

**DOMBIVLI SHIKSHAN PRASARAK MANDAL'S,  
K.V. PENDHARKAR COLLEGE OF ARTS, SCIENCE AND  
COMMERCE, AUTONOMOUS.  
DOMBIVLI (EAST), MAHARASHTRA, 421 203, INDIA**

**Faculty of Sciences  
DEPARTMENT OF CHEMISTRY  
Programme: Bachelor of Science (B.Sc.)**

**SYLLABUS FOR:  
F. Y. B.Sc. – Chemistry Paper I &II  
Choice Based Credit System (CBCS) with effect from the Academic Year  
2021-22**

## **Semester-I**

### **Paper-I (Physical and Inorganic Chemistry)**

**Course Code: PUSCHI21-121**

#### **Learning objectives:**

The learner to be imparted with:

1. Knowledge of Thermodynamics, the terms involved, First Law of Thermodynamics.
2. Understanding chemical calculations.
3. Fundamentals of Chemical Kinetics.
4. Various features of Liquid state of matter.
5. Detailed study of Atomic Structure and periodicity of elements

#### **Learning Outcomes:**

On successful completion of this course students will be able to:

1. Explain the concept of Thermodynamics, explain First Law of Thermodynamics.
2. Distinguish between various types of systems, surroundings etc.
3. Understand the concept of Mole concept and Carry out all related calculations.
4. Understand Chemical Kinetics, rate of reactions, order of reactions and solve numerical problems.
5. Explain the nuance of Surface tension, Viscosity, Refractive index, Liquid crystals.
6. Understand Atomic Structure and correlate the changes in periodic properties of elements.

| Unit      | Topics   | Lectures    |
|-----------|--|-------------|
| <b>I</b>  | <b>1.1 Chemical thermodynamics</b><br><br><b>Thermodynamic terms:</b> Systems, surrounding, boundaries, open, closed and isolated system, intensive and extensive properties, state function and path functions, zeroth law of thermodynamics<br><br><b>First law of thermodynamics:</b> concept of heat (q), work (w), internal energy (U), statement of first law, enthalpy, relation between heat capacity, sign convention, calculation of heat (q), work (w), internal energy (U) and enthalpy (H) ( <b>Numericals expected</b> )<br><br><b>Thermodynamics:</b> Heat of reaction, standard state, enthalpy of formation of molecules, enthalpy of combustion and its applications, calculation of bond energy, bond dissociation energy and resonance energy from thermodynamic data, Kirchhoff's equation ( <b>Numericals expected</b> ) | <b>[10]</b> |
|           | <b>1.2 Chemical Calculations</b><br><br>Expressing concentration of solution: Normality, Molality, Molarity, Formality, Mole fractions, weight ratio, volume ratio, weight to volume ratio, ppm, ppb, millimoles, milliequivalents ( <b>Numericals expected</b> )  | <b>[5]</b>  |
| <b>II</b> | <b>2.1 Chemical kinetics</b><br><br>Rate of reaction, rate constant, measurement of reaction rate, order and molecularity of reaction, integrated rate equation of first and second order reaction (with equal initial concentration of reactants) ( <b>Numericals expected</b> )<br><br>Determination of order of reaction by (a) Integration Method, (b) Graphical Method, (c) Ostwald's Isolation Method, (d) Half Time Method ( <b>Numericals expected</b> )   | <b>[8]</b>  |
|           | <b>2.2 Liquid State</b><br><br>Surface tension: Introduction, method of determination of surface tension by drop number method ( <b>Numericals expected</b> )<br><br>Viscosity: Introduction, coefficient of viscosity, relative viscosity, specific viscosity, reduced viscosity, determination of viscosity by Ostwald viscometer ( <b>Numericals expected</b> )<br><br>Refractive index: Introduction, molar refraction and polarizability, determination of refractive index by Abbe's refractometer ( <b>Numericals expected</b> )  | <b>[7]</b>  |

|            |   |                                      |
|------------|---|--------------------------------------|
|            | Liquid crystals: Introduction, classification and structure of thermotropic phases (Nematic, smectic and cholesteric phases), applications of liquid crystals   |                                      |
| <b>III</b> | <p><b>3.1 Atomic structure:</b><br/>(Qualitative treatment only; it is expected that the learner knows the mathematical statements and understands their physical significance after completing this topic. No derivations of the mathematical equations required)</p> <p>a) Historical perspectives of the atomic structure; Rutherford's Atomic Model, Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Structure of hydrogen atom.</p> <p>b) Hydrogenic atoms:</p> <ol style="list-style-type: none"> <li>1. Simple principles of quantum mechanics;</li> <li>2. Atomic orbitals <ol style="list-style-type: none"> <li>i) Hydrogenic energy levels</li> <li>ii) Shells, subshells and orbitals</li> <li>iii) Electron spin</li> <li>iv) Radial shapes of orbitals</li> <li>v) Radial distribution function</li> <li>vi) Angular shapes of orbitals</li> </ol> </li> <li>3. Many Electron Atoms <ol style="list-style-type: none"> <li>i) Penetration and shielding</li> <li>ii) Effective nuclear charge</li> </ol> </li> <li>4. Aufbau principle</li> </ol> <p><b>3.2: Periodic Table and periodicity:</b> Long form of Periodic Table; Classification for elements as main group, transition and inner transition elements; Periodicity in the following properties: Atomic and ionic size; electron gain enthalpy; ionization enthalpy, effective nuclear charge (Slater's rule); electronegativity; Pauling, Mulliken and Alfred Rochow electronegativities (Numerical problems expected, wherever applicable.)</p> | <p><b>[10]</b></p> <p><b>[5]</b></p> |

#### Learners Space:

1. Thermodynamic processes.
2. Rate of reaction of various types of reactions.
3. Solving interrelated Chemical calculations.
4. Applications of Surface Tension, Viscosity, refractive index.
5. Derivations of the mathematical equations for various models of Atomic Structures.

#### References:

##### Units I & II

1. Atkins P.W. and Paula J.de, Atkin's Physical Chemistry, 10th Ed., Oxford University 12 Press (2014).
2. Ball D.W., Physical Chemistry, Thomson Press, India (2007).

3. Castellan G.W., Physical Chemistry, 4th Ed., Narosa (2004).
4. Mortimer R.G., Physical Chemistry, 3rd Ed., Elsevier: NOIDA, UP (2009).
5. Engel T. and Reid P., Physical Chemistry, 3rd Ed., Pearson (2013).
6. Peter A. and Paula J. de., Physical Chemistry, 10th Ed., Oxford University Press (2014).
7. McQuarrie D.A. and Simon J.D., Molecular Thermodynamics, Viva Books Pvt. Ltd., New Delhi (2004).
8. Levine I.N., Physical Chemistry, 6th Ed., Tata Mc Graw Hill (2010).
9. Metz C.R., 2000 Solved Problems in Chemistry, Schaum Series (2006).
10. Mortimer R.G., Physical Chemistry, 3rd Ed., Elsevier: NOIDA, UP (2009).
11. Banwell C.N., Fundamentals of Molecular Spectroscopy, 4th Ed., Tata McGraw Hill (1994).
12. K.L. Kapoor, A Textbook of Physical Chemistry, Macmillan (2000).
13. Chemical Kinetics and Reaction Dynamics, Santosh K. Upadhyay
14. S. Glastone, Physical Chemistry.

### **Unit III**

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry, Oxford, 1970.
3. Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.
4. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
5. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.

## **Paper-II (Organic and Inorganic Chemistry)**

**Course Code: PUSCHI21-122**

### **Learning Objectives:**

The learner to be imparted with:

1. Classification and Nomenclature of organic compounds.
2. Fundamentals of organic reaction mechanism.
3. Knowledge of Stereo-isomers of organic molecules.
4. Comparative study of group I and II elements and some important inorganic compounds.

### **Learning Outcomes:**

On successful completion of this course students will be able to:

1. Explain the IUPAC rules and write the names of organic molecules.
2. Understand various intricacies of organic reaction mechanism.
3. Identify stereo-isomers of various organic molecules.
4. Differentiate the elements on the basis of their properties. Visualize the use different compounds.

| Unit | Topics  | Lectures              |
|------|---|-----------------------|
| I    | <p><b>Basics of Organic Chemistry</b><br/> <b>1.1 Classification and Nomenclature of Organic Compounds</b></p> <p>Review of basic rules of IUPAC nomenclature. Nomenclature of mono and bi-functional aliphatic compounds on the basis of priority order of the following classes of compounds: alkanes, alkenes, alkynes, haloalkanes, alcohols, ethers, aldehydes, ketones, carboxylic acids, carboxylic acid derivatives (acid halides, esters, anhydrides, amides), nitro compounds, nitriles and amines; including their cyclic analogues.</p> <p><b>1.2 Fundamentals of organic reaction mechanism:</b><br/> <b>Electronic Effects:</b> Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strengths.</p> <p><b>Bond fission:</b> Homolytic and Heterolytic fission with suitable examples. Electrophiles and Nucleophiles; Nucleophilicity and basicity;</p> <p><b>Types (primary, secondary, tertiary, allyl, benzyl), shape and their relative stability of reactive intermediates:</b> Carbocations, Carbanions and Free radicals.</p> <p><b>Introduction to types of organic reactions:</b> Addition, Elimination and Substitution reaction. (With one example of each)</p> | <p>[7]</p> <p>[8]</p> |
| II   | <p><b>2. Stereochemistry I</b></p> <p>Fischer Projection, Newman and Sawhorse Projection formulae (of erythro, threo isomers of tartaric acid and 2,3-dichlorobutane) and their interconversions;</p> <p><b>Geometrical isomerism in alkene and cycloalkanes:</b> cis-trans and syn-anti isomerism E/Z notations with C.I.P rules.</p> <p><b>Optical Isomerism:</b> Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two similar and dissimilar chiral-centres, Distereoisomers, meso structures, racemic mixture and resolution (methods of resolution not expected).</p> <p><b>Relative and absolute configuration:</b> D/L and R/S designations.</p> <p><b>Conformation analysis of alkanes (ethane, propane and n-butane):</b> Relative stability with energy diagrams.</p>  | [15]                  |

|     |   |      |
|-----|---|------|
| III | <b>3.0 Comparative chemistry of Main Group Elements:</b><br><br>Metallic and non-metallic nature, oxidation states, electronegativity, anomalous behavior of second period elements, allotropy, catenation, diagonal relationship. Comparative chemistry of carbides, nitrides, oxides and hydroxides of group I and group II elements. Some important compounds- $\text{NaHCO}_3$ , $\text{Na}_2\text{CO}_3$ , $\text{NaCl}$ , $\text{NaOH}$ , $\text{CaO}$ , $\text{CaCO}_3$ ; oxides of carbon, oxides and oxyacids of sulphur and nitrogen with respect to environmental aspects. | [15] |
|-----|---|------|

#### Learners Space:

1. Understand IUPAC rules for naming organic molecules containing 3-4 functional groups.
2. Study various reaction mechanisms.
3. Various intricacies of isomerism and reactions.
4. Industrial preparation of the compounds studied.

#### References:

##### Unit I & II

1. Morrison, R. T. and Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt Ltd. (Pearson Education).2012
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt Ltd. (Pearson Education).
4. Eliel, E. L. and Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
5. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005. 6. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

##### Unit III

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry, Oxford, 1970.
3. Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.
4. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
5. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.

## **Laboratory Work (Practical) (Sem-I)**

### **Course Code: PUSCHI21-P111**

#### **Learning Objectives:**

The learner will be imparted with

1. Ability to perform time oriented experiments like Kinetics.
2. Knowledge of *Lab to Industry* experimentations, commercial analysis.
3. Knowhow to analyze organic compounds in wet Labs with emphasis on microscale technique from an early age.
4. Basics of quantitative experimentations – Volumetric and Gravimetric experiments.

#### **Learning outcomes:**

On completion of these experimentations, the learner will be able to

1. Perform time oriented experiments.
2. Understand *Lab to Industry* journey in experimentations.
3. Use microscale techniques.
4. Understand the nuance of quantitative experiments.

### **PAPER-I**

#### **1. CHEMICAL KINETICS**

- (1) To prepare 0.1 N succinic acid and standardize NaOH solution of two different concentrations.
- (2) To determine the rate constant for the hydrolysis of ester using HCl as a catalyst.
- (3) To determine enthalpy of dissolution of salt (like KNO<sub>3</sub>).

#### **2. Commercial Analysis**

Commercial Analysis of (any two):

- a) To determine the strength of commercial sample of hydrochloric acid.
- b) To determine the strength of acetic acid – an organic acid by titrimetric method.
- c) To determine the strength of salt of weak acid and strong base.

#### **3. Titrimetric/volumetric analysis:**

To analyze the solution of Na<sub>2</sub>CO<sub>3</sub> and NaHCO<sub>3</sub> using double indicator.

### **PAPER-II**

#### **1. Characterization of organic compounds:**

Characterization of organic compound containing C, H, (O), N, S, X elements.  
(Minimum of six compounds having not more than one functional to be analyzed using microscale technique.)

#### **2. Gravimetric analysis:**



- (1) To determine the percentage purity of sample of  $\text{BaSO}_4$  containing  $\text{NH}_4\text{Cl}$ .
- (2) To determine the percentage purity of sample of  $\text{ZnO}$  containing  $\text{ZnCO}_3$ .

**Reference Books for Practicals:**

1. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
2. Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8th Ed., McGraw-Hill, New York (2003).
3. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001).
4. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
5. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
6. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
7. 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.

**F.Y.BSc. (Sem-II)****Paper-I (Physical and Inorganic Chemistry)****Course Code: PUSCHII21-221****Learning Objectives:**

The learner will be imparted with

1. Different Gas Laws, derivation of such Laws and solving numerical problems.
2. Understanding of Chemical equilibria and second law of thermodynamics.
3. Knowledge of Ionic equilibria and concept of Buffer.
4. Understanding of Molecular Spectroscopy on the basis of Electromagnetic radiation.
5. Solid State Chemistry, Crystal lattice, laws of crystallography.
6. Detailed study of Concept of Qualitative Analysis, common ion effect and acid-base theories.

**Learning outcomes:**

On successful completion of this course students will be able to

1. Explain different Gas Laws, derive relations between them and solve numerical problems.
2. Explain Chemical equilibria, equilibrium constants and understand second law of thermodynamics.
3. Explain ionic equilibria, ionization constants, pH, buffer – its use.
4. Understand fundamentals of molecular spectroscopy, electromagnetic radiation.
5. Understand lattice structure, laws of crystallography.
6. Apply common ion effect, explain precipitation, acid-base theories, distinguish between hard and soft acids and use these for understanding reactions.

| Unit       | Topics  | Lectures   |
|------------|---|------------|
| <b>I</b>   | <b>1.1 Gaseous State</b><br>Ideal gas laws, kinetic theory of gases, Maxwell-Boltzmann's distribution of velocities (qualitative discussion), ideal gases, real gases, compressibility factor, Boyle's temperature ( <b>Numericals expected</b> )   | <b>[8]</b> |
|            | Deviation from ideal gas laws, reasons for deviation from ideal gas laws, Van der Waals equation of state, Joule-Thomson effect: qualitative discussion and experimentation, inversion temperature. ( <b>Numericals expected</b> )<br><br><b>1.2 Chemical Equilibria and Thermodynamic Parameters:</b><br>Reversible and irreversible reactions, law of mass action, dynamic equilibria, equilibrium constant, ( $K_c$ and $K_p$ ), relationship between $K_c$ and $K_p$ , Le Chatelier's principle, factors affecting chemical equilibrium ( <b>Numericals expected</b> )<br><br>Statement of second law of thermodynamics, concepts of entropy and free energy, spontaneity and physical significance of free energy, thermodynamic derivation of equilibrium constant ( <b>Numericals expected</b> ) | <b>[7]</b> |
| <b>II</b>  | <b>2.1 Ionic Equilibria:</b><br>Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water, ionization of weak acids and bases, pH scale, common ion effect, dissociation constants of mono-, di- and triprotic acid (exact treatment for monoprotic acid)<br><br>Buffers: Introduction, types of buffers, derivation of Henderson equation for acidic and basic buffers, buffer action, buffer capacity ( <b>Numericals expected</b> )   | <b>[7]</b> |
|            | <b>2.2 Molecular Spectroscopy:</b><br>Electromagnetic radiation, electromagnetic spectrum, Planck's equation, interaction of electromagnetic radiation with matter: Absorption, emission, scattering, fluorescence, electronic, vibrational and rotational transitions, Beer-Lambert's law ( <b>Numericals expected</b> )   | <b>[4]</b> |
|            | <b>2.3 Solid State Chemistry:</b><br>Types of solids, crystal lattice, lattice points, unit cell, space lattice and lattice plane, laws of crystallography: Law of constancy of interfacial angle, law of symmetry and law of rational indices ( <b>Numericals expected</b> )   | <b>[4]</b> |
| <b>III</b> | <b>3.1 Concept of Qualitative Analysis:</b><br>a) Testing of Gaseous Evolutes, Role of Papers impregnated with Reagents in qualitative analysis (with reference to papers   | <b>[7]</b> |

|  |   |            |
|--|---|------------|
|  | <p>impregnated with starch iodide, potassium dichromate, lead acetate, dimethylglyoxime and oxine reagents).</p> <p>b) Precipitation equilibria, effect of common ions, uncommon ions, oxidation states, buffer action, complexing agents on precipitation of ionic compounds. (Balanced chemical equations and numerical problems expected).</p> <p><b>3.2 Acid Base Theories:</b><br/>Arrhenius, Lowry- Bronsted, Lewis, Solvent – Solute concept of acids and bases, Hard and Soft acids and bases. Applications of HSAB<br/>Applications of acid base chemistry in:<br/>i) Understanding organic reactions like Friedel Craft's (acylation/alkylation) reaction<br/>ii) Volumetric analysis with special reference to calculation of titration curve involving strong acid and strong base.</p> | <b>[8]</b> |
|--|---|------------|

#### Learners Space:

1. Ideal gases, Real Gases. Deviation in behavior.
2. Chemical equilibria in multistep reactions.
3. Various use of Ionic equilibria, common ion effect, precipitation techniques used in Industry.
4. Use of different types of Molecular spectroscopy.
5. Various reagents in qualitative analysis.

#### References:

##### Units I & II

1. Atkins P.W. and Paula J.de, Atkin's Physical Chemistry, 10th Ed., Oxford University 12 Press (2014).
2. Ball D.W., Physical Chemistry, Thomson Press, India (2007).
3. Castellan G.W., Physical Chemistry, 4th Ed., Narosa (2004).
4. Mortimer R.G., Physical Chemistry, 3rd Ed., Elsevier: NOIDA, UP (2009).
5. Engel T. and Reid P., Physical Chemistry, 3rd Ed., Pearson (2013).
6. Peter A. and Paula J. de., Physical Chemistry, 10th Ed., Oxford University Press (2014).
7. McQuarrie D.A. and Simon J.D., Molecular Thermodynamics, Viva Books Pvt. Ltd., New Delhi (2004).
8. Levine I.N., Physical Chemistry, 6th Ed., Tata Mc Graw Hill (2010).
9. Metz C.R., 2000 Solved Problems in Chemistry, Schaum Series (2006).
10. Mortimer R.G., Physical Chemistry, 3rd Ed., Elsevier: NOIDA, UP (2009).
11. Banwell C.N., Fundamentals of Molecular Spectroscopy, 4th Ed., Tata McGraw Hill (1994).
12. K.L. Kapoor, A Textbook of Physical Chemistry, Macmillan (2000).

##### Unit III

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry, Oxford, 1970.

- Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.
- Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
- Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.

## Paper-II (Organic and Inorganic Chemistry)

Course Code: PUSCHII21-222

### Learning Objectives:

The learner will be imparted with

- Various properties and reactions of alkanes, alkenes and alkynes.
- Cycloalkanes, their relative stability and conformational analysis.
- Aromaticity, Huckel's rule, different reactions of aromatic compounds.
- Different types of chemical bond, theories and their limitations.
- Various aspects of Redox reactions.

### Learning outcomes:

On successful completion of this course students will be able to

- Distinguish between carbon-carbon single bond, double bond and triple bond compounds.
- Explain identify reactions of alkanes, alkenes and alkynes.
- Understand the reasons behind the stability of cycloalkanes and explain their conformations.
- Understand aromaticity and write and explain reactions of aromatic compounds.
- Distinguish between different types of bond, theories behind their formation and drawbacks.
- Write and balance redox reactions. Explain single electron and multi electron systems.

| Unit | Topics  | Lectures |
|------|---|----------|
| I    | <b>1. Chemistry of Aliphatic Hydrocarbons</b>   |          |
|      | <b>1.1 Carbon-Carbon sigma bonds:</b><br><b>Chemistry of alkanes:</b> Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation - relative reactivity and selectivity.   | [5]      |
|      | <b>1.2 Carbon-Carbon pi bonds:</b><br><b>Formation of alkenes and alkynes by elimination reactions:</b> Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.<br><br><b>Reactions of alkenes:</b> Electrophilic additions their mechanisms (Markownikoff/ Anti-Markownikoff addition), Mechanism of | [10]     |

|            |   |                        |
|------------|---|------------------------|
|            | <p>oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1, 2-and 1, 4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination using N-bromosuccinimide and mechanism, e.g. propene, 1-butene, toluene, ethylbenzene.</p> <p><b>Reactions of alkynes:</b> Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.</p>   |                        |
| <b>II</b>  | <p><b>2.1 Stereochemistry-II: Cycloalkanes and Conformational Analysis:</b><br/>Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy.</p> <p><b>2.2 Aromatic Hydrocarbons:</b><br/><b>Aromaticity:</b> Hückel's rule anti-aromaticity, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft alkylation/acylation with their mechanism, Hammond's postulate, Directing effects of the groups.</p>  | <p>[5]</p> <p>[10]</p> |
| <b>III</b> | <p><b>3.1: Chemical Bond and Reactivity:</b><br/>Types of chemical bond, comparison between ionic and covalent bonds, polarizability (Fajan's Rule), shapes of molecules, Lewis dot structure, Sidgwick Powell Theory, basic VSEPR theory for AB<sub>n</sub> type molecules with and without lone pair of electrons, isoelectronic principles, applications and limitations of VSEPR theory.</p> <p><b>3.2: Oxidation Reduction Chemistry:</b><br/>a) Reduction potentials<br/>b) Redox potentials: half reactions; balancing redox equations.<br/>c) Redox stability in water<br/>i) Latimer and Frost Diagrams<br/>ii) pH dependence of redox potentials.<br/>d) Applications of redox chemistry<br/>i) Extraction of elements: (example: isolation of copper by auto reduction)<br/>ii) Redox reagents in Volumetric analysis: a) I<sub>2</sub>; b) KMnO<sub>4</sub><br/>iii) Titration curves: a) single electron systems (example Ce(IV) against Fe(II)); and b) Multi electron systems as in KMnO<sub>4</sub> against Fe(II))</p> | <p>[7]</p> <p>[8]</p>  |

### Learners Space:

1. Structure, reactions and mechanism of cycloalkanes and cycloalkenes.
2. Conformation analysis of different cycloalkanes.

3. Aromaticity in fused heterocyclic compounds.
4. Molecular orbital theory.
5. Use of redox reactions in Industry.

#### References:

##### Unit I & II

1. Morrison, R. T. and Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt Ltd. (Pearson Education).2012
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt Ltd. (Pearson Education).
4. Eliel, E. L. and Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
5. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
6. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
7. Organic Chemistry, J. Clayden, N. Greeves, S. Warren, and E. Wothers, Oxford Univ. Press, Oxford (2001).

##### Unit III

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry, Oxford, 1970.
3. Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.
4. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
5. Rodger, G.E. Inorganic and Solid-State Chemistry, Cengage Learning India Edition, 2002.

## Laboratory Work (Practical) (Sem-II)

Course Code: PUSCHII21-P211

#### Learning Objectives:

The learner will be imparted with

1. Additional time bound reaction abilities.
2. Knowledge of MSDS
3. Intricacies of semi-micro qualitative analysis of inorganic ions.
4. Understanding Beer-Lambert's law experimentally.
5. Knowledge of crystallization of organic compounds.
6. Information on TLC
7. Technique of performing redox titration (quantitatively).

#### Learning outcomes:

On completion of these experimentations, the learner will be able to

1. Carry out Kinetics experiments with greater ease.
2. Write MSDS of compounds.

3. Analyze and determine different inorganic ions.
4. Perform redox titrations.

## **PAPER-I**

### **1. Chemical Kinetics:**

- (1) Determine the rate constant for saponification reaction between ethyl acetate and NaOH.
- (2) Determine the rate constant for saponification reaction between methyl acetate and NaOH.

### **2. Analysis of commercial samples:**

To standardize commercial sample of HCl using borax.

Write material safety data sheets (MSDS) of chemicals involved.

### **3. Semi-micro qualitative analysis:**

Qualitative analysis: (at least 4 mixtures to be analyzed)

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

Cations (from amongst):  $\text{Pb}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Sr}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Cd}^{2+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Al}^{3+}$ ,  $\text{Cr}^{3+}$ ,  $\text{K}^{+}$ ,  $\text{NH}_4^{+}$

Anions (from amongst):  $\text{CO}_3^{2-}$ ,  $\text{S}^{2-}$ ,  $\text{SO}_3^{2-}$ ,  $\text{NO}_2^{-}$ ,  $\text{NO}_3^{-}$ ,  $\text{Cl}^{-}$ ,  $\text{Br}^{-}$ ,  $\text{I}^{-}$ ,  $\text{SO}_4^{2-}$ ,  $\text{PO}_4^{3-}$

(Scheme of analysis should avoid use of sulphide ion in any form for precipitation / separation of cations. Mixtures should contain no interfering radicals and not forming insoluble residue)

### **Demonstration Experiment:**

To verify Beer-Lambert's law, using  $\text{KMnO}_4$  solution by colorimetric method.

## **PAPER-II**

### **1. Purification of organic compounds by recrystallization:**

Purification of any three organic compounds by recrystallization selecting suitable solvent. (Provide 1g of sample).

Learners are expected to report a) Solvent for recrystallization. b) Mass and the melting points of purified compound.

