars by paper chromatography
- c) O and P Nitrophenols by TLC.

**Marks -10**

**Marks -5**

**Marks -8**

**Viva**

**Internal assessment**

## **SEMESTER V**

**Paper MM 501      Physical Chemistry II      Marks = 60 [48-Th. + 12-Int.]**

**Objective:** This course tries to formulate the ideas amongst the students in the form of kinetic, solution, equilibrium and surface phenomena.

### **Unit I –Chemical Kinetics**

Molecularity and order of reactions, elementary and complex reactions rate laws, differential and integral forms of rate equations of zero, 1<sup>st</sup>, 2<sup>nd</sup> order reactions, half life periods of 1<sup>st</sup> and 2<sup>nd</sup> order reactions, determination of order of reaction by method of integration, half life period, differential method, isolation method, evaluation of rate constant, integrated equation method, graphical method, Guggenheim method ( 1<sup>st</sup> order reaction ), rate laws and mechanism, steady state approximation.

Rate equation of first order, opposite, parallel, consecutive reaction, chain reactions, chain branching, explosion limit, hydrogen – bromine thermal reaction, effect of temperature on reaction velocities, Arrhenius equation, energy of activation, collision theory of bimolecular reactions, its limitation, activated complex theory, Eyring equation, Lindeman's theory of unimolecular gas phase reaction.

**L-15 Marks: 15**

### **Unit II- Solution and Colligative Properties**

Dilute solutions, lowering of vapour pressure, Rault's and Henry's Laws and their applications, distribution of solutes between two immiscible liquids, Nernst's Distribution law, and solvent extraction.

Thermodynamic derivation using chemical potential to derive relation 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, application in calculating molar masses of normal, associated and dissociated solutes in solution.

**L-10 Marks: 8**

### **Unit III- Ionic equilibrium**

Strong and weak electrolyte with modern classification of electrolytes (true and potential electrolyte), degree of ionization, factors affecting degree of ionization, ionization constant, ionic product of water, ionization of weak acids and bases, pH scale, common ion effect.

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts, buffer solution, derivation of Henderson equation and its applications, buffer capacity, buffer range, buffer action.

Solubility and solubility product of sparingly soluble salts-application of solubility product principle. Qualitative treatment of acid-base titration curves. Theory of acids- base indicators, selection of indicators and their limitations.

**L-10 Marks:10**

#### **Unit-IV Surface Chemistry**

Physical and chemical adsorption of gases on solid surface, adsorption isotherms, types of adsorption isotherm, Freundlich equation, Langmuir adsorption equation

Gibbs adsorption equation, , application of adsorption in chemical analysis and in industry, determination of surface area.

**L-6 Marks: 7**

#### **Unit-V Colloidal state**

Electro kinetic phenomenon- electrophoresis, electro-osmosis, electrical double layer and zeta potential, theory of stabilities of colloids, protective action of Lyophilic sol-gold number, determination of Avogadro's number, coagulation of colloids, Schulz – Hardy rule, association of colloids, emulsions, micelles and their structure, critical micelles concentration, Donnan membrane equilibria.

**L -8 Marks: 8**

#### **Text Books,**

##### **Physical Chemistry:**

- 1) G.W. Castellan, Physical Chemistry, Narosa Publishing House, New Delhi.
- 3) P.C. Rakshit, Physical Chemistry - Science Book Agency, Kolkata
- 4) Physical Chemistry Vols. I, II, III and IV – K.L. Kapoor, MacMillan (India) Ltd., New Delhi
- 5) Advanced Physical Chemistry – J.N. Gurta & H. Snehi, Pragati Prakashan.

##### **Ref. Books:**

- 1) P.W. Atkins, Physical Chemistry, Oxford University Press
- 2) Physical Chemistry – B.R. Puri, L.R. Sharma, Madan S. Pathania, Shobanlal Nagin, Chand & Co.
- 3) Physical Chemistry – D.S. Pahari ( Vol. I & II )
- 4) Physical Chemistry - Levine

#### **Paper MM 502- Physical Lab.**

**Marks- 40 (32 + 8-Int.)**

##### **Physical Experiments Group – A**

1. pH metric titrations of
  - (i) Strong acid and strong base
  - (ii) Weak acid and strong base
2. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.

**Marks – 14**

## Physical Experiments Group – B

3. To determine the concentration of an optically active substance by polarimetric method
4. To determine the specific reaction rate of hydrolysis of methyl acetate catalyzed by hydrogen ion concentration at room temperature.

