

AC 21<sup>st</sup> July, 2018

Item No: 1.3

Hindi Vidya Prachar Samiti's  
**R. J. College of Arts, Science & Commerce**

(RAMNIRANJAN JHUNJHUNWALA COLLEGE)

Ghatkopar (West), Mumbai 400086, Maharashtra, INDIA.

Website: [rjcollege@rjcollege.edu.in](mailto:rjcollege@rjcollege.edu.in) Email : [rjcollege@rjcollege.edu.in](mailto:rjcollege@rjcollege.edu.in)

**Affiliated to UNIVERSITY OF MUMBAI**



## **AUTONOMOUS COLLEGE**

**Revised Syllabus of**

**SYBSc - Chemistry**

**SEM III & IV**

(Choice Based Credit System with effect from the Academic year 2018-19)

**Hindi Vidya Prachar Samiti's  
Ramniranjan Jhunjhunwala College (Autonomous)  
Department of Chemistry**

Proposed draft syllabus for  
B.Sc. (Chemistry)  
Semester – III  
Paper – I

Course code: RJSICHE301  
Total No. of Lectures (45 L)

**Unit I (Physical Chemistry)**

*Learning Objectives:*

1. To understand the free energy functions and partial molal properties.
2. To understand van't Hoff reaction isotherm and isochore.
3. To learn about transport number, Hittorf's rule and Nernst equation.

**1.1 CHEMICAL THERMODYNAMICS-II (8L)**

- 1.1.1 Free Energy Functions: Helmholtz Free Energy, Gibb's Free Energy, Variation of Gibb's free energy with Pressure and Temperature, Gibbs-Helmholtz equation. (Numericals expected).
- 1.1.2 Thermodynamics of Open System: Partial Molal Properties, Chemical Potential and its variation with Pressure and Temperature, Gibb's Duhem equation.
- 1.1.3 Concept of Fugacity and Activity
- 1.1.4 Chemical Equilibrium and Equilibrium Constant: Equilibrium constant,  $K_p$  and  $K_c$  and their inter-relation, Van't Hoff reaction isotherm, Van't Hoff reaction isochore. (Numericals expected).

**1.2 ELECTROCHEMISTRY-II (7 L)**

- 1.2.1 U- tube experiment, Hittorf's rule.
- 1.2.2 Migration of ions, velocity of ions and change in concentration around electrodes(unattackable).
- 1.2.3 Transport number definition and determination by Moving Boundary Method.
- 1.2.4 Factors affecting transport number of ions.
- 1.2.5 Relation between transport number and ionic conductance.
- 1.2.6 Nernst's equation

**Unit II (Inorganic Chemistry)**

*Learning Objectives:*

1. To learn about lattice energy, Bond-Lande equation, Kapustinski equation & Born-Haber cycle.
2. To study the valence bond theory and hybridization.
3. To study the molecular orbital theory and its applications.

## 2.0 Chemical Bonding

### 2.1 Non-Directional Bonding

(3L)

- 2.1.1 Ionic Bond: Conditions for the Formation of Ionic bond.
- 2.1.2 Lattice Energy, Born-Landé Equation
- 2.1.3 Kapustinskii Equation
- 2.1.4 Born-Haber Cycle and its Application  
(Numerical problems are expected wherever possible)

### 2.2. Directional Bonding: Orbital Approach.

(6L)

- 2.2.1 Covalent Bonding : The Valence Bond Theory- Introduction and basic postulates.
- 2.2.2 Interaction between two hydrogen atoms and the Potential energy diagram of the resultant system.
- 2.2.3 Corrections applied to the system of two hydrogen atoms- Formation of H<sub>2</sub>
- 2.2.4 Resonance, rules for resonating or canonical structure, concept for formal charges.
- 2.2.5 Bonding in Polyatomic Species: The role of Hybridization and types of hybrid orbitals- sp, sp<sup>2</sup>, sp<sup>3</sup>, sp<sup>3</sup>d<sup>1</sup>, sp<sup>3</sup>d<sup>2</sup>

### 2.3 Molecular Orbital Theory

(6L)

- 2.3.1 Linear combination of atomic orbitals to give molecular orbitals LCAO-MO approach.
- 2.3.2 Application of LCAO –MO approach to the formation of:
  - a) Homo-nuclear di atomic molecules; H<sub>2</sub>, He<sub>2</sub>, Li<sub>2</sub>, Be<sub>2</sub>, C<sub>2</sub>, N<sub>2</sub>, O<sub>2</sub>, F<sub>2</sub> and Ne<sub>2</sub> ( Discussion should include 2s, 2p interaction; stabilization of p(2p<sub>x</sub>, 2p<sub>y</sub> orbitals) with respect to B<sub>2</sub>, C<sub>2</sub> and N<sub>2</sub> molecular orbital diagram, molecular configuration, bond order, bond energy and magnetic properties of all the homo-nuclear diatomic molecules mentioned.
  - a) Hetero-nuclear diatomic molecules; CO, NO and HCl. (Discussion should include comparison with homo-nuclear diatomic molecules. Molecular orbital diagram with molecular configuration, bond order, stability, magnetic behavior and polarity.

