

**JSS COLLEGE OF ARTS, COMMERCE AND  
SCIENCE (autonomous)**

**Reaccredited by NAAC with 'A' grade  
B N ROAD, MYSURU- 570 025**

**DEPARTMENT OF CHEMISTRY**  
**Syllabus**

**CHOICE BASED CREDIT SYSTEM**

**For B.Sc programmes**

**Physics, Chemistry, Mathematics**  
**Chemistry, Zoology, Biotechnology**  
**Chemistry, Botany, Zoology**

**2017-18**

## Scheme of study for B.Sc. Chemistry under CBCS scheme 2017-18

YR	SEM	COURSE CODE	TITLE OF THE PAPER	NO. OF CREDITS		LECTURE/PRACTICAL HOURS /WEEK		TOTAL TEACHING HOURS	
				THEORY	PRA	THEORY (Hrs)	PRA (Hrs)	THEORY (Hrs)	PRA (Hrs)
I	I	CMA24001	ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS	04	02	04	04	60	60
	II	CMB24001	CHEMICAL ENERGETICS,EQUILIBRIA,& FUNCTIONAL GROUP ORGANIC CHEMISTRY	04	02	04	04	60	60
II	III	CMC24001	SOLUTIONS & ORGANIC CHEMISTRY	04	02	04	04	60	60
	IV	CMD24001	CO-ORDINATION CHEMISTRY & PHYSICAL CHEMISTRY	04	02	04	04	60	60
III	V	<b>Choose any one(DSE)</b>							
		CME24001	INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE	04	1	04	03	60	45
		CME24401	INDUSTRIAL CHEMICALS AND ENVIRONMENT	04	1	04	03	60	45
	VI	<b>Choose any one(DSE)</b>							
		CMF24001	ORGANOMETALLICS, BIOINORGANIC CHEMISTRY, POLY NUCLEAR HYDROCARBONS AND UV,IR SPECTROSCOPY	04	1	04	03	60	45
		CMF24201	QUANTUM CHEMISTRY, SPECTOSCOPY AND PHOTOCHEMISTRY	04	1	04	03	60	45
	V	<b>Choose any one(SEC)</b>							
		CME24201	FUEL CHEMISTRY	02	--	02	--	30	--
		CME24601	BASIC ANALYTICAL CHEMISTRY	02	--	02	--	30	--

### Scheme of assessment for B.Sc. Chemistry under CBCS scheme 2017-18

Year	SEM	COURSE CODE	TITLE OF THE PAPER	CONTINUOUS ASSESSMENT					MAX MARKS			PERCENTAGE			DURATION OF EXAM	
				C1		C2		C3	TH	PR	IA	TH	PR	IA	TH	PR
				TH	PR	TH	PR									
I	I	CMA24001	ATOMIC STRUCTURE ,BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS	10	5	10	5	70	70	70	30	50	20	30	3h	3h
	II	CMB24001	CHEMICAL ENERGETICS,EQUILIBRIA, & FUNCTIONAL GROUP ORGANIC CHEMISTRY	10	5	10	5	70	70	70	30	50	20	30	3h	3h
II	III	CMC24001	SOLUTIONS & ORGANIC CHEMISTRY	10	5	10	5	70	70	70	30	50	20	30	3h	3h
	IV	CMD24001	CO-ORDINATION CHEMISTRY & PHYSICAL CHEMISTRY	10	5	10	5	70	70	70	30	50	20	30	3h	3h
III	V	<b>Choose any one(DSE)</b>														
		CME24001	INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE	10	5	10	5	70	70	70	30	50	20	30	3h	3h
		CME24401	INDUSTRIAL CHEMICALS AND ENVIRONMENT	10	5	10	5	70	70	70	30	50	20	30	3h	3h
	VI	<b>Choose any one(DSE)</b>														
		CMF24001	ORGANOMETALLICS, BIOINORGANIC CHEMISTRY, POLY NUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY	10	5	10	5	70	70	70	30	50	20	30	3h	3h
		CMF24201	QUANTUM CHEMISTRY, SPECTROSCOPY AND PHOTOCHEMISTRY	10	5	10	5	70	70	70	30	50	20	30	3h	3h
V	<b>Choose any one(SEC)</b>															
	CME24201	FUEL CHEMISTRY	15	--	15	--	50	50	--	30	70	---	30	2h	--	
	CME24601	BASIC ANALYTICAL CHEMISTRY	15	--	15	--	50	50	--	30	70	---	30	2h	--	

## SCHEME OF VALUATION FOR PRACTICAL EXAMINATION

- A candidate appearing for the first time should submit a duly signed and certified practical record
- Each candidate has to perform one experiment in the specified duration of three hours for **FIFTY** marks
- Practical record has to be valued for **TEN** marks by examiners at the time of examination
- IA for **TEN** marks in practical is awarded by continuous assessment in the lab

### I. EVALUATION OF EXPERIMENTS:

<b>Sl. no</b>	<b>Component</b>	<b>Marks</b>
1	Procedure writing	05
2	Conducting experiment	40
3	Result	05
4	Viva-voce	10
5	Practical record	10
<b>TOTAL</b>		<b>70</b>

# SEMESTER I

## ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

Theories: 60 Lectures

### CHEMISTRY-DSC 1

#### 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 hydrogen 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  $ml$  and  $ms$ . Shapes of  $s$ ,  $p$  and  $d$  atomic orbitals, nodal planes. Discovery of spin, spin quantum number ( $s$ ) and magnetic spin quantum number ( $ms$ ). 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.

#### Periodic Table and Periodicity:

Classification of elements into s, p, d, and f-blocks, cause of periodicity. Detailed discussion of the following periodic properties of elements with examples

**1). Atomic radius:** Covalent, ionic, Vander Waal's and crystal radii. Additive nature of covalent radii., Determination of ionic radii by Lande's method. Variation of covalent radii in a group and in a period- explanation for the observed trends. Comparison of the size of the atoms with the corresponding anions and cations, Variation of ionic radii in isoelectronic ions.

**2). Ionization enthalpy:** Successive ionization enthalpy, factors affecting ionization enthalpy, applications of ionization enthalpy. Variation in a group and in a period- explanation for the observed trends.

