

# SHRI GURU RAM RAI UNIVERSITY

(Estd. by Govt. of Uttarakhand, vide Shri Guru Ram Rai University Act no. 03 of 2017)



**Syllabus of**

**B.Sc. (CHEMISTRY)**

**(Three Year Course- Semester System)**

**Under CBC**

**Effective from Academic Session**

**2017-2018**

**Syllabus of B.Sc. Chemistry from 2017-18****CBCS system – B.Sc. CHEMISTRY Courses**

	CORE COURSE 6 credits each	ABILITY ENHANCEMENT COMPULSORY COURSE 4 credits each	SKILL ENHANCEMENT COURSE 4 credits each (maximum two)	DISCIPLINE SPECIFIC ELECTIVE 6 credits each
Semester I	BCHC101 Theory Inorganic Chemistry-I Organic Chemistry-I Practical	AECC101/102/103 Environment /English /MIL Communication		
Semester II	BCHC201 Theory Physical Chemistry-I Organic Chemistry-II Practical	AECC201/202/203 Environment /English /MIL Communication		
Semester III	BCHC301 Theory Physical Chemistry-II		BCHS302	

	Organic Chemistry- III Practical			
Semester IV	BCHC401 Theory Inorganic Chemistry- II Physical Chemistry- III Practical		BCHS402	
Semester V			BCHS504	BCHD501 BCHD502 BCHD503
Semester VI			BCHS604	BCHD601 BCHD602 BCHD603

## Chemistry Course [Core Courses]

### Semester I

BCHC101 Theory: Atomic Structure Bonding, & General Organic Chemistry, Aliphatic hydrocarbon Inorganic Chemistry-I, Organic Chemistry-I

Lab- Atomic Structure Bonding, & General Organic Chemistry, Aliphatic hydrocarbon Inorganic Chemistry-I, Organic Chemistry-I

### Semester II

BCHC201 Theory: Chemical Energetics, Equilibria & Functional Organic Chemistry Physical Chemistry-I, Organic Chemistry-II

Lab - Chemical Energetics, Equilibria & Functional Organic Chemistry Physical Chemistry-I Organic Chemistry-II

### Semester III

BCHC301 Theory: Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional group Organic Chemistry Physical Chemistry-II, Organic Chemistry-III

Lab – Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional group Organic Chemistry Physical Chemistry-II, Organic Chemistry-III

### Semester IV

BCHC401 Theory: Coordination chemistry, States of Matter & Chemical Kinetics Inorganic Chemistry-II, Physical Chemistry-III

Lab – Coordination chemistry, States of Matter & Chemical Kinetics Inorganic Chemistry-II, Physical Chemistry-III

**Chemistry Courses [skill enhancement] (Any one of the following may be opted in Semester III or IV or V & one more course may be opted in VI Semester)(Credit: 04 each) -**

Pesticides Chemistry	BCHS302
Chemistry and Cosmetics & Perfumes	BCHS402
Basic Analytical Chemistry	BCHS604
Green Methods in Chemistry	BCHS504

**Chemistry Courses [ discipline elective] (credit -06)**

**Semester- V (Any one)**

Analytical Methods in Chemistry	BCHD501
Polymer Chemistry	BCHD502
Green Chemistry	BCHD503

**Semester – VI (Any one)**

Instrumental Methods of Chemical Analysis	BCHD601
Organometallics, Bio-inorganic, Polynuclear Hydrocarbon, UV and IR Spectroscopy	BCHD602
Molecules of Life	BCHD603

**Total credits (Summary)**

Core courses (Th + Pr.)  $6 \times 4 = 24$  \* 03 (Three Subjects in BSc) = 72

Discipline elective courses (Th + Pr.)  $6 \times 2 = 12$  \* 03 (Three Subjects in BSc) = 36

Ability enhancement course  $4 \times 2 = 8$  (Common in all the three subjects) = 08

Skill enhancement courses  $4 \times 4 = 16$  (One course each from 03 subjects + one course from any of the 03 subjects) = 16

Total 132 credits to be earned in three years BSc course.

**Note** - One credit = 15 h of lecture per semester or 30 h of practical per semester

## Semester I

### **BCHC101: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBS**

**Credits: Theory-04, Practicals-02**

**Theory: 60 Lectures**

#### **Section A: Inorganic Chemistry-1 (30 Periods)**

##### **Atomic Structure:**

- ✓ Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.
- ✓ What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of  $\psi$  and  $\psi^2$ , Schrödinger equation for hydrogen atom. Radial and angular parts of the hydrogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers  $m_l$  and  $m_s$ . Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number ( $s$ ) and magnetic spin quantum number ( $m_s$ ).
- ✓ Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

**(14 Lectures)**

##### **Chemical Bonding and Molecular Structure**

- ✓ Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.
- ✓ Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

- ✓ Concept of resonance and resonating structures in various inorganic and organic compounds.
- ✓ MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and  $\text{NO}^+$ . Comparison of VB and MO approaches.

(16 Lectures)

## Section B: Organic Chemistry-1 (30 Periods)

### Fundamentals of Organic Chemistry

- ✓ Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Mesomeric effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.
- ✓ Structure, shape and reactivity of Intermediates organic molecules: Carbocations, Carbanions and free radicals.
- ✓ Nucleophiles and electrophiles.
- ✓ Strength of organic acids and bases: Comparative study with emphasis on factors affecting pKa values.
- ✓ Aromaticity: Hückel's rule.

(8 Lectures)

### Stereochemistry

- ✓ Conformations with respect to ethane, butane and cyclohexane. Inter conversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms).
- ✓ Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; cis - trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

(10 Lectures)

### Aliphatic Hydrocarbons

- ✓ Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

- ✓ Alkanes: Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.
- ✓ Alkenes: Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk.  $\text{KMnO}_4$ ) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymercuration-demercuration, Hydroboration-oxidation.
- ✓ Alkynes: Preparation: Acetylene from  $\text{CaC}_2$  and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline  $\text{KMnO}_4$ , ozonolysis and oxidation with hot alk.  $\text{KMnO}_4$ .