## Unit-III (Organic Chemistry)

### Learning Objectives:

1. To learn the method of naming aromatic compounds.
2. To understand the concept of aromaticity.
3. To learn the reaction of haloarenes and their mechanism.
4. To know the reaction of phenols.

### 3.1 IUPAC nomenclature of aromatic system and cycloalkanes: Polysubstituted benzene, (3 L)

trisubstituted naphthalenes, disubstituted anthracenes, cycloalkanes and derivatives (up to 6 membered ring)

### 3.2 Aromaticity:

(6L)

- a. Monosubstituted benzene; activation and deactivation of rings, writing resonating structure.
- b. Directive influence at groups in aromatic electrophilic substitutions.
  - i. o/p directing ( activating) e.g. -OH
  - ii. o/p directing ( deactivating) e.g. Halogen
  - iii. m- directing group (deactivating ) e.g. -NO<sub>2</sub> based on electron density distribution and stability of intermediates.

- 3.4 Haloarenes and phenols: (6L)**
- 3.4.1 Haloarenes:** Reactivity of aryl halides towards nucleophilic substitution reactions. Nucleophilic aromatic substitution ( $S_NAr$ ). Addition-elimination mechanism and benzyne mechanism, cine substitution.
- 3.4.2 Phenols:** Preparation methods: from haloarenes, sulphonic acids (phenol, resorcinol, naphthols), acidic characters of phenols; steam volatility of o-nitrophenol.  
**Reaction of phenols:** Nitration, Bromination, O-acylation, Williamson synthesis, Fries rearrangement, Claisen rearrangement

## Semester – III

### Paper – II

Course code: RJSICHE302

Total No. of Lectures (45 L)

#### Unit I (Physical Chemistry)

##### *Learning Objectives:*

1. To learn the types of complex chemical reactions.
2. To understand the concept of activation energy, Arrhenius equation and theories of reaction rates.
3. To learn about ideal & non-ideal solutions and partially miscible liquids.
4. To learn the concepts of distillation, Nernst distribution law and solvent extraction.

#### **1.1 Chemical kinetics-II (7L)**

- 1.1.1 Types of complex chemical reactions: Reversible or opposing, Consecutive and parallel reactions (No derivations, only example expected).  
 Thermal chain reactions:  $H_2$  &  $Br_2$  Reaction (only steps involved, no kinetic expression expected).
- 1.1.2 Effect of temperature on the rate of reaction. Arrhenius equation, concept of energy of activation ( $E_a$ ). (Numericals expected).
- 1.1.3 Theories of Reaction Rates: Collision theory and activated complex theory of bimolecular reactions. Comparison between the two theories (Qualitative treatment only).

#### **2.1 Solutions (8L)**

- 2.1.1 Liquid-liquid Mixtures (Binary mixtures)
- 2.1.2 Completely Miscible Liquids: Raoult's Law and Ideal and Non-ideal Solutions (Positive and Negative Deviations).
- 2.1.3 Partially Miscible Liquids: Partially Miscible Liquids with Upper Critical Solution Temperature (Example: Phenol-Water System), Partially Miscible Liquids with Lower Critical Solution Temperature (Example: Triethylamine-Water System), Partially Miscible Liquids with Upper and Lower Critical Solution Temperature (Example: Nicotine-Water System)
- 2.1.4 Distillation technique- Fractional distillation, Lever rule, Azeotropes, Steam distillation.
- 2.1.5 Nernst distribution law and its application in solvent extraction.

## Unit II (Inorganic Chemistry)

### Learning Objectives:

1. To study the preparation, structure and bonding of compounds of boron.
2. To learn the preparation of extra pure silicon and germanium, structure of  $\text{SiO}_2$  and  $\text{SiCl}_4$ .
3. To study the preparation and structure of oxides of nitrogen.

### 2.0 Selected topics on p block elements (15 L) 2.1 Chemistry of Boron compounds (5 L)

- 2.1.1 Introduction to group 13 elements, Periodicity in properties, Electron deficient compounds –  $\text{BH}_3$ ,  $\text{BF}_3$ ,  $\text{BCl}_3$  with respect to Lewis acidity and applications.
- 2.1.2 Preparation of simple boranes like diborane and tetraborane.
- 2.1.3 Structure and bonding in diborane and tetraborane (2e-3c bonds)
- 2.1.4 Synthesis of Borax.

### 2.2 Chemistry of Silicon and Germanium 2.2.1 Silicon compounds: Occurrence, Structure and inertness of $\text{SiO}_2$ (5 L)

- 2.2.2 Preparation and structure of  $\text{SiCl}_4$
- 2.2.3 Occurrence and extraction of Germanium
- 2.2.4 Preparation of extra pure Silicon and Germanium

### 2.3 Chemistry of Nitrogen family (5 L)

- 2.3.1 Trends in chemical reactivity - Formation of hydrides, halides, oxides with special reference to oxides of nitrogen.
- 2.3.2 Oxides of nitrogen with respect to preparation and structure of  $\text{NO}$ ,  $\text{NO}_2$ ,  $\text{N}_2\text{O}$  and  $\text{N}_2\text{O}_4$ .