### **Demonstration Experiment:**

**Chromatography:** Separation of a mixture of o-and p-nitrophenols by thin layer chromatography (TLC)

### **2. Volumetric analysis/redox titration:**

- 1) To determine the percentage of Copper (II) present in the given copper sulphate solution by iodometric titration.
- 2) To determine the percentage of Iron (II) present in the given ferrous sulphate solution by iodometric titration.

**Reference Books for Practicals:**

1. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
2. Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8th Ed., McGraw-Hill, New York (2003).
3. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001).
4. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
5. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
6. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
7. 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.



**Academic Council dated 10<sup>th</sup> February, 2022 as per Item Number: 3.03**



**DOMBIVLI SHIKSHAN PRASARAK MANDAL'S,  
K.V. PENDHARKAR COLLEGE OF ARTS, SCIENCE AND COMMERCE,  
(AUTONOMOUS) DOMBIVLI (EAST), DIST. THANE  
(Affiliated to University of Mumbai)**

**Faculty of Science**

**DEPARTMENT OF CHEMISTRY**

**(Programme: Bachelor of Science, B.Sc.)**

**SYLLABUS FOR**

**S. Y. B. Sc. – Chemistry (Semester III and IV)**

**Choice Based Credit System (CBCS)**

**(With effect from the Academic Year: 2022-2023)**

## Course Structure S.Y.B.Sc.

| <u>Course Code</u> | <u>SEM III</u>                               | <u>Credit points</u> | <u>Couse code</u> | <u>SEM-IV</u>                                | <u>Credit points</u> |
|--------------------|--|----------------------|-------------------|--|----------------------|
| PUSCHIII22-301     | Paper –I (Physical & Analytical Chemistry)   | 02                   | PUSCHIV22-401     | Paper –I (Physical & Analytical Chemistry)   | 02                   |
| PUSCHIII22-302     | Paper –II (Inorganic & Industrial Chemistry) | 02                   | PUSCHIV22-402     | Paper –II (Inorganic & Industrial Chemistry) | 02                   |
| PUSCHIII22-303     | Paper –III (Organic & Industrial Chemistry)  | 02                   | PUSCHIV22-403     | Paper –III (Organic & Industrial Chemistry)  | 02                   |
| PUSCHIII22-P311    | S.Y.B.Sc. Practicals                         | 03                   | PUSCHIV22-P411    | S.Y.B.Sc. Practicals                         | 03                   |

### Programme Outcomes:

1. To gain the knowledge of Chemistry through theory and practicals.
2. Demonstrate, solve and an understanding of concepts in all disciplines of chemistry.
3. Solve the problem and also think methodically, independently and draw a logical conclusion.
4. Employ critical thinking and the scientific knowledge to design, carry out, record and analyze the results of chemical reactions.
5. To inculcate the scientific temperament in the students and outside the scientific community.
6. To Know structure-activity relationship.
7. Understanding of good laboratory practices and safety.
8. To Develop research-oriented skills.
9. To make learners aware and handle the sophisticated instruments/equipments.

### Course Outcomes:

1. Learners will get knowledge of the fundamental aspects of the various core areas of Chemistry.
2. Learners able to analyze the various observations and chemical phenomena presented to them during the course.
3. Learners will be capable of solving problems in the various units of this course.
4. Learners will get an opportunity to get hands on experience of the various concepts and processes in the various branches of chemistry.
5. Learners can gain knowledge and skills of handling chemicals, reagents, apparatus, instruments and the care and safety aspects involved in such handling.
6. Learners will get knowledge of various unit processes involved under industrial chemistry.

## Paper I - Physical and Analytical Chemistry (PUSCHIII22-301)

| Sr. No. | Units                         | Lectures | Credit points |
|---------|-------------------------------|----------|---------------|
| 1       | Unit-I-Physical Chemistry     | 15       | 02            |
| 2       | Unit-II-Physical Chemistry    | 15       |               |
| 3       | Unit-III-Analytical Chemistry | 15       |               |

### Learning objectives:

The learner to be imparted with:

1. Knowledge of concepts about chemical thermodynamics.
2. Understanding concept of electrochemistry.
3. Fundamentals of chemical kinetics.
4. Role of analytical chemistry.
5. Detailed study of classical methods of analysis and gravimetric analysis.

### Learning outcomes:

On successful completion of this course students will be able to:

1. Explain the concept of Thermodynamics, thermodynamics of open system.
2. Distinguish between conductivity, equivalent and molar conductivity for weak and strong electrolytes.
3. Understand the concept of applications of conductance measurements and solve numericals based on it.
4. Understand purpose of chemical analysis and difference between classical and non-classical methods of analysis.
5. Explain the types of gravimetric analysis and their applications.
6. Understand thermodynamics of ideal solutions, Nernst distribution law and solvent extraction.

|               | Topics  | Lectures  |
|---------------|---|-----------|
| <b>Unit-I</b> | <b>1.1 Chemical thermodynamics-II</b><br>1.1.1 Free energy functions: Helmholtz free energy, Gibb's free energy, Variation of Gibb's free energy with pressure and temperature<br>1.1.2 Gibbs-Helmholtz equation, Van't Hoff reaction isotherm and Van't Hoff reaction isochore (Numericals expected) | <b>15</b> |

|                |  |           |
|----------------|--|-----------|
|                | <p>1.1.3 Thermodynamics of open system: Partial molal properties, Chemical potential and its variation with pressure and temperature, Gibb's Duhem equation</p> <p>1.1.4 Concept of Fugacity and Activity</p> <p><b>1.2 Electrochemistry I</b></p> <p>1.2.1 Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes</p> <p>1.2.2 Kohlrausch law of independent migration of ions</p> <p>1.2.3 Applications of conductance measurements: Determination of degree of ionization and ionization constant of weak electrolyte, solubility and solubility product of sparingly soluble salts, ionic product of water (Numericals expected)</p> <p>1.2.4 Transference number and its experimental determination using Moving boundary method (Numericals expected), Factors affecting transference number</p>   |           |
| <b>Unit-II</b> | <p><b>2.1 Chemical Kinetics-II</b></p> <p>2.1.1 Types of complex chemical reactions: Reversible or opposing, consecutive and parallel reactions (No derivations, only examples expected), Thermal chain reactions: H. and Br. reaction. (Only steps involved, no kinetic expression expected)</p> <p>2.1.2 Effect of temperature on the rate of reaction, Arrhenius equation, Concept of energy of activation (<math>E_a</math>) (Numericals expected)</p> <p>2.1.3 Theories of reaction rates: Collision theory and activated complex theory of bimolecular reactions. Comparison between the two theories (Qualitative treatment only)</p> <p><b>2.2 Solutions</b></p> <p>2.2.1 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</p> <p>2.2.2 Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids with respect to</p> | <b>15</b> |

|                 |  |           |
|-----------------|--|-----------|
|                 | <p>phenol-water, triethanolamine – water and nicotine – water systems</p> <p>2.2.3 Immiscibility of liquids- Principle of steam distillation</p> <p>2.2.4 Nernst distribution law and its applications, solvent extraction</p>   |           |
| <b>Unit-III</b> | <p><b>3.1 Role of Analytical Chemistry</b></p> <p>3.1.1 Language of analytical chemistry: important terms and their significance in analytical chemistry</p> <p>3.1.2 Purpose of chemical analysis; Analysis Based (i) On the nature of information required: (Proximate, Partial, Trace, Complete Analysis) and (ii) On the size of the sample used (Macro, semi-micro and micro analysis)</p> <p>3.1.3 Classical and Non-classical methods of analysis; their types and importance</p> <p><b>3.2. Classical Methods of Analysis</b></p> <p>3.2.1 Titrimetric methods</p> <p>3.2.2 Terms involved in titrimetric methods of analysis comparing volumetry and titrimetry</p> <p>3.2.3 The conditions suitable for titrimetry</p> <p>3.2.4 Types of titrimetry - Neutralization (acidimetry, alkalimetry), Redox, (Iodometry, Iodimetry) Precipitation and Complexometric titrations and indicators used in these titrations</p> <p>3.2.5 Tools of titrimetry: Graduated glasswares and Calibration</p> <p>3.2.6 Standard solutions (primary and secondary standards in titrimetry) and calculations in titrimetry- preparation of standard solutions.</p> <p><b>3.3 Gravimetric analysis</b></p> <p>3.3.1 General introduction to gravimetry</p> <p>3.3.2 Types of gravimetric methods</p> <p>3.3.3 Precipitation gravimetry</p> <p>i) Steps involved in precipitation gravimetry analysis</p> <p>ii) Conditions for precipitation</p> <p>iii) Completion of precipitation</p> <p>iv) Role of Digestion, Filtration, Washing, Drying Ignition of precipitate</p> | <b>15</b> |

|  |  |  |
|--|--|--|
|  | v) Applications of Gravimetric Analysis: Estimation of Nickel in Cu-Ni alloy using dimethyl glyoxime |  |
|--|--|--|

**Justification:** All the papers of S.Y.B.Sc. in both the semesters are rearranged so that students will focus equally on all the branch of chemistry and able to develop interest as in T.Y.B.Sc. students will have different papers for all the branches of chemistry.

**Learner's space:**

1. Applications of conductance measurements.
2. Thermodynamic processes.
3. Types of complex chemical reactions and theories of reaction rates.
4. Select a procedure for analysis.
5. Sources of possible errors in the results obtained.

**Job oriented/Entrepreneurship development topics:** Chemical kinetic, Electrochemistry, thermodynamics, solutions and classical methods of analysis.

**References:**

**Unit I and II**

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4<sup>th</sup> Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
4. Mahan, B.H. University Chemistry 3<sup>rd</sup> Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry 5<sup>th</sup> Ed. Macmillan Publishing Co., New York (1985).
6. K.L. Kapoor A textbook of Physical Chemistry 3<sup>rd</sup> Ed. vol.1,2 Macmillan Publishing Co., New Delhi (2001).

**Unit – III**

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, chapter 3.

7. S.M. Khopkar, “Basic Concepts of Analytical Chemistry”, II<sup>nd</sup> Edition New Age International Publisher
8. Gary D. Christan,” Analytical Chemistry”, VI<sup>th</sup> Edition, Wiley Students Edition, Chapter No 8, 9,10.

### ICT Backup:

1. <https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics-kinetics-spring-2008/video-lectures/>
2. <https://ocw.mit.edu/courses/chemistry/5-111-principles-of-chemical-science-fall-2008/video-lectures/>

### Pedagogy:

The syllabus gives wide scope for effective use of Collaborative Learning Approach, Problem Solving Approach, Inquiry Approach, Deductive Approach, Inductive Approach, Constructivist Approach, Experiential Learning, Analogy Strategy and use of Information and Communication Technology (ICT) which all makes teaching-learning effective and interesting. The use of 5E Learning Model i.e. Engage, Explore, Explain, Elaborate and Evaluate makes teaching-learning and evaluation effective. The outcome of the syllabus is to develop learner’s Critical thinking, Logical thinking, Scepticism and increase the Knowledge Dimension which includes Factual knowledge, Conceptual knowledge, Procedural knowledge and Metacognitive knowledge. The syllabus is framed in such manner that it enhances the effectiveness, excellence, diversity and creativity in the area of teaching-learning of Chemistry. It is intended to encourage teacher and learner to organize learner-centered, activity-based, participatory learning experiences through observation, dialogue, discussion, projects, problem solving and field work/research laboratory visit to integrate the learning of Chemistry with its content and process. Learners are encouraged to ask questions not only during transaction of a concept but also when involved in any teaching-learning experience so that learners get motivated to talk over the issue. This syllabus meant not only to be read, but to be engaged with and involvement in thinking critically. Relevance, Individualization, Feedback, Reinforcement, Facilitation is considered while framing the syllabus.

### MOOC:

| Platform and link   | Course duration | Similarity index (%) | Tentative cost |
|---|-----------------|----------------------|----------------|
| 1. <b>Platform</b> - edx<br><a href="https://www.edx.org/course/thermodynamics-of-materials-2?index=product&amp;queryID=16ea88a6e9dc1981bfe177d9ea37c552&amp;position=21">https://www.edx.org/course/thermodynamics-of-materials-2?index=product&amp;queryID=16ea88a6e9dc1981bfe177d9ea37c552&amp;position=21</a> | 16 weeks        | 50                   | Free           |

|   |          |    |      |
|---|----------|----|------|
| 2. <b>Platform</b> – edx<br><a href="https://www.edx.org/course/chemical-equilibrium-and-kinetics?index=product&amp;queryID=6618c1b3a72754848f94c923738b2a9c&amp;position=17">https://www.edx.org/course/chemical-equilibrium-and-kinetics?index=product&amp;queryID=6618c1b3a72754848f94c923738b2a9c&amp;position=17</a> | 14 weeks | 65 | Free |
| 3. <b>Platform</b> - edx<br><a href="https://www.edx.org/course/basic-analytical-chemistry?index=product&amp;queryID=8292efb76403cb45899c2c432a5a796f&amp;position=1">https://www.edx.org/course/basic-analytical-chemistry?index=product&amp;queryID=8292efb76403cb45899c2c432a5a796f&amp;position=1</a>                 | 6 weeks  | 30 | Free |

## Paper II - Inorganic and Industrial Chemistry (PUSCHIII22-302)

| Sr. No. | Units                         | Lectures | Credit points |
|---------|-------------------------------|----------|---------------|
| 1       | Unit-I-Inorganic Chemistry    | 15       | 02            |
| 2       | Unit-II-Inorganic Chemistry   | 15       |               |
| 3       | Unit-III-Industrial Chemistry | 15       |               |

### Learning objectives:

The learner to be imparted with:

1. Knowledge of chemical bonding.
2. Understanding chemistry of p-block elements.
3. Basics of molecular orbital theory.
4. Identify sources of possible errors in the results obtained.
5. To learn the general principles of metallurgy.

### Learning outcomes:

On successful completion of this course students will be able to:

1. Explain the concept of non-directional and directional bonding.
2. Understand the difference between atomic and molecular orbitals.
3. To calculate bond order and identify magnetic properties of homonuclear diatomic molecules.
4. Understand synthesis of ammonia by Bosch – Haber process.
5. To learn the effect of catalysis.



|        | Topics   | Lectures |
|--------|--|----------|
| Unit-I | <p><b>Chemical Bonding</b></p> <p><b>1.1 Non-Directional Bonding</b></p> <p>1.1.1 Ionic Bond: Conditions for the formation of ionic bond</p> <p>1.1.2 Types of ionic crystals</p> <p>1.1.3 Radius ratio rules</p> <p>1.1.4 Lattice energy, Borne-Lande equation</p> <p>1.1.5 Kapustinski equation</p> <p>1.1.6 Born-Haber cycle and its application</p> <p><b>1.2 Directional Bonding: Orbital Approach</b></p> <p>1.2.1 Covalent Bonding: The Valence Bond Theory- Introduction and basic tenets</p> <p>1.2.2 Interaction between two hydrogen atoms and the potential energy diagram of the resultant system</p> <p>1.2.3 Corrections applied to the system of two hydrogen atoms-formation of H<sub>2</sub></p> <p>1.2.4 Homonuclear diatomic molecules from He<sub>2</sub> to Ne<sub>2</sub></p> <p>1.2.5 Resonance and the concept of formal charge; Rules for resonance or canonical structures</p> <p>1.2.6 Bonding in Polyatomic Species: The role of hybridization and types of hybrid orbitals - <math>sp</math>, <math>sp^2</math>, <math>sp^3</math>, <math>sp^3d</math>, <math>sp^2d^2</math> and <math>sp^2d</math> <math>sp^3d^2</math></p> <p>1.2.7 Equivalent and Non-Equivalent hybrid orbitals</p> <p>1.2.8 Contribution of a given atomic orbital to the hybrid orbitals (with reference to <math>sp^3</math> hybridization as in CH<sub>4</sub>, NH<sub>3</sub> and H<sub>2</sub>O and series like NH<sub>3</sub>, PH<sub>3</sub>, AsH<sub>3</sub>, BiH<sub>3</sub>)</p> <p><b>1.3 Molecular Orbital Theory</b></p> <p>1.3.1 Comparing atomic orbitals and molecular orbitals</p> <p>1.3.2 Linear combination of atomic orbitals to give molecular orbitals (LCAO-MO approach for diatomic homonuclear molecules)</p> <p>1.3.3. Wave mechanical treatment for molecular orbitals (H<sub>2</sub><sup>+</sup> and H<sub>2</sub>)</p> <p>1.3.4. Molecular orbital theory and bond order and magnetic property: with reference to O<sub>2</sub>, O<sub>2</sub><sup>+</sup>, O<sub>2</sub><sup>-</sup>, O<sub>2</sub><sup>2-</sup></p> | 15       |

|                 |  |           |
|-----------------|--|-----------|
|                 | (Problems and numerical problems expected wherever possible)   |           |
| <b>Unit-II</b>  | <p><b>Selected topics on p block elements</b></p> <p><b>2.1 Chemistry of Boron compounds</b></p> <p>2.1.1 Electron deficient compounds – <math>\text{BH}_3</math>, <math>\text{BF}_3</math>, <math>\text{BCl}_3</math> with respect to Lewis acidity and applications</p> <p>2.1.2 Preparation of simple boranes like diborane and tetraborane</p> <p>2.1.3 Structure and bonding in diborane and tetraborane (2e-3c bonds)</p> <p>2.1.4 Synthesis of Borax</p> <p><b>2.2 Chemistry of Silicon and Germanium</b></p> <p>2.2.1 Silicon compounds: Occurrence, Structure and inertness of <math>\text{SiO}_2</math></p> <p>2.2.2 Preparation of structure of <math>\text{SiCl}_4</math></p> <p>2.2.3 Occurrence and extraction of Germanium</p> <p>2.2.4 Preparation of extra pure Silicon and Germanium</p> <p><b>2.3 Chemistry of Nitrogen family</b></p> <p>2.3.1 Trends in chemical reactivity - Formation of hydrides, halides, oxides with special reference to oxides of nitrogen</p> <p>2.3.2 Oxides of nitrogen with respect to preparation and structure of <math>\text{NO}</math>, <math>\text{NO}_2</math>, <math>\text{N}_2\text{O}</math> and <math>\text{N}_2\text{O}_4</math></p> <p>2.3.3 Synthesis of ammonia by Bosch – Haber process</p> | <b>15</b> |
| <b>Unit-III</b> | <p><b>3.1 Inorganic Industrial Chemistry</b></p> <p>3.1.1 Physico-Chemical Principles:</p> <p>i) Criteria for spontaneity of chemical reactions</p> <p>ii) Electrolysis</p> <p>iii) Effect of catalysts</p> <p>iv) General principles of metallurgy.</p> <p>3.1.2 Manufacture of Bulk Chemicals:</p> <p>i) Sulfuric acid (by Contact process)</p> <p><b>3.2 Results of Analysis</b></p> <p>i) Errors in Analysis and their types– Absolute and relative errors, Constant and proportionate errors</p> <p>ii) Precision and Accuracy in Analysis</p> <p>iii) Corrections for Determinate Errors</p>   | <b>15</b> |

**Justification:** Inorganic industrial chemistry which includes electrolysis, metallurgy, effect of catalyst and manufacture of sulfuric acid is introduced in paper-II which is of commercial importance. Knowledge of inorganic industrial chemistry at UG level will be definitely helpful to students while working in industry and even for research activities.

**Learner's space:**

1. Rules for resonance and concept of formal charge with examples.
2. Manufacture of sulfuric acid by contact process.
3. Identify type of error in analysis.
4. Understand chemistry of group 13, 14 and 15 elements.
5. Construct molecular orbital diagram for diatomic homonuclear molecules.

**Job oriented/Entrepreneurship development topics:** Chemical bonding, Chemistry of p-block elements, Inorganic industrial chemistry, Results of analysis

**References:**

**Unit I and II**

1. R. Gopalan, Universities Press India Pvt. Ltd. Inorganic Chemistry for Undergraduates.
2. J. D. Lee, 4<sup>th</sup> Edn., Concise Inorganic Chemistry, ELBS, The group III elements Pg. 359- 648.
3. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3<sup>rd</sup> edition, Oxford University Press (1999) page 325-446.
4. Ramesh Kapoor and R.S. Chopra, Inorganic Chemistry, R. Chand publishers, New Delhi.
5. CNR Rao edited, University General Chemistry, 513-578.
6. James E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity,
7. Cotton and Wilkinson, Advanced Inorganic Chemistry, 3<sup>rd</sup>. Edition.
8. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt. Ltd. (2002).
9. R. Gopalan, Universities Press India Pvt. Ltd. Inorganic Chemistry for Undergraduates.
10. Ramesh Kapoor and R.S. Chopra, Inorganic Chemistry, R. Chand publishers, New Delhi.
11. Emeleus and Anderson, Modern Aspects of Inorganic Chemistry.
12. Cotton and Wilkinson, Advanced Inorganic Chemistry, 3<sup>rd</sup>. Edition.
13. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt. Ltd. (2002).
14. Puri, Sharma and Kalia, Milestone publishers, Principles of Inorganic Chemistry.

### Unit – III

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. Chemical Process Industries: Shreve and Brink, McGraw Hill Book Co. USA.
6. Industrial chemistry (including environmental engineering) by B. K. Sharma, 7<sup>th</sup> Ed. Meerul Goel Publishing House, 1995(660).
7. Unit operations I and II: D. D. Kale, Pune Vidyarthi Griha Prakashan.
8. Unit Process in Organic Synthesis by P. M. Groggins, McGraw Hill Book Co. USA.

### ICT Backup:

1. <https://ocw.mit.edu/courses/chemistry/5-111-principles-of-chemical-science-fall-2008/video-lectures/lecture-1/>
2. <https://www.youtube.com/user/MIT/search?query=chemistry>

### Pedagogy:

Direct instructions, Flipped classrooms, Inquiry-based learning, Game-based learning, Videos, presentations, Group discussions etc.

### MOOC:

| Platform and link   | Course duration                       | Similarity index | Tentative cost |
|---|---------------------------------------|------------------|----------------|
| <b>1. Platform - Udemy</b><br><a href="https://www.udemy.com/course/chemical-bonding/">https://www.udemy.com/course/chemical-bonding/</a>   | 9 sections, 24 lectures (1hr. 52 min) | 30%              | 490/-          |
| <b>2. Platform - Udemy</b><br><a href="https://www.udemy.com/course/chemical-bonding-ionic-covalent-coordinate-bonding-icse/?src=sac&amp;kw=CHEMICAL+BONDING">https://www.udemy.com/course/chemical-bonding-ionic-covalent-coordinate-bonding-icse/?src=sac&amp;kw=CHEMICAL+BONDING</a> | 13 Lectures                           | 60%              | 1280/-         |
| <b>3. Platform - Udemy</b><br><a href="https://www.udemy.com/course/p-block-elements-balancing-of-chemical-equations-for-12th/">https://www.udemy.com/course/p-block-elements-balancing-of-chemical-equations-for-12th/</a>   | 2 sections, 13 lectures (3h 17min)    | 15%              | 385/-          |

|  |                                     |     |       |
|--|-------------------------------------|-----|-------|
| <b>4.. Platform - Udemy</b><br><a href="https://www.udemy.com/course/inorganic-chemistry-by-ad/">https://www.udemy.com/course/inorganic-chemistry-by-ad/</a> | 8 sections, 39 lectures (29h 44min) | 20% | 385/- |
|--|-------------------------------------|-----|-------|

### **Paper III - Organic and Industrial Chemistry (PUSCHIII22-303)**

| <b>Sr. No.</b> | <b>Units</b>                  | <b>Lectures</b> | <b>Credit points</b> |
|----------------|-------------------------------|-----------------|----------------------|
| 1              | Unit-I-Organic Chemistry      | 15              | 02                   |
| 2              | Unit-II-Organic Chemistry     | 15              |                      |
| 3              | Unit-III-Industrial Chemistry | 15              |                      |

#### **Learning objectives:**

The learner to be imparted with:

1. Knowledge of reactions and reactivity of halogenated hydrocarbons.
2. Understanding nomenclature, nature, type and reactivity of organomagnesium and organolithium compounds.
3. To study the general mechanism of nucleophilic addition.
4. Understand unit operations like filtration, distillation and crystallization.
5. Knowledge of basic concepts in instrumental methods.