**3). Electron gain enthalpy:** Successive electron gain enthalpy variation of electron gain enthalpy in period and in a group- explanation for the observed trends.

**4). Electronegativity:** Variation of electronegativity in a group and in a period- explanation for the observed trends. Factors determining electro negativity (charge on the atom and hybridization). Pauling and Mullikan methods (problems to be worked out). Allred-Rochow scale of electronegativity. Applications of electronegativity.

(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 of simple inorganic 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 NO<sup>+</sup>. Comparison of VB and MO approaches. Molecular orbital structures and bond orders of homo and hetero atomic molecules like H<sub>2</sub>, He<sub>2</sub>, He<sub>2</sub><sup>+</sup>, N<sub>2</sub>, O<sub>2</sub>, HF, and CO, Prediction of magnetic properties of these species

**Coordinate bond:** Explanation by taking NH<sub>3</sub>-BF<sub>3</sub> molecule as example.

**Hydrogen bonding:** Definition, inter and intra molecular Hydrogen bonding by taking HF, H<sub>2</sub>O, and nitrophenols as examples. Anomalous properties like physical state, boiling point and solubility. Structure of ice Theories (or nature) of hydrogen bond (electrostatic approach, VBT and MOT treatments)

(16 Lectures)

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

### **Fundamentals of Organic Chemistry**

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

### **Basic Concepts of Organic reaction mechanism:-**

Homolytic and heterolytic cleavages, electrophiles and nucleophiles (their nature with examples). Meaning of the terms with their illustration to show the formation of Carbocations, Carbanions, Free radicals. Stability and structure of primary, secondary and tertiary carbocations, carbanions, free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting  $K_a$  OR  $pK$  values. (acetic acid, propionic acid, Butanoic acid) & (Methylamine, ethylamine and aniline)

(8 Lectures)

### **Stereochemistry: Types of stereoisomers.**

**Optical isomerism; Definition, Elements of symmetry (Plane, centre and alternate axis) Chirality, Optical activity. Optical isomerism in lactic acid, tartaric acid and biphenyls. Racemisation, Resolution, methods of resolution (Chemical and biochemical) Walden Inversion, Asymmetric synthesis (Partial and Absolute) Diastereomers, R/S Nomenclature- CIP rules (upto 2 carbon atoms) Geometrical isomerism- Definition with examples, Geometrical isomerism in aldoximes and ketoximes. Determination of configuration- Beckmann rearrangement. ). E / Z Nomenclature (for upto two C=C**

systems). Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations.

(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 of alkenes, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.

**Alkenes:** Preparation: Elimination reactions: Dehydration of alcohols and dehydrohalogenation of alkyl halides (Saytzeff's rule); 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.

**Dienes:** Types, relative stabilities of dienes, 1,3 Butadiene, 1,2 and 1,4-addition reactions with  $\text{H}_2$  and HBr, Diel's Alder reaction with an example

**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, Acidity of alkynes, addition of bromine, HCN, Acetic acid, water, oxidation with  $\text{KMnO}_4$  and ozonolysis

(12 Lectures)

### Aromatic hydrocarbons; Aromaticity: Benzenoids and Hückel's rule

Preparation (Case benzene): from phenol, by decarboxylation of Carboxylic acids, from acetylene. **Reactions:** Electrophilic substitution: Mechanisms of nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) Orientation- Orienting influence of o-p and m- directing groups

(8 Lectures)

### Reference:

- 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
- R D Madan, Inorganic Chemistry

## CHEMISTRY LAB: DSC 1 LAB:

### ATOMIC STRUCTURE AND ORGANIC CHEMISTRY

(60 Lectures)

#### Section A: Inorganic Chemistry – Volumetric Analysis

1. Estimation of sodium hydroxide using HCl and sodium carbonate crystals
2. Estimation of oxalic acid  $\text{KmnO}_4$ . And Mohr's salt.
3. Estimation of Mohr's salt using  $\text{KmnO}_4$ . and oxalic acid crystals
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  $\text{NaS}_2\text{O}_3$ .
6. Estimation of Hydrogen peroxide using  $\text{KmnO}_4$  and Sodium oxalate crystals
7. Estimation of oxalic acid and Sulphuric acid present in a given mixture.
8. Estimation of oxalic acid using NaOH solution and PHP crystals.

#### 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 Rf value in each case (combination of two compounds to be given)
  - a) Identify and separate the components of a given mixture of two amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography.
  - b) Identify and separate the sugars present in the given mixture by paper chromatography.

#### Reference:

- 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, 5<sup>th</sup> edition, 1996.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.



## SEMESTER-II

### CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL GROUP ORGANIC CHEMISTRY

Theory: 60 Lectures

#### CHEMISTRY-DSC-2

##### Section A: Physical Chemistry-1

(30 Lectures)

##### Chemical energetics

##### Laws of thermodynamics, Zeroth law of thermodynamics- statement

**First law thermodynamics** – statements, mathematical expressions internal energy and its significance.

**Enthalpy**; Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchoff's equation

**Second law of thermodynamics** – spontaneous, non-spontaneous and equilibrium processes, different ways of stating second law – (Clausius, spontaneity, entropy), heat engine, Carnot cycle and its efficiency (derivation). Concept of entropy and its significance in terms of randomness and probability

**Free energy** – Helmholtz and Gibbs free energy and their relationship, Gibbs – Helmholtz's equation at constant pressure and volume (derivations). Thermodynamic criteria of equilibrium and spontaneity, variation of free energy with temperature and pressure. Clausius – Clapeyron equation (to be derived). Applications of integrated form of Clausius – Clapeyron equation and its applications. Van't Hoff's reaction isotherm and isochore equations (derivation), Statement of third law of thermodynamics. (Numerical problems)

**Statistical Thermodynamics:** Introduction, types of statistics. Importance of each statistics. Expression for Bose-Einstein's Statistics (equation to be given) **(12 Lectures)**

##### Chemical Equilibrium:

Characteristics of chemical equilibrium, Law of mass action, equilibrium constant, 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. Effect of change in concentration and temperature. Application of law of mass action for the formation of ammonia, dissociation of phosphorous pentachloride, Relationships between  $K_p$ ,  $K_c$  and  $K_x$  for reactions involving ideal gases.

