## THIRD SEMESTER BSc CHEMISTRY

## DSC-3:Analytical and Organic Chemistry-II

**Contact Hours: 56** **Work load: 4 Hours/Week.**

**Credit Points :4**

**Evaluation: Continuous Internal Assesment-40 Marks**

**Semester End Examination -60 Marks**

## Course Objectives:

1) Interrelationship among frequency, wavelength and wave number and importance of validation parameters of an instrumental method will be taught
2) Principle, instrumentation and applications of spectrophotometry, nephelometry and turbidometry will be taught
3) Fundamentals of separation methods and principles of paper, thin layer and column chromatography will be taught
4) Principle, types and applications of solvent extraction will be taught
5) Principle and mechanism of ion-exchange, types of resins and domestic and industrial applications of ion-exchange chromatography will be taught
6) The concept of mechanism and its importance will be taught to the student
7) Concept and importance of intermediates in organic chemistry will be taught taking proper examples
8) The various techniques for identification of reaction mechanism will be taught to the student taking proper examples
9) Concept of stereochemistry and its importance will be taught.
10) The various projection formulae and the techniques of designating the molecules into R, S, D, L will be taught taking proper examples
11) The theory and concept of Cis-, Trans- isomerism and its importance and the techniques to differentiate between them will be taught taking examples

## Course Specific Outcomes

After the completion of this course, the student would be able to

1) Understand the importance of fundamental law and validation parameters in chemical analysis
2) Know how different analytes in different matrices (water and real samples) can be determined by spectrophotometric, nephelometric and turbidometric methods.

3)Understand the requirement for chemical analysis by paper, thin layer and column chromatography.

4) Apply solvent extraction method for quantitative determination of metal ions in different samples
5) Utilize the ion-exchange chromatography for domestic and industrial applications
6) Explain mechanism for a given reaction.
7) Predict the probable mechanism for an reaction
   Eexplain the importance of reaction intermediates, its role and techniques of generating such intermediates
8) Explain the importance of Stereochemistry in predicting the structure and property of organic molecules.
9) Predict the configuration of an organic molecule and able to designate it.
10) Identify the chiral molecules and predict its actual configuration

# Unit-I

**Quantitataive analysis-Instrumental methods**

Electromagnetic spectrum, absorption of electromagnetic radiation, Definition and units of frequency, wavelength, wave number, Beer's law, Beer-Lambert law derivation, deviations from Beer's law, limitations, construction of calibration graph (Plot of absorbance versus concentration), Evaluation Procedures- standard addition, Internal standard addition, validation parameters-detection limits, sensitivity, dynamic/linearity range, Instrumentation, spectrophotometers, quantitative applications of colorimetry (determination of Fe and Cu) and numerical problems on application of Beer's law.

**10 hrs**

**Nephelometry and Turbidimetry:** Introduction, principle, instrumentations of nephelometry and turbidimetry; effects of concentration, particle size and wavelength on scattering; applications of nephelometry and turbidimetry (determination of $SO_4^{2-}$ and $PO_4^{3-}$) **4 hrs**

# Unit-II

**Separation methods**

**Fundamentals of chromatography**: General description, definition, terms and parameters used in chromatography, classification of chromatographic methods, criteria for selection of stationary and mobile phase and nature of adsorbents. Principles of paper, thin layer, column chromatography. Column efficiency, factors affecting the column efficiency, van Deemter's equation and its modern version.

**3hrs**

**Paper chromatography**: Theory and applications

**Thin layer chromatography (TLC)**: Mechanism, $R_f$ value, efficiency of TLC plates, methodology–selection of stationary and mobile phases, development, spray reagents, identification and detection, qualitative applications. **4 hrs**

**Solvent Extraction:** Types- batch, continous, efficiency, selectivity, distribution coefficient, Nernst distribution law, derivation, factors affecting the partition, relationship between % extraction and volume fraction, Numerical problems on solvent extraction. Solvent extraction of iron and copper. **4hrs**

**Ion-exchange chromatography:** resins, types with examples- cation exchange and anion exchange resins, mechanism of cation and anion exchange process and applications of ion-exchange chromatography (softening of hard water, separation of lanthanides, industrial applications). **03Hrs**

## Unit-III

**Reaction Intermediates: Generation, Stability and Reactions of,**

i) Carbocations: Dienone-phenol; and Pinacol-Pinacolone Rearrangement.
ii) Carbanions :Perkin Reaction,Aldolcondensation,Claisen-Schmith condensation.
iii) Free Radicals : Sandmeyer Reaction
iv) Carbenes and Nitrenes: Singlet and Triplet states, their relative stability and reactions
**v)** Arynes: Formation, detection **8 hrs**

**Methods for Identifying Reaction Mechanism:**

Product analysis, Isolation and Identification of Intermediates, Stereochemical Evidences,Effect of Catalyst,crossover Experiments,Isotopic studies,Kinetic Studies.