#### **Learning outcomes:**

On successful completion of this course students will be able to:

1. Explain the difference between alkyl halides and aryl halides.
2. Understand the nomenclature, preparation and properties of alcohols, phenols and epoxides.
3. Explain the bonding and structure of organic compounds.
4. To learn types of analytical instrumental methods.
5. To learn the applications of UV-Visible spectrophotometry.

|               | <b>Topics</b>  | <b>Lectures</b> |
|---------------|--|-----------------|
| <b>Unit-I</b> | <b>1.1 Reactions and reactivity of halogenated hydrocarbons:</b><br>1.1.1 Alkyl halides: Nucleophilic substitution reactions: $SN^1$ , $SN^2$ and $SN_i$ mechanisms with stereochemical aspects and factors affecting nucleophilic substitution reactions-nature of substrate, solvent, nucleophilic reagent and leaving group | <b>15</b>       |

|                |  |           |
|----------------|--|-----------|
|                | <p>1.1.2 Aryl halides: Reactivity of aryl halides towards nucleophilic substitution reactions. Nucleophilic aromatic substitution (S<sub>N</sub>Ar) addition-elimination mechanism and benzyne mechanism</p> <p><b>1.2 Organomagnesium and organolithium compounds:</b><br/>Nomenclature, nature, type and reactivity of carbon-metal bond. Preparation using alkyl/aryl halide. Structure, stability and reactions with compounds containing acidic hydrogen, carbonyl compounds, CO<sub>2</sub>, cyanides and epoxides</p> <p><b>1.3 Alcohols, phenols and epoxides:</b></p> <p>1.3.1 Alcohols: Nomenclature, Preparation: Hydration of alkenes, hydrolysis of alkyl halides, reduction of aldehydes and ketones, using Grignard reagent. Properties: Hydrogen bonding, types and effect of hydrogen bonding on different properties. Acidity of alcohols, Reactions of alcohols</p> <p>1.3.2 Phenols: Preparation, physical properties and acidic character. Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols</p> <p>1.3.3 Epoxides: Nomenclature, methods of preparation and reactions of epoxides: reactivity, ring opening reactions by nucleophiles</p> <p>(a) In acidic conditions: hydrolysis, reaction with halogen halide, alcohol, hydrogen cyanide.</p> <p>(b) In neutral or basic conditions: ammonia, amines, Grignard reagents, alkoxide</p> |           |
| <b>Unit-II</b> | <p><b>2.1 Carbonyl Compounds:</b></p> <p>2.1.1 Nomenclature of aliphatic, alicyclic and aromatic carbonyl compounds. Structure, reactivity of aldehydes and ketones and methods of preparation; Oxidation of primary and secondary alcohols using PCC, hydration of alkynes, action of Grignard reagent on esters, Rosenmund reduction, Gattermann-Koch formylation and Friedel Craft acylation of arenes</p> <p>2.1.2 General mechanism of nucleophilic addition, and acid catalyzed nucleophilic addition reactions</p>  | <b>15</b> |

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|-----------------|--|-----------|
|                 | <p>2.1.3 Reactions of aldehydes and ketones with <math>\text{NaHSO}_3</math>, <math>\text{HCN}</math>, <math>\text{RMgX}</math>, alcohol, amine, phenyl hydrazine, 2,4-Dinitrophenyl hydrazine, <math>\text{LiAlH}_4</math> and <math>\text{NaBH}_4</math></p> <p>2.1.4 Mechanisms of following reactions: Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt and Cannizzaro reaction</p> <p>2.1.5 Keto-enol tautomerism: Mechanism of acid and base catalysed enolization</p> <p>2.1.6 Bonding and Structure of organic compounds:<br/>Hybridization: <math>\text{sp}^3</math>, <math>\text{sp}^2</math>, <math>\text{sp}</math> hybridization of nitrogen; <math>\text{sp}^3</math> and <math>\text{sp}^2</math> hybridizations of oxygen in Organic compounds (alcohol, carboxylic acid, cyanide and amine) Overlap of atomic orbitals: Overlaps of atomic orbitals to form sigma and pi bonds, shapes of organic molecules.</p>   |           |
| <b>Unit-III</b> | <p><b>3.1 Unit Operations:</b></p> <p>3.1.1 General Idea of the following operations used in industries</p> <p>3.1.2 Filtration: Introduction, filtration process and centrifugation</p> <p>3.1.3 Distillation: Introduction, Batch and Continuous distillations, separation of azeotropes</p> <p>3.1.4 Crystallization: Introduction. Solubility, supersaturation, nucleation, crystal growth. crystallizers and evaporators</p> <p><b>3.2 Basic Concepts in Instrumental methods</b></p> <p>3.2.1 Relation between the Analyte, Stimulus and measurement of change in the observable property</p> <p>3.2.2 Block Diagram of an Analytical instrument</p> <p>3.2.3 Types of Analytical Instrumental methods based on</p> <p>i) Optical interactions (e.g., Spectrometry: UV-visible, Polarimetry)</p> <p>ii) Electrochemical interactions (e.g., Potentiometry, Conductometry)</p> <p>iii) Thermal interactions (e.g., Thermogravimetry)</p> <p><b>3.3 Spectrometry</b></p> <p>3.3.1 Interaction of electromagnetic radiation with matter: Absorption and Emission spectroscopy</p> | <b>15</b> |

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|--|---|--|
|  | <p>3.3.2 Basic Terms: Radiant Power, Absorbance, Transmittance, Monochromatic light, Polychromatic light, Wavelength of maximum absorbance, Absorptivity and Molar Absorptivity</p> <p>3.3.3 Block Diagrams for Single beam and Colorimeter, and Spectrophotometer (Principles, Construction and working-Details of Components expected i.e., source, Sample holder, Filters/Monochromators, Detectors such as Photomultiplier tube)</p> <p>3.3.4 Applications of UV-Visible Spectrophotometry</p> <p>Qualitative analysis such as Identification of functional groups in Organic compounds, Chromophores and Auxochrome, <i>cis</i> and <i>trans</i> isomers</p> |  |
|--|---|--|

**Justification:** Introduction of organic industrial chemistry includes various unit operations such as filtration, distillation and crystallization along with basics concepts in instrumental methods and spectrometry. The detailed knowledge of unit operations will help the UG students to understand the various methods of separations in Industry.

**Learner's space:**

1. Reactivity of aryl halides towards nucleophilic substitution reactions.
2. General mechanism of nucleophilic addition and acid catalyzed nucleophilic addition reactions.
3. Study of interaction of electromagnetic radiation with matter.
4. Understand operations used in industry.
5. Information about components of an analytical instrument.

**Job oriented/Entrepreneurship development topics:** Reactions of alkyl and aryl halides, Chemistry of alcohols, phenols and epoxides, Chemistry of carbonyl compounds, Unit operations and various instrumental methods.

**References:**

**Unit – I and II**

1. Morrison, R. T. and Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education) 2012.
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).



4. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
5. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
6. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
7. Comprehensive Organic Chemistry- The synthesis and reactions of Organic Compounds, Derek barton ,W. David Ollis.
8. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
9. Eliel, E. L. and Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
10. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.

### Unit – III

1. Instrumental Methods of Chemical Analysis by Gurdeep R. Chatwal, Sham K. Anand pp 2.107-2.148
2. Principles of Instrumental Analysis by Skoog, Holler, Nieman, 5th Edition pp 143-172.
3. Instrumental Methods of Analysis by Willard, Merritt, Dean, Settle 7 th Edition pp 118-181.
4. Chemical Process Industries: Shreve and Brink, McGraw Hill Book Co. USA.
5. Industrial chemistry (including environmental engineering) by B. K. Sharma, 7<sup>th</sup> Ed. Meerul Goel Publishing House, 1995(660).
6. Unit operations I and II: D. D. Kale, Pune Vidyarthi Griha Prakashan.
7. Unit Process in Organic Synthesis by P. M. Groggins, McGraw Hill Book Co. USA.

### ICT Backup:

1. <http://mit.uvt.rnu.tn/courses/materials-science-and-engineering/3-091sc-introduction-to-solid-state-chemistry-fall-2010/organic-materials/27-introduction-to-organic-chemistry/>
2. <https://ocw.mit.edu/courses/chemistry/>
3. <https://ocw.mit.edu/courses/captioned/>

### Pedagogy:

Direct instructions, Flipped classrooms, Inquiry-based learning, Game-based learning, Videos, presentations, Group discussions etc.

### MOOC:

| Platform and link   | Course duration | Similarity index | Tentative cost |
|---|-----------------|------------------|----------------|
| 1. <b>Platform</b> - Udemy<br><a href="https://www.udemy.com/course/organic-chemistry-demystified-part-1/">https://www.udemy.com/course/organic-chemistry-demystified-part-1/</a> | 12.5 hours      | 70               | 497/-          |

|  |          |    |                                 |
|--|----------|----|---------------------------------|
| 2. <b>Platform</b> - Swayam<br><a href="https://www.classcentral.com/course/swayam-introductory-organic-chemistry-i-14169">https://www.classcentral.com/course/swayam-introductory-organic-chemistry-i-14169</a> | 8 weeks  | 80 | Free<br><br>Paid<br>Certificate |
| 3. <b>Platform</b> - Swayam<br><a href="https://www.classcentral.com/course/swayam-organic-chemistry-1-14221">https://www.classcentral.com/course/swayam-organic-chemistry-1-14221</a>                           | 15 weeks | 70 | Free<br><br>Paid<br>Certificate |

### **Laboratory work (Practicals) (Semester III) (PUSCHIII22-P311)**

#### **Learning objectives:**

The learner will be imparted with

1. Determination of energy of activation of acid catalyzed hydrolysis of methyl acetate.
2. Identification and separation of cations in a given mixture.
3. Synthesis of organic compounds and their purification.
4. Estimation of total hardness.
5. Verification of Ostwald's dilution law and determination of dissociation constant for weak acid by conductometric method.

#### **Learning outcomes:**

On completion of these experimentations, the learner will be able to

1. Carry out Kinetics experiments with greater ease.
2. Able to calculate total hardness of water sample.
3. Analyze and identify different cations from provided mixture.
4. Perform organic synthesis.

|                | <b>Practicals</b>   |
|----------------|---|
| <b>Paper-I</b> | <b>Physical/Analytical Chemistry</b> <ol style="list-style-type: none"> <li>1. To verify Ostwald's dilution law for weak acid conductometrically.</li> <li>2. To determine dissociation constant of weak acid conductometrically.</li> <li>3. Determination of energy of activation of acid catalyzed hydrolysis of methyl acetate.</li> <li>4. To investigate the reaction between <math>K_2S_2O_8</math> and KI with equal initial concentrations of the reactants.</li> <li>5. To determine solubility of sparingly soluble salts (any two) conductometrically.</li> </ol> |

|                  |   |
|------------------|---|
|                  | 6. Determination of buffer capacity of acid buffer and basic buffer.<br>7. Tools of Analytical Chemistry-I.   |
| <b>Paper-II</b>  | <b>Inorganic Chemistry</b><br>1. Estimation of total hardness of water.<br>2. Investigation of the reaction between copper sulphate and Sodium Hydroxide (Standard EDTA solution to be provided to the learner).<br>3. Identification of cations in a given mixture and Analytically separating them From a mixture containing not more than two of the following: Pb(II), Ba(II), Ca(II), Sr (II), Cu(II), Cd(II), Mg(II), Zn(II), Fe(II), Fe(III), Ni(II), Co(II) Al(III), Cr(III)]<br>4. Estimation of Ba <sup>2+</sup> ions gravimetrically from its solution, containing Fe <sup>+3</sup> /Cu <sup>2+</sup> ions as impurities, as BaSO <sub>4</sub> .<br>5. Gravimetric Estimations i) Nickel (II) as Ni(dmg) |
| <b>Paper-III</b> | <b>Paper III: Organic Chemistry</b><br>Short organic preparation and their purification:<br>Use 0.5-1.0g of the organic compound. Purify the product by recrystallization. Report theoretical yield, percentage yield and melting point of the purified product. Preparation of:<br>i) Cyclohexanone oxime from cyclohexanone<br>ii) Acetanilide from aniline (Green method using water as solvent)<br>iii) p-Nitroacetanilide from acetanilide<br>iv) p-Nitroaniline from p-Nitroacetanilide<br>v) m-Dinitrobenzene from nitrobenzene<br>vi) 5-Nitrosalicylic acid from Salicylic acid   |

**Justification:** As the syllabi has been reshuffled into different branches of chemistry, accordingly practicals are also reshuffled with minor modifications as additions. In paper-II of practicals, learners will learn various concepts and techniques which was not there in the earlier syllabus. In paper-III, Introduction of new experiments: Introduction to green chemistry synthesis, understanding use of strength of various nitrating agents and introduction of multi-step synthesis at S.Y.B.Sc. level.

**Learner's space:**

1. Student's will able to understand and perform practicals of all branches of chemistry.
2. They will learn various tools of analytical chemistry.
3. Able to identify cations present in the given mixture.

4. Students able to estimate hardness of water sample.

**Job oriented/Entrepreneurship development topics:** All the three papers of practicals will be helpful to students to develop their practical as well as research-oriented skills.

## **References:**

### **Paper I**

1. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
2. Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8<sup>th</sup> Ed., McGraw-Hill, New York (2003).
3. Halpern A.M. and McBane G.C., Experimental Physical Chemistry, 3<sup>rd</sup> Ed., W.H. Freeman and Co., New York (2003).
4. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001).

### **Paper II**

1. Practical Inorganic Chemistry by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972).

### **Paper III**

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

## **ICT Backup:**

1. <https://www.futurelearn.com/courses/teaching-practical-science-chemistry>
2. <https://www.udemy.com/course/chemistry-practicals-activities-of-chemical-reactions/>
3. <https://www.youtube.com/watch?v=-YOViFsRz0A>
4. <https://www.youtube.com/watch?v=jltLlzZ6FqU>

**S.Y.B.Sc.**  
**Semester-IV**

**Paper I - Physical and Analytical Chemistry (PUSCHIV22-401)**

| Sr. No. | Units                         | Lectures | Credit points |
|---------|-------------------------------|----------|---------------|
| 1       | Unit-I-Physical Chemistry     | 15       | 02            |
| 2       | Unit-II-Physical Chemistry    | 15       |               |
| 3       | Unit-III-Analytical Chemistry | 15       |               |

**Learning objectives:**

The learner to be imparted with:

1. Phase diagrams of one-component and two-component systems.
2. Understanding concept of electrochemistry.
3. Study of catalysis and mechanism for various types of catalysis.
4. Knowledge of instrumental methods based on the electrochemical properties of the analytes.
5. Detailed study of X-ray diffraction method.

**Learning outcomes:**

On successful completion of this course students will be able to

1. Solve numericals based on Nernst equation.
2. Calculate equilibrium constant from EMF data.
3. Use X-rays in the study of crystal structure.
4. Explain effect of particle size and efficiency of nanoparticles as catalyst.
5. Understand basic principle, working and applications of potentiometer, conductometer and  $p^H$  meter.

|               | Topics  | Lectures  |
|---------------|---|-----------|
| <b>Unit-I</b> | <b>1.1 Electrochemistry-II</b><br>1.1.1 Electrochemical conventions, Reversible and irreversible cells<br>1.1.2 Nernst equation and its importance, Types of electrodes, Standard electrode potential, Electrochemical series (Numericals expected) | <b>15</b> |

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|----------------|--|-----------|
|                | <p>1.1.3 Thermodynamics of a reversible cell, calculation of thermodynamic properties: <math>\Delta G</math>, <math>\Delta H</math> and <math>\Delta S</math> from EMF data. (Numericals expected)</p> <p>1.1.4 Calculation of equilibrium constant from EMF data (Numericals expected)</p> <p>1.1.5 Concentration cells with transference and without transference. Liquid junction potential and salt bridge</p> <p>1.1.6 pH determination using hydrogen electrode and quinhydrone electrode. (Numericals expected)</p> <p><b>1.2 Phase Equilibria</b></p> <p>1.2.1 Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation</p> <p>1.2.2 Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. (numericals expected)</p> <p>1.2.3 Phase diagrams of one-component systems (water and sulphur)</p> <p>1.2.4 Two component systems involving eutectics, congruent and incongruent melting points (lead-silver system)</p> |           |
| <b>Unit-II</b> | <p><b>2.1 Solid State</b></p> <p>2.1.1 Recapitulation of laws of crystallography and types of crystals</p> <p>2.1.2 Characteristics of simple cubic, face centered cubic and body centered cubic systems, interplanar distance in cubic lattice (only expression for ratio of interplanar distances are expected)</p> <p>2.1.3 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)</p> <p><b>2.2 Catalysis</b></p> <p>2.2.1 Types of catalysis, catalytic activity, specificity and selectivity, inhibitors, catalyst poisoning and deactivation</p> <p>2.2.2 Mechanisms and kinetics of acid-base catalyzed reactions, effect of pH</p>   | <b>15</b> |

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|-----------------|---|-----------|
|                 | 2.2.3 Mechanisms and kinetics of enzyme catalyzed reactions (Michaelis-Menten equation)<br>2.2.4 Effect of particle size and efficiency of nanoparticles as catalyst  |           |
| <b>Unit-III</b> | <b>3.0 Instrumental methods based on the electrochemical properties of the analytes</b><br><b>3.1 Potentiometry</b><br>3.1.1 Principle<br>3.1.2 Role of Reference and indicator electrodes<br>3.1.3 Applications in Neutralization reactions with reference to the titration of a Strong acid against a Strong Base (using quinhydrone electrode)<br>3.1.4 Graphical methods for detection of end points<br><b>3.2. pH metry:</b><br>3.2.1 Principle<br>3.2.2 Principle, Construction Working and Care of Combined Glass electrode<br>3.2.3 Applications in Titrimetry (Strong Acid-Strong Base)<br><b>3.3 Conductometry:</b><br>3.3.1 Principle<br>3.3.2 Conductivity cell its construction and care<br>3.3.3 Applications in neutralization, titrimetry with respect to<br>i) Strong Acid-Strong Base<br>ii) Strong Acid-Weak Base<br>iii) Strong Base-weak Acid<br>iv) Weak Acid- Weak Base<br>Advantages & limitations of conductometric titrations | <b>15</b> |

**Justification:** All the papers of S.Y.B.Sc. in both the semesters are rearranged so that students will focus equally on all the branch of chemistry and able to develop interest as in T.Y.B.Sc. students will have different papers for all the branches of chemistry.

**Learner's space:**

1. Study different types of electrodes.
2. Understand instrumental methods based on the electrochemical properties of the analytes.

3. Laws of crystallography and types of crystals.
4. pH determination using hydrogen electrode and quinhydrone electrode and numericals based on it.

**Job oriented skill development topics:** Knowledge of electrochemistry, phase diagrams of one and two component system, X-ray crystallography, Catalysis, Detailed knowledge of potentiometer, PH. meter and conductometer

## **References:**

### **Unit I and II**

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4<sup>th</sup> Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
4. Mahan, B.H. University Chemistry 3<sup>rd</sup> Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry 5<sup>th</sup> Ed. Macmillan Publishing Co., New York (1985).
6. K.L. Kapoor A textbook of Physical Chemistry 3<sup>rd</sup> Ed. vol.1,2 Macmillan Publishing Co., New Delhi (2001).

### **Unit – III**

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. S.M. Khopkar, "Basic Concepts of Analytical Chemistry", 2<sup>nd</sup> Edition New Age International Publisher.
4. Principles of Instrumental analysis, D. A. Skoog, 3<sup>rd</sup> edition, Saunders college publishing. Chapters: 20, 23 Page Nos: 600 - 605, 631, 704 - 711.
5. Vogel's Text book of quantitative inorganic analysis, 4<sup>th</sup> edition, ELBS/ Longman. Chapters: XIV, XV Page nos: 566 - 601, 615 – 625.
6. Instrumental methods of analysis, B. K. Sharma, Goel publishing house. Miscellaneous methods: Chapters: 1, 3, 4 Page nos: 1 - 14, 21 - 57.

## **ICT Backup:**

1. <https://www.coursera.org/learn/physical-chemistry>
2. <https://ocw.mit.edu/courses/chemistry/5-111sc-principles-of-chemical-science-fall-2014/>



**Pedagogy:**

Videos, presentations, Group discussions, Direct instructions, Inquiry-based learning, Game-based learning, Flipped classrooms etc.

**MOOC:**

| Platform and link   | Course duration | Similarity index | Tentative cost |
|---|-----------------|------------------|----------------|
| <b>1. Platform</b> - edx<br><a href="https://www.edx.org/course/introduction-to-solid-state-chemistry?index=product&amp;queryID=8eca38e1295eb1fd1e02087e102e0b3b&amp;position=24">https://www.edx.org/course/introduction-to-solid-state-chemistry?index=product&amp;queryID=8eca38e1295eb1fd1e02087e102e0b3b&amp;position=24</a> | 15 weeks        | 38%              | Free           |
| <b>2. Platform</b> - edx<br><a href="https://www.edx.org/course/thermodynamics-and-phase-equilibria?index=product&amp;queryID=3a9b992bc292b75eb509732159529fb0&amp;position=1">https://www.edx.org/course/thermodynamics-and-phase-equilibria?index=product&amp;queryID=3a9b992bc292b75eb509732159529fb0&amp;position=1</a>       | 16 weeks        | 73%              | Free           |

**Paper II - Inorganic and Industrial Chemistry (PUSCHIV22-402)**

| Sr. No. | Units                         | Lectures | Credit points |
|---------|-------------------------------|----------|---------------|
| 1       | Unit-I-Inorganic Chemistry    | 15       | 02            |
| 2       | Unit-II-Inorganic Chemistry   | 15       |               |
| 3       | Unit-III-Industrial Chemistry | 15       |               |

**Learning objectives:**

The learner to be imparted with:

1. Chemistry of transition metals.

2. Nature of metal-ligand bond.
3. Introduction to essential and non-essential elements in biological systems.
4. Study of acidity of cations and basicity of anions.
5. Extraction, purification of copper, silver and aluminium.

#### **Learning outcomes:**

On successful completion of this course students will be able to

1. Study the magnetic properties of transition metal compounds.
2. Identify complexes which obeys 18 electron rule.
3. Learn applications of co-ordination chemistry.
4. Classify cations on the basis of acidity category.
5. To understand nature of indeterminate errors, criteria for rejection of doubtful result and test of significance.

|               | <b>Topics</b>  | <b>Lectures</b> |
|---------------|--|-----------------|
| <b>Unit-I</b> | <b>1.1 Comparative chemistry of the transition metals:</b><br>1.1.1 Position in the periodic table; Natural occurrence principal ores and minerals<br>1.1.2 Significance of special stability of $d^0$ , $d^5$ and $d^{10}$ leading to variable oxidation states; Unusual oxidation states and their stabilities in aqueous solutions (with special reference to vanadium, and chromium)<br>1.1.3 Origin of colour for transition metals and their compounds: such as reflectivity, surface coatings, particle size, packing density for metals and nature of d-orbitals, number of electrons in the d-orbitals, geometry, and ability for charge transfer)<br>1.1.4 Magnetic properties of transition metal compounds: Origin of magnetism-spin and orbital motion of electrons; equation for spin only and spin-orbital magnetism in terms of Bohr magnetons (No derivation of relevant equations expected); Reasons for quenching of orbital moments<br>1.1.5 Chemistry of Titanium and vanadium: properties of Oxides and chlorides; use in titrimetric analysis | <b>15</b>       |

|                |  |           |
|----------------|--|-----------|
|                | <p>1.1.6 Qualitative tests for transition metal ions: General considerations in devising tests (with reference to Chromium, Manganese, iron, Cobalt Nickel and Copper)</p> <p><b>1.2 Coordination Chemistry:</b></p> <p>1.2.1 Introduction to Chemistry of Coordination Compounds</p> <p>i) Historical perspectives: Early ideas on coordination compounds</p> <p>ii) Basic terms and nomenclature</p> <p>iii) Types of ligands</p> <p>iv) Isomerism: General Types with special reference to stereoisomerism of coordination compounds (C.N. = 6)</p> <p>v) Evidence for the formation of coordination compounds</p> <p>1.2.2 Theories of coordination compounds</p> <p>i) Werner's Theory of coordination compounds</p> <p>ii) Effective atomic number rule</p> <p>iii) Eighteen electron rule</p> <p>1.2.3 Nature of the Metal-Ligand Bond:</p> <p>i) Valence Bond Theory; Hybridization of the central metal orbitals-<math>sp^3</math>, <math>sd^3/d^3s</math>, <math>sp^3d^2/d^2sp^3</math>, <math>sp^2d</math></p> <p>ii) Inner and outer orbital complexes of (suitable examples of Mn(II) Fe(II), Fe(III), Co(II)/Co(III), Ni(II), Cu(II), Zn(II) complexes with ligands like aqua, ammonia <math>CN^-</math> and halides may be used)</p> <p>iii) Limitations of V.B.T.</p> <p>1.2.4 Application of coordination compounds</p> |           |
| <b>Unit-II</b> | <p><b>2.0 Ions in aqueous medium</b></p> <p><b>2.1 Acidity of Cations and Basicity of Anions</b></p> <p>i) Hydration of Cations; Hydrolysis of Cations predicting degree of hydrolysis of Cations-effect of Charge and Radius</p> <p>ii) Latimer Equation. Relationship between <math>pK_a</math>, acidity and <math>z^2/r</math> ratios of metal ions graphical Presentation</p> <p>iii) Classification of cations on the basis of acidity category – Non acidic, moderately acidic, strongly acidic, very strongly acidic with <math>pK_a</math> values range and examples</p>   | <b>15</b> |

|                 |   |           |
|-----------------|---|-----------|
|                 | iv) Hydration of Anions; Effect of Charge and Radius; Hydration of anions- concept, diagram classification on the basis of basicity<br><b>2.2 Introduction to bioinorganic chemistry</b><br>2.2.1 Essential and non-essential elements in biological systems<br>2.2.2 Biological importance of metal ions such as $\text{Na}^+$ , $\text{K}^+$ , $\text{Fe}^{+2}/\text{Fe}^{+3}$ and $\text{Cu}^{+2}$ (Role of $\text{Na}^+$ AND $\text{K}^+$ w. r. t ion pump)   |           |
| <b>Unit-III</b> | <b>3. Industrial inorganic chemistry</b><br><b>3.1 Extraction and purification of:</b><br>3.1.1 Copper (from pyrites) by pyrometallurgy and electrolysis<br>3.1.2 Silver by hydrometallurgy<br>3.1.3 Aluminium by electrometallurgy<br><b>3.2 Nature of indeterminate errors:</b><br>3.2.1 The true and acceptable value of a result of analysis<br>3.2.2 Measures of central tendency: mean, median. mode, average<br>3.2.3 Measures of dispersion: Absolute deviation, relative deviation, relative average deviation, standard deviation, (s, sigma) variance, coefficient of variation<br><b>3.3 Criteria for rejection of doubtful result:</b><br>3.3.1 2.5 d rule<br>3.3.2 4.0 d rule<br>3.3.3 Q test<br><b>3.4 Test of Significance:</b><br>3.4.1 Null hypothesis<br>3.4.2 F-test (variance ratio test)<br>(Numerical problems expected) | <b>15</b> |

**Justification:** Inorganic industrial chemistry which includes extraction and purification of copper, silver and aluminium is introduced in paper-II which is of commercial importance. Knowledge of inorganic industrial chemistry at UG level will be definitely helpful to students while working in industry and even for research activities.

**Learner's space:**

1. Study of comparative chemistry of transition metals.
2. Nomenclature of co-ordination chemistry.
3. Understand valence bond theory and its applications.

4. To learn industrial inorganic chemistry.
5. The use of statistical methods in chemical analysis.

**Job oriented skill development topics:** Chemistry of transition elements, Co-ordination chemistry, Acidity of cations and basicity of anions, Bio-inorganic chemistry, Extraction and purification of copper, silver and aluminium, Nature of errors.