(12 Lectures)

**Reference Books:**

- Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
- Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3<sup>rd</sup> ed., Wiley.
- Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
- Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 2006.
- Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
- McMurry, J.E. Fundamentals of Organic Chemistry, 7<sup>th</sup> Ed. Cengage Learning India Edition, 2013.
- Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
- Eliel, E.L. Stereochemistry of Carbon Compounds, Tata McGraw Hill education, 2000.
- Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
- Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
- Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
- Puri Sharma Kalia, Principles Of Organic Chemistry, Milestone Publishers



**CHEMISTRY LAB: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS****60 Hrs****Section A: Inorganic Chemistry - Volumetric Analysis**

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with  $\text{KMnO}_4$ .
3. Estimation of water of crystallization in Mohr's salt by titrating with  $\text{KMnO}_4$ .
4. Estimation of Fe (II) ions by titrating it with  $\text{K}_2\text{Cr}_2\text{O}_7$  using internal indicator.
5. Estimation of Cu (II) ions iodometrically using  $\text{Na}_2\text{S}_2\text{O}_3$ .

**Section B: Organic Chemistry**

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
2. Separation of mixtures by Chromatography: Measure the  $R_f$  value in each case (combination of two compounds to be given)

Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography

Identify and separate the sugars present in the given mixture by paper chromatography.

**Reference Books:**

- Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
- Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
- Dr O P Pandey, D N Bajpai & Dr D Giri, Practical Chemistry, S Chand

## Semester II

### **CHEMISTRY: BCHC201 CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY**

**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

#### **Section A: Physical Chemistry-1 (30 Lectures)**

##### **Chemical Energetics**

- ✓ Review of thermodynamics and the Laws of Thermodynamics.
- ✓ Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation.
- ✓ Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

**(10 Lectures)**

##### **Chemical Equilibrium:**

- ✓ Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between  $G$  and  $G^\circ$ , Le Chatelier's principle. Relationships between  $K_p$ ,  $K_c$ .

**(08 Lectures)**

##### **Ionic Equilibria:**

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

**(12 Lectures)**

#### **Section B: Organic Chemistry-2 (30 Lectures)**

**Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.**

- ✓ Aromatic hydrocarbons Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

- ✓ Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

**(8 Lectures)**

### **Alkyl and Aryl Halides**

- ✓ Alkyl Halides: Preparation: from alkenes and alcohols.
- ✓ Types of Nucleophilic Substitution ( $SN^1$  and  $SN^2$ ) reactions.
- ✓ Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.
- ✓ Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions.
- ✓ Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by -OH group) and effect of nitro substituent. Benzyne Mechanism:  $KNH_2/NH_3$  (or  $NaNH_2/NH_3$ ).
- ✓ Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

**(8 Lectures)**

### **Alcohols, Phenols and Ethers (Upto 5 Carbons)**

- ✓ Alcohols: Preparation: Preparation of  $1^\circ$ ,  $2^\circ$  and  $3^\circ$  alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.
- ✓ Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk.  $KMnO_4$ , acidic dichromate, conc.  $HNO_3$ ). Oppeneauer oxidation Diols: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.
- ✓ Phenols: (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts.
- ✓ Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben-Hoesch Condensation, Schotten – Baumann Reaction.
- ✓ Ethers (aliphatic and aromatic): Cleavage of ethers with HI.
- ✓ Aldehydes and ketones (aliphatic and aromatic): (Formaldehyde, acetaldehyde, acetone and benzaldehyde) Preparation: from acid chlorides and from nitriles. Reactions – Reaction with HCN, ROH,  $NaHSO_3$ ,  $NH_2-G$  derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation.

Clemmensen reduction and Wolff Kishner reduction. Meerwein-Ponndorf Verley reduction.

**(14 Lectures)**

**Reference Books:**

- Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
- McMurry, J.E. Fundamentals of Organic Chemistry, 7<sup>th</sup> Ed. Cengage Learning India Edition, 2013.
- Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
- Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
- Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
- Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
- Arun Bahl, B S Bahl & G D Tuli, Essentials Of Physical Chemistry, S. Chand
- Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
- Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
- Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
- Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985)
- R L Madan , Chemistry For Degree Students, S. Chand
- Puri Sharma Pathania, Principles of Physical Chemistry, Vishal Publishing Co.

**CHEMISTRY LAB: CHEMICAL ENERGETICS, EQUILIBRIA &  
FUNCTIONAL ORGANIC CHEMISTRY**

**60 Hrs**

**Section A: Physical Chemistry**

**Thermochemistry**

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO<sub>3</sub>, NH<sub>4</sub>Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water.

## **Ionic equilibria**

### pH measurements

- a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
- b) Preparation of buffer solutions:
  - (i) Sodium acetate-acetic acid
  - (ii) Ammonium chloride-ammonium hydroxide

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

## **Section B: Organic Chemistry**

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.
3. Preparations: Mechanism of various reactions involved to be discussed.  
Recrystallisation, determination of melting point and calculation of quantitative yields to be done
  - (a) Bromination of Phenol/Aniline
  - (b) Benzoylation of amines/phenols
  - (c) Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone

### **Reference Books**

- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Dr O P Pandey, D N Bajpai & Dr D Giri, Practical Chemistry, S Chand

**Semester III****CHEMISTRY BCHC 301: SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC CHEMISTRY-II****(Credits: Theory-04, Practicals-02)****Theory: 60 Lectures****Section A: Physical Chemistry-2 (30 Lectures)****Solutions**

- ✓ Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes.
- ✓ Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.

**(8 Lectures)****Phase Equilibrium**

- ✓ Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, FeCl<sub>3</sub>-H<sub>2</sub>O and Na-K only).