## Unit III (Organic Chemistry)

### Learning Objectives:

1. To learn absolute configuration of stereoisomers.
2. To know the reasons for reactivity of carbonyl compounds & to study mechanism of some name reactions involving  $>\text{C}=\text{O}$  group.

### 3.1 Stereochemistry –III (5 L)

- 3.1.1 Absolute configuration: E-Z, R-S nomenclature ( molecules having maximum two asymmetric centers)
- 3.1.2 Resolution of racemates; Chemical method with illustrative examples.
- 3.1.3 Conformation of n-butane: syn-anti nomenclature, relative stabilities, energy diagram

### 3.2 Chemistry of carbonyl compounds (10L)

- 3.2.1 Preparation of aliphatic, acyclic and aromatic compounds- oxidation of alcohols, Rosenmund reduction, Gattermann Koch formylation, Friedel Crafts acylation.
- 3.2.2 General mechanism of nucleophilic addition across  $>\text{C}=\text{O}$ . Reactions of  $>\text{C}=\text{O}$  with  $\text{HCN}$ ,  $\text{NaHSO}_3$ , alcohol, amines, hydroxylamine, phenyl hydrazine,  $\text{LiAlH}_4$ , and  $\text{NaBH}_4$ .
- 3.2.3 Keto-enol tautomerism: Mechanism of acid and base catalyzed enolization.
- 3.2.4 Name reactions (Mechanism). Knoevenagel reaction, Benzoic condensation, Cannizzaro reaction.

Semester – III  
Paper – III  
Course code: RJSICHE303  
Total No. of Lectures (45 L)

*Learning Objectives:*

1. Introduce wide range of techniques that are useful in Quantitative analysis
2. Provide background of numerous analytical methods.
3. Teach Laboratory skills and consequently enhance the confidence of students catered from various fields of science, in their ability to obtain high quality analytical data.

**Unit I (Analytical Chemistry)**

**Unit-I Introduction, Classical Methods of Analysis & Statistical Treatment of Analytical Data-I**

<b>1.1</b>	<b>Introduction to Analytical Chemistry</b>	<b>04 L</b>
<b>1.1.1</b>	Analytical Chemistry & chemical analysis, Analysis Based on (i) the nature of information required: (Proximate, Partial, Trace, Complete Analysis) and (ii) the size of the sample used (Macro, semi-micro and micro analysis),	
<b>1.1.2</b>	Classical and Non-Classical methods of analysis with emphasis on the property being measured	
<b>1.2</b>	<b>Classical Methods of Analysis- Titrimetric Methods</b>	<b>02 L</b>
<b>1.2.1</b>	Terms used in titrimetric analysis: titrant, titrand, titration, equivalence point, end point, titration error, indicator,	
<b>1.2.2</b>	Standard solutions: Primary and secondary standards	
<b>1.3</b>	<b>Neutralisation Titrations</b>	<b>03 L</b>
<b>1.3.1</b>	Concept of pH and its importance in neutralisation titrations	
<b>1.3.2</b>	Construction of titration curve (on the basis of change in pH ) and choice of indicators in the following titrations: i. Strong acid v/s strong base ii. Weak acid v/s Strong base	
<b>1.4</b>	<b>Statistical Treatment of Analytical Data-I</b>	<b>06L</b>
<b>1.4.1</b>	Types of errors: Determinate & Indeterminate errors, source wise classification of determinate errors, constant and proportionate errors	
<b>1.4.2</b>	Accuracy & precision, Measures of central tendency :mean,median, mode Measures of dispersion: absolute deviation, relative deviation, range, average deviation, relative average deviation, standard deviation, variance and coefficient of variation. <b>(Numerical problems wherever possible expected )</b>	

**Unit II (Analytical Chemistry)**

## UNIT – II : Instrumental Methods-I

- 2.1 Types of Analytical Instrumental methods based on** **01 L**
- Optical properties (e.g. uv-visible spectrometry, Polarimetry)
  - Electrochemical properties (e.g. Potentiometry, Conductometry,)
  - Thermal effects (e.g. Thermogravimetry)
- 2.2 Spectrometry** **11 L**
- 2.2.1** Interaction of electromagnetic radiation with matter: Absorption and Emission spectroscopy
- 2.2.2** Basic Terms: Radiant Power, Absorbance, Transmittance, Monochromatic light, Polychromatic light, Wavelength of maximum absorbance, Absorptivity and Molar Absorbivity
- 2.2.3** Statement and derivation of Beer's Law and Lambert's Law, Combined Mathematical Expression of Beer –Lambert's Law, Validity of Beer-Lambert's Law, Deviations from Beer-Lambert's Law ((Real deviations, Instrumental deviations and Chemical deviations)(**Numerical problems expected**)
- 2.2.4** Instrumentation for absorption spectroscopy: Block diagrams for Single beam colorimeter and spectrophotometer(principle, construction & working)
- 2.2.5** Applications of UV-Visible Spectrophotometry  
Qualitative analysis, & Quantitative analysis by Calibration curve method
- 2.3 Photometric Titrations** **03 L**
- 2.3.1** Principle and Instrumentation of Photometric titration
- 2.3.2** Types of Photometric titration Curves with examples.