## **References:**

### **Unit I and II**

1. R. Gopalan, Universities Press India Pvt. Ltd. Inorganic Chemistry for Undergraduates.
2. J. D. Lee, 4<sup>th</sup> Edn., Concise Inorganic Chemistry, ELBS, The group III elements Pg. 359- 648.
3. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3<sup>rd</sup> edition, Oxford University Press (1999) page 325-446.
4. Ramesh Kapoor and R.S. Chopra, Inorganic Chemistry, R. Chand publishers, New Delhi.
5. CNR Rao edited, University General Chemistry, 513-578.
6. James E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity,
7. Cotton and Wilkinson, Advanced Inorganic Chemistry, 3<sup>rd</sup>. Edition.
8. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt. Ltd. (2002).
9. R. Gopalan, Universities Press India Pvt. Ltd. Inorganic Chemistry for Undergraduates.
10. Ramesh Kapoor and R.S. Chopra, Inorganic Chemistry, R. Chand publishers, New Delhi.
11. Emeleus and Anderson, Modern Aspects of Inorganic Chemistry.
12. Cotton and Wilkinson, Advanced Inorganic Chemistry, 3<sup>rd</sup>. Edition.
13. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt. Ltd. (2002).
14. Puri, Sharma and Kalia, Milestone publishers, Principles of Inorganic Chemistry.

### **Unit – III**

1. Fundamental of Analytical Chemistry by Douglas A. Skoog, West, F. James Holler, S. R. Crouch.
2. Modern Analytical Chemistry by David Harvey, McGraw-Hill Higher Education (page numbers 53 - 84).
3. Chemical Process Industries: Shreve and Brink, McGraw Hill Book Co. USA.
4. Industrial chemistry (including environmental engineering) by B. K. Sharma, 7<sup>th</sup> Ed. Meerul Goel Publishing House, 1995(660).
5. Unit operations I and II: D. D. Kale, Pune Vidyarthi Griha Prakashan.
6. Unit Process in Organic Synthesis by P. M. Groggins, McGraw Hill Book Co. USA.

## ICT Backup:

1. <https://ocw.mit.edu/courses/captioned/#chemistry>
2. <https://ocw.mit.edu/courses/chemistry/5-111sc-principles-of-chemical-science-fall-2014/>

## Pedagogy

Direct instructions, Flipped classrooms, Inquiry-based learning, Game-based learning, Videos, presentations, Group discussions etc.

## MOOC

| Platform and link   | Course duration                        | Similarity index (%) | Tentative cost |
|---|--|----------------------|----------------|
| 1. <b>Platform</b> - edx<br><a href="https://www.edx.org/course/chemical-equilibrium-and-kinetics?index=product&amp;queryID=19cbbf05b2b46d972ee88be136a0dbf7&amp;position=1">https://www.edx.org/course/chemical-equilibrium-and-kinetics?index=product&amp;queryID=19cbbf05b2b46d972ee88be136a0dbf7&amp;position=1</a> | 14 weeks                               | 35                   | Free           |
| 2. <b>Platform</b> - Udemy<br><a href="https://www.udemy.com/course/industrial-metallurgy/">https://www.udemy.com/course/industrial-metallurgy/</a>   | 14 lectures (2hr. 24 min total length) | 50                   | 1280/-         |
| 3. <b>Platform</b> - edx<br><a href="https://www.edx.org/course/basic-analytical-chemistry?index=product&amp;queryID=b7310b8687f6783606b3ef51134ddd0d&amp;position=1">https://www.edx.org/course/basic-analytical-chemistry?index=product&amp;queryID=b7310b8687f6783606b3ef51134ddd0d&amp;position=1</a>               | 6 weeks                                | 40                   | Free           |

### Paper III - Organic and Industrial Chemistry (PUSCHIV22-403)

| Sr. No. | Units                         | Lectures | Credit points |
|---------|-------------------------------|----------|---------------|
| 1       | Unit-I-Organic Chemistry      | 15       | 02            |
| 2       | Unit-II-Organic Chemistry     | 15       |               |
| 3       | Unit-III-Industrial Chemistry | 15       |               |

#### Learning objectives:

The learner to be imparted with:

1. Nomenclature, preparation and properties of carboxylic acids and their derivatives.
2. Reactions of sulphonic acids.
3. Chemistry of nitrogen containing compounds and heterocyclic compounds.
4. Separation techniques based on various parameters.
5. Concept of chromatography and their types.

#### Learning outcomes:

On successful completion of this course students will be able to

1. Study various reactions of carboxylic acid.
2. Understand electrophilic substitution in aromatic amines: bromination, nitration and sulphonation.
3. Principle, techniques and applications of paper and thin layer chromatography.
4. Study mechanism of various unit processes.

|               | Topics  | Lectures  |
|---------------|---|-----------|
| <b>Unit-I</b> | <b>1.1 Carboxylic Acids and their Derivatives:</b><br>1.1.1 Nomenclature, structure and physical properties, acidity of carboxylic acids, effects of substituents on acid strength of aliphatic and aromatic carboxylic acids<br>1.1.2 Preparation of carboxylic acids: oxidation of alcohols and alkyl benzene, carbonation of Grignard and hydrolysis of nitriles<br>1.1.3 Reactions: Acidity, salt formation, decarboxylation, Reduction of carboxylic acids with $\text{LiAlH}_4$ , diborane, Hell-Volhard-Zelinsky reaction, Conversion of carboxylic acid to acid | <b>15</b> |

|                |  |           |
|----------------|--|-----------|
|                | <p>chlorides, esters, amides and acid anhydrides and their relative reactivity</p> <p>1.1.4 Mechanism of nucleophilic acyl substitution and acid-catalysed nucleophilic acyl substitution. Interconversion of acid derivatives by nucleophilic acyl substitution</p> <p>1.1.5 Mechanism of Claisen condensation and Dieckmann condensation</p> <p><b>1.2 Sulphonic acids:</b></p> <p>1.2.1 Nomenclature</p> <p>1.2.2 Preparation of aromatic sulphonic acids by sulphonation of benzene (with mechanism), toluene and naphthalene</p> <p>1.2.3 Reactions: Acidity of arene sulfonic acid, Comparative acidity of carboxylic acid and sulfonic acids. Salt formation, desulphonation. Reaction with alcohol, phosphorous pentachloride, IPSO substitution</p>   |           |
| <b>Unit-II</b> | <p><b>Nitrogen containing compounds and heterocyclic compounds:</b></p> <p><b>2.1 Amines:</b></p> <p>Nomenclature, effect of substituent on basicity of aliphatic and aromatic amines</p> <p>2.1.1 Preparation: Reduction of aromatic nitro compounds using catalytic hydrogenation, chemical reduction using Fe-HCl, Sn-HCl, Zn-acetic acid, reduction of nitriles, ammonolysis of halides, reductive amination, Hofmann bromamide reaction</p> <p>2.1.2 Reactions- Salt Formation, N-acylation, N-alkylation, Hofmann's exhaustive methylation (HEM), Hofmann-elimination reaction, reaction with nitrous acid, carbylamine reaction, Electrophilic substitution in aromatic amines: bromination, nitration and sulphonation</p> <p><b>2.2 Diazonium Salts:</b></p> <p>Preparation and their reactions/synthetic application - Sandmeyer reaction, Gattermann reaction, Gomberg reaction, Replacement of diazo group by -H, -OH. Azo coupling with phenols, naphthols and aromatic amines, reduction of diazonium salt to aryl hydrazine and hydroazobenzene</p> <p><b>2.3 Heterocyclic Compounds:</b></p> | <b>15</b> |



|                 |  |           |
|-----------------|--|-----------|
|                 | <p>2.3.1 Classification, nomenclature, electronic structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom</p> <p>2.3.2 Synthesis of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, and Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis)</p> <p>2.3.3 Reactivity of furan, pyrrole and thiophene towards electrophilic substitution reactions on the basis of stability of intermediate and of pyridine on the basis of electron distribution. Reactivity of pyridine towards nucleophilic substitution on the basis of electron distribution</p> <p>2.3.4 Reactions of furan, pyrrole and thiophene: halogenation, nitration sulphonation, Vilsmeier-Haack reaction, Friedel-Crafts reaction. Furan: Diels-Alder reaction, Ring opening. Pyrrole: Acidity and basicity of pyrrole. Comparison of basicity of pyrrole and pyrrolidine</p> <p>2.3.5 Pyridine: Basicity. Comparison of basicity of pyridine, pyrrole and piperidine. Sulphonation of pyridine (with and without catalyst), reduction and action of sodamide (Chichibabin reaction)</p> |           |
| <b>Unit-III</b> | <p><b>3.1 Unit Processes:</b></p> <p>3.1.1 Hydrogenation: Introduction, hydrogenation with molecular hydrogen and catalyst and its mechanism. Commercial hydrogenation of oils and phenol</p> <p>3.1.2 Nitration: Introduction, nitration with mixed acids (nitrating mixture and its mechanism). Commercial nitration of benzene, nitrobenzene and toluene</p> <p>3.1.3 Sulphonation: Introduction, sulphonation with sulphuric acid and oleum and its mechanism, commercial sulphonation of benzene (manufacture of dodecyl benzene sulphonate (DBS). and naphthalene</p> <p><b>3.2 Separation Techniques</b></p> <p>3.2.1 An Introduction to Analytical Separations and its importance in analysis</p> <p>3.2.2 Estimation of an analyte without effecting separation</p>   | <b>15</b> |

|  |  |  |
|--|--|--|
|  | <p>3.2.3 Types of separation methods</p> <p>i) Based on Solubilities (Precipitation, Filtration, Crystallization)</p> <p>ii) Based on Gravity- Centrifugation</p> <p>iii) Based on volatility-Distillation</p> <p>iv) Based on Electrical effects - Electrophoresis</p> <p>v) Based on retention capacity of a Stationary Phase - Chromatography</p> <p>vi) Based on distribution in two immiscible phases-Solvent Extraction</p> <p>vii) Based on capacity to exchange with a resin-Ion Exchange</p> <p><b>3.3 Chromatography</b></p> <p>3.3.1 Introduction to Chromatography</p> <p>3.3.2 Classification of chromatographic methods based on stationary and mobile phase</p> <p>3.3.3 Paper Chromatography: Principle, techniques and applications of Paper Chromatography in separation of cations</p> <p>3.3.4 Thin layer Chromatography Principle, technique and Applications in determining the purity of a given solute; Following progress of a given reaction</p> |  |
|--|--|--|

**Justification:** Introduction of organic industrial chemistry includes various unit processes such as hydrogenation, nitration, sulphonation along with paper and thin layer chromatography. The detailed knowledge of unit processes will help the students to understand the various unit processes carried out in industry at UG level.

**Learner's space:**

1. Study of carboxylic acids, sulphonic acids.
2. To learn the reactions of furan, pyrrole and thiophene.
3. Understand analytical separations and its importance in analysis.
4. To learn various chromatographic techniques.

**Job oriented/Entrepreneurship development topics:** Chemistry of carboxylic and sulphonic acids, Chemistry of nitrogen containing compounds, Unit processes and chromatography.

## References:

### Unit I and II

1. Morrison, R. T. and Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education) 2012.
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
5. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
6. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
7. Comprehensive Organic Chemistry- The synthesis and reactions of Organic Compounds, Derek barton ,W. David Ollis.
8. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
9. Eliel, E. L. and Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
10. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.

### Unit III

1. D. A. Skoog, D. M. West, F. J. Holler, and S. R. Crouch, Analytical Chemistry: An Introduction, 7th ed., Chapter 15, pp. 345-381.
2. A.I. Vogel. "Textbook of Quantitative Inorganic Analysis," Longman, London (1961).
3. R.V. Dilts. "Analytical Chemistry. Methods of Separation," van Nostrand, N.Y. (1974).
4. Some Experiments for B. Tech in Chemistry & Chemical Technology compiled by Prof. J.B. BARUAH, Mrs. Abhilasha Mohan Baruah and Mr. Parikshit Gogo.
5. Industrial chemistry (including environmental engineering) by B. K. Sharma, 7<sup>th</sup> Ed. Meerul Goel Publishing House, 1995(660).
6. Unit operations I and II: D. D. Kale, Pune Vidyarthi Griha Prakashan.
7. Unit Process in Organic Synthesis by P. M. Groggings, McGraw Hill Book Co. USA.
8. Chemical Process Industries: Shreve and Brink, McGraw Hill Book Co. USA.

## ICT Backup:

1. [http://ifs.se/IFS/Documents/Other/Video%20Lectures%20book%20Organic%20Chemistry\\_Atta-ur-Rahman%20and%20Syeda%20Sadiah%20Khatoon.pdf](http://ifs.se/IFS/Documents/Other/Video%20Lectures%20book%20Organic%20Chemistry_Atta-ur-Rahman%20and%20Syeda%20Sadiah%20Khatoon.pdf)
2. <https://ocw.mit.edu/courses/chemistry/5-111-principles-of-chemical-science-fall-2008/video-lectures/lecture-1/>

**Pedagogy:**

Direct instructions, Flipped classrooms, Inquiry-based learning, Game-based learning, Videos, presentations, Group discussions etc.

**MOOC:**

| Platform and link   | Course duration         | Similarity index (%) | Tentative cost |
|---|-------------------------|----------------------|----------------|
| 1. <b>Platform</b> – Udemy<br><a href="https://www.udemy.com/course/organic-chemistry-online-course-lectures-examples-rahch110-rahsoft/">https://www.udemy.com/course/organic-chemistry-online-course-lectures-examples-rahch110-rahsoft/</a> | 15hr. 8min total length | 70                   | 1280/-         |
| 2. <b>Platform</b> – Udemy<br><a href="https://www.udemy.com/course/iupac-nomenclature-of-organic-compounds/">https://www.udemy.com/course/iupac-nomenclature-of-organic-compounds/</a>   | 4hr. 19min total length | 40                   | 1280/-         |

**Laboratory work (Practicals) (Semester IV) (PUSCHIV22-P411)****Learning objectives:**

The learner will be imparted with

1. Determination of amount of HCl in the given sample potentiometrically.
2. Qualitative analysis of bi-functional organic compounds using micro-scale technique.
3. Synthesis of inorganic complexes by various methods.
4. Chemical kinetics experiments to compare the strengths of HCl and H<sub>2</sub>SO<sub>4</sub>.

**Learning outcomes:**

On completion of these experimentations, the learner will be able to

1. Determine standard EMF and the standard free energy change of Daniel cell potentiometrically.
2. To synthesize various inorganic complexes.
3. Compare the strengths of HCl and H<sub>2</sub>SO<sub>4</sub> by studying kinetics of acid hydrolysis of methyl acetate.
4. Perform qualitative analysis of bi-functional organic compounds.

|                  | <b>Practicals</b>   |
|------------------|---|
| <b>Paper-I</b>   | <b>Physical/Analytical Chemistry</b> <ol style="list-style-type: none"> <li>1. To determine standard EMF and the standard free energy change of Daniel cell potentiometrically.</li> <li>2. To determine the amount of HCl in the given sample potentiometrically.</li> <li>3. Compare the strengths of HCl and H<sub>2</sub>SO<sub>4</sub> by studying kinetics of acid hydrolysis of methyl acetate.</li> <li>4. Estimation of given acid by conductometric titration with strong base.</li> <li>5. Estimation of Fe(II) in the given solution by titrating against K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> potentiometrically.</li> <li>6. Tools of Analytical Chemistry-II.</li> </ol> |
| <b>Paper-II</b>  | <b>Inorganic Chemistry</b> <ol style="list-style-type: none"> <li>1. Inorganic preparations:               <ol style="list-style-type: none"> <li>i) Nickel dimethyl glyoxime using microscale method.</li> <li>ii) Tris (ethylene diamine) nickel (II) thiosulphate.</li> <li>iii) Sodium Hexanitrocobaltate (III)</li> </ol> </li> <li>2. Estimation of sulphate as BaSO<sub>4</sub>.</li> </ol>  |
| <b>Paper-III</b> | <b>Paper III: Organic Chemistry</b> <p>Qualitative Analysis of bi-functional organic compounds.</p> <p>The analysis is to be carried out using micro-scale technique.</p> <ol style="list-style-type: none"> <li>2. Industrial visit.</li> </ol>  |

**Justification:** As the syllabi has been reshuffled into different branches of chemistry, accordingly practicals are also reshuffled with minor modifications as additions. In Paper-III, qualitative analysis of bi-functional organic compounds will be carried out using micro-scale technique. In Paper-III, industrial visit is included which was not there in existing syllabus. Industrial visit will be organized to give students access to first-hand information.

**Learner's space:**

1. Student's will able to understand and perform practicals of all branches of chemistry.
2. They will learn various tools of analytical chemistry.
3. Able to prepare various inorganic complexes.
4. Students able to qualitative analysis of bifunctional organic compounds using micro-scale techniques.

**Job oriented/Entrepreneurship development topics:** All the three papers of practicals will be helpful to students to develop their practical as well as research-oriented skills.

**References:**

**Paper I:**

1. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
2. Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8<sup>th</sup> Ed., McGraw-Hill, New York (2003).
3. Halpern A.M. and McBane G.C., Experimental Physical Chemistry, 3<sup>rd</sup> Ed., W.H. Freeman and Co., New York (2003).
4. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001).

**Paper II:**

1. Practical Inorganic Chemistry by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972).

**Paper III:**

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

**ICT Backup:**

1. <https://www.udemy.com/course/chemistry-practicals-activities-of-chemical-reactions/>
2. <https://www.classcentral.com/course/teaching-practical-science-chemistry-9116>
3. <https://www.youtube.com/watch?v=fJDc7gHfGzI>
4. <https://www.youtube.com/watch?v=-YOViFsRz0A>

**Syllabus of following universities referred:**

1. Savitribai Phule Pune University, Pune
2. Shivaji University, Kolhapur
3. University of Kolkata, Kolkata

4. Banaras Hindu University, Varanasi
5. Harvard University, Massachusetts, USA

**EVALUATION SCHEME:**

**EXAMINATION PATTERN**

External Exam: 60 marks

Internal Exam: 40 marks

**External Exam Paper Pattern:**

Total marks: 60

Duration: 2 hr.

|           |   |  |                 |
|-----------|---|--|-----------------|
| <b>1.</b> | <b>EXTERNAL ASSESSMENT FOR THEORY<br/>(Semester End Examination)</b>        |  | <b>60 Marks</b> |
|           | N.B. 1. All questions are compulsory<br>2. All questions carry equal marks. |  |                 |
|           | Q.1   | Based on Unit-I, II and III<br>A) Multiple choice questions<br>B) Fill in the blanks<br>C) Short questions (one or two line) | 06<br>03<br>03  |
|           | Q.2<br>A)<br>OR<br>B)<br>P)<br>OR<br>Q)                                     | Unit-I   | 06/07<br>06/05  |
|           | Q.3<br>A)<br>OR<br>B)<br>P)<br>OR<br>Q)                                     | Unit-II  | 06/07<br>06/05  |
|           | Q.4<br>A)<br>OR<br>B)<br>P)   | Unit-III   | 06/07<br>06/05  |

|  |          |  |    |
|--|----------|--|----|
|  | OR<br>Q) |  |    |
|  | Q.5      | Unit-I to III (Solve any three out of six) | 12 |

### Internal Exam Pattern: 40 marks

| 2.  | INTERNAL ASSESSMENT   | 40 Marks |
|-----|---|----------|
| 2.1 | One class test (Objectives/ Multiple Choice)                    | 20 Marks |
| 2.2 | Assignment/ Project/ Presentation/Book or research paper Review | 15 Marks |
| 2.3 | Active participation, Overall performance                       | 05 Marks |

### Evaluation Pattern for S.Y.B.Sc. (PRACTICALS)

Practical examination of each paper for 50 marks will be held for three and half hours.

| 3. | EXTERNAL ASSESSMENT FOR PRACTICALS | 150 Marks |
|----|------------------------------------|-----------|
|    | For SEM-III and IV                 |           |
|    | Experiment No. 1 (Paper-I)         | 40        |
|    | Experiment No. 2 (Paper-II)        | 40        |
|    | Experiment No. 3 (Paper-III)       | 40        |
|    | Viva                               | 15        |
|    | Journal                            | 15        |
|    | TOTAL MARKS                        | 150       |

Students will have to perform the necessary experiments in each semester and all experiments should be reported in journal.

### Passing Standard:

1. The student will have to secure a minimum of 40% marks in internal assessment as well as semester end examination per theory paper, for all the theory papers.
2. The college will conduct the semester examinations of 50 marks per practical paper at the end of each semester. The student will have to secure a minimum of 40% marks in the examination per practical paper, for all the above practical papers.



**DOMBIVLI SHIKSHAN PRASARAK MANDAL'S,  
K.V. PENDHARKAR COLLEGE OF ARTS, SCIENCE AND  
COMMERCE, AUTONOMOUS.  
DOMBIVLI (EAST), MAHARASHTRA, 421 203, INDIA.**

**Faculty of Sciences  
DEPARTMENT OF CHEMISTRY  
Programme: Bachelor of Science (B.Sc.)**

**SYLLABUS FOR:  
T. Y. B.Sc. – Chemistry (Six Units)  
Choice Based Credit System (CBCS) with effect from the Academic  
Year 2021-22**

## SEMESTER V

### PHYSICAL CHEMISTRY

COURSE CODE: PUSCHV21511

CREDITS: 02

LECTURES: 60

| UNIT    | TOPIC  | NO. OF Lectures |
|---------|--|-----------------|
| UNIT I  | 1.0 MOLECULAR SPECTROSCOPY   | 15L             |
|         | <p>1.1 <b>Rotational Spectrum:</b> Introduction to dipole moment, polarization of a bond, bond moment, molecular structure, .Rotational spectrum of a diatomic molecule, rigid rotor, moment of inertia, energy levels, conditions for obtaining pure rotational spectrum, selection rule, nature of spectrum, determination of internuclear distance and isotopic shift.</p> <p>1.2 <b>Vibrational spectrum:</b> Vibrational motion, degrees of freedom, modes of vibration, vibrational spectrum of a diatomic molecule, simple harmonic oscillator, energy levels, zero point energy, conditions for obtaining vibrational spectrum, selection rule, nature of spectrum.</p> <p>1.3 <b>Vibrational-Rotational spectrum of diatomic molecule:</b> energy levels, selection rule, nature of spectrum, P and R branch lines. Anharmonic oscillator - energy levels, selection rule, fundamental band, overtones. Application of vibrational-rotational spectrum in determination of force constant and its significance. Infrared spectra of simple molecules like H<sub>2</sub>O and CO<sub>2</sub>.</p> <p>1.4 <b>Raman Spectroscopy :</b> Scattering of electromagnetic radiation, Rayleigh scattering, Raman scattering, nature of Raman spectrum, Stoke's lines, anti-Stoke's lines, Raman shift, quantum theory of Raman spectrum, comparative study of IR and Raman spectra, rule of mutual exclusion- CO<sub>2</sub> molecule.</p> |                 |
| UNIT II | 2.0 CHEMICAL THERMODYNAMICS  | 10 L            |
|         | <p>2.1.1 <b>Colligative properties:</b> Vapour pressure and relative lowering of vapour pressure.<br/>Measurement of lowering of vapour pressure - Static and Dynamic method.</p>  |                 |
|         | <p>2.1.2 <b>Solutions of Solid in Liquid:</b><br/>2.1.21 Elevation in boiling point of a solution, thermodynamic derivation relating elevation in boiling point of the solution and molar mass of non-volatile solute.<br/>2.1.22 Depression in freezing point of a solution, thermodynamic</p>  |                 |

|          |  |     |
|----------|--|-----|
|          | derivation relating the depression in the freezing point of a solution and the molar mass of the non-volatile solute. Beckmann Method and Rast Method.   |     |
|          | 2.1.3 <b>Osmotic Pressure</b> : Introduction, thermodynamic derivation of Van't Hoff equation, Van't Hoff Factor. Measurement of Osmotic Pressure - Berkeley and Hartley's Method, Reverse Osmosis.  |     |
|          | 2.2 CHEMICAL KINETICS  | 5 L |
|          | 2.2.1 <b>Collision theory of reaction rates</b> : Application of collision theory to 1. Unimolecular reaction Lindemann theory and 2. Bimolecular reaction.<br>(derivation expected for both)<br><br>2.2.2 Classification of reactions as slow, fast and ultra -fast. Study of kinetics of fast reactions by Stop flow method and Flash photolysis (No derivation expected). |     |
|          |  |     |
| UNIT III | 3.0 NUCLEAR CHEMISTRY  | 15L |
|          | 3.1. <b>Introduction:</b> Basic terms-radioactive constants (decay constant, half life and average life) and units of radioactivity  |     |
|          | 3.2 <b>Detection and Measurement of Radioactivity:</b> Types and characteristics of nuclear radiations, behaviour of ion pairs in electric field, detection and measurement of nuclear radiations using G. M. Counter and Scintillation Counter.   |     |
|          | 3.3 <b>Application of use of radioisotopes as Tracers</b> : chemical reaction mechanism, age determination - dating by C <sup>14</sup> .   |     |
|          | 3.4 <b>Nuclear reactions:</b> nuclear transmutation (one example for each projectile), artificial radioactivity, Q - value of nuclear reaction, threshold energy.  |     |
|          | 3.5 <b>Fission Process</b> : Fissile and fertile material, nuclear fission, chain reaction, factor controlling fission process. multiplication factor and critical size or mass of fissionable material, nuclear power reactor and breeder reactor.  |     |
|          | 3.6 <b>Fusion Process</b> : Thermonuclear reactions occurring on stellar bodies and earth.   |     |
|          |  |     |
| UNIT IV  | 4.1 SURFACE CHEMISTRY  | 6L  |
|          | 4.1.1 <b>Adsorption:</b> Physical and Chemical Adsorption, types of adsorption isotherms . Langmuir's adsorption isotherm (Postulates and derivation expected).<br>B.E.T. equation for multilayer adsorption, (derivation not expected). Determination of surface area of an adsorbent using B.E.T. equation.  |     |
|          | 4.2 COLLOIDAL STATE  | 9L  |
|          | 4.2.1 <b>Introduction to colloids</b> - Emulsions, Gels and Sols   |     |
|          | 4.2.2 <b>Electrical Properties</b> : Origin of charges on colloidal particles, Concept of electrical double layer, zeta potential, Helmholtz and Stern model.<br>Electro-kinetic phenomena - Electrophoresis, Electro-osmosis, Streaming potential, Sedimentation potential; Donnan Membrane   |     |

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|  | Equilibrium.   |  |
|  | 4.2.3 <b>Colloidal electrolytes</b> : Introduction, micelle formation,                                     |  |
|  | 4.2.4 <b>Surfactants</b> : Classification and applications of surfactants in detergents and food industry. |  |

### Reference Books :

1. Physical Chemistry, Ira Levine, 5th Edition, 2002 Tata McGraw Hill Publishing Co.Ltd.
2. Physical Chemistry, P.C. Rakshit, 6th Edition, 2001, Sarat Book Distributors, Kolkata.
3. Physical Chemistry, R.J. Silbey, & R.A. Alberty, 3rd edition , John Wiley & Sons, Inc [part 1]
4. Physical Chemistry, G. Castellan, 3rd edition, 5th Reprint, 1995 Narosa Publishing House.
5. Modern Electrochemistry, J.O.M Bockris & A.K.N. Reddy, Maria Gamboa – Aldeco 2nd Edition, 1st Indian reprint,2006 Springer
6. Fundamental of Molecular Spectroscopy, 4<sup>th</sup> Edn., Colin N Banwell and Elaine M McCash Tata McGraw Hill Publishing Co. Ltd. New Delhi, 2008.
7. Physical Chemistry, G.M. Barrow, 6th Edition, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
8. The Elements of Physical Chemistry, P.W. Atkins, 2nd Edition, Oxford Universtity Press Oxford.
9. Physical Chemistry, G.K. Vemullapallie, 1997, Prentice Hall of India, Pvt.Ltd. New Delhi.
10. Principles of Physical Chemistry B.R. Puri, L.R. Sharma, M.S. Pathania, VISHAL PUBLISHING Company, 2008.
11. Textbook of Polymer Science, Fred W Bilmeyer, John Wiley & Sons (Asia) Ple. Ltd., Singapore, 2007.
12. Polymer Science, V.R. Gowariker, N.V. Viswanathan, Jayadev Sreedhar, New Age International (P) Ltd., Publishers, 2005.
13. Essentials of Nuclear Chemistry, Arnika, Hari Jeevan , New Age International (P) Ltd., Publishers, 2011..
14. Chemical Kinetics,K. Laidler, Pearson Education India, 1987.