**(8 Lectures)****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 methods. 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. Conductometric titrations (only acid-base).

**(6 Lectures)**

**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. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data.
- ✓ Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge.
- ✓ pH determination using hydrogen electrode and quinhydrone electrode.
- ✓ Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).

**(8 Lectures)****Section B: Organic Chemistry-3 (30 Lectures)**

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

**Carboxylic acids (aliphatic and aromatic) and their derivatives**

- ✓ Preparation: Acidic and Alkaline hydrolysis of esters. Reactions: Hell–Vohlard - Zelinsky Reaction.
- ✓ Carboxylic acid derivatives (aliphatic): Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

**(6 Lectures)****Amines and Diazonium Salts**

- ✓ Amines (Aliphatic and Aromatic): Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction.
- ✓ Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO<sub>2</sub>, Schotten–Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.
- ✓ Diazonium salts: Preparation: from aromatic amines.
- ✓ Reactions: conversion to benzene, phenol, dyes.

**(6 Lectures)****Amino Acids, Peptides and Proteins:**

- ✓ Preparation of Amino Acids: Strecker synthesis, Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.

- ✓ Reactions of Amino acids: ester of–COOH group, acetylation of–NH<sub>2</sub>group, complexation with Cu<sup>2+</sup>ions, ninhydrin test.
- ✓ Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.
- ✓ Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.

**(10 Lectures)**

### **Carbohydrates:**

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

**(8 Lectures)**

### **Reference Books:**

- Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
- Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
- Mahan, B.H. University Chemistry, 3rd Ed. Narosa (1998).
- Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).
- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7<sup>th</sup>Ed., W. H. Freeman.
- Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.

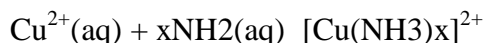
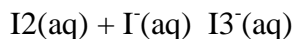


**CHEMISTRY LAB: SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE,  
ELECTROCHEMISTRY & FUNCTIONAL ORGANIC CHEMISTRY-II      60 Hrs**

**Section A: Physical Chemistry**

**Distribution**

Study of the equilibrium of one of the following reactions by the distribution method:



**Phase equilibria**

- Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.
- Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
- Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

**Conductance**

- Determination of cell constant
- Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
- Perform the following conductometric titrations:
  - Strong acid vs. strong base
  - Weak acid vs. strong base

**Potentiometry**

Perform the following potentiometric titrations:

- Strong acid vs. strong base
- Weak acid vs. strong base
- Potassium dichromate vs. Mohr's salt

**Section B: Organic Chemistry**

Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

- Separation of amino acids by paper chromatography
- Determination of the concentration of glycine solution by formylation method.
- Titration curve of glycine

4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. Differentiation between a reducing and a nonreducing sugar.

**Reference Books:**

- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

**Semester IV**

**CHEMISTRY BCHC401 : COORDINATION CHEMISTRY, STATES OF MATTER & CHEMICAL KINETICS**

**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

**Transition Elements (3d series)**

- ✓ General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.
- ✓ Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

**(12 Lectures)**

**Coordination Chemistry**

- ✓ Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6.
- ✓ Drawbacks of VBT. IUPAC system of nomenclature.

**(8 Lectures)**

**Crystal Field Theory**

- ✓ Crystal field effect, octahedral geometry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral geometry. Factors affecting the magnitude of splitting, Spectrochemical series. Comparison of CFSE for Oh and Td

complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.

**(10 Lectures)**

### **Section B: Physical Chemistry-3 (30 Lectures)**

#### **Kinetic Theory of Gases**

- ✓ Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation.
- ✓ Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO<sub>2</sub>.
- ✓ Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance.
- ✓ Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

**(8 Lectures)**

#### **Liquids**

- ✓ 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 only).

**(6 Lectures)**

#### **Solids**

- ✓ Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angle.
- ✓ Law of rational indices. Miller indices. X-Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

**(8 Lectures)**

**Chemical Kinetics**

- ✓ The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half-life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions.

**(8 Lectures)****Reference Books:**

- Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
- Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
- Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
- Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
- Cotton, F.A. & Wilkinson, G. Basic Inorganic Chemistry, Wiley.
- Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press.
- Wulfsberg, G. Inorganic Chemistry, Viva Books Pvt. Ltd.
- Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd., 2008.

**CHEMISTRY LAB-: COORDINATION CHEMISTRY, STATES OF  
MATTER & CHEMICAL KINETICS** **60 HRS**

**Section A: Inorganic Chemistry**

Semi-micro qualitative analysis using H<sub>2</sub>S of mixtures - not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

Cations : NH<sub>4</sub><sup>+</sup>, Pb<sup>2+</sup>, Ag<sup>+</sup>, Bi<sup>3+</sup>, Cu<sup>2+</sup>, Cd<sup>2+</sup>, Sn<sup>2+</sup>, Fe<sup>3+</sup>, Al<sup>3+</sup>, Co<sup>2+</sup>, Cr<sup>3+</sup>, Ni<sup>2+</sup>, Mn<sup>2+</sup>, Zn<sup>2+</sup>, Ba<sup>2+</sup>, Sr<sup>2+</sup>, Ca<sup>2+</sup>, K<sup>+</sup>

Anions : CO<sub>3</sub><sup>2-</sup>, S<sup>2-</sup>, SO<sub>4</sub><sup>2-</sup>, S<sub>2</sub>O<sub>3</sub><sup>2-</sup>, NO<sub>3</sub><sup>-</sup>, CH<sub>3</sub>COO<sup>-</sup>, Cl<sup>-</sup>, Br<sup>-</sup>, I<sup>-</sup>, NO<sub>2</sub><sup>-</sup>, SO<sub>4</sub><sup>2-</sup>, PO<sub>4</sub><sup>3-</sup>, BO<sub>3</sub><sup>3-</sup>, C<sub>2</sub>O<sub>4</sub><sup>2-</sup>, F<sup>-</sup>