**Marks – 14**

**Viva**  
**Internal**

**Marks- 4**  
**Marks- 8**

aper: MM 503 Inorganic Chemistry II Total Marks = 60[48-Th. + 12-Int.]

**Objective: The objective of the paper is to give knowledge on organometallic compounds, clusters and organic reagents in inorganic analysis.**

### **UNIT –I: Organometallic compounds:**

Definition, electron count, 18 electron rule, isolobal analogy, structure and bonding in some Organometallic compounds (Metal –Olefins compound, metal – ligand  $\sigma$  -bonded compounds, ferrocene). Oxidative addition and reductive elimination reaction. Uses of some organometallic compounds as catalysis (Wilkinson's catalyst, Vaska's compound and  $\text{HCo}(\text{CO})_4$ )

**Metal carbonyls:** Structure, bonding and IR spectral studies of terminal and bridged carbonyls.

L-12, Marks = 15

### **UNIT – II: Transition metal clusters:**

Definition of cluster, metal – metal bond in cluster, synthesis of metal carbonyl cluster of Cr, Fe and Mo (only low nuclearity clusters up to 4 metal atoms). Closed shell electronic requirement for cluster compounds –rules for Polyhedral Skeletal Electron Pair Theory.

**Nitrosyl compounds:** Synthesis, properties and structures of nitrosyls of Fe, Co and Ni.

L -12, Marks = 15

### **UNIT – III: Error in quantitative analysis:**

Accuracy, precession, deviation, standard deviation, classification of errors, minimization of errors, significant figures.

**Indicators:** Choice of indicators in neutralization, redox, adsorption and complexometric reactions.

L-10, Marks-12

### **UNIT – IV:**

#### **Organic reagents in inorganic analysis :-**

Cupferron, dithizone, benzoin- $\alpha$ - oxime, 1- nitroso-2- naphthol, diphenyl carbazide, diphenyl carbazone, salicylaloxime, 1,10- phenanthroline, magneson, thiourea, zinc uranyl acetate, oxine.

L-10, Marks = 6



**Text Books:**

- 1) Basic Inorganic Chemistry – Cotton and Wilkinson
- 3) Inorganic Chemistry – J.D. Lee
- 4) Inorganic Chemistry – Huhey
- 5) General Inorganic Chemistry – (Part-I & Part-II), R. Sarkar
- 6) Advanced Inorganic Chemistry – R.D. Madan

**Ref. Books:**

- 1) Selected Topics in Inorganic chemistry – Malik, Tuli and Madan
- 2) Inorganic Chemistry – Shriver & Atkins
- 3) Greenwood, N.N. Earnshaw, Chemistry of the Elements, Butterworth-Heinemann.
- 4) Basolo F and Pearson R.C., Mechanism of Inorganic chemistry – John Wiley & Sons.

**Paper MM 504 Inorganic Lab.****Marks 40 (32 +8-Int .)****Inorganic Chemistry**

Volumetric titrations

**Marks 28**

- i) Estimation of  $\text{Fe}^{+2}/\text{Ca}^{+2}$  by EDTA
- ii) Estimation of  $\text{Cu}^{+2}/\text{Fe}^{+2}$  by iodometric method
- iii) Estimation of  $\text{CO}_3^{-2} + \text{HCO}_3^{-1}$  in mixture
- iv) Estimation of Total hardness of water samples

**Viva****Marks 4****Internal****Marks 8****Paper MM 505 Organic Chemistry-III****Total Marks: 60[48-Th. +12-Int.]**

*Objective:* To acquire knowledge in different types of reaction and to understand biochemistry.

**Unit-I**

**Pericyclic reactions:** Definition. The conservation of orbital symmetry, Woodward-Hoffmann rules HOMO-LUMO approach.

**Cyclo addition reactions:** (2+2) and (2+4) cyclo additions.

Diels Alder Reaction, 1,3, dipolar cyclo addition

Sigma tropic rearrangements Cope and Claisen rearrangement electrocyclic reactions

**L-10, Marks -8**

## Unit-II (Bio-molecules)

Carbohydrates- Occurrence, classification and biological importance, General properties of Glucose and Fructose (open and cyclic structure )

Monosaccharides: Constitution and absolute configuration of glucose and fructose, Epimerization, Mutarotation, Determination of ring size of Glucose and fructose. Haworth projections and conformational structures. Ascending and descending in monosaccharides, Interconversions of Aldoses and Ketoses.