## SEMESTER V

T.Y.B.Sc      Physical Chemistry Practical

COURSE CODE: PUSCHV21P511 CREDITS: 02

### Non-Instrumental

#### **Colligative properties**

To determine the molecular weight of compound by Rast Method

#### **Chemical Kinetics**

To determine the order between  $K_2S_2O_8$  and KI by fractional change method. **(six units and three units)**

#### **Surface phenomena**

To investigate the adsorption of acetic acid on activated charcoal and test the validity of Freundlich adsorption isotherm.

### **Instrumental**

#### **Potentiometry**

To determine the solubility product and solubility of AgCl potentiometrically using chemical cell.

#### **Conductometry**

To determine the velocity constant of alkaline hydrolysis of ethyl acetate by conductometric method.

#### **pH-metry**

To determine acidic and basic dissociation constants of amino acid and hence to calculate isoelectric point.

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### **Reference books**

1. Practical Physical Chemistry 3rd edition A.M.James and F.E. Prichard , Longman publication
2. Experiments in Physical Chemistry R.C. Das and B. Behra, Tata Mc Graw Hill
3. Advanced Practical Physical Chemistry J.B.Yadav, Goel Publishing House
4. Advanced Experimental Chemistry. Vol-I J.N.Gurtu and R Kapoor, S.Chand and Co.
5. Experimental Physical Chemistry By V.D.Athawale.
6. Senior Practical Physical Chemistry By: B. D. Khosla, V. C. Garg and A. Gulati, R Chand and Co.. 2011

## **SEMESTER VI**

### **PHYSICAL CHEMISTRY**

**COURSE CODE: PUSCHVI21611      CREDITS: 02**

**LECTURES: 60**

|        |   |    |
|--------|---|----|
| UNIT I | 1.1 ELECTROCHEMISTRY  | 7L |
|        | 1.1.1 <b>Activity and Activity Coefficient:</b> Lewis concept, ionic strength, Mean ionic activity and mean ionic activity coefficient of an electrolyte, expression for activities of electrolytes. Debye-Huckel limiting law (No derivation). |    |
|        | 1.1.2 <b>Classification of cells:</b> Chemical cells and Concentration cells.<br>Chemical cells with and without transference, Electrode Concentration cells, Electrolyte concentration cells with and without transference                     |    |

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|          | (derivations are expected),   |      |
|          | 1.2 APPLIED ELECTROCHEMISTRY  | 8L   |
|          | 1.2.1 <b>Polarization</b> : concentration polarization and its elimination  |      |
|          | 1.2.2 <b>Decomposition Potential and Overvoltage</b> : Introduction, experimental determination of decomposition potential, factors affecting decomposition potential. Tafel's equation for hydrogen overvoltage, experimental determination of over –voltage                       |      |
| UNIT II  | 2.0 POLYMERS  | 15L  |
|          | 2.1 <b>Basic terms</b> : macromolecule, monomer, repeat unit, degree of polymerization.   |      |
|          | 2.2. <b>Classification of polymers</b> : Classification based on source, structure, thermal response and physical properties.   |      |
|          | 2.3. <b>Molar masses of polymers</b> : Number average, Weight average, Viscosity average molar mass, Monodispersity and Polydispersity  |      |
|          | 2.4. <b>Method of determining molar masses of polymers</b> : Viscosity method using Ostwald Viscometer. (derivation expected)   |      |
|          | 2.5. <b>Light Emitting Polymers</b> : Introduction, Characteristics, Method of preparation and applications.  |      |
|          | 2.6. <b>Antioxidants and Stabilizers</b> : Antioxidants , Ultraviolet stabilizers, Colourants, Antistatic agents and Curing agents.   |      |
|          |   |      |
| UNIT III | 3.1 BASICS OF QUANTUM CHEMISTRY   | 10 L |
|          | 3.1.1 <b>Classical mechanics</b> : Introduction, limitations of classical mechanics, Black body radiation, photoelectric effect, Compton effect.  |      |
|          | 3.1.2 <b>Quantum mechanics</b> : Introduction, Planck's theory of quantization, wave particle duality, de –Broglie's equation, Heisenberg's uncertainty principle.  |      |
|          | 3.1.3 <b>Progressive and standing waves</b> - Introduction, boundary conditions, Schrodinger's time independent wave equation (No derivation expected), interpretation and properties of wave function.   |      |
|          | 3.1.4 <b>Quantum mechanics</b> : State function and its significance, Concept of operators - definition, addition, subtraction and multiplication of operators, commutative and non - commutative operators, linear operator, Hamiltonian operator, Eigen function and Eigen value. |      |
|          | 3.2 RENEWABLE ENERGY RESOURCES  | 5L   |
|          | 3.2.1. <b>Renewable energy resources</b> : Introduction.  |      |
|          | 3.2.2 <b>Solar energy</b> : Solar cells, Photovoltaic effect, Differences between conductors,semiconductors ,insulators and its band gap, Semiconductors as solar energy converters, Silicon solar cell   |      |
|          | 3.2.3. <b>Hydrogen</b> : Fuel of the future, production of hydrogen by direct electrolysis of water, advantages of hydrogen as a universal energy medium.   |      |

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| UNIT IV | 4.1 NMR -NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY  | 7L |
|         | <b>4.1.1. Principle :</b> Nuclear spin, magnetic moment, nuclear 'g' factor, energy levels, Larmor precession, Relaxation processes in NMR ( spin -spin relaxation and spin - lattice relaxation).<br><b>4.1.2. Instrumentation:</b> NMR Spectrometer |    |
|         | 4.2 ELECTRON SPIN RESONANCE SPECTROSCOPY  |    |
|         | <b>4.2.1. Principle:</b> fundamental equation, g-value -dimensionless constant or electron g-factor, hyperfine splitting.<br><b>4.2.2. Instrumentation:</b> ESR spectrometer, ESR spectrum of hydrogen and deuterium.                                 | 8L |

**Note : Numericals and Word Problems are Expected from All**

**Units Reference Books :**

1. Physical Chemistry, Ira Levine, 5th Edition, 2002 Tata McGraw Hill Publishing Co.Ltd.
2. Physical Chemistry, P.C. Rakshit, 6th Edition, 2001, Sarat Book Distributors, Kolkota.
3. Physical Chemistry, R.J. Silbey, & R.A. Alberty, 3rd edition , John Wiley & Sons, Inc [part 1]
4. Physical Chemistry, G. Castellan, 3rd edition, 5th Reprint, 1995 Narosa Publishing House.
5. Modern Electrochemistry, J.O.M Bockris & A.K.N. Reddy, Maria Gamboa – Aldeco 2nd Edition, 1st Indian reprint,2006 Springer
6. Fundamental of Molecular Spectroscopy, 4<sup>th</sup> Edn., Colin N Banwell and Elaine M McCash Tata McGraw Hill Publishing Co. Ltd. New Delhi, 2008.
7. Physical Chemistry, G.M. Barrow, 6th Edition, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
8. The Elements of Physical Chemistry, P.W. Atkins, 2nd Edition, Oxford Universtity Press Oxford.
9. Physical Chemistry, G.K. Vemullapallie, 1997, Prentice Hall of India, Pvt.Ltd. New Delhi.
10. Principles of Physical Chemistry B.R. Puri, L.R. Sharma, M.S. Pathania, VISHAL PUBLISHING Company, 2008.
11. Textbook of Polymer Science, Fred W Bilmeyer, John Wiley & Sons (Asia) Ple. Ltd., Singapore, 2007.
12. Polymer Science, V.R. Gowariker, N.V. Viswanathan, Jayadev Sreedhar, New Age International (P) Ltd., Publishers, 2005.
13. Essentials of Nuclear Chemistry, Arnikar, Hari Jeevan , New Age International (P) Ltd., Publishers, 2011..
14. Chemical Kinetics,K. Laidler, Pearson Education India, 1987.



**SEMESTER VI  
PHYSICAL CHEMISTRY**

**COURSE CODE: PUSCHVI21P611**

**CREDITS: 02**

**Non-Instrumental**

**Chemical Kinetics**

To interpret the order of reaction graphically from the given experimental data and calculate the specific rate constant.

(No fractional order)

**Viscosity**

To determine the molecular weight of high polymer polyvinyl alcohol (PVA) by viscosity measurement.

**Instrumental**

**Potentiometry**

To determine the amount of iodide, bromide and chloride in the mixture by potentiometric titration with silver nitrate.

To determine the number of electrons in the redox reaction between ferrous ammonium sulphate and ceric sulphate potentiometrically.

**Conductometry**

To titrate a mixture of weak acid and strong acid against strong base and estimate the amount of each acid in the mixture conductometrically.

**Colorimetry**

To estimate the amount of Fe(III) in the complex formation with salicylic acid by Static Method.

**Reference books**

1. Practical Physical Chemistry 3rd edition A.M.James and F.E. Prichard , Longman publication
2. Experiments in Physical Chemistry R.C. Das and B. Behra, Tata Mc Graw Hill
3. Advanced Practical Physical Chemistry J.B.Yadav, Goel Publishing House
4. Advanced Experimental Chemistry. Vol-I J.N.Gurtu and R Kapoor, S.Chand and Co.
5. Experimental Physical Chemistry By V.D.Athawale.
6. Senior Practical Physical Chemistry By: B. D. Khosla, V. C. Garg and A. Gulati, R Chand and Co.. 2011

**SEMESTER V**  
**INORGANIC CHEMISTRY**

COURSE CODE: PUSCHV21512

CREDITS: 02

LECTURES: 60

| <b>UNIT I</b>   | <b>L/Week</b> |
|---|---------------|
| <b>1. Molecular Symmetry and Chemical Bonding</b>   |               |
| <b>1.1 Molecular Symmetry (6L)</b>  |               |
| 1.1.1 Introduction and Importance of Symmetry in Chemistry.   |               |
| 1.1.2 Symmetry elements and Symmetry operations.  |               |
| 1.1.3 Concept of a Point Group with illustrations using the following point groups : (i) $C_{\infty v}$ (ii) $D_{\infty h}$ (iii) $C_{2v}$ (iv) $C_{3v}$ (v) $C_{2h}$ and (vi) $D_{3h}$                                       |               |
| <b>1.2 Molecular Orbital Theory for heteronuclear diatomic molecules and polyatomic species (9L)</b>  |               |
| 1.2.1 Comparison between homonuclear and heteronuclear diatomic molecules.  |               |
| 1.2.2. Heteronuclear diatomic molecules like CO, NO and HCl, appreciation of modified MO diagram for CO.  |               |
| 1.2.3 Molecular orbital theory for $H_3$ and $H^+$ (correlation diagram expected).  |               |
| 1.2.4. Molecular shape to molecular orbital approach in $AB_2$ molecules. Application of symmetry concepts for linear and angular species considering $\sigma$ - bonding only.<br>(Examples like : i) $BeH_2$ , ii) $H_2O$ ). |               |
| <b>UNIT-II</b>  |               |
| <b>2 SOLID STATE CHEMISTRY</b>  |               |
| <b>2.1 Structures of Solids (11L)</b>   |               |
| 2.2.1 Explanation of terms viz. crystal lattice, lattice point, unit cell and lattice constants.  |               |
| 2.1.2 Closest packing of rigid spheres (hcp, ccp), packing density in simple cubic, bcc and fcc lattices. Relationship between density, radius of unit cell and lattice parameters.   |               |

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| 2.1.3 Stoichiometric Point defects in solids (discussion on Frenkel and Schottky defects expected).   |  |
| <b>2.2 Superconductivity (4L)</b>   |  |
| 2.2.1 Discovery of superconductivity.   |  |
| 2.2.2 Explanation of terms like superconductivity, transition temperature, Meissner effect.   |  |
| 2.2.3 Different types of super conductors viz.conventional superconductors, alkali metal fullerenes, high temperature super conductors.   |  |
| 2.2.4 Brief application of superconductors.   |  |
| <b>UNIT-III</b>   |  |
| <b>3.0 CHEMISTRY OF INNER TRANSITION ELEMENTS (15L)</b>   |  |
| <b>3.1 Introduction:</b> Position in periodic table and electronic configuration of lanthanides and actinides.  |  |
| <b>3.2 Chemistry of Lanthanides with reference to</b> (i) lanthanide contraction and its consequences(ii) Oxidation states (iii) Ability to form complexes (iv) Magnetic and spectral properties                                  |  |
| <b>3.3 :</b> Occurrence, extraction and separation of lanthanides by (i) Ion Exchange method and (ii) Solvent extraction method (Principles and technique)  |  |
| <b>3.4</b> Applications of lanthanides  |  |
| <b>UNIT-IV</b>  |  |
| <b>4. SOME SELECTED TOPICS</b>  |  |
| <b>4.1 Chemistry of Non-aqueous Solvents (5 L)</b>  |  |
| 4.1.1 Classification of solvents and importance of non-aqueous solvents.  |  |
| 4.1.2 Characteristics and study of liquid ammonia, dinitrogen tetra oxide as non-aqueous solvents with respect to : (i) acid-base reactions and (ii) redox reactions.   |  |
| <b>4.2 Comparative Chemistry of Group 16 (5L)</b>   |  |
| 4.2.1 Electronic configurations, trends in physical properties, allotropy   |  |
| 4.2.2 Manufacture of sulphuric acid by Contact process.   |  |
| <b>4.3 Comparative Chemistry of Group 17 (5L)</b>   |  |
| 4.3.1 Electronic configuration , General characteristics, anomalous properties of fluorine, comparative study of acidity of oxyacids of chlorine w.r.t acidity, oxidising properties and structures(on the basis of VSEPR theory) |  |
| 4.3.2 Chemistry of interhalogens with reference to preparations, properties and structures (on the basis of VSEPR theory) .   |  |
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## **REFERENCES**

### **SEM-V**

#### **Unit-I**

1. Per Jensen and Philip R. Bunker , Fundamentals of Molecular Symmetry , Series in Chemical Physics, Taylor & Francis Group
2. J. S. Ogden, Introduction to Molecular Symmetry, Oxford University Press
3. Derek W. Smith, Molecular orbital theory in inorganic chemistry Publisher: Cambridge University Press
4. C. J. Ballhausen, Carl Johan Ballhausen, Harry B. Gray Molecular Orbital Theory: An Introductory Lecture Note and Reprint Volume Frontiers in chemistry Publisher W.A. Benjamin, 1965
5. Jack Barrett and Mounir A Malati, Fundamentals of Inorganic Chemistry, Affiliated East west Press Pvt. Ltd., New Delhi.
6. Satya Prakash, G.D.Tuli, R.D. Madan , , Advanced Inorganic Chemistry.S. Chand & Co Ltd

#### **Unit-II**

1. Lesley E. Smart, Elaine A. Moore Solid State Chemistry: An Introduction, 2nd Edition CRC Press,
2. C. N. R. Rao Advances in Solid State Chemistry
3. R.G. Sharma Superconductivity: Basics and Applications to Magnets
4. Michael Tinkham ,Introduction to Superconductivity: Vol I (Dover Books on Physics)
5. R. Gopalan, Inorganic Chemistry for Undergraduates, Universities Press India.
6. Richard Harwood, Chemistry, Cambridge University Press,
7. Satya Prakash, G.D.Tuli, R.D. Madan , , Advanced Inorganic Chemistry.S. Chand & Co Ltd .

#### **Unit-III**

1. Cotton, Wilkinson, Murillo and Bochmann, Advanced Inorganic Chemistry, 6<sup>th</sup> Edition.
2. Greenwood, N.N. and Earnshaw, Chemistry of the Elements, Butterworth Heinemann. 1997.
3. Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.
4. G. Singh, Chemistry of Lanthanides and Actinides, Discovery Publishing House
5. Simon Cotton , Lanthanide and Actinide Chemistry Publisher: Wiley-Blackwell

#### **Unit-IV**

1. B. H. Mahan, University Chemistry, Narosa publishing.

2. R. Gopalan, Inorganic Chemistry for Undergraduates, Universities Press India.
3. J. D. Lee, Concise Inorganic Chemistry, 4<sup>th</sup> Edn., ELBS,
4. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3<sup>rd</sup> edition, Oxford University Press
5. Cotton, Wilkinson, Murillo and Bochmann, Advanced Inorganic Chemistry, 6<sup>th</sup> Edition.
6. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt., Ltd. (2002).
7. Richard Harwood, Chemistry, chapter 10 Industrial inorganic chemistry
8. Greenwood, N.N. and Earnshaw, Chemistry of the Elements, Butterworth Heinemann. 1997.
9. Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993
10. Satya Prakash, G.D. Tuli, R.D. Madan, Advanced Inorganic Chemistry. S. Chand & Co Ltd 2004

## **Practicals**

### **SEMESTER V**

### **INORGANIC CHEMISTRY**

**COURSE CODE: PUSCHV21P511**

**CREDITS: 02**

#### **I. Inorganic preparations**

1. Preparation of Potassium diaquobis- (oxalato)cuprate (II)
2. Preparation of Ferrous ethylene diammonium sulphate.
3. Preparation of bisacetyl acetonato copper (II)

#### **II. Determination of percentage purity of the given water soluble salt and qualitative detection w.r.t added cation and/or anion (qualitative analysis only by wet tests).**

(Any three salts of transition metal ions)

#### **Reference Books (practicals)**

1. Vogel Textbook of Quantitative Chemical Analysis G.H. Jeffery, J. Basset.

2. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N.Dhur & Sons Pvt Ltd .
3. Vogel's. Textbook of. Macro and Semimicro qualitative inorganic analysis. Fifth edition.

## SEMESTER VI

### INORGANIC CHEMISTRY

**COURSE CODE: PUSCHVI21612**

**CREDITS: 02**

**LECTURES: 60**

| (Numericals and word problems are expected)  |               |
|--|---------------|
| <b>UNIT-I</b>  | <b>L/week</b> |
| <b>1.Theories of the metal-ligand bond (I) (15L)</b>   |               |
| <b>1.1</b> Limitations of Valence Bond Theory.   |               |
| <b>1.2</b> Crystal Field Theory and effect of crystal field on central metal valence orbitals in various geometries from linear to octahedral(from coordination number 2 to coordination number 6) |               |
| <b>1.3</b> Splitting of <i>d</i> orbitals in octahedral, square planar and tetrahedral crystal fields.   |               |
| <b>1.4</b> Distortions from the octahedral geometry : (i) effect of ligand field and (ii) Jahn-Teller distortions.   |               |
| <b>1.5</b> Crystal field splitting parameters $\Delta$ ; its calculation and factors affecting it in octahedral complexes, Spectrochemical series.   |               |
| <b>1.6</b> Crystal field stabilization energy(CFSE), calculation of CFSE for octahedral complexes with $d^0$ to $d^{10}$ metal ion configurations.   |               |
| <b>1.7</b> Consequences of crystal field splitting on various properties such as ionic radii, hydration energy and enthalpies of formation of metal complexes of the first transition series.      |               |
| <b>1.8</b> Limitations of CFT : Evidences for covalence in metal complexes (i) intensities of d-d transitions, (ii) ESR spectrum of $[\text{IrCl}_6]^{2-}$ (iii) Nephelauxetic effect.             |               |
| <b>UNIT-II</b>   |               |
| <b>2.Theories of the metal-ligand bond (II)</b>  |               |
| <b>2.1 Molecular orbital Theory for coordination compounds. (4L)</b>   |               |

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| 2.1.1 Identification of the central metal orbitals and their symmetry suitable for formation of $\sigma$ bonds with ligand orbitals.   |  |
| 2.1.2 Construction of ligand group orbitals.   |  |
| 2.1.3 Construction of $\sigma$ -molecular orbitals for an $ML_6$ complex.  |  |
| 2.1.4 Effect of $\pi$ -bonding on complexes .  |  |
| 2.1.5 Examples like $[FeF_6]^{4-}$ , $[Fe(CN)_6]^{4-}$ , $[FeF_6]^{3-}$ , $[Fe(CN)_6]^{3-}$ , $[CoF_6]^{3-}$ , $[Co(NH_3)_6]^{+3}$   |  |
| <b>2.2 Stability of Metal-Complexes (4L)</b>   |  |
| 2.2.1 Thermodynamic and kinetic perspectives of metal complexes with examples.   |  |
| 2.2.2 Stability constants: stepwise and overall stability constants and their interrelationship.   |  |
| 2.2.3 Factors affecting thermodynamic stability.   |  |
| <b>2.3 Reactivity of metal complexes. (4L)</b>   |  |
| 2.3.1 Comparison between Inorganic and organic reactions.  |  |
| 2.3.2 Types of reactions in metal complexes.   |  |
| 2.3.3 Inert and labile complexes : correlation between electronic configurations and lability of complexes.  |  |
| 2.3.4 Ligand substitution reactions : Associative and Dissociative mechanisms.   |  |
| 2.3.5 Acid hydrolysis, base hydrolysis and anation reactions.  |  |
| <b>2.4 Electronic Spectra. (3L)</b>  |  |
| 2.4.1 Origin of electronic spectra   |  |
| 2.4.2 Types of electronic transitions in coordination compounds: intra- ligand, Charge transfer and intra-metal transitions.   |  |
| 2.4.3 Selection rules for electronic transitions.  |  |
| 2.4.4 Electronic configuration and electronic micro states, Terms and Term symbols for transition metal ions, rules for determination of ground state term.  |  |
| 2.4.5 Determination of Terms for $p^2$ and $d^1$ electronic configurations.  |  |
| <b>UNIT-III</b>  |  |
| <b>3 ORGANOMETALLIC CHEMISTRY (15L)</b>  |  |
| <b>3.1 Organometallic Compounds of main group metal (6L)</b>   |  |
| 3.1.1 General characteristics of various types of organometallic compounds, viz. ionic, $\sigma$ -bonded and electron deficient compounds.   |  |
| 3.1.2 General synthetic methods of organometallic compounds : (i) Oxidative-addition, (ii) Metal-metal exchange (transmetallation), (iii) Carbanion-halide exchange, (iv) Metal-hydrogen exchange (metallation) and (v) Methylene-insertion reactions. |  |
| 3.1.3 Some chemical reactions of organometallic compounds:   |  |

|   |  |
|---|--|
| (i) Reactions with oxygen and halogens, (ii) Alkylation and arylation reactions (iii) Reactions with protic reagents, (iv) Redistribution reactions and (v) Complex formation reactions.      |  |
| <b>3.2 Metallocenes (5L)</b>  |  |
| Introduction, Ferrocene : Synthesis, properties, structure and bonding on the basis of VBT.   |  |
| <b>3.3 Catalysis (4L)</b>   |  |
| 3.3.1 Comparison between homogeneous and heterogeneous catalysis  |  |
| 3.3.2 Basic steps involved in homogeneous catalysis   |  |
| 3.3.3 Mechanism of Wilkinson's catalyst in hydrogenation of alkenes.  |  |
|   |  |
| <b>UNIT-IV</b>  |  |
| <b>4 SOME SELECTED TOPICS (15L)</b>   |  |
| <b>4.1 Metallurgy ( 7L)</b>   |  |
| 4.1.1 Types of metallurgies,  |  |
| 4.1.2 General steps of metallurgy; Concentration of ore, calcinations, roasting, reduction and refining.  |  |
| 4.1.3 Metallurgy of copper: occurrence, physicochemical principles, Extraction of copper from pyrites & refining by electrolysis.   |  |
| <b>4.2 Chemistry of Group 18 (5L)</b>   |  |
| 4.2.1 Historical perspectives   |  |
| 4.2.2 General characteristics and trends in physical and chemical properties  |  |
| 4.2.3 Isolation of noble gases  |  |
| 4.2.4 Compounds of Xenon (oxides and fluorides) with respect to preparation and structure (VSEPR)   |  |
| 4.2.5 Uses of noble gases   |  |
| <b>4.3 Introduction to Bioinorganic Chemistry. (3L)</b>   |  |
| 4.3.1 Essential and non essential elements in biological systems.   |  |
| 4.3.2 Biological importance of metal ions such as $\text{Na}^+$ , $\text{K}^+$ , $\text{Fe}^{+2}/\text{Fe}^{+3}$ and $\text{Cu}^{+2}$ (Role of $\text{Na}^+$ and $\text{K}^+$ w.r.t ion pump) |  |



## References.

### SEM-VI

#### Unit-I:

1. Geoffrey A. Lawrance Introduction to Coordination Chemistry John Wiley & Sons.
2. R. K. Sharma Text Book of Coordination Chemistry Discovery Publishing House
3. R. Gopalan , V. Ramalingam Concise Coordination Chemistry , Vikas Publishing House;
4. Shukla P R, Advance Coordination Chemistry , Himalaya Publishing House
5. Glen E. Rodgers, Descriptive Inorganic, Coordination, and Solid-State Chemistry Publisher: Thomson Brooks/Cole

#### Unit-II:

1. Ramesh Kapoor and R.S. Chopra, **Inorganic Chemistry**, R. Chand publishers,
2. Basolo, F, and Pearson, R.C., Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY,
3. Twigg ,Mechanisms of Inorganic and Organometallic Reactions  
Publisher: Springer
4. R.K. Sharma Inorganic Reaction Mechanisms Discovery Publishing House
5. M. L. Tobe Inorganic Reaction Mechanisms Publisher Nelson, 1972

#### Unit-III:

- 1 Cotton, Wilkinson, Murillo and Bochmann, Advanced **Inorganic Chemistry**, 6<sup>th</sup> Edition..
- 2 H.W. Porterfield, Inorganic Chemistry, Second Edition, Academic Press, 2005
- 3 Purecell, K.F. and Kotz, J.C., Inorganic Chemistry W.B. Saunders Co. 1977.
- 4 Robert H. Crabtree ,The Organometallic Chemistry of the Transition Metals,  
Publication by John Wiley & Sons
- 5 B D Gupta & Anil J Elias Basic Organometallic Chemistry: Concepts, Syntheses and Applications, University press
- 6 Ram Charan Mehrotra, Organometallic Chemistry: A Unified Approach, New Age International.