(Spot tests should be carried out wherever feasible)

1. Estimate the amount of nickel present in a given solution as bis(dimethylglyoximate) nickel(II) or aluminium as oximate in a given solution gravimetrically.
2. Draw calibration curve (absorbance at  $\lambda_{\max}$  vs. concentration) for various concentrations of a given coloured compound (KMnO<sub>4</sub>/ CuSO<sub>4</sub>) and estimate the concentration of the same in a given solution.
3. Determine the composition of the Fe<sup>3+</sup>-salicylic acid complex solution by Job's method.
4. Estimation of (i) Mg<sup>2+</sup> or (ii) Zn<sup>2+</sup> by complexometric titrations using EDTA.
5. Estimation of total hardness of a given sample of water by complexometric titration.
6. Determination of concentration of Na<sup>+</sup> and K<sup>+</sup> using Flame Photometry.

**Section B: Physical Chemistry**

**(I) Surface tension measurement (use of organic solvents excluded).**

- a) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
- b) Study of the variation of surface tension of a detergent solution with concentration.

**(II) Viscosity measurement (use of organic solvents excluded).**

- a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.
- b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

**(III) Chemical Kinetics**

Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:
  - a. Acid hydrolysis of methyl acetate with hydrochloric acid.
  - b. Saponification of ethyl acetate.

- c. Compare the strengths of HCl and H<sub>2</sub>SO<sub>4</sub> by studying kinetics of hydrolysis of methyl acetate

**Reference Books:**

- Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
- Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

## Skill Enhancement Course

(Credit: 04 each, Any two maximum)

### BCHS302 PESTICIDE CHEMISTRY

(Credits: 04)

60 Lectures

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion ); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).

#### Practicals

To calculate acidity/alkalinity in given sample of pesticide formulations as per BIS specifications.

Preparation of simple organophosphates, phosphonates and thiophosphate

#### Reference Book:

Cremlyn, R. Pesticides. Preparation and Modes of Action, John Wiley & Sons, New York, 1978

### BCHS 402 CHEMISTRY OF COSMETICS & PERFUMES

(Credits: 04)

60 Lectures

**A general study including preparation and uses of the following:** Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

#### Practicals

Preparation of talcum powder.

Preparation of shampoo.

Preparation of enamels.

Preparation of hair remover.

Preparation of face cream.

Preparation of nail polish and nail polish remover.

#### Reference Books:

E. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.

P.C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.

Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).

## **BCHS504 GREEN METHODS IN CHEMISTRY**

**(Credits: 04)**

**Theory: 60 Lectures**

### **Theory and Hand-on Experiments**

**Introduction:** Definitions of Green Chemistry. Brief introduction of twelve principles of Green Chemistry with examples, special emphasis on atom economy, reducing toxicity, green solvents, Green Chemistry and catalysis and alternative sources of energy, Green energy and sustainability

**The following Real-World Cases in Green Chemistry should be discussed:**

- Surfactants for carbon dioxide: Replacing smog producing and ozone depleting solvents with CO<sub>2</sub> for precision cleaning and dry cleaning of garments.
- Designing of environmentally safe marine antifoulant.
- Rightfit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments.
- An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

### **Practicals**

Preparation and characterization of biodiesel from vegetable oil.

Extraction of D-limonene from orange peel using liquid CO<sub>2</sub> prepared from dry ice.

Mechano chemical solvent free synthesis of azomethine.

Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper(II).

### **Reference Books:**

Anastas, P.T. & Warner, J.K. Green Chemistry- Theory and Practical, Oxford University Press (1998).

Matlack, A.S. Introduction to Green Chemistry, Marcel Dekker (2001).

Cann, M.C. & Connely, M.E. Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).

Ryan, M.A. & Tinnensand, M. Introduction to Green Chemistry, American Chemical Society, Washington (2002).

Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. Green Chemistry Experiments: A monograph I.K. International Publishing House Pvt Ltd. New Delhi, Bangalore.



Lancaster, M. Green Chemistry: An introductory text RSC publishing, 2nd Edition.

Sidhwani, I.T., Saini, G., Chowdhury, S., Garg, D., Malovika, Garg, N. Wealth from waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated "A Social Awareness Project", Delhi University Journal of Undergraduate Research and Innovation,1(1): 2015

## **BCHS604 BASIC ANALYTICAL CHEMISTRY**

**(Credits: 04)**

**60 Lectures**

**Introduction:** Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

**Analysis of soil:** Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators

Determination of pH of soil samples.

Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

**Analysis of water:** Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

Determination of pH, acidity and alkalinity of a water sample.

Determination of dissolved oxygen (DO) of a water sample.

**Analysis of food products:** Nutritional value of foods, idea about food processing and food preservations and adulteration.

Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.

Analysis of preservatives and colouring matter.

**Chromatography:** Definition, general introduction on principles of chromatography- paper chromatography and TLC .

**Analysis of cosmetics:** Major and minor constituents and their function

Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.

Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

### **Reference Books:**

Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis. 7<sup>th</sup> Ed. Wadsworth Publishing Co. Ltd., Belmont, California, USA, 1988.

Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.

Skoog, D.A.; West, D.M. & Holler, F.J. Fundamentals of Analytical Chemistry 6<sup>th</sup>Ed., Saunders College Publishing, Fort Worth (1992).

Harris, D. C. Quantitative Chemical Analysis, W. H. Freeman.

Dean, J. A. Analytical Chemistry Notebook, McGraw Hill.

Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India.

Freifelder, D. Physical Biochemistry 2<sup>nd</sup>Ed., W.H. Freeman and Co., N.Y. USA (1982).

Cooper, T.G. The Tools of Biochemistry, John Wiley and Sons, N.Y. USA. 16 (1977).