**(6 Lectures)**

##### Ionic Equilibria:

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, Arrhenius theory of electrolytic dissociation, merits and demerits, Kohlrausch's law of independent migration of ions and applications. Transport number by moving boundary method, 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 effect of temperature on degree of hydrolysis, pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Activity and activity coefficients, definition and their relation, ionic strength and its calculation. Debye Huckel theory of

strong electrolytes ( relaxation time effect, electrophoretic effect and viscous effect). Debye-Huckel Onsager equation (no derivation), Debye-Huckel limiting equation for activity coefficients (no derivation). Role of solvents in altering the strengths of acids and bases.  
**(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.

### Alkyl and Aryl Halides

**Alkyl Halides:** Nomenclature-Preparation: from alkenes and alcohols. Reactions- Types of Nucleophilic Substitution ( $SN^1$ ,  $SN^2$  and  $SN^i$ ) reactions. Mechanisms, Energy profile diagram for  $SN^1$  and  $SN^2$  reactions. Reactions: Elimination reactions- $E_1$  and  $E_2$ , Mechanisms and hydrolysis

**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

**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 (alk.  $KMnO_4$ , acidic dichromate). Oppeneauer oxidation, Interconversions among primary, secondary and tertiary alcohols.

**Diols:** Oxidation of diols. Pinacol-Pinacolone rearrangement.

**Trihydric alcohols-** Glycerol-Synthesis from propene, Reactions of glycerol with HI, oxalic acid,  $HNO_3$  and dehydrating agent ( $P_2O_5$  or  $H_2SO_4$ ).

**Phenols:** (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Schotten – Baumann Reaction. Acidity of phenols. Effect of substitution on acidity of phenols.

**Ethers:** Nomenclature, Williamson ether synthesis, reactions of ethers-Cleavage. Ziesel's method of estimation. Epoxides:- Synthesis, Acid and Base catalyzed opening of epoxides. Crown ethers: Introduction and applications

**Aldehydes and ketones (aliphatic and aromatic):** (Formaldehyde, acetaldehyde, acetone and benzaldehyde) Preparation: from acid chlorides and from alcohols.

Reactions – Reaction with HCN, ROH,  $NaHSO_3$ ,  $NH_2-G$  derivatives. Iodoform test. Mechanisms of Aldol Condensation, Cannizzaro's reaction, perkins reaction and Benzoin condensation.

Illustrations of Clemensen reduction, Wolff Kishner reduction, Meerwein-Ponndorf-Verley reduction, Gattermann-Koch reaction and Baeyer-Villiger oxidation.

**(14 Lectures)**

**Carboxylic acids** and their derivatives ; Preparation: From Nitriles and by Arndt-Eistert reaction Acidic and Alkaline hydrolysis of esters. Reactions: Hell – Vohlar-Zelinsky Reaction. Acidity of carboxylic acids. Resonance structure of carboxylate ion and its stability. Effect of substitution on acidity of carboxylic acids

**Carboxylic acid derivatives** (aliphatic): Preparation of Acid chlorides, Anhydrides, Esters and Amides from acids.

**Hydroxy acids**:- Synthesis of Lactic, Tartaric and citric acids. Effect of heat on  $\alpha, \beta, \gamma$ -hydroxyl acids (**8 Lectures**)

**Reference:**

- 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.
- 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).

**CHEMISTRY LAB- DSC 2 LAB:**

**CHEMICAL ENERGETICS AND ORGANIC CHEMISTRY**

**60 Lectures**

**Section A: Physical Chemistry**

**Conductance**

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

**Potentiometry**

Perform the following potentiometric titrations:

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

**Colorimetric estimation of  $\text{Cu}^{2+}$  /  $\text{Fe}^{3+}$**

**Determination of refractive index of the mixture**

**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) PH titration of strong acid with strong base.

- c) Determination of pK<sub>a</sub> of weak acid by potentiometric titration.
- d) 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.
  - (d) Preparation of acetanilide from aniline.
  - (e) Preparation of p-bromo acetanilide
  - (f) Preparation of benzoic acid from benzaldehyde by oxidation.

### **Reference :**

- 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)

## SEMESTER-III

### SOLUTIONS AND ORGANIC CHEMISTRY

Theory: 60 Lectures

#### CHEMISTRY-DSC -3

Theory: 60 Lectures

#### Section A: Physical Chemistry-2 (30 Lectures)

##### Solutions

Concentrations-different ways of expression, solutions of gases in gases, Henry's law, 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. Chemical potential of ideal and non ideal solution: Gibbs Duhem-Morgules equation. Entropy change of mixing for an ideal solution

##### Liquid mixtures:

Classification of binary mixtures into partially miscible, completely miscible and immiscible pairs of liquids. Principle of steam distillation Raoult's law, Critical solution temperature, partially miscible liquids: phenol water system, triethyl-amine water system and nicotine water system, Binary mixtures of completely miscible liquids, vapour pressure – composition diagrams and vapour pressure – temperature diagram. Classification into types- obeying Raoult's law (type I), positive deviation (type II), negative deviation (type III) from Raoult's law. Principles of fractional distillation, fractional distillation type I, type II and type III liquid mixtures, azeotropic mixtures. Binary mixtures of completely miscible liquids, principles of steam distillation – applications. (to be briefed)

##### Colligative properties

**Introduction:** vapour pressure, variation of vapour pressure with temperature (explanation with graph). Definition of boiling point and freezing point. Effect of dissolution of solute, vapour pressure of the solvent, lowering of vapour pressure, Raoult's law – relation between relative lowering of vapour pressure and molar mass. Determination of molar mass of solute by dynamic method, problems.

**Elevation of boiling point:** – definition and its relation to lowering of vapour pressure and molar mass (to be derived). Ebullioscopic constant of the solvent and its relation to the boiling point (only equation). Determination of molar mass of the solute by Walker-Lumsden's method,

**Depression in freezing point:** – definition. Relation to lowering of vapour pressure and molar mass (to be derived). Cryoscopic constant, its relation to the melting point (only equation). Determination of molar mass of non-volatile solute by Beckmann's method. Abnormal molecular weights – causes - vant Hoff's factor, evaluation of degree of dissociation and association. Problems pertaining to all the colligative properties

(12 Lectures)

##### Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Phase diagrams of one-

component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver,  $\text{FeCl}_3\text{-H}_2\text{O}$  and Na-K only).