#### Unit-IV

- 1 R. Gopalan, Inorganic Chemistry for Undergraduates, Universities Press India.
- 2 D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3<sup>rd</sup> edition, Oxford University Press
- 3 Cotton, Wilkinson, Murillo and Bochmann, Advanced Inorganic Chemistry, 6<sup>th</sup> Edition.
- 4 Jack Barrett and Mounir A Malati, Fundamentals of Inorganic Chemistry, Affiliated East west Press Pvt. Ltd., New Delhi.
- 5 R.Gopalan, Chemistry for undergraduates. Chapter 18. Principles of Metallurgy.(567-591)
- 6 Puri ,Sharma Kalia Inorganic chemistry. Chapter 10, Metals and metallurgy.(328-339)

- 7 Greenwood, N.N. and Earnshaw, Chemistry of the Elements, Butterworth Heinemann. 1997.
- 8 Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.
- 9 Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
- 10 Satya Prakash, G.D.Tuli, R.D. Madan , , Advanced Inorganic Chemistry.S. Chand & Co Ltd

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## **PRACTICALS**

### **SEMESTER VI INORGANIC CHEMISTRY**

**COURSE CODE: PUSCHVI21P611**

**CREDITS: 02**

#### **I. Inorganic preparations**

1. Preparation of Tris(acetylacetonato) iron(III)
2. Green synthesis of bis(dimethylglyoximato) nickel(II) complex using nickel carbonate and sodium salt of dmg .
3. Preparation of potassium trioxalato aluminate (III)

#### **II. Determination of percentage purity of the given water-soluble salt and qualitative detection w.r.t added cation and/or anion (qualitative analysis only by wet tests).**

(Any three salts of main group metal ions)

#### **Reference Books (practicals)**

4. Vogel Textbook of Quantitative Chemical Analysis G.H. Jeffery, J. Basset.
5. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N.Dhur & Sons Pvt Ltd .
6. Vogel's. Textbook of. Macro and Semimicro qualitative inorganic analysis. Fifth edition.

**COURSE CODE: PUSCHV21513**

**CREDITS: 02**

**LECTURES: 60**

**Unit I**

**1.1 Mechanism of organic reactions (10 L)**

- 1.1.1 The basic terms & concepts: bond fission, reaction intermediates, electrophiles & nucleophiles, ligand, base, electrophilicity vs. acidity & nucleophilicity vs basicity.
- 1.1.2 Neighbouring group participation in nucleophilic substitution reactions: participation of lone pair of electrons, kinetics and stereochemical outcome.
- 1.1.3 Acyl nucleophilic substitution (Tetrahedral mechanism): Acid catalyzed esterification of carboxylic acids (  $A_{AC}2$ ) and base promoted hydrolysis of esters (  $B_{AC}2$ ).
- 1.1.4 Pericyclic reactions, classification and nomenclature
- 1.1.4.1 Electro cyclic reactions (ring opening and ring closing), cycloaddition, sigma tropic Rearrangement, group transfer reactions, cheletropic reaction (definition and one example of each type)
- 1.1.4.2 Pyrolytic elimination: Cope, Chugaev, pyrolysis of acetates

**References:**

- 1. A guidebook to mechanism in Organic Chemistry, 6<sup>th</sup> edition, Peter Sykes, Pearson education, New Delhi
- 2. Organic Reaction Mechanism, 4<sup>th</sup> edition, V. K. Ahluwalia, R. K. Parashar, Narosa Publication.
- 3. Organic reactions & their mechanisms, 3<sup>rd</sup> revised edition, P.S. Kalsi, New Age International Publishers.
- 4. M.B.Smith and J. March, Advanced organic chemistry- reactions mechanism and structure, 5<sup>th</sup> edition.

**1.2 Photochemistry (5 L)**

- 1.2.1 Introduction: Difference between thermal and photochemical reactions. Jablonski diagram, singlet and triplet states, allowed and forbidden transitions, fate of excited molecules, photosensitization.
- 1.2.2 Photochemical reactions of olefins: photoisomerization, photochemical rearrangement of 1,4-dienes (di-  $\pi$  methane)
- 1.2.3 Photochemistry of carbonyl compounds: Norrish I, Norrish II cleavages. Photo reduction (e.g. benzophenone to benzpinacol)

**References:**

- 1. Organic Chemistry, 7<sup>th</sup> Edition, R.T. Morrison, R. N. Boyd & S. K. Bhattacharjee, Pearson.
- 2. Organic chemistry, 8<sup>th</sup> edition, John Mc Murry

**Unit II**

**2.1 Stereochemistry I (5 L)**

- 2.1.1 Molecular chirality and elements of symmetry: Mirror plane symmetry, inversion center,

2.1.2 Chirality of compounds without a stereo genic center: cummulenes and biphenyls.

**References:**

1. L. Eliel , stereochemistry of carbon compounds, Tata McGraw Hill
2. Stereochemistry P.S.Kalsi , New Age International Ltd.,4<sup>th</sup> Edition
3. Stereochemistry by Nassipuri.

**2.2 Agrochemicals  
(4 L)**

- 2.2.1 General introduction & scope, meaning & examples of insecticides, herbicides, fungicide, rodenticide, pesticides, plant growth regulators.
- 2.2.2 Advantages & disadvantages of agrochemicals
- 2.2.3 Synthesis & application of IAA ( Indole Acetic Acid) & Endosulphan,
- 2.2.4 Bio pesticides – Neem oil & Karanj oil.

**References:**

1. Insecticides & pesticides: Saxena A. B., Anmol publication.
2. Growth regulators in Agriculture & Horticulture: Amarjit Basra, CRC press 2000.
3. Agrochemicals and pesticides: A.Jadhav and T.V.Sathe.

**2.3 Heterocyclic Chemistry: (6 L)**

- 2.3.1 Reactivity of pyridine-N-oxide, quinoline and iso-quinoline.
- 2.3.2 Preparation of pyridine-N-oxide, quinoline (Skraup synthesis) and iso-quinoline ( Bischler-Napieralski synthesis).
- 2.3.3 Reactions of pyridine-N-oxide: halogenation, nitration and reaction with  $\text{NaNH}_2/\text{liq.NH}_3$ , n-BuLi.
- 2.3.4 Reactions of quinoline and isoquinoline; oxidation, reduction, nitration, halogenation and reaction with  $\text{NaNH}_2/\text{liq.NH}_3$ , n-BuLi.

**References**

1. Name Reactions in Heterocyclic Chemistry, Jie-Jack Li, Wiley-Interscience publications, 2005.
2. Handbook of Heterocyclic Chemistry, 2<sup>nd</sup> Edition, Alan R. Katritzky and Alexander F. Pozharskii, Elsevier Science Ltd, 2000.
3. Heterocyclic Chemistry, 5<sup>th</sup> Edition, John A. Joule and Keith Mills, Wiley publication, 2010.
4. Heterocyclic chemistry, 3<sup>rd</sup> Edition, Thomas L. Gilchrist, Pearson Education, 2007.

**Unit III**

**3.1 IUPAC (5 L)**

IUPAC Systematic nomenclature of the following classes of compounds (including compounds upto two substituents / functional groups):

- 3.1.1 Bicyclic compounds – spiro, fused and bridged (upto 11 carbon atoms) – saturated and unsaturated compounds.
- 3.1.2 Biphenyls
- 3.1.3 Cummulenes with upto 3 double bonds
- 3.1.4 Quinolines and isoquinolines

**References**

1. Nomenclature of Organic Chemistry: IUPAC recommendations and preferred Names 2013, RSC publication.
2. IUPAC nomenclature by S.C.Pal.

### 3.2 Synthesis of organic compounds (10L)

- 3.2.1 Introduction: Linear and convergent synthesis, criteria for an ideal synthesis, concept of chemo selectivity and regioselectivity with examples, calculation of yields.
- 3.2.2 Multicomponent Synthesis: Mannich reaction and Biginelli reaction. Synthesis with examples (no mechanism)
- 3.2.3 Green chemistry and synthesis:  
Introduction: Twelve principles of green chemistry, concept of atom economy and E-factor, calculations and their significance, numerical examples.
  - i) Green reagents: dimethyl carbonate.
  - ii) Green starting materials : D-glucose
  - iii) Green solvents : supercritical CO<sub>2</sub>
  - iv) Green catalysts: Bio catalysts.
- 3.2.4 Planning of organic synthesis
  - i) synthesis of nitroanilines. (*o* & *p*)
  - ii) synthesis of halobenzoic acid. (*o* & *p*)
  - iii) Alcohols (primary / secondary / tertiary) using Grignard reagents.
  - iv) Alkanes (using organo lithium compounds)

#### Reference:

1. Green chemistry an introductory text : Mike Lancaster.
2. Green chemistry: V. K. Ahluwalia (Narosa publishing house pvt. ltd.)
3. Green chemistry an introductory text : RSC publishing.
4. New trends in green chemistry V. K. Ahluwalia, M. Kidwai, Klumer Academic publisher
5. Green chemistry by V. Kumar.
6. Organic chemistry: Francis Carey
7. Organic chemistry: Carey and Sundberg.

### Unit IV

#### 4.1 Spectroscopy I (5 L)

- 4.1.1 Introduction: Electromagnetic spectrum, units of wavelength and frequency
- 4.1.2 UV – Visible spectroscopy: Basic theory, solvents, nature of UV-Visible spectrum, concept of chromophore, auxochrome, bathochromic and hypsochromic shifts, hyperchromic and hypochromic effects, chromophore-chromophore and chromophore-auxochrome interactions.
- 4.1.3 Mass spectrometry: Basic theory. Nature of mass spectrum. General rules of fragmentation. Importance of molecular ion peak, isotopic peaks, base peak, nitrogen rule, rule of 13 for determination of empirical formula and molecular formula. Fragmentation of alkanes and aliphatic carbonyl compounds.

#### References:

1. Organic spectroscopy (Second edition), Jag Mohan ,Narosa publication
2. Spectroscopy, Pavia, Lampman, Kriz, Vyvyan.

3. Elementary organic spectroscopy (Third edition), Y.R.Sharma, S.Chand publication.. 15
4. Introduction to spectroscopy (third edition), Pavia ,Lampman,Kriz,john vondeling,Emily Barrosse.
5. Organic chemistry Paula Y. Bruice, Pearson education.
6. Spectral identification of organic molecules by Silverstein.
7. Absorption spectroscopy of organic molecules by V.M.Parikh.

#### **4.2 Natural Products:**

**(10L)**

- 4.2.1. Terpenoids: Introduction, Isoprene rule, special isoprene rule and the gem-dialkyl rule.
- 4.2.2 Citral:
  - a) Structural determination of citral.
  - b) Synthesis of citral from methyl heptenone
  - c) Isomerism in citral. (cis and trans form).
- 4.2.3. Alkaloids Introduction and occurrence.  
Hofmann's exhaustive methylation and degradation in: simple open chain and N – substituted monocyclic amines.
- 4.2.4 Nicotine:
  - a) Structural determination of nicotine. (Pinner's work included)
  - b) Synthesis of nicotine from nicotinic acid
  - c) Harmful effects of nicotine.
- 4.2.5 Hormones:  
Introduction, structure of adrenaline (epinephrine), physiological action of adrenaline.  
Synthesis of adrenaline from
  - a) Catechol
  - b) p-hydroxybenzaldehyde (Ott's synthesis)

#### **References:**

1. Chemistry of natural products by Chatwal Anand – Vol I and Vol II
2. Chemistry of natural products by O.P. Agarwal
3. Chemistry of natural products by Meenakshi Sivakumar and Sujata Bhat.
4. Organic chemistry by Morrison and Boyd, 7<sup>th</sup> edition.
5. I.L.Finar, Vol-I and Vol-II, 5<sup>th</sup> edition.

### **PRACTICALS SEMESTER V (ORGANIC CHEMISTRY)**

**COURSE CODE: PUSCHV21P512**

**CREDITS: 02**

**A) SEMESTER V:** Separation of Binary solid-solid mixture (2.0 gms mixture to be given).

1. Minimum Six mixtures to be completed by the students.
2. Components of the mixture should include water soluble and water insoluble acids (carboxylic acid), water insoluble phenols (2-naphthol, 1-naphthol), water insoluble bases

(nitroanilines), water soluble neutral (thiourea) and water insoluble neutral compounds (anilides, amides, m-DNB, hydrocarbons)

After correct determination of chemical type, the separating reagent should be decided by the student for separation.

4. Follow separation scheme with the bulk sample of binary mixture.

5. After separation into component A and component B, one component (decided by the examiner) is to be analyzed and identified with m.p..

#### References:

1. Practical organic chemistry – A. I. Vogel
2. Practical organic chemistry – H.Middleton.
3. Practical organic chemistry – O.P.Aggarwal.

## SEMESTER VI ORGANIC CHEMISTRY

**COURSE CODE: PUSCHVI21613**

**CREDITS: 02**

**LECTURES: 60**

### Unit I

#### 1.1 Stereochemistry II

(10 L)

1.1.1 Stereoselectivity and stereospecificity: Idea of enantioselectivity (ee) and diastereoselectivity (de), Topicity : enantiotopic and diastereotopic atoms, groups and faces.

1.1.2 Stereochemistry of –

- i) Substitution reactions :  $S_Ni$  (reaction of alcohol with thionyl chloride)
- ii) Elimination reactions:  $E_2$ -Base induced dehydrohalogenation of 1-bromo-1,2-diphenylpropane.
- iii) Addition reactions to olefins:
  - a) bromination (electrophilic anti addition)
  - b) syn hydroxylation with  $OsO_4$  and  $KMnO_4$
  - c) epoxidation followed by hydrolysis.

#### References:

Refer Stereochemistry –I (Sem-V, Unit-II)

#### 1.2 Amino acids & Proteins

(5 L)

1.2.1  $\alpha$ -Amino acids: General Structure, configuration, and classification based on structure and nutrition. Properties: pH dependency of ionic structure, isoelectric point and zwitter ion. Methods of preparations: Strecker synthesis, Gabriel phthalamide synthesis.

1.2.2 Polypeptides and Proteins: nature of peptide bond. Nomenclature and representation of polypeptides (di- and tri-peptides) with examples Merrifield solid phase polypeptide synthesis.

.Protiens: general idea of primary, secondary, tertiary & quaternary structure

**References:**

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1. Biochemistry, 8<sup>th</sup> Ed., Jeremy Berg, Lubert Stryer, John L. Tymoczko, Gregory J. Gatto Pub.  
W. H. Freeman Publishers
2. Lehninger Principles of Biochemistry 7<sup>th</sup> Ed., David Nelson and Michael Cox, Publisher W. H. Freeman
3. Name Reactions – Jie Jack Li, 4<sup>th</sup> Edition, Springer Pub.

**Unit II****2.1 Molecular Rearrangements****(5 L)**

Mechanism of the following rearrangements with examples and stereochemistry wherever applicable.

- 2.1.1 Migration to the electron deficient carbon: Pinacol-pinacolone rearrangement.
- 2.1.2 Migration to the electron deficient nitrogen: Beckmann rearrangement.
- 2.1.3 Migration involving a carbanion : Favorski rearrangement.
- 2.1.4 Name reactions: Michael addition, Wittig reaction.

**References:**

Refer Mechanism of organic reaction (Sem-V, Unit-I)

**2.2 Carbohydrates****(10 L)**

- 2.2.1 Introduction: classification, reducing and non-reducing sugars, DL notation
- 2.2.2 Structures of monosaccharides: Fischer projection (4-6 carbon monosaccharides) and Haworth formula (furanose and pyranose forms of pentoses and hexoses)  
Interconversion: open chain and Haworth forms of monosaccharides with 5 and 6 carbons.  
Chair conformation with stereochemistry of D-glucose, Stability of chair form of D-glucose
- 2.2.3 Stereoisomers of D-glucose: enantiomer, diastereomers, anomers, epimers.
- 2.2.4 Mutarotation in D-glucose with mechanism
- 2.2.5 Chain lengthening & shortening reactions: Modified Kiliani-Fischer synthesis (D-arabinose to D-glucose and D-mannose), Wohl method (D-glucose to D-arabinose)
- 2.2.6 Reactions of D-glucose and D-fructose:
  - (a) Osazone formation (b) reduction:  $\text{H}_2/\text{Ni}$ ,  $\text{NaBH}_4$  (c) oxidation: bromine water,  $\text{HNO}_3$ ,  $\text{HIO}_4$  (d) acetylation (e) methylation: (d) and (e) with cyclic pyranose forms
- 2.2.7 Glycosides: general structure

**References:**

1. Organic chemistry (fourth edition), G. Marc Loudon, Oxford University press.
2. Introduction to Organic Chemistry (Third edition), Andrew Streitwieser, Jr. Clayton H. Heathcock, Macmillan publishing.
3. Organic chemistry fourth edition, Morrison and Boyd.
4. Introduction to Organic chemistry, John McMurry.
5. Organic chemistry volume-1&2 (fifth and sixth edition) I.L. Finar.

**Unit III****3.1 Spectroscopy II****(10 L)**

- 3.1.1 IR Spectroscopy: Basic theory, nature of IR spectrum, selection rule, fingerprint region.
- 3.1.2 PMR Spectroscopy: Basic theory of PMR, nature of PMR spectrum, chemical shift ( $\delta$  unit), standard for PMR, solvents used. Factors affecting chemical shift: (1) inductive effect (2) anisotropic effect (with reference to  $\text{C}=\text{C}$ ,  $\text{C}\equiv\text{C}$ ,  $\text{C}=\text{O}$  and benzene ring). Spin-spin coupling and



coupling constant. application of deuterium exchange technique. application of PMR in structure determination.

- 3.1.3** Spectral characteristics of following classes of organic compounds, including benzene and monosubstituted benzenes, with respect to IR and PMR: (1) alkanes (2) alkenes (3) alkynes (4) haloalkanes (5) alcohols (6) carbonyl compounds (7) ethers (8) amines (broad regions characteristic of different groups are expected).

Problems of structure elucidation of simple organic compounds using individual or combined use of UV-Vis, IR, Mass and NMR spectroscopic technique are expected. (Index of hydrogen deficiency should be the first step in solving the problems).

**References:**

Refer spectroscopy –I, (Sem-V, Unit-IV)

**3.2 Nucleic Acids**

**(5 L)**

Controlled hydrolysis of nucleic acids. sugars and bases in nucleic acids. Structures of nucleosides and nucleotides in DNA and RNA. Structures of nucleic acids (DNA and RNA) including base pairing.

**References:**

1. Organic chemistry R.T.Morrison and R.N.Boyd, 6<sup>th</sup> edition, pearson education
2. S.H.Pine, organic chemistry 4<sup>th</sup> edition. McGraw Hill

**Unit IV**

**4.1 Polymer**

**(8 L)**

- 4.1.1** Introduction: terms monomer, polymer, homopolymer, copolymer, thermo plastics and thermosets.
- 4.1.2** Addition polymers: polyethylene, polypropylene, teflon, polystyrene, PVC, Uses.
- 4.1.3** Condensation polymers: polyesters, polyamides, polyurethanes, polycarbonates, phenol formaldehyde resins. Uses.
- 4.1.4** Stereochemistry of polymers: Tacticity, mechanism of stereochemical control of polymerization using Ziegler Natta catalysts.
- 4.1.5** Natural and synthetic rubbers: Polymerisation of isoprene: 1,2 and 1,4 addition (cis and trans), Styrene butadiene copolymer.
- 4.1.6** Additives to polymers: Plasticisers, stabilizers and fillers.
- 4.1.7** Biodegradable polymers: Classification and uses. polylactic acid structure, properties and use for packaging and medical purposes.

(Note : Identification of monomer in a given polymer & structure of polymer for a given monomer is expected. condition for polymerization is not expected)

**References:**

1. Polymer chemistry by M.G.Arora, K.Singh.
2. Polymer science – a text book by Ahluwalia and Mishra
3. Introduction to polymer chemistry - R.Seymour, Wiley Interscience.

**4.2 Catalysts and Reagents**

**(7 L)**

Study of the following catalysts and reagents with respect to functional group transformations and selectivity (no mechanism).

- 4.2.1** Catalysts: Catalysts for hydrogenation:
  - a. Raney Nickel

- b. Pt and  $\text{PtO}_2$  (  $\text{C}=\text{C}$ ,  $\text{CN}$ ,  $\text{NO}_2$ , aromatic ring)
- c.  $\text{Pd/C}$  :  $\text{C}=\text{C}$ ,  $\text{COCl} \rightarrow \text{CHO}$  (Rosenmund)
- d. Lindlar catalyst: alkynes

#### 4.2.2 Reagents:

- a.  $\text{LiAlH}_4$  (reduction of  $\text{CO}$ ,  $\text{COOR}$ ,  $\text{CN}$ ,  $\text{NO}_2$ )
- b.  $\text{NaBH}_4$  (reduction of  $\text{CO}$ )
- c.  $\text{SeO}_2$  (Oxidation of  $\text{CH}_2$  alpha to  $\text{CO}$ )
- d. mCPBA (epoxidation of  $\text{C}=\text{C}$ )
- e. NBS (allylic and benzylic bromination)

#### References:

- 1. Organic chemistry by Francis Carey – McGrawHill .
- 2. Organic chemistry by Carey and Sundberg, Part A & B

## PRACTICALS SEMESTER VI ORGANIC CHEMISTRY

**COURSE CODE: PUSCHVI21P612**

**CREDITS: 02**

**A) SEMESTER VI:** Separation of Binary liquid-liquid and liquid- solid mixture.

- 1. Minimum Six mixtures to be completed by the students.
- 2. Components of the liq-liq mixture should include volatile liquids like acetone, methylacetate, ethylacetate, isopropylalcohol, ethyl alcohol, EMK and non volatile liquids like chlorobenzene, bromobenzene, aniline, N,N dimethylaniline, acetophenone, nitrobenzene, ethyl benzoate.
- 3. Components of the liq- solid mixture should include volatile liquids like acetone, methylacetate, ethylacetate, ethyl alcohol, IPA, EMK and solids such as water insoluble acids, phenols, bases, neutral.
- 4. A sample of the mixture one ml to be given to the student for detection of the physical type of the mixture.
- 5. After correct determination of physical type, separation of the binary mixture to be carried out by distillation method using microscale technique.
- 6. After separation into component A and component B, the compound to be identified can be decided by examiner.

#### References:

- 4. Practical organic chemistry – A. I. Vogel
- 5. Practical organic chemistry – H.Middleton.
- 6. Practical organic chemistry – O.P.Aggarwal.