L-10, Marks 12

## Unit-III Nucleic acids & Enzymes:

Components of Nucleic acids, Nucleosides and Nucleotides. Structure Synthesis and Reactions of Adenine, Guanine, Cytosine, Uracil & Thymine. Polynucleotides: Structure of DNA (Watson – Crick Model) and RNA, Genetic code.

Biological roles of DNA and RNA, Replication. Transcription and Translation (elementary idea only)

**Enzymes and their functions as catalyst** – Classification- Active site, Specificity, Mechanism of Enzyme action, Co-enzyme, Application of **Enzymes**.

L-10, Marks -10

## Unit-IV Pharmaceutical compounds: Structure and Importance

Introduction to natural and synthetic medicinal compounds: Azadirachtin (neem) Curcumin (haldi)

Vitamin C- Their Medicinal values, Drug Action

Classification, Structure, preparation and Therapeutic uses of **Antipyretics**: Paracetamol, **Analgesic**: Aspirin, Ibuprofen (with green synthesis)

**Antimalarials**: Chloroquine. **Antacids**: Ranitidine, **Antibacterial**: povidone –Iodine solutions, Sulphonamide and other sulphadugs.

An elementary treatment of Antibiotics and detailed study of **chloramphenicol**.

L-12, Marks -10

## Unit-V Terpenes

Occurrence, classification Isoprene Rule. Elucidations of structure and synthesis of **Citral**, **Neral** and  $\alpha$ -**Terpineol**).

L-8. Marks -8

## Text Books,

- 1) Organic Chemistry: I.L. Finers, Vol. I & II ELBS
- 2) Organic Chemistry Morrison and R.N. Boyd
- 3) Advanced Organic Chemistry: Reaction Mechanism & Structure – Jerry March Wiley Eastern.
- 4) P.S. Kalsi Textbook of Organic Chemistry

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- 1) A Guide book to Mechanism in Organic Chemistry, P. Sykes, McGraw Hill
- 2) Advanced Organic Chemistry - B.S. Bahl and A. Bahl
- 3) Organic reaction mechanism – R.K. Bansal, Tata McGraw Hill
- 4) Advanced General Organic Chemistry – S.C. Ghosh

**Paper MM 506 Organic Lab .**

**Marks 40 (32 +8-In.)**

**A) Organic Quantitative analysis**

- i) Determination amount of glucose by titration with fehling” s solution.
- ii) Determination of equivalent mass of an acid by direct titration method
- iii) Determination of glycine by formal titration
- iv) To determine the percentage purity of the given carbonyl compound by 2,4dinitrophenylhydrazine (Gravimetric method) **Marks 23**

**B) Food Analysis**

Turmeric, mustard oil, common salts ,milk ,sugar. Coffee. Honey. Pulses, cereals, spices –qualitative aspect only **Marks 5**

**Viva**

**Marks 4**

**Internal**

**Marks 8**

**Paper: MM 507 Symmetry and Quantum Chemistry Total Marks: 60[48-Th. +12-Int.]**

**Objective:** The objective of the paper is to have a knowledge on quantum mechanics with special reference to classical mechanics, symmetry and bonding.

**Unit – I: Symmetry and Group theory:**

Symmetry elements and symmetry operations. Definition of group, symmetry group, point group and space group. Perspective sketch and point group of some common molecules ( H<sub>2</sub>, HF, CO<sub>2</sub>, C<sub>2</sub>H<sub>2</sub>, C<sub>2</sub>H<sub>4</sub>, CHCl<sub>3</sub>, PCl<sub>5</sub>, NH<sub>3</sub>, BF<sub>3</sub>, [ PtCl<sub>4</sub>]<sup>2-</sup>, BrF<sub>5</sub> ), symmetry and mathematical tools, matrix algebra, great orthogonality theorem (deduction not necessary ). Character table for C<sub>2v</sub> and C<sub>3v</sub> point groups, reducible and irreducible representation. Determination of  $\Gamma_v$  for C<sub>2v</sub> and C<sub>3v</sub> point groups. Crystallographic point group, crystal system, Bravais lattice.