## UNIT III (Industrial & Environmental Chemistry)

### *Learning Objectives:*

- To study non-renewable & renewable sources, their origin and uses.
- To learn characterization of waste & removing contaminants from waste by different methods.

### **3.1 Industrial & Environmental Chemistry - I**

#### **3.1 Sources of Organic Compounds** **(8 L)**

##### **3.1.1 Introduction**

- Non-renewable : Coal ,Petroleum ,Natural gas.
- Renewable : Biomass

**3.1.2 Coal :** Structure & types of coal, destructive distillation of coal, coal tar refining ,coal Liquefaction, Coal gasification.

**3.1.3 Petroleum :** Characteristics , composition & origin of petroleum ,Refining of petroleum:Fractional distillation, chemical methods of refining: Cracking, Reforming.

**3.1.4 Natural gas :** Composition, conversion to methane, higher alkanes, Aromatic compounds.

**3.1.5 Synthetic gas composition:** Production of syn-gas from coal , natural gas, biomass.  
Synthetic uses of syn-gas: production of methanol, hydroformylation of olefins.

**3.1.6 Biomass:** Transforming biomass into chemicals.

**3.1.7 Biofuels :** Methanol, ethanol, biodiesel.

## **3.2 Environmental Studies**

**(7 L)**

3.2.1 Characterization of waste: biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), aerobic and anaerobic processes.

3.2.2 Removing of solid contaminants, physical and chemical principles such as coagulation, flocculation and sedimentation.

3.2.3 Primary, secondary and tertiary treatment of liquid effluents.

## Chemistry Practicals Course code: RJSCHPR3

### *Learning Objectives:*

1. To understand S.O.P of electrical instruments.
2. To develop skills in analysis of water insoluble inorganic mixture following S.M. techniques.
3. To help students in understanding of organic identification.
4. To enable students to learn one step organic derivatization.

### **Inorganic**

#### **1. Qualitative analysis: (at least 6 mixtures to be performed)**

Semi-micro inorganic qualitative analysis of a sample containing two cations and two anions.

Dry test and wet tests to be performed.

Cations (from amongst):

$Ba^{2+}$ ,  $Ca^{2+}$ ,  $Sr^{2+}$ ,  $Cu^{2+}$ ,  $Co^{2+}$ ,  $Fe^{3+}$ ,  $Ni^{2+}$ ,  $Zn^{2+}$ ,  $Mg^{2+}$ ,  $Al^{3+}$ ,  $K^+$ ,  $NH_4^+$

Anions (From amongst):

$CO_3^{2-}$ ,  $SO_3^{2-}$ ,  $NO_2^-$ ,  $NO_3^-$ ,  $Cl^-$ ,  $Br^-$ ,  $SO_4^{2-}$ ,  $PO_4^{3-}$

#### **2. Volumetric Estimation:**

- i) Estimation of iron present in the given ferric alum solution using diphenylamine indicator.
- ii) Estimation of lead by complexometry. (Standardization of EDTA to be done)

### **Organic**

- a) Identification of organic compounds (solid/liquid) containing bifunctional groups with C,H, (O), N, S, halogen (Minimum 6 compounds)
- b) Derivatisation of an organic compound with a given functional group. Preparation of suitable derivative, purification drying and MP determination.
  - i) Iodoform from acetone
  - ii) Cyclohexanone oxime from cyclohexanone.
  - iii) Phthalic anhydride from phthalic acid by sublimation



### Physical

1. To verify Oswald's dilution law for a weak acid conductometrically.
2. To investigate the reaction between  $K_2S_2O_8$  (potassium persulphate) and KI (potassium iodide) with equal in initial concentration.
3. To determine the amount of HCl in the given sample potentiometrically.
4. To determine the critical solution temperature (CST) of Phenol-water system and comment on CST.

### Analytical

- 1 Assay and calculation of % error in the neutralization titration of given commercial sample of aspirin by using I.P.
- 2 Estimation & calculation of % error in the conductometric titration of given acid with strong base
- 3 Calculation of % error in the colorimetric estimation of copper ions in the given solution by using calibration curve method
- 4 Determination of  $\lambda_{max}$  and molar absorptivity ( $\epsilon$ ) of manganese in  $KMnO_4$  by using spectrophotometer .

## Unit I (Physical Chemistry)

### *Learning Objectives:*

1. To learn the basic concepts of photochemistry and photochemical phenomena.
2. To learn the basics of nuclear chemistry and quantum chemistry.

### **1.2 Photochemistry (7L)**

- 1.2.1 Introduction. Difference between Thermal and Photochemical reactions. Laws of Photochemistry. Grotthus-Draper Law, Stark-Einstein law. Einstein of energy. (Numericals expected).
- 1.2.2 Quantum efficiency, determination using actinometer. (Numericals expected).
- 1.2.3 Photochemical reactions and Primary and secondary processes. Reactions with High and Low quantum efficiency (explain with examples). Reasons for high and low quantum efficiency.
- 1.2.4 Photochemical Phenomenon. Fluorescence, Phosphorescence, Chemiluminescence, Ozone formation/ depletion.