**SEMESTER V**  
**ANALYTICAL CHEMISTRY**

**COURSE CODE: PUSCHV21514****CREDITS: 02****LECTURES: 60**

| UNIT I : INTRODUCTION TO QUALITY CONCEPTS,CHEMICAL CALCULATIONS AND SAMPLING |   |   |      |
|--|---|---|------|
| 1.1  | Quality in Analytical Chemistry                                   |   | 05 L |
|  |   |   |      |
|  | 1.1.1   | Concepts of Quality, Quality Control and Quality Assurance  |      |
|  | 1.1.2   | Importance of Quality concepts in Industry  |      |
|  | 1.1.3   | Chemical Standards and Certified Reference Materials; Importance in chemical analysis<br><br>Quality of material: Various grades of laboratory reagents   |      |
|  |   |   |      |
| 1.2  | Chemical Calculations (Numericals and word problems are expected) |   | 04 L |
|  |   |   |      |
|  | 1.2.1   | Inter conversion of various concentration units.<br>(Conversion of concentration from one unit to another unit with examples)   |      |
|  | 1.2.2   | Percent composition of elements in chemical compounds   |      |
|  |   |   |      |
| 1.3  | Sampling  |   | 06 L |
|  |   |   |      |
|  | 1.3.1   | Purpose, significance and difficulties encountered in sampling  |      |
|  | 1.3.2   | Sampling of solids: Sample size – bulk ratio, size to weight ratio, multistage and sequential sampling, size reduction methods, sampling of compact solids, equipments and methods of sampling of compact solids, sampling of particulate solids, methods and equipments used for sampling of particulate solids. |      |
|  | 1.3.3   | Sampling of liquids: Homogeneous and heterogeneous, Static and flowing liquids.   |      |
|  | 1.3.4   | Sampling of gases: Ambient and stack sampling: Apparatus and methods for sampling of gases.   |      |

|  |   |   |      |
|--|---|---|------|
|  | 1.3.5   | Collection, preservation and dissolution of the sample.   |      |
|  |   |   |      |
| UNIT II : CLASSICAL METHODS OF ANALYSIS (TITRIMETRY) (3 & 6 UNITS) |   |   |      |
| 2.1  | Redox Titrations (Numerical and word Problems are expected)                                   |   | 08 L |
|  |   |   |      |
|  | 2.1.1   | Introduction  |      |
|  | 2.1.2   | Construction of the titration curves and calculation of $E_{\text{system}}$ in aqueous medium in case of:<br>(1) One electron system<br>(2) Multielectron system  |      |
|  | 2.1.3   | Theory of redox indicators, Criteria for selection of an indicator<br>Use of diphenyl amine and ferroin as redox indicators   |      |
|  |   |   |      |
| 2.2  | Complexometric Titrations   |   | 07 L |
|  |   |   |      |
|  | 2.2.1   | Introduction, construction of titration curve   |      |
|  | 2.2.2   | Use of EDTA as titrant and its standardisation, absolute and conditional formation constants of metal EDTA complexes, Selectivity of EDTA as a titrant.<br>Factors enhancing selectivity with examples.<br>Advantages and limitations of EDTA as a titrant. |      |
|  | 2.2.3   | Types of EDTA titrations.   |      |
|  | 2.2.4   | Metallochromic indicators, theory, examples and applications  |      |
|  |   |   |      |
| UNIT III: OPTICAL METHODS  |   |   |      |
| 3.1  | Atomic Spectroscopy: Flame Emission spectroscopy(FES) and Atomic Absorption Spectroscopy(AAS) |   | 07 L |
|  | 3.1.1   | Introduction, Energy level diagrams, Atomic spectra, Absorption and Emission Spectra  |      |
|  | 3.1.2   | Flame Photometry – Principle, Instrumentation (Flame atomizers, types of Burners, Wavelength selectors, Detectors)  |      |
|  | 3.1.3   | Atomic Absorption Spectroscopy – Principle, Instrumentation (Source, Chopper, Flame and Electrothermal Atomiser)  |      |
|  | 3.1.4   | Quantification methods of FES and AAS – Calibration curve method, Standard addition method and Internal standard method.  |      |
|  | 3.1.5   | Comparison between FES and AAS  |      |

|   |                  |  |             |
|---|------------------|--|-------------|
|   | 3.1.6            | Applications, Advantages and Limitations   |             |
|   |                  |  |             |
| <b>3.2</b>                                | <b>Molecular</b> | <b>Fluorescence and Phosphorescence Spectroscopy</b>   | <b>04L</b>  |
|   | 3.2.1            | Introduction and Principle   |             |
|   | 3.2.2            | Relationship of Fluorescence intensity with concentration  |             |
|   | 3.2.3            | Factors affecting Fluorescence and Phosphorescence   |             |
|   | 3.2.4            | Instrumentation and applications   |             |
|   | 3.2.5            | Comparison of Fluorimetry and Phosphorimetry   |             |
|   | 3.2.6            | Comparison with Absorption methods   |             |
| <b>3.3</b>                                |                  | <b>Turbidimetry and Nephelometry</b>   | <b>04 L</b> |
|   | 3.3.1            | Introduction and Principle   |             |
|   | 3.3.2            | Factors affecting scattering of Radiation:<br>Concentration, particle size, wavelength, refractive index   |             |
|   | 3.3.3            | Instrumentation and Applications   |             |
|   |                  |  |             |
| <b>UNIT IV: METHODS OF SEPARATION – I</b> |                  |  |             |
| <b>4.1</b>                                |                  | <b>Solvent Extraction</b>  | <b>06 L</b> |
|   | 4.1.1            | Factors affecting extraction: Chelation, Ion pair formation and Solvation  |             |
|   | 4.1.2            | Graph of percent extraction versus pH.<br>Concept of $[pH]_{1/2}$ and its significance (derivation not expected)   |             |
|   | 4.1.3            | Craig's counter current extraction: Principle, apparatus and applications  |             |
|   | 4.1.4            | Solid phase extraction: Principle, process and applications with special reference to water and industrial effluent analysis.  |             |
|   | 4.1.5            | Comparison of solid phase extraction and solvent extraction.   |             |
|   |                  |  |             |
| <b>4.2</b>                                |                  | <b>High Performance Liquid chromatography (HPLC)</b>   | <b>06L</b>  |
|   | 4.2.1            | Introduction and Principle<br>Instrumentation- components with their significance: Solvent Reservoir, Degassing system, Pumps-(reciprocating pumps, screw driven- syringe type pumps, pneumatic pumps, advantages and disadvantages of each pump), Precolumn, Sample injection system, HPLC Columns, Detectors(UV – Visible detector, Refractive index detector) |             |
|   | 4.2.2            | Qualitative and Quantitative Applications of HPLC  |             |
|   |                  |  |             |

|     |  |  |      |
|-----|--|--|------|
| 4.3 | High Performance Thin Layer Chromatography (HPTLC) |  | 03 L |
|     | 4.3.1  | Introduction and Principle<br>Stationary phase, Sample application and mobile phase  |      |
|     | 4.3.2  | Detectors<br>a) Scanning densitometer- Components.<br>Types of densitometer- Single beam and Double beam<br>b) Fluorometric Detector |      |
|     | 4.3.3  | Advantages, disadvantages and applications   |      |
|     | 4.3.4  | Comparison of TLC and HPTLC  |      |

### REFERENCES

|     |   |                      |
|-----|---|----------------------|
| 1.  | 3000 solved problems in Chemistry, David E. Goldberg, PhD., Schaums Outline   | Unit/s: (1.2)        |
| 2.  | A guide to Quality in Analytical Chemistry: An aid to accreditation, CITAC and EURACHEM, (2002),  | Unit/s (1.1)         |
| 3.  | A premier sampling solids, liquids and gases, Smith Patricia I, American statistical association and the society for industrial and applied mathematics, (2001) | Unit/s (1.3)         |
| 4.  | Analytical Chemistry, Gary.D Christan, 5th edition  | Unit/s (4.1,4.2,4.3) |
| 5.  | Analytical Chemistry Skoog, West ,Holler, 7th Edition:  | Unit/s (2.1)         |
| 6.  | Analytical Chromatography, Gurdeep R Chatwal, Himalaya publication  | Unit/s (4.1,4.2,4.3) |
| 7.  | Basic Concepts of Analytical Chemistry, by S M Khopkar, new Age International (p) Limited   | Unit/s (4.1,4.2,4.3) |
| 8.  | Chemical methods of separation, J A Dean, Van Nostrand Reinhold, 1969   | Unit/s (4.1,4.2,4.3) |
| 9.  | Fundamentals of Analytical Chemistry by Skoog and West , 8th Edition  | Unit/s (4.1,4.2,4.3) |
| 10. | Handbook of quality assurance for the analytical chemistry laboratory, 2nd Edn., James P. Dux Van Nostr and Reinhold, 1990                                      | Unit/s (1.1)         |
| 11. | High Performance Thin Layer Chromatography by Dr P.D. Sethi, CBS Publisher and Distribution   | Unit/s(4.1,4.2,4.3)  |
| 12. | High Performance Thin Layer Chromatography in Food analysis, by Prem kumar, CBS Publisher and distributor   | Unit/s (4.1,4.2,4.3) |
| 13. | Instrumental methods of Analysis, by Dr Supriya S   | Unit/s (4.1,4.2,4.3) |

|     |  |                                   |
|-----|--|-----------------------------------|
|     | Mahajan, Popular Prakashan Ltd   |                                   |
| 14. | Instrumental methods Of Analysis, by Willard Merritt Dean, 7th Edition, CBS Publisher and distribution Pvt Ltd                             | Unit/s (3.1,3.2,3.3)              |
| 15. | Instrumental Methods of Chemical Analysis by B.K. Sharma Goel Publishing House   | Unit/s (4.1,4.2,4.3)              |
| 16. | Principles of Instrumental Analysis , 5th Edition, By Skoog, Holler, Nieman  | Unit/s (4.1,4.2,4.3)(3.1,3.2,3.3) |
| 17. | Quality control and Quality assurance in Analytical Chemical Laboratory, Piotr Konieczka and Jacek Namiesnik, CRC press (2018)             | Unit/s (1.1)                      |
| 18. | Quality in the Analytical Chemistry Laboratory, Elizabeth Prichard, Neil T. Crosby, Florence Elizabeth Prichard, John Wiley and Sons, 1995 | Unit/s (1.1)                      |
| 19. | Solvent extraction and ion exchange, J Marcus and A. S. Kertes Wiley INC 1969  | Unit/s (4.1,4.2,4.3)              |
| 20. | Thin Layer Chromatography, A LAB. Handbook, Egon Stahl, Springer International Student Edition   | Unit/s (4.1,4.2,4.3)              |

**PRACTICALS**  
**SEMESTER V**  
**ANALYTICAL CHEMISTRY**

**COURSE CODE: PUSCHV21P513**

**CREDITS: 02**

|  |
|--|
| <ol style="list-style-type: none"> <li>1. Spectrophotometric estimation of fluoride</li> <li>2 Estimation of magnesium content in Talcum powder by complexometry, using standardized solution of EDTA</li> <li>3 Determination of COD of water sample.</li> <li>4 To determine potassium content of a Fertilizer by Flame Photometry (Calibration curve method).</li> <li>5 To determine the amount of persulphate in the given sample solution by back titration with standard Fe (II) ammonium sulphate solution.</li> <li>6 To determine the amount of sulphate in given water sample turbidimetrically.</li> </ol> |
|--|

**Note: Calculation of percent error is expected for all the experiments.**

## REFERENCES

|    |   |
|----|---|
| 1. | Vogel's Textbook of Quantitative Chemical Analysis, 5thEdn., G. H. Jeffery, J Bassett, J Memdham and R C Denney, ELBS with Longmann (1989). |
| 2. | Vogel's Textbook of Quantitative Chemical analysis, Sixth edition, J.Mendham et.al  |

### SEMESTER VI ANALYTICAL CHEMISTRY

**COURSE CODE: PUSCHVI614**
**CREDITS: 02**
**LECTURES: 60**

#### UNIT I: ELECTRO ANALYTICAL TECHNIQUES

|            |  |            |
|------------|--|------------|
| <b>1.1</b> | <b>Polarography (Numerical and word problems are expected)</b>   | <b>11L</b> |
| 1.1.1      | Difference between potentiometry and voltammetry, Polarizable and non-polarizable electrodes   |            |
| 1.1.2      | Basic principle of polarography<br>H shaped polarographic cell, DME (construction, working, advantages and limitations)  |            |
| 1.1.3      | DC polarogram: Terms involved - Residual current, Diffusion current, Limiting current, Half-Wave Potential<br>Role and selection of supporting electrolyte, Interference of oxygen and its removal, polarographic Maxima and Maxima Suppressors<br>Qualitative aspects of Polarography: Half wave potential $E_{1/2}$ , Factors affecting $E_{1/2}$<br>Quantitative aspects of polarography: Ilkovic equations: various terms involved in it (No derivation) |            |
| 1.1.4      | Quantification<br>1) Wave height – Concentration plots (working plots/calibration)<br>2) Internal standard (pilot ion) method<br>3) Standard addition method   |            |
| 1.1.5      | Applications advantages and limitations  |            |
|            |  |            |
| <b>1.2</b> | <b>Amperometric Titrations</b>   | <b>04L</b> |
| 1.2.1      | Principle, Rotating Platinum Electrode(Construction, advantages and limitations)   |            |
| 1.2.2      | Titration curves with example  |            |
| 1.2.3      | Advantages and limitations   |            |
|            |  |            |

#### UNIT II: METHODS OF SEPARATION - II

|            |  |             |
|------------|--|-------------|
| <b>2.1</b> | <b>Gas Chromatography (Numerical and word problems are expected)</b> | <b>09 L</b> |
|------------|--|-------------|



|            |                                    |  |             |
|------------|------------------------------------|--|-------------|
|            | 2.1.1                              | Introduction, Principle, Theory and terms involved   |             |
|            | 2.1.2                              | Instrumentation: Block diagram and components, types of columns, stationary phases in GSC and GLC, Detectors: TCD, FID, ECD  |             |
|            | 2.1.3                              | Qualitative, Quantitative analysis and applications  |             |
|            | 2.1.4                              | Comparison between GSC and GLC   |             |
| <b>2.2</b> | <b>Ion Exchange Chromatography</b> |  | <b>06 L</b> |
|            | 2.2.1                              | Introduction, Principle.   |             |
|            | 2.2.2                              | Types of Ion Exchangers, Ideal properties of resin   |             |
|            | 2.2.3                              | Ion Exchange equilibria and mechanism, selectivity coefficient and separation factor<br>Factors affecting separation of ions |             |
|            | 2.2.4                              | Ion exchange capacity and its determination for cation and anion exchangers.   |             |
|            | 2.2.5                              | Applications of Ion Exchange Chromatography with reference to Preparation of demineralised water, Separation of amino acids  |             |
|            |                                    |  |             |

### UNIT III: FOOD AND COSMETICS ANALYSIS

|            |                                       |  |             |
|------------|---------------------------------------|--|-------------|
| <b>3.1</b> | <b>Introduction to food chemistry</b> |  | <b>10 L</b> |
|            | 3.1.1                                 | Food processing and preservation:<br>Introduction, need, chemical methods, action of chemicals (sulphur dioxide, boric acid, sodium benzoate, acetic acid, sodium chloride and sugar) and pH control<br>Physical methods (Pasteurization and Irradiation)                    |             |
|            | 3.1.2                                 | Determination of boric acid by titrimetry and sodium benzoate by HPLC.   |             |
|            | 3.1.3                                 | Study and analysis of food products and detection of adulterants<br><br><b>1) Milk:</b><br><br>Composition & nutrients, types of milk (fat free, organic and lactose milk)<br>Analysis of milk for lactose by Lane Eynon's Method<br><br><b>2) Honey:</b><br><br>Composition |             |
|            |                                       |  |             |

|   |                        |  |             |
|---|------------------------|--|-------------|
|   |                        | Analysis of reducing sugars in honey by Coles Ferricyanide method<br><br><b>3) Tea:</b><br>Composition, types (green tea and mixed tea)<br>Analysis of Tannin by Lowenthal's method<br><br><b>4) Coffee:</b><br>Constituents and composition, Role of Chicory<br>Analysis of caffeine by Bailey Andrew method  |             |
| <b>3.2</b>  | <b>Cosmetics</b>       |  | <b>05 L</b> |
|   | 3.2.1                  | Introduction and sensory properties  |             |
|   | 3.2.2                  | Study of cosmetic products –<br><br><b>1) Face powder:</b><br>Composition<br>Estimation of calcium and magnesium by complexometric titration<br><br><b>2) Lipstick:</b><br>Constituents<br>Ash analysis for water soluble salts: borates, carbonates and zinc oxide<br><br><b>3) Deodorants and Antiperspirants:</b><br>Constituents, properties<br>Estimation of zinc by gravimetry   |             |
|   |                        |  |             |
| <b>UNIT IV:THERMAL METHODS AND ANALYTICAL METHOD</b><br><b>VALIDATION</b> |                        |  |             |
| <b>4.1</b>  | <b>Thermal Methods</b> |  | <b>12 L</b> |
|   | 4.1.1                  | Introduction to various thermal methods<br>(TGA, DTA and Thermometric titration)   |             |
|   | 4.1.2                  | <b>Thermogravimetric Analysis(TGA)</b><br>Instrumentation-block diagram,thermobalance (Basic components: balance, furnace, temperature measurement and control, recorder)<br><br>Thermogram (TG curve) for $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$ and $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$<br>Factors affecting thermogram-Instrumental factors and Sample characteristics<br><br>Applications:<br>Determination of drying and ignition temperature range<br>Determination of percent composition of binary mixtures |             |

|            |                   |   |            |
|------------|-------------------|---|------------|
|            |                   | (Estimation of Calcium and Magnesium oxalate)   |            |
|            | 4.1.3             | <b>Differential Thermal Analysis (DTA):</b><br>Principle, Instrumentation, and Reference material used<br>Differential thermogram ( DTA curve) $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$ and $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$<br>Applications<br>Comparison between TGA and DTA. |            |
|            | 4.1.4             | <b>Thermometric Titrations</b> – Principle and Instrumentation<br>Thermometric titrations of :<br>1) $\text{HCl}$ v/s $\text{NaOH}$<br>2) Boric acid v/s $\text{NaOH}$<br>3) Mixture of $\text{Ca}^{+2}$ and $\text{Mg}^{+2}$ v/s EDTA<br>4) $\text{Zn}^{+2}$ with Disodium Tartarate.            |            |
| <b>4.2</b> | <b>Analytical</b> | <b>Method Validation</b>  | <b>03L</b> |
|            | 4.2.1             | Introduction and need for validation of a method  |            |
|            | 4.2.2             | Validation Parameters: Specificity, Selectivity, Precision, Linearity, Accuracy and Robustness  |            |

**Note: Concept of sensitivity is to be discussed for all techniques and instruments mentioned in the syllabus.**

### REFERENCES

|    |   |                  |
|----|---|------------------|
| 1. | An Advance Dairy chemistry, V 3, P. F. Fox, P. L. H. McSweeney Springer       | Unit/s (3.1,3.2) |
| 2. | Analysis of food and Beverages, George Charalanbous, Academic press 1978      | Unit/s (3.1,3.2) |
| 3. | Analytical Chemistry of Open Learning(ACOL), James W. Dodd & Kenneth H. Tonge | Unit/s (4.1,4.2) |
| 4. | Analytical chemistry David Harvey The McGraw Hill Companies, Inc.             | Unit/s (4.1,4.2) |
| 5. | Analytical Chemistry, Gary.D Christan, 5th edition                            | Unit/s (2.1,2.2) |
| 6. | Analytical chemistry, R. K. Dave.   | Unit/s (2.1,2.2) |

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|-----|---|---------------------------------------|
| 7.  | Chemical methods of separation, J A Dean, Van Nostrand Reinhold, 1969   | Unit/s (2.1,2.2)                      |
| 8.  | Egyankosh.ac.in/bitstream/123456789/43329/1/Unit-8  | Unit/s (1.1,1.2,1.3)                  |
| 9.  | Food Analysis, Edited by S. Suzanne Nielsen, Springer   | Unit/s (3.1,3.2)                      |
| 10. | Food Analysis: Theory and practice, Yeshajahu Pomeranz, Clifton E. Meloan, Springer                                     | Unit/s (3.1,3.2)                      |
| 11. | Formulation and Function of cosmetics, Sa Jellineck   | Unit/s (3.1,3.2)                      |
| 12. | Fundamentals of Analytical Chemistry, D .A. Skoog and D. M. West and F. J. Holler Holt., Saunders 6th Edition (1992)    | Unit/s (2.1,2.2)                      |
| 13. | Government of India publications of food drug cosmetic act and rules.   | Unit/s (3.1,3.2)                      |
| 14. | Harry's Cosmetology, Longman scientific co.   | Unit/s (3.1,3.2)                      |
| 15. | High Performance Thin Layer Chromatography in Food analysis, by Prem kumar, CBS Publisher and distributor               | Unit/s (3.1,3.2)                      |
| 16. | Instrumental methods Of Analysis, by Willard Merritt Dean, 7thEdition, CBS Publisher and distribution Pvt Ltd           | Unit/s (1.1,1.2,1.3)<br>(4.1,4.2,4.3) |
| 17. | Introduction to Polarography and Allied Techniques, By Kamala Zutshi, New Age International, 2006.                      | Unit/s (1.1,1.2,1.3)                  |
| 18. | Modern cosmetics, E. Thomessen Wiley Inter science  | Unit/s (3.1,3.2)                      |
| 19. | Principles of Instrumental Analysis , 5th Edition, By Skoog, Holler, Nieman   | Unit/s (4.1,4.2,4.3)                  |
| 20. | Principles of Polarography by Jaroslav Heyrovský , Jaroslav Kůta, 1st Edition, Academic Press, eBook ISBN: 978148326478 | Unit/s (1.1,1.2,1.3)                  |
| 21. | Solvent extraction and ion exchange, J Marcus and A. S. Kertes Wiley INC 1969   | Unit/s (2.1,2.2,)                     |

**PRACTICALS**  
**SEMESTER VI**  
**ANALYTICAL CHEMISTRY**

**COURSE CODE: PUSCHVIP614**

**CREDITS: 02**

- 1 Estimation of Chromium in water sample spectrophotometrically by using Diphenyl carbazide.
- 2 Estimation of reducing sugar in honey by Willstatter method.
- 3 Estimation of  $Mg^{+2}$  &  $Zn^{+2}$  by anion exchange resin. using an anion exchange resin
- 4 Estimation of acetic acid in Vinegar sample by using Quinhydrone electrode potentiometrically.
- 5 Determination of phosphoric acid in cola sample pH metrically.

**Note: Calculation of percent error is expected for all the experiments.**

**References:**

|    |   |
|----|---|
| 1. | Vogel's Textbook of Quantitative Chemical Analysis, 5thEdn., G. H. Jeffery, J Bassett, J Mendham and R C Denney, ELBS with Longmann (1989). |
| 2. | Vogel's Textbook of Quantitative Chemical analysis, Sixth edition, J.Mendham et.al  |
| 3. | The chemical analysis of food and food products III edition Morris Jacob  |
| 4. | The chemical analysis of food by David Pearson and Henry Edward   |

## SEMESTER V

### Applied Component (Drugs and Dyes)

**COURSE CODE:**  
**PUSCHV21AC501**

**CREDITS: 02**

**LECTURES: 60**

| Unit     |            |              | Topics   |             |
|----------|------------|--------------|--|-------------|
| <b>I</b> | <b>1.1</b> |              | <b>General Introduction to Drugs</b>   | <b>(8L)</b> |
|          |            | 1.1.1        | Definition of a drug, sources of drugs, requirements of an ideal drug, classification of drugs (based on therapeutic action),  |             |
|          |            | 1.1.2        | Nomenclature of drugs: Generic name, Brand name, Systematic name   |             |
|          |            | 1.1.3        | Definition of the following medicinal terms: Pharmacon, Pharmacology, Pharmacophore, Prodrug, Half – life efficiency, LD <sub>50</sub> , ED <sub>50</sub> , GI <sub>50</sub> Therapeutic Index.  |             |
|          |            | 1.1.4        | Brief idea of the following terms: Receptors, Agonists, Antagonists, Drug-receptor interaction, Drug Potency, Bioavailability, Drug toxicity, Drug addiction, Spurious Drugs, Misbranded Drugs, Adulterated Drugs, Pharmacopoeia.  |             |
|          |            |              |  |             |
|          | <b>1.2</b> |              | <b>Routes of Drug Administration and Dosage Forms</b>  | <b>(3L)</b> |
|          |            | 1.2.1        | Oral and Parenteral routes with advantages and disadvantages.  |             |
|          |            | 1.2.2        | Formulations & combination formulation, Different dosage forms (including Patches & Adhesives, emphasis on sustained release formulations and enteric coated tablets).   |             |
|          |            |              |  |             |
|          | <b>1.3</b> |              | <b>Pharmacodynamic agents:</b> A brief introduction of the following pharmacodynamic agents and the study with respect to their chemical structure, chemical class, therapeutic uses, and side effects.  |             |
|          |            | <b>1.3.1</b> | <b>CNS Drugs:</b><br>Classification based on pharmacological actions: CNS Depressants & CNS Stimulants. Concept of sedation and hypnosis, anaesthesia. <ul style="list-style-type: none"> <li>• Phenytoin (Hydantoin)</li> <li>• Trimethadione (Oxazolidinediones) (<b>Synthesis from acetone</b>)</li> <li>• Alprazolam (Benzodiazepines)</li> <li>• Levetiracetam (Pyrrolidines)</li> <li>• Amphetamine (Phenethylamine) (<b>Asymmetric synthesis from phenyl acetic acid</b>)</li> <li>• Chlorpromazine (Phenothiazines)</li> </ul> | <b>(4L)</b> |
|          |            |              |  |             |

### UNIT-II (Drugs)

|          |            |  |  |             |
|----------|------------|--|--|-------------|
| <b>2</b> | <b>2.1</b> |  | <b>Analgesics, Antipyretics and Anti-inflammatory Drugs.</b> | <b>(4L)</b> |
|----------|------------|--|--|-------------|

|  |  |       |  |  |
|--|--|-------|--|--|
|  |  | 2.1.1 | <b>Analgesics and Antipyretics</b><br>2 Morphine (Phenanthrene alkaloids)<br>2 Tramadol (Cyclohexanols) ( <b>Synthesis from salicylic acid</b> )<br>2 Aspirin (Salicylates)<br>2 Paracetamol (p-Amino phenols) |  |
|--|--|-------|--|--|

|  |     |       |  |      |
|--|-----|-------|--|------|
|  |     | 2.1.2 | <b>Anti-inflammatory Drugs</b><br>Mechanism of inflammation and various inflammatory conditions. <ul style="list-style-type: none"> <li>• Steroids: Prednisolone, Betamethasone</li> <li>• Sodium Diclofenac, Aceclofenac (N- Aryl anthranilic acids) (<b>Synthesis from 2,6-dichlorodiphenyl amine</b>)</li> </ul>  |      |
|  |     |       |  |      |
|  | 2.2 |       | <b>Antihistaminic Drugs</b>  | (2L) |
|  |     |       | <ul style="list-style-type: none"> <li>• Diphenhydramine (Ethanol amines)</li> <li>• Cetrizene (Piperazine) (<b>Synthesis from 4-Chlorobenzhydryl chloride</b>)</li> <li>• Chlorpheniramine maleate (Ethyl amines)</li> <li>• Pantoprazole (Benzimidazoles)</li> </ul>   |      |
|  |     |       |  |      |
|  | 2.3 |       | <b>Cardiovascular drugs</b>  | (3L) |
|  |     |       | Classification based on pharmacological action <ul style="list-style-type: none"> <li>• Isosorbide dinitrate (Nitrates)</li> <li>• Valsartan (Amino acids) (structure not expected)</li> <li>• Atenolol (Aryloxy propanol amines) (<b>Synthesis from 3-Hydroxy phenyl acetamide</b>)</li> <li>• Amlodipine (Pyridines)</li> <li>• Frusemide /Furosemide (Sulfamoyl benzoic acid)</li> <li>• Rosuvastatin (Pyrimidine)</li> </ul> |      |
|  |     |       |  |      |
|  | 2.4 |       | <b>Antidiabetic Agents</b>   | (2L) |
|  |     |       | General idea and types of diabetes; Insulin therapy <ul style="list-style-type: none"> <li>• Glibenclamide (Sulphonyl ureas)</li> <li>• Metformin (Biguanides)</li> <li>• Dapagliflozin (Pyranose)</li> <li>• Pioglitazone (Thiazolidinediones) (<b>Synthesis from 2-(5-ethylpyridin-2-yl) ethanol</b>)</li> </ul>   |      |
|  |     |       |  |      |
|  | 2.5 |       | <b>Antiparkinsonism Drugs</b>  | (2L) |
|  |     |       | Idea of Parkinson's disease. <ul style="list-style-type: none"> <li>• Procyclidine hydrochloride (Pyrrolidines)</li> <li>• Ethopropazine hydrochloride (Phenothiazines)</li> <li>• Levodopa (Amino acids) (<b>Synthesis from Vanillin</b>)</li> </ul>  |      |
|  |     |       |  |      |
|  | 2.6 |       | <b>Drugs for Respiratory System</b><br>General idea of: Expectorants; Mucolytes; Bronchodilators; Decongestants; Antitussives <ul style="list-style-type: none"> <li>• Ambroxol (Cyclohexanol) (<b>Synthesis from paracetamol</b>)</li> <li>• Salbutamol (Phenyl ethyl amines)</li> <li>• Oxymetazoline (Imidazolines)</li> </ul>  | (2L) |

- |  |  |  |                               |  |
|--|--|--|-------------------------------|--|
|  |  |  | • Codeine Phosphate (Opiates) |  |
|--|--|--|-------------------------------|--|

**Reference Books: (For units I & II)**

- 3 Foye's principles of medicinal chemistry. 6th Edition, Edited by Davis William & Thomas Lemke, Indian edition by B I Publication Pvt Ltd, Lippincott Williams & Wilkins.
- 3 Text book of organic medicinal & pharmaceutical chemistry. Wilson & Gilvold, 11th Edition by John H Block, John M Beale Jr.
- 3 Medicinal chemistry. Ashutosh Kar, New Age International Pvt. Ltd Publisher. 4<sup>th</sup> edition.
- 3 Burger's Medicinal Chemistry, Drug Discovery and Development. Abraham and Rotella. Wiley
- 3 Medicinal chemistry. Ashutosh Kar, New Age International Pvt. Ltd Publisher. 4<sup>th</sup> edition.
- 3 Medicinal chemistry. V.K. Ahluwalia and Madhu Chopra, CRC Press.
- 3 Principle of medicinal chemistry. Vol 1 & 2 S. S. Kadam, K. R. Mahadik, K. G. Bothara
- 3 The Art of Drug synthesis. Johnson and Li. Wiley, 2007.
- 3 The organic chemistry of drug design & drug action. 2<sup>nd</sup> ed. By Richard B Silvermann, Academic Press.
- 3 The Organic Chemistry of Drug Synthesis. Lednicher and Mitscher, Wiley.