**L-18, Marks = 15**

**Unit – II :Quantum Chemistry and Chemical Bonding :**

Black body radiation – Planck’s hypothesis, photoelectric effect, deBroglie hypothesis and Heisenberg’s uncertainty principle. Postulates of quantum mechanics, quantum mechanical operators. Normalization of wave functions- expectation values. Interpretation of the wave function – orthogonal and ortho normal wave functions. Schrodinger equation and its application to a particle in a box ( vigorous treatment one and three dimensional boxes) energy levels, wave functions, probability distribution functions. Nodal properties, degeneracy. Qualitative treatment of (i) rigid rotator (ii) harmonic oscillator and (iii) hydrogen atom - Schrodinger equation for hydrogen atom: energy levels and quantum numbers, the radial and angular part of wave functions, two dimensional plots of probability density. The hydrogen like wave functions –Stern Gerlach experiment, electron spin and spin quantum numbers, Pauli’s exclusion principle – illustration by He atom.

**L-18, Marks= 25**

**Unit – III Chemical Bonding:** Covalent bonding, valence bond and molecular orbital approaches. LCAO – MO treatment of  $H_2^+$  and  $H_2$  molecules. Valence bond treatment of  $H_2$  molecules (Heitler London treatment). Localized and non localized molecular orbitals of homo nuclear and hetero nuclear diatomic molecules ( $H_2^+$ ,  $H_2$ ,  $N_2$ ,  $NO$ ,  $CO$ ,  $HF$ ,  $CN$ ,  $CN^-$ ).

**L-15, Marks=8**

**Text Books:**

- 1) Quantum Chemistry – Ira N. Levine, PHI, New Delhi
- 2) Introductory Quantum Chemistry – A.K. Chandra, Tata- McGraw
- 3) F.A. Cotton, Chemical applications of group theory, Wiley Eastern Ltd. , New Delhi

- Ref. Books:**
- 1) Quantum Chemistry, R.K. Prasad
  - 2) Quantum Chemistry, B. K. Sen

**Paper MM 508 Inorganic Lab. Total Marks -40 (32+8-Int)**

**A. Inorganic preparation & Crystallization Marks (16+12)**

- i) Chrome alum
- ii) hexamine Cobalt III Chloride
- iii) Chloropenta amin cobalt III chloride
- iv) Mohr's Salt
- v) Potassium trioxalato chromate (III)
- vi) Potassium trioxalato Ferrate (III)

**B. Viva**

**Marks-4**

**C. Internal assessment**

**Marks -8**

**SEMESTER VI**

**Paper MM 601 Physical Chemistry III Total Marks: 60[48-Th.+12-Int.]**

*Objective:* To understand different Topics like photo chemistry, macromolecules, catalysis and statistical thermodynamics.

**Unit I- Photochemistry**

Absorption of light, Lambert- Beer's law, laws of photochemistry, quantum yield, photochemical equilibrium, reasons of high and low quantum yield, photodimerisation - dimerisation of Anthracene, photochemical reaction- $H_2$ ,  $Cl_2$ ,  $H_2-Br_2$ , dissociation of  $HI$ , fluorescence, phosphorescence, chemiluminescence ,bioluminescence, photosensitized reaction, photoelectric effect, photoelectric cell, introduction to lasers.

**L-10, Marks: 10**

### **Unit II- Macromolecules**

Step reaction polymerization, degree of polymerization, addition polymerization, free-radical polymerization, anionic, cationic polymerization and their kinetic studies weight and number average molecular weight, viscometric and osmometric methods of molecular weight determination, Carother equation, Zeigler Natta catalysts, Co-polymerisation.

**L-10, Marks: 8**

### **Unit III- Catalysis**

Criteria of catalysis, homogeneous and heterogeneous catalysis, effect of temperature on surface reactions, effect of particle size and efficiency of nano particles as catalysts, autocatalysis, catalytic poison, enzyme catalysis-mechanism and Michaelis-Menten equation.

**L-10 Marks:8**

### **Unit IV- Phase Equilibria**

Definition of phase components, degree of freedom, thermodynamic derivation of phase rule, application of phase rule to one component-water and sulphur, Application of phase rule to two component systems (solid-liquid equilibrium)-simple eutic Pb-Ag, KI-H<sub>2</sub>O, two component systems with congruent melting point (Zn-Mg), two component system with incongruent melting point (Na<sub>2</sub>SO<sub>4</sub>-H<sub>2</sub>O) interpretation of vapour pressure composition and temperature- composition phase diagram, distillation of liquid mixtures and azeotropic mixture.

Clapeyron equation, Clausius-Clapeyron equation, their derivation and application.