Vogel, A. I. Vogel's Qualitative Inorganic Analysis 7<sup>th</sup>Ed., Prentice Hall.

Robinson, J.W. Undergraduate Instrumental Analysis 5<sup>th</sup>Ed., Marcel Dekker, Inc., New York (1995).

## **CHEMISTRY- ( DISCIPLINE SPECIFIC ELECTIVES)**

**(Semester V, Select any one course)**

### **BCHD501: ANALYTICAL METHODS IN CHEMISTRY**

**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

#### **Qualitative and quantitative aspects of analysis:**

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

**(5 Lectures)**

#### **Optical methods of analysis:**

- ✓ Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.
- ✓ **UV-Visible Spectrometry:** Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument;
- ✓ **Basic principles of quantitative analysis:** estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.
- ✓ **Infrared Spectrometry:** Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques.

Structural illustration through interpretation of data, Effect and importance of isotope substitution.

- ✓ **Flame Atomic Absorption and Emission Spectrometry:** Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

(25 Lectures)

#### **Thermal methods of analysis:**

- ✓ Theory of thermogravimetry (TG), basic principle of instrumentation.
- ✓ Techniques for quantitative estimation of Ca and Mg from their mixture.

(5 Lectures)

#### **Electroanalytical methods:**

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

(10 Lectures)

#### **Separation techniques:**

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

#### **Chromatography:**

- ✓ Classification, principle and efficiency of the technique.
- ✓ Mechanism of separation: adsorption, partition & ion exchange.

#### **Development of chromatograms:**

- ✓ Frontal, elution and displacement methods.
- ✓ Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.

**Stereoisomeric separation and analysis:**

- ✓ Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC).

**(15 Lectures)**

**Reference Books:**

Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley & Sons, 1989. th Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis, 7 Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.

Christian, G.D; Analytical Chemistry, 6<sup>th</sup> Ed. John Wiley & Sons, New York, 2004.

Harris, D. C. Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.

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

Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.

Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.

Ditts, R.V. Analytical Chemistry; Methods of Separation, van Nostrand, 1974.

**PRACTICALS LAB: ANALYTICAL METHODS IN CHEMISTRY****60 Hrs****I. Separation Techniques**

## 1. Chromatography:

## (a) Separation of mixtures

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

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

(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their  $R_f$  values.

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

## II. Solvent Extractions:

- (i) To separate a mixture of  $\text{Ni}^{2+}$  &  $\text{Fe}^{2+}$  by complexation with DMG and extracting the  $\text{Ni}^{2+}$ -DMG complex in chloroform, and determine its concentration by spectrophotometry.
  - (ii) Solvent extraction of zirconium with amberlite LA-1, separation from a mixture of irons and gallium.
3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.
  4. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.
  5. Analysis of soil:
    - (i) Determination of pH of soil.
    - (ii) Total soluble salt (iii) Estimation of calcium, magnesium, phosphate, nitrate
  6. Ion exchange:
    - (i) Determination of exchange capacity of cation exchange resins and anion exchange resins.
    - (ii) Separation of metal ions from their binary mixture.
    - (iii) Separation of amino acids from organic acids by ion exchange chromatography.

## III Spectrophotometry

1. Determination of pKa values of indicator using spectrophotometry.
2. Structural characterization of compounds by infrared spectroscopy.
3. Determination of dissolved oxygen in water.
4. Determination of chemical oxygen demand (COD).
5. Determination of Biological oxygen demand (BOD).
6. Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

## Reference Books:

- Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley & Sons, 1989.
- Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis, 7<sup>th</sup> Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
- Christian, Gary D; Analytical Chemistry, 6<sup>th</sup> Ed. John Wiley & Sons, New York, 2004.
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.

- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
- Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
- Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
- Ditts, R.V. Analytical Chemistry; Methods of Separation, van Nostrand, 1974.

## **BCHD 502 : POLYMER CHEMISTRY**

**(Credits: Theory-06, Practicals-02)**

**Theory: 60 Lectures**

### **Introduction and history of polymeric materials:**

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers.

**(4 Lectures)**

### **Functionality and its importance:**

Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bi-functional systems, Poly-functional systems.

**(8 Lectures)**

### **Kinetics of Polymerization:**

Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

**(8 lectures)**

### **Crystallization and crystallinity:**

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

**(4 Lectures)**

**Nature and structure of polymers-Structure Property relationships.**

**(2 Lectures)**

**Determination of molecular weight of polymers** ( $M_n$ ,  $M_w$ , etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance.

Polydispersity index.

**(8 Lectures)**

**Glass transition temperature (T<sub>g</sub>) and determination of T<sub>g</sub>**, Free volume theory, WLF equation, Factors affecting glass transition temperature (T<sub>g</sub>).

**(8 Lectures)**

**Polymer Solution** – Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures.

**(8 Lectures)**

**Properties of Polymers (Physical, thermal, Flow & Mechanical Properties).**

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes,

Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].

**(10 Lectures)**

**Reference Books:**

- Seymour, R.B. & Carraher, C.E. Polymer Chemistry: An Introduction, Marcel Dekker, Inc. New York, 1981.
- Odian, G. Principles of Polymerization, 4<sup>th</sup> Ed. Wiley, 2004.
- Billmeyer, F.W. Textbook of Polymer Science, 2<sup>nd</sup> Ed. Wiley Interscience, 1971.
- Ghosh, P. Polymer Science & Technology, Tata McGraw-Hill Education, 1991.
- Lenz, R.W. Organic Chemistry of Synthetic High Polymers. Interscience Publishers, New York, 1967.