### **1.2 Nuclear chemistry-I (4L)**

#### **Nuclear Stability & Radioactivity:**

Factors affecting stability of nucleus: Mass defect of Nucleus, binding energy, binding energy per nucleon, binding energy curve, N/P ratio, Odd-Even number rule, Magic numbers. (problems on mass defect, binding energy, binding energy per nucleon is expected)

### **1.3 Basics of quantum chemistry (4 L)**

Concept of quantization, atomic spectra (no derivation), wave particle duality, uncertainty principle, wave function and its interpretation, well-behaved function.

## Unit II (Inorganic Chemistry)

### *Learning Objectives:*

1. To study the characteristic properties of 3d transition elements and ions.
2. To learn the terminologies of coordination chemistry as well as theories associated with coordination compounds.

### **2.1 Transition elements (7 L)**

- 2.1.1 Position in the periodic table and electronic configuration.
- 2.1.2 Chemistry of 3 d transition elements with reference to oxidation states. Unusual oxidation states and their stabilities in aqueous solutions ( with special reference to vanadium and chromium). Colour, magnetic property, ability to form complexes.
- 2.1.3 Study of oxides and chlorides of Titanium and Vanadium w.r.t. physical and chemical properties.
- 2.1.4 Qualitative tests for transition metal ions: General considerations in devising test (with

reference to Chromium, Manganese, Iron, Cobalt, Nickel and Copper).

## **2.2 Coordination Chemistry: (8 L)**

### **2.2.1 Introduction to chemistry of coordination compounds**

1. Historical perspectives: Early ideas on coordination compounds
2. Basic terms and nomenclature.
3. Types of ligands.
4. Isomerism; General types with special reference to stereoisomerism of coordination compounds (C.N.=6).
5. Evidence for the formation of coordination compounds.
6. Application of coordination compounds.

### **2.2.2 Theories of co-ordination compounds**

1. Werner's theory of co-ordination compounds.
2. Effective atomic number rule.
3. Eighteen electron rule.

### **2.2.3 Nature of the Metal-Ligand Bond.**

1. Valance bond theory: Hybridisation of the central metal orbitals-  $sp^3$ ,  $dsp^2$ ,  $sp^2d$ ,  $sp^3d^1$ ,  $d^2sp^3$  (Inner orbital complexes),  $sp^3d^2$  (outer orbital complexes)  
Discussion should include the ions : Mn(II), Fe(II), Fe(III), Co(II), Co(III), Ni(II), Cu(II), Zn(II) complexes with ligands like aqua, ammonia,  $CN^-$  and Halides.
2. Limitations of V.B.T.

## **Unit III (Organic Chemistry)**

*Learning Objectives:*

1. To study the reactions of aromatic amino compounds.
2. To synthesize the variety of organic compounds from diazonium salt.
3. Introduction of heterocyclic chemistry.

### **3.1 Aromatic amino compounds: (8 L)**

- 3.1.1 Preparation: Reduction of aromatic nitro compounds using catalytic hydrogenation, Fe-HCl and Zn/ HOAc, reduction of nitriles, ammonolysis of halides, Hoffmann bromamide reaction.
- 3.1.2 Effect of substituents on basicity of amines.
- 3.1.3 Reactions: salt formation, N-alkylation, N-acylation, carbylamine reaction, Electrophilic substitution in aromatic amines: bromination, nitration and sulphonation.
- 3.1.4 Diazonium salts: preparation of diazonium salt, mechanism of diazotization, synthetic applications: Sandmeyer, Gattermann and Gomberg reactions, replacement of diazo group by -H, -OH, reduction to aryl hydrazines.

### **3.2 Heterocyclic Chemistry (7L)**

- 3.2.1 **Introduction:** Electronic structure and aromaticity of furan, thiophene, pyrrole and pyridine.
- 3.2.2 **Synthesis:** Synthesis of furan, thiophene, pyrrole by Paal-Knorr synthesis, pyridine by Hantzsch synthesis

- 3.2.3 **Reactivity:** Reactivity towards electrophilic substitution in furan, thiophene, pyrrole on the basis of stability of intermediate, nucleophilic substitution in pyridine on the basis of electron distribution.
- 3.2.4 **Reactions:** the following reactions of furan, thiophene and pyrrole: Nitration, Sulphonation, Halogenation, Friedel-Crafts reactions, Vilsmeier-Haack formylation. Sulphonation of pyridine with and without catalyst, catalytic hydrogenation of pyridine, Chichibabin reaction.

## Paper – II

Course code: RJSCH402  
Total No. of Lectures (45 L)

### Unit I (Physical chemistry)

#### *Learning Objectives:*

1. To understand the characteristics of cubic crystal system and use of XRD in determination of crystal structure.
2. To learn the concepts of homogenous, heterogeneous as well as enzyme catalysis.