### Unit III (Dyes)

|          |            |       |  |             |
|----------|------------|-------|--|-------------|
| <b>3</b> | <b>3.1</b> |       | Introduction to the dye-stuff Industry   | <b>(5L)</b> |
|          |            | 3.1.1 | Dyes   |             |
|          |            |       | <p>Definition of dyes, requirements of a good dye i.e. Colour, Chromophore and Auxochrome, Solubility, Linearity, Coplanarity, Fastness, Substantivity, Economic viability.</p> <p>Definition of fastness and its properties and Mordants with examples</p> <p>Explanation of nomenclature or abbreviations of commercial dyes with at least one example suffixes – G, O, R, B, K, L, C, S H, 6B, GK, 6GK,</p> <p>Naming of dyes by colour index (two examples) used in dye industries.</p>                                    |             |
|          |            | 3.1.2 | Natural and Synthetic Dyes   |             |
|          |            |       | <p>Natural Dyes: Definition and limitations of natural dyes. Examples and uses of natural dyes w.r.t Heena, Turmeric, Saffron, Indigo, Madder, Chlorophyll –<b>names</b> of the chief dyeing material/s in each natural dye [<b>structures not expected</b>],</p> <p>Synthetic dyes: Definition of synthetic dyes, primaries and intermediates. Important milestones in the development of synthetic dyes – Emphasis on Name of the Scientist, dyes and the year of the discovery is required. (structure is not expected)</p> |             |
|          | <b>3.2</b> |       | Substrates for Dyes : Types of fibres  | <b>(3L)</b> |
|          |            | 3.2.1 | Natural: cellulosic and proteinaceous fibres, examples – wool, silk and cotton structures and names of dyes applied on each of them.   |             |
|          |            | 3.2.2 | Semi – synthetic: definition and examples [structures not expected]  |             |
|          |            | 3.2.3 | Synthetic: Nylon, Polyesters and Polyamides structures and names of dyes applied on each of them   |             |
|          |            | 3.2.4 | Blended fabrics: definition and examples [structures not expected]   |             |
|          |            | 3.2.5 | Binding forces of dyes on substrate: ionic forces, covalent linkages, hydrogen bonding, vander-walls forces  |             |
|          | <b>3.3</b> |       | Classification of dyes based on applications and dyeing methods  | <b>(7L)</b> |
|          |            | 3.3.1 | Dyeing methods   |             |
|          |            |       | <p>Basic Operations involved in dyeing process:</p> <p>i. Preparation of fibres                      ii. Preparation of dyebath</p> <p>iii. Application of dyes                      iv. Finishing</p>   |             |
|          |            |       | <p>Dyeing Method of Cotton Fibres:</p> <p>(i) Direct dyeing                      (ii) Vat dyeing</p> <p>(iii) Mordant dyeing                      (iv) Disperse dyeing</p>   |             |

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|--|--|-------|---|--|
|  |  |       |   |  |
|  |  | 3.3.2 | Classification of dyes based on applicability on substrates (examples with structures)<br>4 Acid Dyes- Orange II,<br>4 Basic Dyes-methyl violet,<br>4 Direct cotton Dyes- Benzofast Yellow 5GL<br>4 Azoic Dyes – Diazo components; Fast yellow G, Fast orange R.<br>Coupling components. Naphthol AS, Naphthol ASG<br>4 Mordant Dyes-Eriochrome Black A, Alizarin.<br>4 Vat Dyes- Indanthrene brown RRD,<br>4 Sulphur Dyes- Sulphur Black T (no structure)<br>4 Disperse Dyes-Celliton Fast brown 3R,<br>4 Reactive Dyes- Cibacron Brilliant Red B, |  |
|  |  | 3.3.3 | Optical Brighteners: General idea, important characteristics of optical brighteners and their classes [Stilbene, Coumarin, Heterocyclic vinylene derivatives, Diaryl pyrazolines, Naphthylamide derivatives] general structure of each class.   |  |
|  |  |       |   |  |

#### **Unit – IV (Dyes)**

|          |            |       |   |             |
|----------|------------|-------|---|-------------|
| <b>4</b> | <b>4.1</b> |       | <b>Colour and Chemical Constitution of Dyes</b>   | <b>(4L)</b> |
|          |            | 4.1.1 | Absorption of visible light, Colour of wavelength absorbed, Complementary colour.   |             |
|          |            | 4.1.2 | Relation between colour and chemical constitution.  |             |
|          |            |       | (i) Armstrong theory (quinonoid theory) and its limitations.<br>(ii) Witt's Theory: Chromophore, Auxochrome, Bathochromic & Hypsochromic Shift, Hypochromic & Hyperchromic effect<br>(iii) Valence Bond theory, comparative study and relation of colour in the following classes of compounds/dyes: Benzene, Nitrobenzene, Nitroanilines, Nitrophenols, Benzoquinones, Azo, Triphenyl methane, Anthraquinones.<br>(iv) Molecular Orbital Theory. |             |
|          | <b>4.2</b> |       | <b>Unit process and Dye Intermediates</b>   |             |
|          |            | 4.2.1 | <b>A brief idea of Unit Processes</b>   | <b>(3L)</b> |
|          |            |       | Introduction to primaries and intermediates   |             |
|          |            |       | Unit processes: definition and brief ideas of below unit processes:<br>(a) Nitration (b) Sulphonation (c) Halogenation<br>(d) Diazotization: (3 different methods & its importance)<br>(e) Ammonolysis (f) Oxidation<br>NB: Definition, Reagents, Examples of each unit processes mentioned above with reaction conditions (mechanism is not expected)  |             |
|          |            |       |   |             |

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|  |  |       |  |             |
|  |  | 4.2.2 | <b>Preparation of the Following Intermediates</b>  | <b>(8L)</b> |
|  |  |       | <u>Benzene derivatives:</u> Benzenesulphonic acid; 1,3-Benzenedisulphonic acid; sulphanilic acid; o-, m-, p-chloronitrobenzenes; o-, m-, p-nitroanilines; o-, m-, p-phenylene diamines; Naphthol ASG |             |
|  |  |       | <u>Naphthalene Derivative:</u> Schaeffer acid; Tobias acid; Naphthionic acid; N.W. acid; cleve-6-acid; H-acid; Naphthol AS   |             |
|  |  |       | <u>Anthracene Derivative:</u> 1-Nitroanthraquinone; 1-Aminoanthraquinone Anthraquinone-2-sulphonic acid; Benzanthrone.   |             |
|  |  |       |  |             |

### References (For Units III & IV):

- 5 Chemistry of Synthetic Dyes, Vol I – VIII, Venkatraman K., Academic Press 1972
- 5 The Chemistry of Synthetic Dyes and Pigments, Lubs H.A., Robert E Krieger Publishing Company, NY ,1995
- 5 Chemistry of Dyes and Principles of Dyeing, Shenai V.A., Sevak Publications, 1973

### I] Practicals

### SEMESTER V

### (Drugs and Dyes)

**COURSE CODE: PUSCHV21ACP511**

**CREDITS: 02**

- 6 Estimation of Ibuprofen (back titration method)
- 6 Estimation of Acid neutralizing capacity of a drug
- 6 Preparation of Aspirin from salicylic acid.
- 6 Separation of components of natural pigments by paper chromatography (eg: chlorophyll)

### II] Project:

**Preparation of Orange II dye (semi-microscale 1.0gms) and its use for dyeing different fabrics**

## SEMESTER VI

### (Drugs and Dyes)

**COURSE CODE: PUSCHAC611**
**CREDITS: 02**
**LECTURES: 60**

### UNIT – I (Drugs)

|          |            |       |   |             |
|----------|------------|-------|---|-------------|
| <b>1</b> | <b>1.1</b> |       | <b>Drug Discovery, Design and Development</b>   | <b>(6L)</b> |
|          |            | 1.1.1 | Discovery of a Lead compound: Screening, drug metabolism studies and clinical observation, Lipinski's rule of 5   |             |
|          |            | 1.1.2 | Medicinal properties of compounds from Natural Sources: Anti-infective and anticancer properties of Turmeric (Curcumin)   |             |
|          |            | 1.1.3 | Development of drug: The Pharmacophore identification, modification of structure or functional group, Structure activity relationship (Sulphonamides).  |             |
|          |            | 1.1.4 | Structure modification to increase potency: Homologation, Chain branching and Extension of the structure.   |             |
|          |            | 1.1.5 | Computer assisted drug design.  |             |
|          | <b>1.2</b> |       | <b>Drug Metabolism:</b> Introduction, Absorption, Distribution, Bio-transformation, Excretion Different types of chemical transformation of drugs with specific examples.   | <b>(3L)</b> |
|          | <b>1.3</b> |       | <b>Chemotherapeutic Agents:</b> Study of the following chemotherapeutic agents with respect to their chemical structure, chemical class, therapeutic uses, side effects and introduction to MDR wherever applicable.  |             |
|          |            | 1.3.1 | <b>Antibiotics and antivirals:</b> Definition, <ul style="list-style-type: none"> <li>• Amoxicillin (<math>\beta</math>-lactum antibiotics)</li> <li>• Cefpodoxime (Cephalosporins)</li> <li>• Doxycycline (Tetracyclines)</li> <li>• Levofloxacin (Quinolones) (<b>Synthesis from 2,3,4 – Trifluoro -1-nitrobenzene</b>)</li> <li>• Aciclovir/Acyclovir (Purines)</li> </ul> | <b>(2L)</b> |
|          |            | 5.3.2 | <b>Antimalarials:</b> Types of malaria; Symptoms; Pathological detection during window period (Life cycle of the parasites not to be discussed) <ul style="list-style-type: none"> <li>• Chloroquine (3-Amino quinolones)</li> <li>• Artemether (Benzodioxepins)</li> </ul> <b>Following combination to be discussed:</b> Artemether-Lumefantrine (no structure)              | <b>(2L)</b> |
|          |            | 1.3.3 | <b>Anthelmintics and AntiFungal agents</b><br>Drugs effective in the treatment of Nematodes and Cestodes infestations.  | <b>(2L)</b> |

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|  |  |  | 3. Diethyl carbamazepine (Piperazines)<br>4. Albendazole (Benzimidazoles) ( <b>Synthesis from 2- Nitroaniline</b> )<br>5. Clotrimazole (Imidazole)<br>6. Fluconazole (Triazole) ( <b>Synthesis from 1- Bromo – 2,4-difluorobenzene</b> ) |  |
|--|--|--|--|--|

**UNIT – II(Drugs)**  
**Chemotherapeutic Agents continued.**

|   |     |  |   |      |
|---|-----|--|---|------|
| 2 | 2.1 |  | <b>Antiamoebic Drugs</b><br>Types of Amoebiasis <ul style="list-style-type: none"> <li>Metronidazole, Ornidazole, Tinidazole (Imidazole)</li> </ul> Synthesis of Metronidazole from glyoxal by Debus-Radziszewski imidazole synthesis route<br><br><b>Following combination therapy to be discussed:</b> Ciprofloxacin-Tinidazole   | (1L) |
|   | 2.2 |  | <b>Antitubercular and Antileprotic Drugs</b><br>Types of Tuberculosis; Symptoms and diagnosis of Tuberculosis.<br>Types of Leprosy.<br>General idea of Antibiotics used in their treatment. <ul style="list-style-type: none"> <li>PAS (Amino salicylates)</li> <li>Isoniazide (Hydrazides)</li> <li>Pyrazinamide (Pyrazines)</li> <li>(+) Ethambutol (Aliphatic diamines) (<b>Synthesis from 1- Nitropropane</b>)</li> <li>Dapsone(Sulphonamides) (<b>Synthesis from 4- Chloronitrobenzene</b>)</li> <li>Clofazimine (Phenazines)</li> <li>Bedaquiline (Quinoline)</li> </ul> <b>Following combination therapy to be discussed:</b><br>(i) Rifampin + Ethambutol + Pyrazinamide<br>(ii) Rifampin + Isoniazide + Pyrazinamide | (3L) |
|   | 2.3 |  | <b>Anti-Neoplastic Drugs</b><br>Idea of malignancy; Causes of cancer<br>Brief idea of Immuno Stimulants &Immuno depressants <ul style="list-style-type: none"> <li>Lomoustine (Nitrosoureas)</li> <li>Anastrozole(Triazoles) (<b>Synthesis from 3,5-bis (bromo methyl) toluene</b>)</li> <li>Cisplatin (Chloro Platinum)</li> <li>Vincristine, Vinblastine, Vindesine) (Vinca alkaloids) (structure not expected)</li> </ul>  | (2L) |
|   | 2.4 |  | <b>Anti-HIV Drugs</b><br>Idea of HIV pathogenicity, Symptoms of AIDS <ul style="list-style-type: none"> <li>AZT/Zidovudine, Lamivudine,DDI (Purines)</li> </ul>   | (1L) |
|   | 2.5 |  | <b>Drug Intermediates:</b> Synthesis and uses <ol style="list-style-type: none"> <li>2,3,6-Triamino-6- hydroxypyrimidine from Guanidine</li> <li>p-[2'-(5-Chloro-2-methoxy benzamido) ethyl]-benzenesulphonamide from Methyl-5-chloro-2- methoxybenzene</li> <li>3-(p-Chlorophenyl)-3- hydroxypiperidine from 3-Chloroacetophenone</li> </ol>   | (2L) |

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|  |            |  | 4. p-Acetyl amino benzenesulphonyl chloride from Aniline<br>5. Epichlorohydrine from propene   |             |
|  | <b>2.6</b> |  | <b>Nano particles in Medicinal Chemistry</b><br>Introduction; Carbon nano particles (structures) and Carbon nano tubes: <ul style="list-style-type: none"> <li>• Functionalization for Pharmaceutical applications</li> <li>• Targeted drug delivery</li> <li>• In vaccine (Foot and mouth disease)</li> <li>• Use in Bio-physical treatment.</li> </ul> Gold nano particles in treatment of: Cancer; Parkinsonism; Alzheimer.<br>Silver nano particles: Antimicrobial activity. | <b>(4L)</b> |
|  | <b>2.7</b> |  | <b>Drugs and Environmental Aspects</b> <ul style="list-style-type: none"> <li>• Impact of Pharma-industry on environment,</li> <li>• International regulation for human experimentation with reference to: “The Nuremberg Code” and “The Helsinki Declaration”.</li> </ul>   | <b>(2L)</b> |

### Reference Books (For Units I & II):

- 2) Foye's principles of medicinal chemistry. 6th Edition, Edited by Davis William & Thomas Lemke, Indian edition by B I Publication Pvt Ltd, Lippincott Williams & Wilkins.
  - 3) Text book of organic medicinal & pharmaceutical chemistry. Wilson & Gisovolds, 11th Edition by John H Block, John M Beale Jr.
  - 4) Medicinal chemistry. Ashutosh Kar, New Age International Pvt. Ltd Publisher. 4<sup>th</sup> edition.
  - 5) Burger's Medicinal Chemistry, Drug Discovery & Development. Abraham & Rotella. Wiley
  - 6) Medicinal chemistry. Ashutosh Kar, New Age International Pvt. Ltd Publisher. 4<sup>th</sup> edition.
  - 7) Medicinal chemistry. V.K. Ahluwalia and Madhu Chopra, CRC Press.
  - 8) Principle of medicinal chemistry. Vol 1 & 2 S. S. Kadam, K. R. Mahadik, K. G. Bothara
  - 9) The Art of Drug synthesis. Johnson and Li. Wiley, 2007.
  - 10) The organic chemistry of drug design & drug action. 2<sup>nd</sup> ed. By Richard B Silvermann, Academic Press.
  - 11) The Organic Chemistry of Drug Synthesis. Lednicer and Mitscher, Wiley.
  - 12) Text book of drug design and discovery. Povl-Krog-Sgaard-Larsen, Tommy Liljefors and ULF Madsen, 3rd Edition Taylor & Francis.
  - 13) Bio-applications of nanoparticles. Edited by Warren C.W. Chan, Springer Publication.
  - 14) Nanoparticle and technology for drug delivery (Drugs and pharmaceutical sciences). Ram B.Gupta & Uday B.Kompella Pub. Informa Healthcare.
  - 15) Nano forms of carbon and its applications. Edited by Maheshwar Sharon and Madhuri Sharon. Monad Nanotech Pvt. Ltd.
  - 16) Environmental Chemistry. A. K. De
  - 17) Text Book on Law and Medicine. Chokhani and Ghormade. 2<sup>nd</sup> Edition. Hind Law House, Pune.
  - 18) Essentials of Medical Pharmacology. K D Tripathi, Jaypee Brothers Medical publishers Pvt. Ltd.
- Practical organic chemistry, Vogel.

## SEMESTER VI

### Unit – III (Dyes)

|   |     |       |  |       |
|---|-----|-------|--|-------|
| 3 | 3.1 |       | <b>Classification of Dyes based on Chemical Constitution and Synthesis of Selected Dyes</b> (Synthesis of the dyes marked with * is expected)  | (12L) |
|   |     |       | <b>i) Nitro Dye:</b> Naphthol Yellow S   |       |
|   |     |       | <b>ii) Nitroso Dye:</b> Gambine Y  |       |
|   |     |       | <b>iii) Azo dyes:</b><br>a) Monoazo dyes: Orange IV *(from sulphanilic acid) & Eriochrome Black T* (from $\beta$ - naphthol)<br>b) Bisazo dyes: Congo Red* (from nitrobenzene)<br>c) Trisazo Dye: Direct Deep Black EW* (from benzidine)   |       |
|   |     |       | <b>iv) Diphenylmethane dye:</b> Auramine O* (from N,N-dimethyl aniline)  |       |
|   |     |       | <b>v) Triphenylmethane dye:</b><br>a) Diamine series: Malachite Green* (from benzaldehyde)<br>b) Triamine series: Acid Magenta<br>c) Phenol series: Rosolic acid   |       |
|   |     |       | <b>vi) Heterocyclic Dyes:</b><br>a) Thiazine dyes: Methylene Blue<br>b) Azine dyes: Safranin T* (from o-toluidine)<br>c) Xanthene Dyes: Eosin* (from phthalic anhydride)<br>d) Oxazine Dyes: Capri Blue<br>e) Acridine Dyes: Acriflavine   |       |
|   |     |       | <b>vii) Quinone Dyes:</b><br>a) Naphthaquinone: Naphthazarin<br>b) Anthraquinone Dyes: Indanthrene Blue* (from anthraquinone)  |       |
|   |     |       | <b>viii) Indigoid Dyes:</b> Indigo* (from aniline + monochloroacetic acid)   |       |
|   |     |       | <b>ix) Phthalocyanine Dyes:</b> Monastral Fast Blue B  |       |
|   | 3.2 |       | <b>Health and Environmental Hazards of Synthetic Dyes and their Remediation Processes</b>  | (3L)  |
|   |     | 3.2.1 | <b>Impact of the textile and leather dye Industry on the environment</b> with special emphasis on water pollution  |       |
|   |     | 3.2.2 | <b>Health Hazards:</b> Toxicity of dyes w.r.t food colours.  |       |
|   |     | 3.2.3 | <b>Effluent Treatment Strategies:</b><br>Brief introduction to effluent treatment plants (ETP)<br>Primary Remediation processes: (Physical Processes) Sedimentation, Aeration, Sorption (activated charcoal, fly ash etc.)<br><br>Secondary Remediation processes: Biological Remediation<br>Biosorption, bioremediation and biodegradation<br><br>Chemical Remediation: Oxidation Processes (chlorination),<br>Coagulation-flocculation-Precipitation |       |

**Unit – IV (Dyes)**

|          |            |       |   |             |
|----------|------------|-------|---|-------------|
| <b>4</b> | <b>4.1</b> |       | <b>Non-textile uses of dyes:</b>  | <b>(8L)</b> |
|          |            | 4.1.1 | <b>Biomedical uses of dyes</b><br>i) Dyes used in formulations (Tablets, capsules, syrups etc)<br>Indigo carmine, Sunset yellow, Tartrazine<br>ii) Biological staining agents<br>Methylene blue, Crystal violet and Safranin T<br>iii) DNA markers<br>Bromophenol blue, Orange G, Cresol red<br>iv) Dyes as therapeutics<br>Mercurochrome, Acriflavine, Crystal Violet, Prontosil |             |
|          |            | 4.1.2 | <b>Dyes used in food and cosmetics:</b><br>i) Properties of dyes used in food and cosmetics<br>ii) Introduction to FDA and FSSAI<br>iii) Commonly used food colours and their limits  |             |
|          |            | 4.1.3 | <b>Paper and leather dyes</b><br>i) Structural features of paper and leather<br>ii) Dyes applicable to paper and leather  |             |
|          |            | 4.1.4 | <b>Miscellaneous dyes</b><br>i) Hair dyes<br>ii) Laser dyes<br>iii) Indicators<br>iv) Security inks<br>iv) Coloured smokes and camouflage colours   |             |
|          | <b>4.2</b> |       | <b>Pigments</b>   | <b>(3L)</b> |
|          |            |       | Definition of pigments, examples, properties of pigments, difference between dyes and pigments.<br>Definition of Lakes and Toners   |             |
|          | <b>4.3</b> |       | <b>Dyestuff Industry - Indian Perspective</b>   | <b>(4L)</b> |
|          |            | 4.3.1 | Growth and development of the Indian Dyestuff Industry  |             |
|          |            | 4.3.2 | Strengths, Weaknesses, Opportunities and Challenges of the Dyestuff industry in India   |             |
|          |            | 4.3.3 | Make in India - Future Prospects of the Dye Industry  |             |



### References (For Units III & IV)

- 3) Chemistry of Synthetic Dyes, Vol I – IV, Venkatraman K., Academic Press 1972
- 4) The Chemistry of Synthetic Dyes and Pigments, Lubs H.A., Robert E Krieger Publishing Company, NY ,1995
- 5) Chemistry of Dyes and Principles of Dyeing, Shenai V.A., Sevak Publications, 1973
- 6) Environmental Studies, Joseph Benny, Tata McGraw Hill Education, 2005
- 7) Fundamental Concepts of Environmental Chemistry, Sodhi. G. S., Alpha Science International, 2009
- 8) Planning Commission, Niti Aayog, FSSAI and FDA websites
- 9) Green Chemistry for Dyes Removal from Waste Water- Research Trends and Applications, Ed. Sharma S.K., Wiley, 2015
- 10) Environmental Pollution- Monitoring and Control, Khopkar S.M., New Age International (P) Ltd, New Delhi, 1982

### Practicals

#### SEMESTER V

#### (Drugs and Dyes)

**COURSE CODE: PUSCHVI21ACP611**

**CREDITS: 02**

- 2) O-Methylation of  $\beta$ -naphthol.
- 3) Preparation of Paracetamol from p-aminophenol.
- 4) Preparation of Fluorescein
- 5) TLC of a mixture of dyes (safranin-T, Indigo carmine, methylene blue)

**II] Preparation of monograph of any one drug from syllabus by I.P. method.**

**OR**

**Industrial visit Report.**

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