**CHEMISTRY PRACTICAL : POLYMER CHEMISTRY**

**60 Hrs**

**1. Polymer synthesis**

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
  - a. Purification of monomer
  - b. Polymerization using benzoyl peroxide (BPO) / 2,2'-azo-bis-isobutyronitrile (AIBN)

2. Preparation of nylon 66/6
1. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein
  - a. Preparation of IPC
  - b. Purification of IPC
  - c. Interfacial polymerization
3. Redox polymerization of acrylamide
4. Precipitation polymerization of acrylonitrile
5. Preparation of urea-formaldehyde resin
6. Preparations of novalac resin/resold resin.
7. Microscale Emulsion Polymerization of Poly(methylacrylate).

### **Polymer characterization**

1. Determination of molecular weight by viscometry:
  - (a) Polyacrylamide-aq.NaNO<sub>2</sub> solution
  - (b) (Poly vinyl propylidene (PVP) in water
2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of “head-to-head” monomer linkages in the polymer.
3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).
4. Testing of mechanical properties of polymers.
5. Determination of hydroxyl number of a polymer using colorimetric method.

### **Polymer analysis**

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
2. Instrumental Techniques
3. IR studies of polymers
4. DSC analysis of polymers
5. Preparation of polyacrylamide and its electrophoresis

### **Reference Books:**

- M.P. Stevens, Polymer Chemistry: An Introduction, 3<sup>rd</sup> Ed., Oxford University Press, 1999.
- H.R. Allcock, F.W. Lampe & J.E. Mark, Contemporary Polymer Chemistry, 3<sup>rd</sup> ed. Prentice-Hall (2003)



- F.W. Billmeyer, Textbook of Polymer Science, 3<sup>rd</sup> ed. Wiley-Interscience (1984)
- J.R. Fried, Polymer Science and Technology, 2<sup>nd</sup> ed. Prentice-Hall (2003)
- P. Munk & T.M. Aminabhavi, Introduction to Macromolecular Science, 2<sup>nd</sup> ed. John Wiley & Sons (2002)
- L. H. Sperling, Introduction to Physical Polymer Science, 4<sup>th</sup> ed. John Wiley & Sons (2005)
- M.P. Stevens, Polymer Chemistry: An Introduction 3<sup>rd</sup> ed. Oxford University Press (2005).
- Seymour/ Carraher's Polymer Chemistry, 9<sup>th</sup> ed. by Charles E. Carraher, Jr. (2013).

## **BCHD503: GREEN CHEMISTRY**

**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

### **Introduction to Green Chemistry**

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry.

Limitations/ Obstacles in the pursuit of the goals of Green Chemistry

**(4 Lectures)**

### **Principles of Green Chemistry and Designing a Chemical synthesis**

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following:

- § Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products , Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions.
- § Prevention/ minimization of hazardous/ toxic products reducing toxicity.  
risk = (function) hazard × exposure; waste or pollution prevention hierarchy.
- § Green solvents– supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluoruous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents.
- § Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy.
- § Selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups.

- § Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.
- § Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD “What you don’t have cannot harm you”, greener alternative to Bhopal Gas Tragedy (safer route to carbonyl) and Flixborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.
- § Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

**(30 Lectures)**

### **Examples of Green Synthesis/ Reactions and some real world cases**

- 1.Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)
- 2.Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction
- 3.Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)
- 4.Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO<sub>2</sub> for precision cleaning and dry cleaning of garments.
- 5.Designing of Environmentally safe marine antifoulant.
- 6.Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments.
- 7.An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.
- 8.Healthier fats and oil by Green Chemistry: Enzymatic interesterification for production of no Trans-Fats and Oils
- 9.Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting

**(16 Lectures)**

### **Future Trends in Green Chemistry**

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solvent less reactions; co crystal controlled solid state synthesis (C<sup>2</sup>S<sup>3</sup>); Green chemistry in sustainable development.

**(10 Lectures)**

**Reference Books:**

- Ahluwalia, V.K. & Kidwai, M.R. New Trends in Green Chemistry, Anamalaya Publishers (2005).
- Anastas, P.T. & Warner, J.K.: Green Chemistry - Theory and Practical, Oxford University Press (1998).
- Matlack, A.S. Introduction to Green Chemistry, Marcel Dekker (2001).
- Cann, M.C. & Connely, M.E. Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
- Ryan, M.A. & Tinnesand, M. Introduction to Green Chemistry, American Chemical Society, Washington (2002).
- Lancaster, M. Green Chemistry: An Introductory Text RSC Publishing, 2<sup>nd</sup> Edition, 2010.

**CHEMISTRY PRACTICAL : GREEN CHEMISTRY****60 hrs****1. Safer starting materials**

- Preparation and characterization of nanoparticles of gold using tea leaves.

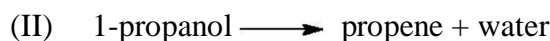
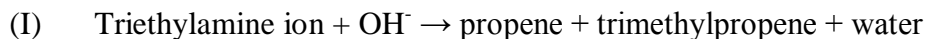
**2. Using renewable resources**

- Preparation of biodiesel from vegetable/ waste cooking oil.

**3. Avoiding waste**

Principle of atom economy.

- Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.
- Preparation of propene by two methods can be studied



- Other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy.

**4. Use of enzymes as catalysts**

- Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.

**5. Alternative Green solvents**Extraction of D-limonene from orange peel using liquid CO<sub>2</sub> prepared from dry ice.

Mechanochemical solvent free synthesis of azomethines

## 6. Alternative sources of energy

- Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II).
- Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

### Reference Books:

- Anastas, P.T & Warner, J.C. Green Chemistry: Theory and Practice, Oxford University Press (1998).
- Kirchoff, M. & Ryan, M.A. Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington DC (2002).
- Ryan, M.A. Introduction to Green Chemistry, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).
- Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. Green Chemistry Experiment: Amonograph International Publishing House Pvt Ltd. New Delhi. Bangalore CISBN 978-93-81141-55-7 (2013).
- Cann, M.C. & Connelly, M. E. Real world cases in Green Chemistry, American Chemical Society (2008).