#### **1.1 Solid State (7L)**

- 1.1.1 Recapitulation of laws of crystallography and types of crystals.
- 1.1.2 Characteristics of simple cubic, Face centred cubic and body centred cubic systems, interplanar distance in simple cubic lattice & expression for ratio for all three types.
- 1.1.3 Use of X-rays in the study of crystal structure, Bragg's equation (Derivation expected), X-rays diffraction method of studying crystal lattice structure, structure of NaCl and KCl. Determination of Avogadro's number (Numericals expected).

#### **1.2 Catalysis (8L)**

- 1.2.1 Types of catalysis, Catalytic activity, Specificity and selectivity, Inhibitors, Catalyst poisoning and Deactivation.
- 1.2.2 Mechanism and kinetics of acid-base catalyzed reactions, effect of pH.
- 1.2.3 Mechanism and kinetics of enzyme catalyzed reactions (Michaelis-Menten equation).
- 1.2.4 Effect of particle size and efficiency of nano particles as catalyst.

### Unit II (Inorganic Chemistry)

#### *Learning Objectives:*

1. To understand the acidity of cations and basicity of anions in aqueous medium.
2. To learn the properties and applications of oxoacids of N, P & S.

#### **2. Ions in aqueous medium**

##### **2.1 Acidity of Cations and Basicity of Anions (10 L)**

- i. Hydration of Cations: Hydrolysis of Cations predicting degree of hydrolysis of Cations- effect of Charge and Radius.

- ii. Latimer Equation, Relationship between  $pK_a$ , acidity and  $z^2/r$  ratios of metal ions graphical presentation.
- iii. Classification of cations on the basis of acidity category-Non-acidic, moderately acidic, strongly acidic, very strongly acidic with  $pK_a$  values range and examples.
- iv. Hydration of anions: effect of charge and radius, hydration of anions and classification on the basis of basicity.

**2.2 Chemistry of Volatile Oxides and Oxo-acids. (5L)**

- i. Physical properties of concentrated oxo-acids like Sulphuric, Nitric and Phosphoric acid.
- ii. Application of these acids.

**Unit III (Organic Chemistry)**

*Learning Objectives:*

- 1. To compare reactivities of aromatic carboxylic acids & sulphonic acids.
- 2. To learn reactions of aromatic acids.

**3.1 Aromatic carboxylic acids & its derivatives: (10 L)**

- 3.1.1 Preparation of carboxylic acids (with reference to benzoic acid, salicylic acid & phthalic acid) oxidation of alcohols & alkyl benzene, carbonation of Grignard reagent and hydrolysis of Nitriles. Kolbe-Schmidt synthesis (mechanism).
- 3.1.2 Effects of substitution on strength of aromatic carboxylic acids.
- 3.1.3 Reactions: salt formation, decarboxylation reduction with  $LiAlH_4$ , Hell-Volard-Zelinsky reaction, conversion of acid to acid chloride, amide, anhydride & ester (mechanism of esterification).
- 3.1.3 Name Reaction (Mechanism): Claisen condensation and Dieckmann condensation.

**3.2 Aromatic sulfonic acids: (5 L)**

- 3.2.1 Preparation of aromatic sulfonic acids: Commonly used sulfonating agents. Sulfonation of benzene (with mechanism), mono-substituted benzenes and naphthalene.
- 3.2.2 Comparative study of acidity of  $Ar-COOH$  and  $Ar-SO_3H$ .
- 3.2.3 Reaction: salt formation, reaction with alcohol,  $PCl_5$ , IPSO, substitution, Desulphonation.

**Paper – III**

**Course code: RJSCH403**

**Total No. of Lectures (45 L)**

*Learning Objectives:*

- 1. Introduce wide range of techniques that are useful in Quantitative analysis
- 2. Provide background of numerous analytical methods.
- 3. Teach Laboratory skills and consequently enhance the confidence of students catered from various fields of science, in their ability to obtain high quality analytical data.

## Unit I (Analytical Chemistry)

### Unit-I: Statistical Treatment of Analytical Data-II

&

#### Separation Technique-Chromatography

#### 1.1 Statistical Treatment of Analytical Data-II 10 L

- 1.1.1 Gaussian distribution curve, Equation and salient features of Gaussian distribution curve
- 1.1.2 Concept of confidence limits and confidence interval and its computation using (i) Population standard deviation (ii) Student's *t* test (iii) Range
- 1.1.3 Criteria for rejection of doubtful result (i) 2.5 d rule (ii) 4.0 d rule (iii) Q test
- 1.1.4 Test of Significance (i) Null hypothesis (ii) F-test (variance ratio test)
- 1.1.5 Graphical representation of data and obtaining best fitting straight line by using method of averages (i) For line passing through origin (ii) For line not passing through origin.

*(Numerical problems wherever possible expected)*

#### 1.2 Separation Technique-Chromatography 05 L

- 1.2.1 Introduction to Chromatography
- 1.2.2 Classification of chromatographic methods based on stationary and mobile phase
- 1.2.3 Paper Chromatography: Principle, Techniques and Applications.
- 1.2.4 Thin layer Chromatography: Principle, Technique and Applications.