**L-10, Marks: 12**

### **Unit V -Statistical Thermodynamics**

Distribution, most probable distribution and thermodynamic probability, computation of thermodynamic probability of distribution of identical but distinguishable particles, Boltzmann Distribution law, relationship between entropy and thermodynamic probability, Thermodynamic Functions and the Molecular partition Function and the significance, translation, rotational and vibrational partition functions, evaluation of translation partition function using particle in a box model for ideal mono atomic gas, Boltzmann relation between entropy and thermodynamic probability, partition function and thermodynamic functions, Sackur-Tetrode equation.

**L-10 Marks: 10**

### **Text Books,**

#### **Physical Chemistry:**

- 1) G.W. Castellan, Physical Chemistry, Narosa Publishing House, New Delhi.
- 2) P.C. Rakshit, Physical Chemistry - Science Book Agency, Kolkata
- 3) Physical Chemistry Vols. I, II, III and IV – K.L. Kapoor, MacMillan (India) Ltd., New Delhi
- 4) Advanced Physical Chemistry – J.N. Gurta & H. Snehi, Pragati Prakashan.

### **Ref. Books:**

- 1) P.W. Atkins, Physical Chemistry, Oxford University Press
- 2) Physical Chemistry – B.R. Puri, L.R. Sharma, Madan S. Pathania, Shobanlal Nagin, Chand & Co.
- 3) Physical Chemistry – D.S. Pahari ( Vol. I & II )
- 4) Physical Chemistry - Levine

**Paper MM 602 Physical Lab.**

**Total Marks-40 (32+8Int.)**

**Physical Chemistry (Group A)**

1. To study the rate constant of hydrolysis of sucrose by polarimeter
2. To study the distribution of iodine between  $\text{CCl}_4$  and water.
3. To Perform potentiometric titrations
4. Perform potentiometric titrations
  - (i) Strong acid- strong base
  - (ii) Weak acid-strong base

**Marks -14**

**Physical Chemistry (Group B)**

5. To obtain Freundlich isotherm for adsorption of oxalic acid on activated charcoal.
6. Conductometric titrations involving
  - i) Strong acid- strong base
  - ii) Weak acid- strong base
  - iii) Strong acid-weak base
7. Potentiometric titration of Mohr's salt with  $\text{K}_2\text{Cr}_2\text{O}_7$

**Marks -14**

**Viva**

**Marks- 4**

**Internal**

**Marks – 8**

**Paper : MM 603 Inorganic Chemistry III Total Marks :60 [ 48-Th.+12-Int.]**

*Objective:* To understand materials chemistry as well as role of metal in biological system.

**UNIT I: Bioinorganic Chemistry:-**

Metal ion in biological system, role of alkali and alkaline earth metals, iron, copper, cobalt, zinc and molybdenum. Metalloprotein and metalloenzymes, hemoglobin, myoglobin, plastocyanin, vitamin  $\text{B}_{12}$ , carbonic anhydrase and nitrogenase.

**Metal ion in medicine** -- cis platin and carbo platin. Use of EDTA in chelation therapy.

L-15, **Marks= 16**

**UNIT-II: Introduction to material chemistry:**

Idea about supra molecular interaction. Solid state reactions. Nano materials – synthesis and characterization. C – C composite, polymer and nanocomposite. Introduction of chemistry of clay (Kaolinite, Montmorillonite and Laponite).

L -10, **Marks = 10**

**UNIT – III: Analytical chemistry:**

**Introduction to Spectrochemical methods:-**

Molecular absorption spectroscopy, Molecular Fluorescence spectroscopy, Atomic absorption spectroscopy, Fourier Transform Infra Red spectroscopy –Principles and applications only. Analysis of real samples.

**Chromatographic Methods:**

Paper, TLC, Column, Gas chromatography – separation of compounds, development and  $R_f$  values. HPLC – principle only.

L-10, Marks = 10

**UNIT IV: Industrial chemistry:**

- a) **Industrial water treatment:** Demineralized water and effluent treatment.
- b) **Cement and ceramics:** Various types of cements, their composition, manufacture and setting of cement. Ceramics.
- c) **Paints:** Constituents, role of binder and solvent, lead and zinc containing paints.
- d) **Introduction to Chemical Toxicology:**  
Metal poisoning due to Pb, Cd and Hg, hazard from radioactive fallout. Definition and principles of green chemistry.