**(Semester VI, select any one course)**

**BCHD601: INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS**

**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

**Introduction to spectroscopic methods of analysis:**

Recap of the spectroscopic methods covered in detail in the core chemistry syllabus: Treatment of analytical data, including error analysis. Classification of analytical methods and the types of instrumental methods. Consideration of electromagnetic radiation.

**(4 Lectures)**

**Molecular spectroscopy:**

Infrared spectroscopy: Interactions with molecules: absorption and scattering. Means of excitation (light sources), separation of spectrum (wavelength dispersion, time resolution), detection of the signal (heat, differential detection), interpretation of spectrum (qualitative, mixtures, resolution), advantages of Fourier Transform (FTIR). Samples and results expected. Applications: Issues of quality assurance and quality control, Special problems for portable instrumentation and rapid detection.

UV-Visible/ Near IR –emission, absorption, fluorescence and photoacoustic. Excitation sources(lasers, time resolution), wavelength dispersion (gratings, prisms, interference filters, laser, placement of sample relative to dispersion, resolution), Detection of signal (photocells, photomultipliers, diode arrays, sensitivity and S/N), Single and Double Beam instruments, Interpretation (quantification, mixtures, absorption vs. fluorescence and the use of time, photoacoustic, fluorescent tags).

**(16 Lectures)**

**Separation techniques**

Chromatography: Gas chromatography, liquid chromatography, supercritical fluids, Importance of column technology (packing, capillaries), Separation based on increasing number of factors (volatility, solubility, interactions with stationary phase, size, electrical field), Detection: simple vs. specific (gas and liquid), Detection as a means of further analysis (use of tags and coupling to IR and MS), Electrophoresis (plates and capillary) and use with DNA analysis.

Immunoassays and DNA techniques

Mass spectroscopy: Making the gaseous molecule into an ion (electron impact, chemical ionization), Making liquids and solids into ions (electrospray, electrical discharge, laser desorption, fast atom bombardment), Separation of ions on basis of mass to charge ratio,

Magnetic, Time of flight, Electric quadrupole. Resolution, time and multiple separations, Detection and interpretation (how this is linked to excitation).

**(16 Lectures)**

**Elemental analysis:**

Mass spectrometry (electrical discharges).

Atomic spectroscopy: Atomic absorption, Atomic emission, and Atomic fluorescence.

Excitation and getting sample into gas phase (flames, electrical discharges, plasmas), Wavelength separation and resolution (dependence on technique), Detection of radiation (simultaneous/scanning, signal noise), Interpretation (errors due to molecular and ionic species, matrix effects, other interferences).

**(8 Lectures)**

**NMR spectroscopy:** Principle, Instrumentation, Factors affecting chemical shift, Spin-coupling, Applications.

**(4 Lectures)**

Electro analytical Methods: Potentiometry & Voltammetry

**(4 Lectures)**

Radiochemical Methods

**(4 Lectures)**

X-ray analysis and electron spectroscopy (surface analysis)

**(4 Lectures)**

**Reference books:**

- Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
- Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis, 7<sup>th</sup> Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
- P.W. Atkins: Physical Chemistry.
- G.W. Castellan: Physical Chemistry.
- C.N. Banwell: Fundamentals of Molecular Spectroscopy.
- Brian Smith: Infrared Spectral Interpretations: A Systematic Approach.
- W.J. Moore: Physical Chemistry.

**PRACTICAL : INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS****60 hrs**

1. Safety Practices in the Chemistry Laboratory
2. Determination of the isoelectric pH of a protein.
3. Titration curve of an amino acid.
4. Determination of the void volume of a gel filtration column.
5. Determination of a Mixture of Cobalt and Nickel (UV/Vis spec.)
6. Study of Electronic Transitions in Organic Molecules (i.e., acetone in water)
7. IR Absorption Spectra (Study of Aldehydes and Ketones)
8. Determination of Calcium, Iron, and Copper in Food by Atomic Absorption
9. Quantitative Analysis of Mixtures by Gas Chromatography (i.e., chloroform and carbon tetrachloride)
10. Separation of Carbohydrates by HPLC
11. Determination of Caffeine in Beverages by HPLC
12. Potentiometric Titration of a Chloride-Iodide Mixture
13. Cyclic Voltammetry of the Ferrocyanide/Ferricyanide Couple
14. Nuclear Magnetic Resonance
15. Use of fluorescence to do “presumptive tests” to identify blood or other body fluids.
16. Use of “presumptive tests” for anthrax or cocaine
17. Collection, preservation, and control of blood evidence being used for DNA testing
18. Use of capillary electrophoresis with laser fluorescence detection for nuclear DNA (Y chromosome only or multiple chromosome)
19. Use of sequencing for the analysis of mitochondrial DNA
20. Laboratory analysis to confirm anthrax or cocaine
21. Detection in the field and confirmation in the laboratory of flammable accelerants or explosives
22. Detection of illegal drugs or steroids in athletes
23. Detection of pollutants or illegal dumping
24. Fibre analysis

**Reference books:**

1. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.

2. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis, 7<sup>th</sup> Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
3. Cann, M. C. & Thomas, P. Real world cases in Green Chemistry, American Chemical Society (2008).
4. Lancaster, M. Green Chemistry: An Introductory Text RSC Publishing, 2<sup>nd</sup> Edition, 2010.
5. Pavia, D.L., Lampman, G.M., Kriz, G.S. & Engel, R.G. Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach, W.B.Saunders, 1995.



**BCHD602                      ORGANOMETALLICS,        BIOINORGANIC        CHEMISTRY,  
POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY**

**(Credits: Theory-04, Practicals-02)                      Lectures: 60**

**Section A: Inorganic Chemistry-4 (30 Lectures)**

**Chemistry of 3d metals**

Oxidation states displayed by Cr, Fe, Co, Ni and Cu.