**(5 Lectures)**

### **Conductance and Electrochemistry**

Introduction, conductance (specific, equivalent and molar conductance – definition and SI unit), conductance cell and cell constant, determination of equivalent conductance by meter-bridge method, variation of  $\Lambda$  and  $k$  with dilution, ionic mobility, ionic conductance and their relationship. Kohlrausch's law and its significance, transport number – definition and explanation, anomalous transport number, relationship between ionic conductance and transport number (to be derived). Determination of transport number by Hittorff's and moving boundary method (transport number of  $\text{H}^+$  using  $\text{CdCl}_2$  as supporting electrolyte) (Numerical problems to be worked out).

### **Application of conductance measurement:**

- a) Solubility and solubility product of sparingly soluble salt.
- b) Ionic product of water
- c) degree of ionization of weak electrolyte
  - I. conductometric titration (strong acid Vs strong base, weak acid Vs strong base, strong acid Vs weak base, weak acid and weak base with examples)
  - II. hydrolysis constant (taking aniline hydrochloride as an example)

### **Electromotive force:**

Electrolytic and electro chemical cells, Single electrode potential, sign of electrode potential (reduction potential to be adopted) convention of representing a cell, electrode reaction of a Daniell cell, EMF and standard EMF of a cell, cell reaction, reversible and irreversible cells. Nernst equation (to be derived) and calculation of electrode potential, primary reference electrode – standard hydrogen electrode, secondary reference electrode – calomel and Ag - AgCl electrode – construction and working, electro-chemical series, equilibrium constant and free energy of a cell reaction, and its derivation, concentration cells with and without transference, EMF of concentration cells, liquid junction potential and salt bridge. Numerical problems on Nernst equation and EMF calculation. Fuel cells – working of  $\text{H}_2\text{O}_2$  fuel cell and its importance.

### **Application of EMF measurements:**

- a) Determination of pH of a solution using quinhydrone electrode and glass electrode using dip type calomel electrode – principles and procedure.
- b) Potentiometric titration – principle, location of end points in neutralization reactions ( $\text{NaOH}$  Vs  $\text{HCl}$ ), Oxidation – reduction reactions ( $\text{K}_2\text{Cr}_2\text{O}_7$  Vs FAS), precipitation reaction ( $\text{KCl}$  Vs  $\text{AgNO}_3$ ) and complex reactions ( $\text{ZnSO}_4$  Vs  $\text{K}_3[\text{Fe}(\text{CN})_6]$ )

**(13 Lectures)**

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

### **Organometallic compounds:-**

Definition with example. Organo magnesium compounds (Grignard reagents) Formation ethyl magnesium bromide and its synthetic applications (synthesis of alcohols, acids, aldehydes, ketones and carboxylic acids)

Organo zinc compounds:- Preparation of diethyl zinc and its applications

Organolithium Compounds:- Preparation and synthetic applications of LDA

### **Amines and Diazonium Salts**

Amines:- Definition, classification with example. Synthesis by Gabriel phthalimide method, reduction of amides. Separation of amine mixture by Hinsberg's method. Distinction tests for  $1^\circ$ ,  $2^\circ$ ,  $3^\circ$  amines (acetylation and Hoffmann's exhaustive methylation). Action of nitrous acid on different amines (Both aliphatic and aromatic

1°, 2°, 3° amines), basicity of amines, effect of substituent on basicity of aliphatic and aromatic amines. Hoffmann-Martius rearrangement.

**Diazonium Compounds:** Preparation, mechanism of preparation and synthetic applications of benzene diazonium chloride. Conversion to phenol, halobenzene, phenyl hydrazine and coupling reaction.

(10 Lectures)

**Amino Acids, Peptides and Proteins:**

Preparation of Amino Acids: Strecker synthesis using Gabriel's Phthalimidesynthesis. 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,

Elementary account of Primary, Secondary, Structure of proteins. Peptides (Amides) Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyl oxycarbonyl and Carbobenzoxy carbonyl) (4 Lectures)

**Carbohydrates:** Definition and importance, classification based on composition with examples-reducing and non-reducing sugars. Monosaccharides:- Glucose- reactions of glucose (with H<sub>2</sub>N-OH, HCN, C<sub>6</sub>H<sub>5</sub>NHNH<sub>2</sub>, Br<sub>2</sub> water, Conc. HNO<sub>3</sub>, reductions with HI/red P, Methanol(dry HCl), acetic anhydride and reduction reactions. Mutarotation. Structural elucidation of glucose and fructose :- open chain structure, ring structure- Fisher and Haworth structure. Determination of ring size by methylation method. Fischer and Haworth structures of fructose, galactose and mannose Interconversions reactions-1) Ascending (Killiani's synthesis) 2) Descending (Wohl's degradation) 3) Aldose to Ketose 4) Ketose to Aldose 5) Epimerization

Disaccharides:- structural elucidation of sucrose, structural formulae of maltose and lactose (Haworth structure). Polysaccharides:- Partial structural formulae of starch and Cellulose. (8 Lectures)

**Alkaloids:-** definition, classification based on heterocyclic rings-isolation, synthesis and structural elucidation of nicotine. Structure of Morphine, Atropine, Cocaine & physiological importance of alkaloids.