L-12, Marks = 12

**Text Books:**

- 1) Basic Inorganic Chemistry – Cotton and Wilkinson
- 7) Inorganic Chemistry – J.D. Lee
- 8) Inorganic Chemistry – Huhey
- 9) General Inorganic Chemistry – (Part-I & Part-II), R. Sarkar
- 10) Advanced Inorganic Chemistry – R.D. Madan

**Ref. Books:**

- 5) Selected Topics in Inorganic chemistry – Malik, Tuli and Madan
- 6) Inorganic Chemistry – Shriver & Atkins
- 7) Greenwood, N.N. Earnshaw, Chemistry of the Elements, Butterworth-Heinemann.
- 8) Basolo F and Pearson R.C., Mechanism of Inorganic chemistry – John Wiley & Sons.

**Paper MM 604 Inorganic Lab.**

**Marks - 40 (32+8Int)**

Quantitative analysis

**Marks: 28**

- i) Estimation of Nickel (ii) using DMG
- ii) Estimation of  $\text{SO}_4^{2-}$  by using  $\text{BaCl}_2$  method
- iii) Estimation of Cu as  $\text{CuSCN}$
- iv) Estimation of percentage of mixed oxide in an ore Hematite, dolomite, limestone

**Viva**

**Marks: 4**

**Internal**

**Marks: 8**

**Paper MM 605 Organic Chemistry IV**

**Total Marks: 60 [48-Th.+12-Int.]**

*Objective:* This paper highlights the concept of disconnection approach in organic chemistry as well as different analytical tools like UV, IR, NMR in organic chemistry. Importance of dyes, lipids, polymers are also dealt with.

**Unit-I Disconnection approach in organic synthesis:**

Elementary idea about disconnection, functional group interchange (FGI), functional group addition (FGA). Synthone and synthetic equivalent simple examples of reaction leading to C-C bond formation (Corey. House, Wittig & aldol condensation), Synthesis of monofunctionalised com. 1, 2, difunctionalised compounds (Pinacol Pinacolone, Keto aldehydes, Keto carboxylic acid) 1, 3, difunctionalized compounds ( $\beta$ - Hydroxy)

**L-10, Marks = 10**

**Unit-II**

**UV Spectroscopy:** Types of electronic transitions,  $\lambda_{\max}$ , Chromophores and Auxochromes, Bathochromic and Hypsochromic Shift, Intensity of Absorption

Application of Woodward rules for calculation of  $\lambda_{\max}$  for the following system:  $\alpha\beta$ -unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes, alicyclic, homonuclear and heteronuclear.

**IR Spectroscopy:** Fundamental and Non- fundamental molecular vibrations. IR absorption positions of O, N, S containing functional groups, Effect of H-bonding on IR absorption, 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 Alkenes, Alkynes, Cycloalkanes, carbonyl compounds and benzene.

Study of simple NMR spectra.

Applications of IR, NMR and UV in Structural Identification of Simple Organic Molecules.

**L-15, Marks = 10**

**Unit-III**

**Lipids:**

Classification of Oils and Fats and their vegetable origin, structure of common fatty acid present.

Structure, properties and biological importance of triglycerides and phosphoglycerides

Change of flavor of oils, Reversion and Rancidity, Saponification value and Iodine number.

**L-8, Marks = 4**

**Unit-IV:**

**Dyes:**

Classification, elementary idea of color and constitution, Chemistry of Dying. Synthesis and application of- Azo dyes-Methyl Orange and Congo red Triphenyl Methane Dyes-Malachite Green, Rosaniline and Crystal Violet. Phthalein Dyes- Phnolphthalein and Fluorescein. Vat Dyes: Alizarin and Indigotin.

**L-5, Marks = 8**

**Unit-V:**

**Polymers**

Types of polymers- Isotactic, syndiotactic and atactic polymers.

Number average molecular weight, weight average molecular weight, Degree of Polymerisation, Polydispersity Index.

Polymerisation Reaction-Addition and Condensation-Mechanism of cationic, anionic and free radical polymerization. Ziegler-Natta Polymerization of alkanes.



Preparation and applications of plastics- Thermo-setting (Urea-formaldehyde, Phenol-formaldehyde, polyurethanes and thermo softening (PVC, Polythene) Polymer additives  
Synthetic fibers: Rayon, Nylon-6, terephthalic acid  
Fabrics- natural and synthetic (acrylic, polyamide, polyester)  
Rubbers-natural and synthetic: Buna-S, Chloroprene and neoprene, vulcanization  
Elementary idea on Bio-degradable and conducting polymers with examples.