A study of the following compounds (including preparation and important properties);

Peroxo compounds of Cr,  $K_2Cr_2O_7$ ,  $KMnO_4$ ,  $K_4[Fe(CN)_6]$ , sodium nitroprusside,  $[Co(NH_3)_6]Cl_3$ ,  $Na_3[Co(NO_2)_6]$ .

**(6 Lectures)**

**Organometallic Compounds**

Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals.  $\pi$ -acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies).

**(12 Lectures)**

**Bio-Inorganic Chemistry**

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to  $Na^+$ ,  $K^+$  and  $Mg^{2+}$  ions: Na/K pump; Role of  $Mg^{2+}$  ions in energy production and chlorophyll. Role of  $Ca^{2+}$  in blood clotting, stabilization of protein structures and structural role (bones).

**(12 Lectures)**

**Section B: Organic Chemistry-4 (30 Lectures)**

**Polynuclear and heteronuclear aromatic compounds:**

Properties of the following compounds with reference to electrophilic and nucleophilic substitution:

Naphthalene, Anthracene, Furan, Pyrrole, Thiophene, and Pyridine.

**(6 Lectures)**

**Active methylene compounds:**

Preparation: Claisen ester condensation. Keto-enol tautomerism.

Reactions: Synthetic uses of ethylacetoacetate (preparation of non-heteromolecules having upto 6 carbon).

**(6 Lectures)****Application of Spectroscopy to Simple Organic Molecules**

Application of visible, ultraviolet and Infrared spectroscopy in organic molecules. Electromagnetic radiations, electronic transitions,  $\lambda_{\max}$  &  $\epsilon_{\max}$ , chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating  $\lambda_{\max}$  of conjugated dienes and  $\alpha, \beta$  – unsaturated compounds. Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on  $>C=O$  stretching absorptions).

**(18 Lectures)****Reference Books:**

- James E. Huheey, Ellen Keiter & Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
- G.L. Miessler & Donald A. Tarr: Inorganic Chemistry, Pearson Publication.
- J.D. Lee: A New Concise Inorganic Chemistry, E.L.B.S.
- F.A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley & Sons.
- I.L. Finar: Organic Chemistry (Vol. I & II), E.L.B.S.
- John R. Dyer: Applications of Absorption Spectroscopy of Organic Compounds, Prentice Hall.
- R.M. Silverstein, G.C. Bassler & T.C. Morrill: Spectroscopic Identification of Organic Compounds, John Wiley & Sons.
- R.T. Morrison & R.N. Boyd: Organic Chemistry, Prentice Hall.
- Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
- Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.

**PRACTICAL****60 hrs****Section A: Inorganic Chemistry**

1. Separation of mixtures by chromatography: Measure the  $R_f$  value in each case.

(Combination of two ions to be given)

Paper chromatographic separation of  $Fe^{3+}$ ,  $Al^{3+}$  and  $Cr^{3+}$  or

Paper chromatographic separation of  $Ni^{2+}$ ,  $Co^{2+}$ ,  $Mn^{2+}$  and  $Zn^{2+}$

2. Preparation of any two of the following complexes and measurement of their conductivity:

(i) tetraamminecarbonatocobalt (III) nitrate

(ii) tetraamminecopper (II) sulphate

(iii) potassium trioxalatoferrate (III) trihydrate

Compare the conductance of the complexes with that of M/1000 solution of NaCl, MgCl<sub>2</sub> and LiCl<sub>3</sub>.

### **Section B: Organic Chemistry**

Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

#### **Reference Books:**

- A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel: Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.

**BCHD603 MOLECULES OF LIFE****(Credits: Theory-04, Practicals-02)****Theory: 60 Lectures****Unit 1: Carbohydrates****(10 Periods)**

Classification of carbohydrates, reducing and non-reducing sugars, General Properties of Glucose and Fructose, their open chain structure. Epimers, mutarotation and anomers. Determination of configuration of Glucose (Fischer proof).

Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose.

Linkage between monosachharides, structure of disacharrides (sucrose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

**Unit 2: Amino Acids, Peptides and Proteins****(12 Periods)**

Classification of Amino Acids, Zwitterion structure and Isoelectric point.

Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C-terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butylloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis.

**Unit 3: Enzymes and correlation with drug action****(12 Periods)**

Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action(Including stereospecificity), Enzyme inhibitors and their importance, phenomenon of inhibition(Competitive and Non-competitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure –activity relationships of drug molecules, binding role of –OH group,-NH<sub>2</sub> group, double bond and aromatic ring,

**Unit 4: Nucleic Acids****(10 Periods)**

Components of Nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), other components of nucleic acids, Nucleosides and nucleotides (nomenclature), Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA(types of RNA), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation.

**Unit 5: Lipids****(8 Periods)**

Introduction to lipids, classification. Oils and fats common fatty acids present in oils and fats, Omega fatty acids, Trans fats, Hydrogenation, Saponification value, Iodine number.

Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

**Unit 6: Concept of Energy in Biosystems****(8 Periods)**

**Recommended Texts:**

- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7<sup>th</sup>Ed., W. H. Freeman.
- Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.

**LAB****60 hrs**

1. Separation of amino acids by paper chromatography
2. To determine the concentration of glycine solution by formylation method.
3. Study of titration curve of glycine
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. To determine the saponification value of an oil/fat.
7. To determine the iodine value of an oil/fat
8. Differentiate between a reducing/ nonreducing sugar.
9. Extraction of DNA from onion/cauliflower
10. To synthesise aspirin by acetylation of salicylic acid and compare it with the ingredient of an aspirin tablet by TLC.

**Recommended Texts:**

- Furniss, B.S.; Hannaford, A.J.; Rogers, V.; Smith, P.W.G.; Tatchell, A.R. Vogel's Textbook of Practical Organic Chemistry, ELBS.
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.