**Vitamins:-** Definition, classification, structural elucidation and synthesis of vit-A, Synthesis of vit-C, Sources & importance of Vitamin-B, calciferol, E, D & K

**Hormones:-** definition, classification, synthesis and functions of adrenaline and thyroxine.

**Terpenes:-** definition, isoprene rule, Classification, isolation (Solvent extraction and Steam distillation), structural elucidation of citral and its synthesis, structural formulae of  $\alpha$ -terpeneol, Camphor and menthol. (8 Lectures)

**Reference:**

- 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).
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- 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.
- Puri & Sharma, A Textbook of Chemistry

**CHEMISTRY LAB-DSC -3 LAB:  
SOLUTIONS AND ORGANIC, CHEMISTRY**

**60 Lectures**

**Section A: Physical Chemistry**

**Section A: Physical Chemistry**

**Thermo chemistry**

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 Transition temperature of the given salt hydrate.
5. Determination of enthalpy of hydration of copper sulphate.
6. Determination of CST OF phenol water system
7. Determination of % of NaCl

**Section B: Organic Chemistry**

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

**II**

1. Separation of amino acids by paper chromatography
2. Determination of the concentration of glycine solution by formylation method.
3. 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:**

- 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

### COORDINATION CHEMISTRY AND PHYSICAL CHEMISTRY

Theory: 60 Lectures

#### CHEMISTRY-DSC-4

##### Chemistry of transition elements:

Position in the periodic table, electronic configuration, general characteristics-atomic and ionic radii, ionization energy, variable oxidation states, (Latimer diagrams) spectral properties, redox potentials, colour and magnetic properties, catalytic activity, complex formation and interstitial compounds formation (3d, 4d and 5d series).

**Chemistry of inner transition elements:** Lanthanides: Electronic configuration and position in the periodic table, oxidation states, spectral properties, colour and magnetic properties, complex formation and ionic radii, lanthanide contraction – cause & its consequences and solvent extraction method.

**General survey of actinides** – comparison with lanthanides, transuranic elements. Action of ion exchange resins – cation exchange and anion exchange resins, exchange of inorganic ions, ion exchange capacity, separation of lanthanides by ion-exchange method. Comparison of d and f block elements.

(12 Lectures)

##### Coordination Chemistry

Ligands, classification of ligands and chelation, nomenclature of co-ordination compounds, physical methods in the study of complexes – change in conductance, colour and pH. Stability of complexes – stability constant, a brief outline of thermodynamic stability of metal complexes, factors affecting the stability of complexes. Polynuclear complexes, inner metallic complexes. Sidwick-EAN rule

**Isomerism in co-ordination complexes:** Stereo-isomerism – Geometrical and optical isomerism exhibited by co-ordination compounds of co-ordination number 4 and 6.

**Metal-ligand bonding in transition metal complexes:**

**Valence bond theory:** Salient features, formation of octahedral complexes on the basis of VBT, outer and inner orbital octahedral complexes-  $[\text{Fe}(\text{CN})_6]^{4-}$ ,  $[\text{Fe}(\text{CN})_6]^{3-}$ ,  $[\text{Co}(\text{CN})_6]^{3-}$ ,  $[\text{CoF}_6]^{3-}$   $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$  and  $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ . Formation of tetrahedral and square planar complexes on the basis of VBT –  $[\text{Ni}(\text{CN})_4]^{2-}$ ,  $[\text{Cu}(\text{NH}_3)]^{2+}$ ,  $[\text{Zn}(\text{NH}_3)_4]^{2+}$  and  $[\text{Ni}(\text{CO})_4]$ , limitations of VBT.

**Crystal field theory:** Important features of crystal field theory, crystal field splitting of d-orbitals in tetrahedral, octahedral and square planar complexes, crystal field stabilization energy (CFSE), factors affecting the magnitude of  $\Delta_o$ , (nature of ligand, oxidation state of the metal ion, size of the orbitals, geometry of the complex), high spin (HS) and low spin (LS) complexes. Spectrochemical series, magnetic properties of metal complexes based on crystal field theory- $[\text{Co}(\text{NH}_3)_6]^{3+}$ ,  $[\text{CoF}_6]^{3-}$ ,  $[\text{Fe}(\text{CN})_6]^{4-}$ ,  $[\text{Fe}(\text{CN})_6]^{3-}$  and  $[\text{Ni}(\text{CN})_4]^{2-}$ . Magnetic susceptibility, measurement of magnetic moment by Gouy's method. Tetragonal distortion of octahedral geometry. Jahn-Teller distortion. Applications of complex formation in biological systems

(18 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**

#### **Properties of liquids**

**Viscosity** : Definition of coefficient of viscosity, factors affecting viscosity – temperature, size, mass, shape of molecules, intermolecular forces, determination of viscosity of liquids by Ostwald's method..

**Surface tension** : Definition, effect of temperature and solute on surface tension. Determination of surface tension of liquids using stalagmometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only).

**Parachor** : Definition, sudge equation, calculation of parachor and its application w.r.t. the elucidation of structures- of benzene, quinine and isocyanide ion (Numerical problems).

**Polarization**- induced, orientation and molar polarization – definitions, Clausius-Mossotti equation (no derivation) and its application.

**(8 Lectures)**

#### **Solids :**

Introduction, laws of crystallography - law of constancy of interfacial angles, law of rational indices- weiss and miller indices. Unit cell, Space lattices and lattice planes, seven crystal systems, lattice planes in cubic crystals (Simple cubic, body centered cubic and face centered cubic).

Elements of symmetry – plane, axis and centre, elements of symmetry in cubic system, types of lattices, Bragg's equation and its derivation. X-ray diffraction and determination of crystal structure of rock salt by rotating crystal method. Application of X-ray studies – distance between lattice planes, density of crystals, determination of Avogadro number. (Numerical problems) Defects in crystals.

#### **Liquid crystals:**

Mesomorphic state – definition, classification of liquid crystals smectic and nematic with examples, molecular arrangement in the two types and uses. Nano materials – definition, properties and application

**(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 (Differential method, integration, half-life period and isolation methods) Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory based on hard sphere model and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only). **(6Lectures)**

**Reference:**

- 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.
- R D Madan, Textbook of Chemistry
- Madan, Malik Tuli, Comprehensive Chemistry
- Satyaprakash, Text book of Chemistry

**CHEMISTRY LAB-DSC-4 LAB:  
COORDINATION CHEMISTRY AND PHYSICAL CHEMISTRY**

**60 Lectures**

**Section A: Inorganic Chemistry**

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

Cations : NH<sub>4</sub><sup>+</sup>, Pb<sup>2+</sup>, Bi<sup>3+</sup>, Cu<sup>2+</sup>, Cd<sup>2+</sup>, Fe<sup>3+</sup>, Al<sup>3+</sup>, Co<sup>2+</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>, Na<sup>+</sup>, K<sup>+</sup>

Anions : CO<sub>3</sub><sup>2-</sup>, S<sup>2-</sup>, SO<sub>3</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>, 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. Estimation of (i) Mg<sup>2+</sup> or (ii) Zn<sup>2+</sup> by complexometric titrations using EDTA.
3. Estimation of total hardness of a given sample of water by complexometric titration.