**L-8, Marks =10**

### **Unit –VI Green Chemistry**

Introduction to the principles of green chemistry -prevention of waste , atom economy ,less hazardous chemical synthesis. Designing a green synthesis , Safer chemical ,Safer solvent and auxiliaries design for energy efficiency ,reduce derivatives ,renewable feedstock ,catalysis design for degradation , clean routes , green reaction conditions ,ultrasound associated reaction , microwave induced reactions , reaction in aqueous conditions ,solid state and solid phase reactions, Green methods for removal of pollutants .

Use of green reagents, green catalysts (Zeolites, enzymes etc.) and green solvents; applications of green chemistry (from laboratory to industries) Green chemistry in everyday life.

**L-5, Marks = 6**

### **Text Books,**

Organic Chemistry: I.L. Finers, Vol. I & II ELBS

Organic Chemistry Morrison and R.N. Boyd

Advanced Organic Chemistry: Reaction Mechanism & Structure – Jerry March  
Wiley Eastern.

P.S. Kalsi Textbook of Organic Chemistry

### **Ref. Books:**

A Guide book to Mechanism in Organic Chemistry, P. Sykes, McGraw Hill

Advanced Organic Chemistry - B.S. Bahl and A. Bahl

Organic reaction mechanism – R.K. Bansal, Tata McGraw Hill

Advanced General Organic Chemistry – S.C. Ghosh

### **Paper MM 606      Organic Lab      Marks 40 (32 + 8- Int.)**

#### **Organic Quantitative analysis**

- 1) Two step preparations (separation by TLC)
  - a) Benzophenone to benzophenone oxime to benzoinilide
  - b) Benzoin to benzil to benzilic acid
  - c) Benzophenone to benzopinacol to benzopinacolone
  - d) Aniline to acetanilide to p-nitroacetanilide

**Marks 20**

- 2) Use of Steam distillation/Soxhlet apparatus for essential oil extraction

- 3) TLC analysis

**Marks 3.5X2**

**Viva**

**Marks-5**

**Internal Assessment**

**Marks-8**

### **Paper MM 607      Spectroscopy**

**Total Marks: 60 [48-Th. +12-Int.]**

Objective: This paper deals with the interaction of electromagnetic radiation with matter in various forms.

**Unit-I Molecular structure**

Interaction of electromagnetic radiation with molecules and various types of spectra, Microwave spectra: diatomic molecules, intensities of spectral lines, Determination of bond length of diatomic molecules, isotopic substitution.

**L- 8, Marks: 8**

**Unit-II Vibrational spectroscopy**

Classical equation of vibration, vibrational energies of diatomic molecules, zero point energy, Concepts of normal vibration and normal coordinate, force constant, effect of isotopic substitution, vibrational frequency, Fundamental frequencies, overtones, hot bands, degree of freedom of polyatomic molecules, and concept of group frequencies.

**L-15, Marks:12**

**Unit-III Raman spectroscopy**

Qualitative treatment of Rotational Raman Effect, Vibrational Raman spectra, Stokes and antistokes lines, Structure elucidation by vibrational spectroscopy (AB, A<sub>2</sub>B, and AB<sub>3</sub>), stretching frequencies of bonds and functional groups (Example from both organic and inorganic molecules, correlation of vibrational spectra with molecular structure).

**L-8, Marks: 10**

**Unit IV Electronic spectroscopy**

The Beer – Lambert Law, molar absorption coefficient, selection rules for electronic transitions, vibrational structures, Franck-Condon principle calculation of electronic transitions of polyenes using free electron model, chromophores.

**L-7, Marks:08**

**Unit V Spin resonance, spectroscopy**

Principle of NMR, Larmour precession, chemical shift and low resolutions spectra, different scales, spin-spin coupling and high resolution spectra, Interpretation of PMR spectra of (ethanol, 1- and 2-chloropropane, acetaldehyde, cyanohydrin and 1,2 & 1,3- Dichloropropane). Electron spin resonance (ESR) spectroscopy and its principle, hyperfine structure, ESR of simple free radicals.

**L-12, Marks: 10**

**Text Books:**

C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, Tata-McGraw Hill  
Molecular Spectroscopy, G.M. Barrow  
Spectroscopy, Satyanarayana

**Ref. Books:**

- 1) Spectroscopy – Vol. I , II & III – Strawghan and Walker, (Chapman & Hall)

In the final semester (vi), Students have to carry out project work either at their respective colleges or any other R & D laboratory (private, public and govt.) or at the department of chemistry D.U., under guidance of a faculty member.

The area of the work is to be decided by the advisor.