**6 hrs**

## Unit-IV

**Stereochemistry of Organic Compounds**:

Fischer projection,Newmann and Sawhorse projection formulae and thei interconversions.

Geometrical isomerism : Cis-trans and syn-anti isomerism, E/Z notations with C.I.P rules.

Optical Isomerism :Optical activity, Specific rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral centres, Diasteroisomers, meso structures, Racemic mixtures and Resolution, Relative and absolute configuration, D/L and R/S designations

**14 hrs**

**References** :


1) Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8th edition, Saunders College Publishing, New York (2005).
2) Analytical Chemistry, G.D. Christian, 6th edition, Wiley-India (2007).

3) Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, PHI Learning Pvt Ltd.NewDelhi(2009).
4) Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D.Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt.Ltd.(2007).
5) Organic Reaction Mechanism by V.K.Ahluwalia and R.K.Parashar (Narosa Publishers)
6) Organic Chemistry by S.M.Mukherji,S.P.Sinh and R.K.Kapoor (Narosa Publishers)
7) Morrison R.N and Boyd R.N,OrganicChemistry,Darling Kindersley(India)Pvt.Ltd.(Pearson Education)
8) Finar I.L,Organic Chemistry(Volume I); Finar I.L (Volume II) Stereochemistry and the Chemistry of Natural Products.,Dorling Kindersley(India)Pvt.Ltd.(Pearson Education)
9) Kalsi P.S.Stereochemistry,conformation and Mechanism,New age International
10) Eliel E.L and wilenS.H,Stereochemistry of Organic Compounds,Wiley,(London)

## PRACTICALS

**Credit Points: 2** **Teaching Hours:4 hrs**

**Evaluation : ContinuousInternal Assessment-25 marks**

**Semester End Examination :25 marks**

## Course Objectives

1) To impart skills related to preparation of stock and working solutions and handling of instrumental methods
2) To know the principle of colorimetric analysis and construction of calibration plot
3) To understand the chemistry involved in colorimetric determination of metal ions and anions
4) To determine $R_f$ values of different metal ions present in a mixture
5) To impart knowledge on the importance of functional groups in organic compounds.
6) Techniques to identify the functional groups in an compound by performing physical and chemical tests
7) To record its melting point/boiling point.
8) To prepare suitable derivative for that compound and to characterize it.

**Course Specific outcomes**

After the completion of this course, the student would be able to

1) Understand the importance of instrumental methods for quantitative applications

2) Apply colorimetric methods for accurate determination of metal ions and anions in water or real samples
3) Understand how functional groups in an compound is responsible for its characteristic property
4) Learn the importance of qualitative tests in identifying functional groups.
5) Learn how to prepare a derivative for particular functional groups and how to purify it'

## PART-A (Analytical Chemistry)

1) Colorimetric determination of copper using ammonia solution
2) Colorimetric determination of iron using thiocyanate solution
3) Colorimetric determination of nickel using DMG solution
4) Colorimetric determination of nitrite in a water sample (diazo coupling Reaction/Griess reagent
5) Determination of $R_f$ values of two or three component systems by TLC
**6)** Separation of different metal ions by paper chromatography/ Solvent extraction of iron using oxine solution **(demonstration)**

## PART-B(Organic Chemistry)

Qualitative analysis of bifunctional Organic compounds such as 1)Salycilic acid ,p-Chloro benzoic acid 2) o-Cresol,p-Cresol,Resorcinol,o- Nitrophenol,p-nitophenol 3)o-Nitro aniline,p-Nitroaniline,p-Toluidine, 4)Ethyl Salicylate, Salicylaldehyde, Acetophenone, p-Nitrotoluene,,Benzamide etc.(Atleast 6-8 compounds to be analysed in a semester )

**References**

1) Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D.Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt.Ltd.(2007)
2) Vogels Text Book of Qualitative Chemical Analysis,ELBS

**Semester 3** B Sc / B Sc (Honors)

**Title of the Course: Open Elective-3: ATOMIC STRUCTURE, BONDING AND CONCEPTS IN ORGANIC CHEMISTRY**

**Contact Hours: 42** **Workload: 3 hours per week**
**Credit Points: 3**
**Evaluation: Continuous Internal Assessment - 40 marks**
**Semester End Examination - 60 marks**

**Course Objectives:**

- To develop an understanding of principles of Atomic structure
- To know the importance of quantum numbers, writing of electronic configurations and represention of orbitals
- To develop an understanding of the periodic trends
- To understand the nature of bonding and to predict the shapes of molecules
- To construct MO energy level diagrams and predict the properties of molecules
- To understand the formation of sigma and pi bonds and the bond strength.
- To study the classification of organic reactions
- To learn nomenclature preparation and reactions of alkanes, alkenes, alkynes and stability of alicyclic compounds