**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 Determination molecular weight of the given non volatile solute by Walker Lumsden method.

**(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. Kinetics of rate of decomposition of H<sub>2</sub>O<sub>2</sub> catalysed by FeCl<sub>3</sub>

**Reference:**

- 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).

**INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE**

Theory: 60 Lectures

**Silicate Industries**

**Glass:** Rawmaterials, Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

**Ceramics:** Important clays and feldspar, ceramic, their types and manufacture. Hightechnology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre.

**Cement:** Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

**Abrasives:** Definition, classification with examples – hardness, manufacture and applications of carborundum, alundum and tungsten carbide.

**Refractories:** Definition, properties, classification with examples. Different steps involved in the manufacture of refractories. Applications of refractories.

**Inorganic polymers:**

Definition – examples, general properties, comparison with organic polymers, glass transition temperature Silicones: Definition, nomenclature, preparation (linear, cross-linked and cyclic). Factors affecting the nature of silicon polymers, properties (chemical and thermal stabilities( chemical properties) uses of silicon polymers, silicon fluids/oils – uses, silicon elastomers / rubbers, silicon resins (preparation and uses)

**Phosphazenes:** Definition, types, structures, preparation, properties and uses. Crystalline polymetaphosphates – Maddrell's and Kuroll's salts – properties and uses. Nature of bonding in phosphazenes.

**Fluorocarbons:** Definition, examples, preparation, properties and uses of Freon-12, Freon-22, PTFE and poly per fluorovinyl chloride.

**Non-aqueous solvents:**

**Liquid ammonia-** Reasons for the solvent properties, typical reactions- solubility of alkali metals; acid-base, precipitation, ammonolysis, Ionization of weak acids, advantages and disadvantages.

**Liquid SO<sub>2</sub>-** Reasons for the solvent properties, typical reactions-acid-base, solvolysis, precipitation, amphoteric and redox reactions **(25 Lectures)**

**Fertilizers:**

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate. **(5 Lectures)**

**Surface Coatings:**

Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolytic and electroless), metal spraying and anodizing.

**(10 Lectures)**

**Batteries:**

Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

**(4 Lectures)**

**Alloys:**

Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Properties and applications of steel. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels. Production of Ferro alloys: Ferro chrome and Ferro manganese.

**(8 Lectures)**

**Catalysis:**

General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples). Theories of catalysis, Auto catalyst. Industrial applications, Deactivation or regeneration of catalysts. Phase transfer catalysts, application of zeolites as catalysts.

**(4 Lectures)**

**Chemical explosives:**

Origin of explosive properties in organic compounds, Classification with examples, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.

**(4 Lectures)**

**Reference:**

- E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
- R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
- W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
- J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
- P. C. Jain & M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
- R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
- B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut

**CHEMISTRY PRACTICAL - DSE LAB:  
INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE**

**60 Lectures**

**Section A: Gravimetric estimations**

1. Gravimetric estimation of Barium as barium sulphate.
2. Gravimetric estimation of Iron as Iron oxide
3. Gravimetric estimation of Copper as Copper thiocyanate
4. Gravimetric estimation of Nickel as nickeldimethylglyoximate
5. Gravimetric estimation of magnesium as Magnesiumhydroxyquenolate
6. Gravimetric estimation of Sulphate as barium sulphate
7. Gravimetric estimation of Manganese from pyrolusite ore

**Section B: Volumetric estimations**

1. Determination of Iodine value of edible oil
2. Determination saponification value of edible oil
3. Separation of Green leaf pigments by TLC
4. Determination of amount of acetic cid in a given wine sample
5. Determination of total acidity of vineger
6. Determination of vitamin C in orange juice.

**Reference:**

- E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
- R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
- W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
- J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
- P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
- R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
- Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).



**INDUSTRIAL CHEMICALS AND ENVIRONMENT**

Theory: 60 Lectures

**Industrial Gases and Inorganic Chemicals**

*Industrial Gases:* Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

*Inorganic Chemicals:* Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda,

common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

**(10 Lectures)****Industrial Metallurgy**

Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology

**(4 Lectures)****Environment and its segments**

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur.

Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution

Pollution by SO<sub>2</sub>, CO<sub>2</sub>, CO, NO<sub>x</sub>, H<sub>2</sub>S and other foul smelling gases. Methods of estimation of CO, NO<sub>x</sub>, SO<sub>x</sub> and control procedures

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

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

Water purification methods: Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal.

Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water

**(30 Lectures)**

### **Energy & Environment**

Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc.

Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

**(10 Lectures)**

### **Biocatalysis**

Introduction to biocatalysis: Importance in “Green Chemistry” and Chemical Industry.

**(6 Lectures)**

### **Reference:**

- E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
  - R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
  - J. A. Kent: *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
  - S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
  - K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
  - S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.
  - S.E. Manahan, *Environmental Chemistry*, CRC Press (2005).
  - G.T. Miller, *Environmental Science* 11th edition. Brooks/ Cole (2006).
  - A. Mishra, *Environmental Studies*. Selective and Scientific Books, New Delhi (2005).
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## CHEMISTRY PRACTICAL - DSE LAB: INDUSTRIAL CHEMICALS & ENVIRONMENT

60 Lectures

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method ( $\text{AgNO}_3$  and potassium chromate).
6. Estimation of total alkalinity of water samples ( $\text{CO}_3^{2-}$ ,  $\text{HCO}_3^-$ ) using double titration method.
7. Measurement of dissolved  $\text{CO}_2$ .
8. Study of some of the common bio-indicators of pollution.
9. Estimation of SPM in air samples.
10. Preparation of borax/ boric acid.

### Reference:

- E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
  - R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
  - J. A. Kent: *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
  - S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
  - K. De, *Environmental Chemistry*: New Age International Pvt. Ltd, New Delhi.
  - S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.
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## ORGANOMETALLICS, BIOINORGANIC CHEMISTRY, POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY

Theory: 60 Lectures

### DSE-1:

#### Section A: Inorganic Chemistry-4

(30 Lectures)

**Metallurgy:** Terms and principles involved in metallurgy, Ellingham's diagram, Types of metallurgy: Pyro metallurgy- extraction of Nickel by sulphide ore- general metallurgy followed by Mond's process ( purification, Manganese from oxides ores- Reduction by the Aluminothermite process- refining by electrolytic process.