## Unit II (Analytical Chemistry)

### UNIT - II : Instrumental Methods-II

&

#### Separation techniques-Solvent Extraction

#### 2.1 Instruments based on electrochemical properties of analyte

#### 2.1.1 Potentiometry 04 L

Principle, role of reference and indicator electrodes, applications in neutralisation reactions with reference to the titration of a strong acid against a strong base using quinhydrone electrode, Graphical methods for detection of end points, Advantages & limitations of potentiometric titrations

#### 2.1.2 Conductometry 05 L

Basic principle, conductivity cell: construction & care, Applications in neutralization titration w.r.t.

- i. Strong acid v/s strong base
- ii. Weak acid v/s Strong base
- iii. Weak base v/s strong acid

- iv. Weak acid v/s weak base
- Advantages & limitations of conductometric titrations
- 2.2 Separation techniques-Solvent Extraction** **06 L**
- 2.2.1** Introduction, Nernst distribution Law, Partition Coefficient, Distribution Ratio.
- 2.2.2** Conditions of extraction: Equilibration time, Solvent volumes, temperature, pH.
- 2.2.3** Single step and multistep extractions (derivation expected), Percentage extraction for single step and multistep extractions (derivation expected) , Separation factor
- 2.2.4** Batch and continuous extractions.

### **Unit III (Industrial & Environmental Chemistry)**

#### *Learning Objectives:*

1. To study basic information about oils, fats, soaps & detergents.
2. To understand various aspects of chemical industry & effect of industrial effluents on environment.

### **3.1 Industrial & Environmental Chemistry - II:** **(8 L)**

#### **3.1.1 General principles of metallurgy**

#### **3.1.2** Extraction and purification of:

- i) Copper ( from pyrites) by pyrometallurgy and electrolysis
- ii) Silver by hydrometallurgy
- iii) Aluminium by electrometallurgy.

#### **3.2.1 Environmental Aspects of Chemical Industry** **(7 L)**

- i. Volatile organic compounds (VOC)
- ii. Hydrocarbons as air pollutants
- iii. Carbon emission-carbon credit, carbon neutrality, carbon offsetting.
- iv. Material Safety Data Sheet (MSDS)

#### **3.2.2 Toxicology**

- i. Concept and important terms
- ii. Common environmental toxicants.
- iii. Organic toxicants: Chlorinated hydrocarbon, Polyaromic hydrocarbon (PAH) & their toxic effects.
- iv. Toxic effects of pesticides.
- v. Case study: Bhopal gas tragedy.

## Chemistry Practicals

Course code: RJSCHPR4

#### *Learning Objectives:*

1. To understand chromatographic techniques of separations of metals.
2. To prepare students to estimate different inorganic compounds using volumetric technique.
3. Understanding organic synthesis with respect to calculation of yield.

## Inorganic

### a) Volumetric Estimation:

1. Estimation of  $\text{Na}_2\text{CO}_3$  &  $\text{NaHCO}_3$  using double indicator.
2. Estimation of boric acid for its percentage purity.
3. Estimation of  $\text{KIO}_3$  for its percentage purity.
4. Commercial analysis of organic acid (Vinegar).
5. Estimation of total hardness of water.

### b) Inorganic Preparation:

1. Copper acetylacetonate.
2. Hexamine Nickel (II) chloride
3.  $\text{CuCl}_2 \cdot 2\text{DMSO}$

## Organic

### a) Organic Estimation:

- i) Determination of equivalent weight of organic acid by alkalimetry.
- ii) Estimation of amide by hydrolysis.
- iii) Estimation of aniline by bromination.

### b) Organic preparation:

- i) Acetanilide from aniline.
- ii) m-dinitrobenzene from Nitrobenzene.
- iii) p-bromoacetanilide from acetanilide.
- iv) Tribromoaniline from aniline.

## Physical

1. To determine standard E.M.F. of Daniel cell and the standard Gibbs free energy change for the cell reaction potentiometrically.
2. To compare the strengths of  $\text{HCl}$  and  $\text{H}_2\text{SO}_4$  by studying kinetics of acid hydrolysis of methyl acetate.
3. To prepare acidic buffer and basic buffer and determine their buffer capacity.
4. To verify Henderson's equation.

## Analytical

- 1 Paper chromatography: Separation of cations like  $\text{Fe(III)}$ ,  $\text{Ni(II)}$  and  $\text{Cu(II)}$  in a sample.
- 2 To investigate the partition of Ferric ions between organic (Ethyl acetate) and aqueous phase and thereby to determine the (i) partition Coefficient of  $\text{Fe(III)}$  between ethyl acetate and water (ii) extraction efficiency of ethyl acetate as the solvent of extraction.
- 3 pH metry : Estimation of vitamin C content in a given sample by titration with  $\text{NaOH}$  pH metrically and calculation of % error .



- 4 Potentiometry : Estimation of Fe(II) in the given solution by titrating against  $K_2Cr_2O_7$  potentiometrically and calculation of % error.