On completion of the project work students have to submit the work in the form of a dissertation followed by oral presentation in the presence of faculty member and an external expert.

**Marks 22**

**Viva**

**Marks 10**

**Internal**

**Marks 8**

### **Additional Recommended Books**

#### **Physical Chemistry (Major Course)**

1. G.W Castellan, Physical Chemistry, Narosa Publishing House, New Delhi.
2. P.W Atkins, Physical Chemistry, Oxford University Press.
3. P. C Rakshit, Physical Chemistry, Science Book Agency, Kolkata.
4. C.N Banwell and E.M McCash, Fundamentals of Molecular Spectroscopy 4<sup>th</sup> Edition, Tata Mc Graw-Hill, New Delhi.
5. F. A Cotton, Chemical Application of Group Theory, Wiley Eastern Ltd, New Delhi.
6. B.R Puri, L.R Sharma, Madan .S. Pathania, Shoban Lal Nagin Chand and CO., Jalandhar
7. K.L Kapoor, Physical Chemistry, Vol II – Vol V, Macmillan, India, Ltd.
8. K.J Laidler, Chemical Kinetics, Pearson Education, New Delhi.
9. Modern Electrochemistry Vol I. Bokris and Reddy, Plenum Press
10. Quantum Chemistry, Ira N. Levine, PHI New Delhi
11. Quantum Chemistry, R. K. Prasad, New Age Publication
12. Introductory Quantum Chemistry, A. K. Chandra

#### **Inorganic Chemistry (Major Course)**

1. Greenwood, N.N. and Earnshwa, Chemistry of the elements, Butterworth-Heinemann.
2. Lee, J.D. Concise Inorganic Chemistry, ELBS.
3. Canham, G.R. and Uverton, T., Descriptive Inorganic Chemistry, Freeman & Co.
4. Cotton, F.A. and Wilkinson, G, Advanced Inorganic Chemistry Wiley VCH
5. Basolo F and Pearson R C, Mechanism of Inorganic Chemistry John Wiley & Sons.

#### **Organic Chemistry (Major Course)**

1. I.L. Finer, Organic Chemistry (Vol.I<sup>m</sup>-1) and volume -2
2. Advance Organic Chemistry: Reaction Mechanism & Structure- Jerry March Wiley Eastern.
3. A guide book to mechanism in Organic Chemistry-Peter Stykes, Longman.
4. Organic Chemistry Morrison and Boyd.
5. Organic Chemistry: Solomons and Fryhle
6. Reaction mechanisms & problems in Organic Chemistry P. Chattopadhyaya
7. E L Eliel , S H Wilen Stereochemistry of Organic Compound, Wiley: London
8. I L Finar vol. 2: Stereochemistry and the chemistry of Natural products, Dorling Kindersley Pvt. Ltd. (Pearson Education )
9. Jeremy M Berg, John L Tymoczko and Lubert Stryer Biochemistry , Sixth Edition .
10. P S Kalsi Textbook of Organic Chemistry ( Ist Ed.) New Age International Pvt Ltd.

11. Fred W Billimeyer Textbook of Polymer Science ,John Wiley and Sons. Inc.
12. V K Ahluwalia M Kidwai New Trends In Green Chemistry ,Anamaya Pub.
13. Anastas Paul Williamson Green Chemistry : Oxford University Press .
14. D H Williams ,I Fleming Spectroscopic Methods in Organic Chemistry Tata M Hill
15. Organic Chemistry, Clayden, Greeves Warren.
16. Organic reaction mechanism third edition V.K.Ahluwalia.Narosa Publishing House

**Spectroscopy:**

16. Fundamentals of Molecular Spectroscopy, C.N. Banwell, Tata McGraw Hill.
17. Physical Methods for Chemistry, R.S. Drago, Saunders Company.
18. Infrared and Raman Spectra: Inorganic and Coordination Compounds, K. Nakamoto,Wiley.
19. Solving problems with NMR Spectroscopy, Atta-ur-Rahman, Academic Press, Elsevier.
20. Application of Spectroscopy of Organic Compounds J.R.Dyer, Prentice Hall.
21. Spectroscopic Methods in Organic Chemistry, D.H.Williams,Fleming,Tata McGraw-Hill.

**Organic practical:**

12. A I Vogel A Text book of Practical Organic Chemistry .
13. A I Vogel Quantitative Organic Analysis .
14. Satish Agarwala ,R C Agarwala Advanced Organic Analysis .