Hydro metallurgy: Extraction of Gold from native ore by cyanide process, and refining by leaching process.

Electro metallurgy: Extraction of Lithium by fusion method Followed by electrolysis of lithium chloride.

Powder metallurgy: Importance, metal powder production & applications. Production of Tungsten powder. Principles of Electroplating. (10 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. Preparation, properties, bonding and applications of alkyls and aryls of Li, Al, Hg, Sn and Ti.

Nature of M-CO bonding in carbonyls. Preparation, properties and structures of mononuclear and binuclear metal carbonyls- $\text{Ni}(\text{CO})_4$ ,  $\text{Cr}(\text{CO})_6$ ,  $\text{Fe}(\text{CO})_5$ ,  $\text{Mn}_2(\text{CO})_{10}$ ,  $\text{Co}_2(\text{CO})_8$ . Applications of EAN rule to mononuclear metal carbonyls.

Behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies). (10 Lectures)

#### Chemistry of nonmetals:

**Boron:** Boron hydrides – Diborane – preparation, properties, uses and structure  
**Carbon:** Fullerenes- Production, structure of  $\text{C}_{60}$  and  $\text{C}_{70}$ . Diamond and Graphite-Properties and structure.

**Silicon:** Structure of silica. Silicates-types of silicates with examples.

**Nitrogen:** Preparation (any two methods), properties, uses, structure of hydrazine, hydroxyl amine and hydrazoic acid.

**Sulphur:** Preparation, properties, structures and applications of thionyl chloride, sulphuryl chloride and  $\text{SF}_6$ .

**Halogens:** Preparation, properties and structure of bleaching powder.

**Pseudo halogens:** preparation, properties and structure of cyanogens, thiocyanogen, tellurocyanogen and oxocyanogen. (any one method of preparation and any three properties to be discussed). (5 Lectures)

#### Bio-Inorganic Chemistry

A brief introduction to bio-inorganic chemistry. Essential and trace elements in biological process. Role of metal ions present in biological systems with special reference to  $\text{Na}^+$ ,

$K^+$  and  $Ca^{2+}$ ,  $Mg^{2+}$  ions: Na/K pump; Role of  $Mg^{2+}$  ions in energy production and chlorophyll. Role of  $Ca^{2+}$  in blood clotting, Enzymatic role of Iron in Hemoglobin and myoglobin, Magnesium in Chlorophyll, Cobalt in Vitamin B12.  
Stabilization of protein structures and structural role (bones).  
Biological functions and toxicity of Cr, Mn, Co, Ni, I, Hg, Mo, and Se. **(5 Lectures)**

## **Section B: Organic Chemistry-4**

**(30 Lectures)**

### **Polynuclear and heteronuclear aromatic compounds:**

Polynuclear Hydrocarbons: Resonance structures of Naphthalene, anthracene and Phenanthracene.

Structural elucidation of naphthalene. Reactions of naphthalene- oxidation, reduction and electrophilic substitution reactions

**Heterocyclic Compounds:** Definition, classification with examples, synthesis of Furan, thiophene, pyrrole, pyridine, indole (Fischer method), quinoline (Skrup's synthesis), isoquinoline, pyrimidine (one method each). Aromaticity and basicity of pyrrole and pyridine. Electrophilic substitution reactions of pyrrole and pyridine.

**Uric acid-** Structure, Synthesis. Conversion of uric to purine and caffeine

**Dyes:** Colour and Constitution, Witt's theory, Classification of dyes based on structures with examples, synthesis of Methyl orange, Bismark brown, indigo and malachite green, structural elucidation of alizarin and its synthesis.

**Drugs:** Chemotherapy and chemotherapeutic agents, definition of drugs, types of drugs, antipyretics, analgesics, anaesthetics, sedatives, narcotics, antiseptics, antibacterials, antibiotics, antimalarials and sulpha drugs with examples. Synthesis of paracetamol, sulphanilamide, sulphaguanidine **(13 lectures)**

**Active methylene compounds:** Definition, Ethyl acetoacetate and diethyl malonate preparation, Mechanism of Claisen condensation, keto-enol tautomerism and its evidence. Synthetic applications of EAA and DEM:- Synthesis of mono carboxylic acids, dicarboxylic acids-succinic acid, adipic acid, antipyrine, Barbituric acid, acetyl acetone, Crotonic acid and Cinnamic acid. **(4 lectures)**

### **Application of Spectroscopy to Simple Organic Molecules**

Application of visible, ultraviolet and Infrared spectroscopy in organic molecules. Electromagnetic radiations, electronic transitions,  $\lambda_{max}$ , chromophore, auxochrome, bathochromic and hypsochromic shifts. Woodward rules for calculating  $\lambda_{max}$  of conjugated dienes

**IR-Spectroscopy:** Introduction, functional group region and finger print region stretching frequency, Graphical representation of IR spectra of benzoic acid and methyl benzoate. Absorption frequencies of Simple functional groups

**NMR Spectroscopy:** Basic principles of proton magnetic resonance, nuclear magnetic spin quantum number I, influence of the magnetic field on the spin of nuclei, magnetic resonance-chemical shift ( $\delta$  value), use of TMS as reference, nuclear shielding effects, equivalent and non-equivalent protons, spin-spin splitting.

NMR spectra of Simple organic molecules (like ethyl alcohol, ethane, propane, benzene, toluene, acetone, and methyl chloride) to be discussed. **(13 Lectures)**

### **Reference:**

- 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

## QUANTUM CHEMISTRY, SPECTROSCOPY & PHOTOCHEMISTRY

Theory: 60 Lectures

### Quantum Chemistry

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and “particle-in-a-box” (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy.

Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component.

Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.

Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of  $H_2$ . Bonding and antibonding orbitals. Qualitative extension to  $H_2$ . Comparison of LCAO-MO and VB treatments of  $H_2$  (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic ( $BeH_2$ ,  $H_2O$ ) molecules. Qualitative MO theory and its application to  $AH_2$  type molecules. (24 Lectures)

### Molecular Spectroscopy:

Interaction of electromagnetic radiation with molecules and various types of spectra; BornOppenheimer approximation.

Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

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

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

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals. **(24 Lectures)**

### **Photochemistry**

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

**(12 Lectures)**

### **Reference:**

- Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
- Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
- House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
- Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
- Kakkar, R. Atomic & Molecular Spectroscopy: Concepts & Applications, Cambridge University Press (2015).

### **DSE LAB**

60 Lectures

UV/Visible spectroscopy

- I. Study the 200-500 nm absorbance spectra of  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  (in 0.1 M  $\text{H}_2\text{SO}_4$ ) and determine the  $\lambda_{\text{max}}$  values. Calculate the energies of the two transitions in different units (J molecule<sup>-1</sup>, kJ mol<sup>-1</sup>, cm<sup>-1</sup>, eV).
- II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of  $\text{K}_2\text{Cr}_2\text{O}_7$ .
- III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

Colourimetry

- I. Verify Lambert-Beer's law and determine the concentration of  $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$  in a solution of unknown concentration
- II. Determine the concentrations of  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  in a mixture.
- III. Study the kinetics of iodination of propanone in acidic medium
- IV. Determine the amount of iron present in a sample using 1,10-phenanthroline.
- V. Determine the dissociation constant of an indicator (phenolphthalein).
- VI. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
- VII. Analyse the given vibration-rotation spectrum of  $\text{HCl}(\text{g})$

### **Reference :**

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



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

## CHEMISTRY PRACTICAL - DSE LAB

60 lectures

### Section A: Inorganic Chemistry

1. Separation of mixtures by chromatography: Measure the R<sub>f</sub> value in each case. (Combination of two ions to be given)  
Paper chromatographic separation of Fe<sup>3+</sup>, Al<sup>3+</sup> and Cr<sup>3+</sup> or Paper chromatographic separation of Ni<sup>2+</sup>, Co<sup>2+</sup>, Mn<sup>2+</sup> and Zn<sup>2+</sup>
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: Volumetric analysis

1. Estimation of iron in the given sample of Hematite by dichromate method
2. Estimation of % of calcium in lime stone by oxalate method
3. Estimation of manganese in the given sample of pyrolusite
4. Estimation of magnesium in the given sample of Dolomite by EDTA method
5. Determination of % purity of copper in the given sample of copper wire
6. Determination of COD of water.
7. Estimation of available chlorine in bleaching powder
8. Estimation of total hardness of different samples of water using EDTA & ZnSO<sub>4</sub>.

### Reference:

- 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.

## V SEMESTER

### SEC-1 FUEL CHEMISTRY

#### SKILL ENHANCEMENT COURSE-SEC

30 Lectures

Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value

**Coal:** Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar based chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

**Petroleum and Petrochemical Industry:** Composition of crude petroleum, Refining and different types of petroleum products and their applications.

Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

**Lubricants:** Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloud point, pour point) and their determination.

#### Reference :

- Stocchi, E. Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK (1990).
- Jain, P.C. & Jain, M. Engineering Chemistry Dhanpat Rai & Sons, Delhi.
- Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).

**BASIC ANALYTICAL CHEMISTRY**

30 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

- a. Determination of pH of soil samples.
- b. 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.

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

- a. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.
- b. Analysis of preservatives and colouring matter.

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

- a. Paper chromatographic separation of mixture of metal ion ( $\text{Fe}^{3+}$  and  $\text{Al}^{3+}$ ).
- b. To compare paint samples by TLC method. **Ion-exchange:** Column, ion-exchange chromatography etc. Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).

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

- a. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.
- b. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

### Suggested Applications (Any one):

- a. To study the use of phenolphthalein in trap cases.
- b. To analyze arson accelerants.
- c. To carry out analysis of gasoline.

### Suggested Instrumental demonstrations:

- a. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry. 104
- b. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.
- c. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drink.

### Reference:

- 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.
  - Vogel, A. I. *Vogel's Quantitative Chemical Analysis* 6<sup>th</sup> Ed., Prentice Hall.
  - Robinson, J.W. *Undergraduate Instrumental Analysis* 5<sup>th</sup> Ed., Marcel Dekker, Inc., New York (1995).
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**Pattern of question paper  
I to VI semesters**

**Time :3.00hrs**

**Max marks: 70**

**PART-A**

I. Answer the following questions

1x10=10

- a)
- b)
- c)
- d)
- e)
- f)
- g)
- h)
- i)
- j)

**PART-B**

II Answer any three questions

(Questions carrying 4,4,2- 3,3,4- 6,4 and 5,5 marks may be given)

3x10=30

- 2)
- 3)
- 4)
- 5)

**PART-C**

III Answer any three questions

(Questions carrying 4,4,2- 3,3,4- 6,4 and 5,5 marks may be given)

3x10=30

- 6)
- 7)
- 8)
- 9)

**Pattern of question paper for SEC**

**Time :2.30.00hrs**  
**50**

**Max marks:**

**PART-A**

I. Answer the following questions

1x10=10

- a)
- b)
- c)
- d)
- e)
- f)
- g)
- h)
- i)
- j)

**PART-B**

II Answer any four questions

(Questions carrying 4,4,2- 3,3,4- 6,4 and 5,5 marks may be given)

4x10=40

- 2)
- 3)
- 4)
- 5)

## LIST OF EXAMINERS

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2. Dr B K Kendagannaswamy  
Chairperson, Dept of Chemistry  
JSS College, B N Road Mysuru
3. D S Prabhakar  
Temp Asst Professor, Dept of Chemistry  
JSS College, B N Road Mysuru
4. Shwetha P  
Temp Asst Professor , Dept of Chemistry  
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6. Dr Madhusudana Reddy, Asso Prof, MSCW, Mysuru
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17. Dr Devaraju, Asso Prof, Yuvarajas College, Mysuru
18. Dr Sudha B S, Asso Prof, Yuvarajas College, Mysuru
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36. Dr Dayananda, , Asso Prof, MSCW, Mysuru
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38. Dr Nanjundaswamy, Govt College for boys(autonomous) , Mandya
39. Pallavi , , Temp Asst Prof, Mysuru
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