## REFERENCES

### Physical Chemistry

1. B.R.Puri,L.R.Sharma, M.J. Pathania, Principles of physical chemistry VISHAL PUBLISHING company, 2018.
2. Negi & Anand- Physical chemistry- Eastern Wiley pvt. Ltd
3. K.L. Kapoor- Physical Chemistry-Macmillan- 4 volumes.
4. S. Glasstone- Text book of physical chemistry-Macmillan (India) Ltd.
5. Arun Bahl, B.S.Bahl.G.D.Tuli- Essentials of physical chemistry, S.Chand & Company 2010.
6. Chatwal and Anand, Instrumental methods of chemical analysis, 5<sup>th</sup> Edition Himalaya publishing.
7. R.K.Prasad, Quantum Chemistry,Wiley Eastern, New Delhi, 1992.
8. A.K.Chandra, Introductory Quantum chemistry, Tata McGraw Hill

### Inorganic Chemistry

1. Principles of inorganic chemistry Puri, Sharma & Kalia.
2. Inorganic chemistry, 3<sup>rd</sup> Edition, Alansharpe, 2002, Replika press pvt. Ltd.
3. Inorganic chemistry, R.L.Madan, G.D.Tuli, 1999, S.Chand & Company Ltd.
4. Chemistry of the elements, N.N.Greenwood, A.Earnshaw, 2005, Elsevier publication.
5. Inorganic chemistry, Weller, Overton, 2016, Oxford Science Publication.
6. D.F.Shriver and P.W. Atkins, Inorganic Chemistry, 3<sup>rd</sup> Edition Oxford University Press, (1999).
7. D. Banerjea, Coordination chemistry, Tata McGraw Hill, New Delhi, (1993).
8. J. Barrett, 'Inorganic Chemistry in Aqueous Solutions', The Royal society of Chemistry (2003).
9. T. Moeller and R.O'Connor, 'Ions in Aqueous Systems'; McGraw-Hill Book Company, (1972).
10. Environmental Chemistry – A.K. Bhagt and C.R. Chatwal, Himalaya Publishing house.

### Organic Chemistry

1. Morrison R.T. and Boyd, R.N. Organic chemistry, Dorling Kindersley (India)pvt. Ltd. (Pearson Education), 2012.
2. Eliel E.L. and Wilers, S.H. Stereochemistry of organic compounds,Jhon Wiley & sons.
3. Kalsi ,P.S. Stereochemistry Conformation and Mecahnism,New Age International, 2005.
4. Mc Murry, J.E.Fundamentals of Organic Chemistry, 7<sup>th</sup> Ed. Cengage Learning India Edition, 2013.
5. IUPAC nomenclature by S.C.Pal
6. T.W. Gratan Solomons, organic chemistry,6<sup>th</sup> edition, John Willy & sons.

7. B.Y.Paula organic chemistry 3<sup>rd</sup> edition pearson education.
8. S.H.Pine organic chemistry 5<sup>th</sup> edition Mcgraw Hill international edition.
9. Francis A. Carey organic chemistry 3<sup>rd</sup> edition Tata-Mcgraw Hill publication.
10. Hetrocyclic chemistry by Raj K. Bansal, New age international publishers.
11. Hetrocyclic chemistry 3<sup>rd</sup> edition Thomas L. Gilchrist Pearson.

### **Analytical Chemistry**

1. Instrumental Analysis by Douglas A. Skoog, F. James Holler, Stanley R. Crouch
2. Instrumental methods of analysis by Willard, H.H.; Merritt, L.L. Jr.; Dean, J.A.; Settle, 7<sup>th</sup> Edition
3. Fundamental of Analytical Chemistry by Douglas A. Skoog, West, F. James Holler, S. R. Crouch
4. Modern Analytical Chemistry by David Harvey, McGraw-Hill Higher Education
5. Skoog et al. "Fundamentals of Analytical chemistry" Cengage Learning, Eight Edition, chapter 13, 14 and 15
6. Day and Underwood, "Quantitative analysis" prentice hall 1991, chapter3
7. Modern Analytical Chemistry , David Harvey ( page numbers 232 -265)
8. D.A. Skoog, D.M. West, F.J. Holler and CX.R. Crouch – Fundamentals of Analytical chemistry, 8<sup>th</sup> edition
9. G.H. Morrison and H. Freiser , Solvent extraction in analytical chemistry
10. P. G. Swell and B. Clarke, Chromatographic separations , Analytical chemistry by open Learning , John Wiley and sons, 1987
11. Modern Analytical Chemistry , David Harvey ( page numbers 596 -606)
12. Modern Analytical Chemistry , David Harvey ( page numbers 215 -217)

### **Industrial & Environmental Chemistry**

1. Environmental chemistry by V.K.Ahluwalia
2. Unit operations and processes – P.H.Groggins.
3. Coal and combustion: Dr. Kale
4. Industrial Chemistry-B.K.Sharma, Goyal publishing house.
5. Renewable sources of energy and environment: E. Hinnawi and A.K.Biswas
6. Industrial Chemistry –E Stoch, Vol-I, Ellis Horwood Ltd. UK.
7. An Introduction to Industrial Organic Chemistry –Wiseman and Peter