**COURSE CONTENT**

**Unit I: Atomic Structure and Periodic Properties**
History of an atom. Idea of de Broglie matter waves. Heisenberg uncertainty principle. Schrödinger wave equation, significance of wave functions, Bohr's model of hydrogen atom and its limitations. Quantum numbers and their importance, atomic orbitals and shapes of s, p, d orbitals , Multi-electron atoms, Aufbau and Pauli exclusion principle and Hund's multiplicity rule- Electronic configurations of the elements (atomic no. up to 30), effective nuclear charge and shielding.
**(8 hours)**

**Periodic Properties**

Atomic radius, Covalent, ionic and van der Waal radii-explanation with examples. Definition and periodicity of the following properties - ionic radii, ionisation potential, electron affinity and electronegativity, methods of determination of electronegativity. Factors affecting the values of ionisation energy. **(6 hours)**

**Unit II: Chemical Bonding**
Ionic Solids– Ionic structures (NaCl, CsCl, $TiO_2$, ZnS), radius ratio rule and coordination number, limitation of radius ratio rule, lattice energy and Born-Haber cycle, solvation energy and solubility of ionic solids, polarizing power and polarisability of ions, Fajan's rule and their consequences.
**(4 hours)**
Covalent Bond – Valence bond theory and its limitations, directional characteristics of covalent bond, various types of hybridization with examples and shapes of simple inorganic molecules and ions. Shapes of $NH_3$, $I_3^+$, $I_3^-$ , $SF_4$, $ClF_3$, $IF_5$, $ICl_2^-$ and $H_2O$ using valence shell electron pair repulsion (VSEPR) theory, linear combination of atomic orbitals (LCAO), bonding, nonbonding and antibonding molecular orbitals, physical picture of bonding and antibonding wave

functions. Applications of MO theory to explain the stability of homo dinuclear ($He_2$, $N_2$, $O_2$, $F_2$, $C_2$) and hetero dinuclear (NO and CO) molecules. Comparison of M.O. and V.B. Models. **(7 hours)**

Metallic bond-free electron, Band theory-electrical properties of metals, semiconductors and insulators.
Weak interactions – Hydrogen bonding and its consequences, van der Waals forces.
(**3 hours)**

**Unit III: Bonding and molecular structure and hydrocarbons**
**Bonding and molecular structure:** Introduction to organic chemistry, atomic orbitals,sigma and pi bond formation-molecular orbital [MO] method,sp,$sp^2$and $sp^3$ hybridization,bond length, bond dissociation energies and bond angles(open chain and cyclic compounds). Electronegativity and polarity of the bonds. Classification and reactions of organic compounds (with examples). **7 Hours**

**Alkanes, Alkenes and Alkynes**
Definition,Nomenclature,preparations (any two methods)
Reactions: Electrophilic, nucleophilic and free radical addition reactions
**Alicyclic compounds:**
Nomenclature, preparation and stability of cyclopropane, cyclobutane, cyclopentane and cyclohexane.
**7 Hours**

**Reference Books:**


1. Concise Inorganic Chemistry, J. D. Lee, ELBS, 1996.
2. Inorganic Chemistry, A. K. Das
3. Inorganic Chemistry: Principles of Structure and Reactivity, Huheey, J. E., Keiter, E.A., Keiter, R.L. & Medhi, O. K. Pearson Education India, 2006.
4. Inorganic Chemistry, Shriver, D.F. & Atkins, P.W.Oxford University Press.
5. Schaum's Outline Series Theory and Problems of Organic Chemistry.SI (metric) edition Herbert Meislich,Howard Nechamkin and Jacob Sharefkin.
6. Organic chemistry. Robert T.Morrison Robert N. Boyd,6thEdition
7. Organic Chemistry Volume-1, I.L.Finar


**COURSE OUTCOME:**

On completion of the course the student will learn and be able to understand/explain

- the concept of atomic structure, significance of quantum numbers, filling of electrons of atoms/ions in various orbitals as per rules
- the trends in periodic properties
- the structures of ionic solids, applications of B-H cycle, solubility of compounds and consequences of polarization of ions
- the shapes of molecules/ions based on VSEPR theory
- the construction of MO energy level diagrams and prediction of properties of molecules/ions like bond order, bond energies, bond lengths and magnetic properties.
- the formation of sigma and pi bonds and the bond strength
- the classification of organic reactions
- nomenclature preparation, and reactions of alkanes, alkenes, alkynes and stability of alicyclic compounds.

# CHEMISTRY

## DSC-4: Inorganic and Physical Chemistry-II

## Contact Hours: 56 Work load: 4 Hours/Week.

## Credit Points :4

## Evaluation: Continuous Internal Assesment-40 Marks

## Semester End Examination -60 Marks

**Course Objectives:**

Students learn about

1. Different types of bonding in molecules/compounds/ions
2. The structures of molecules/compounds/ions based on different models/theories
3. Properties of compounds based on bonding and structure
4. The fundamentals of thermodynamics including the laws, the concept of entropy and free energy functions and their applications.
5. The concepts of surface chemistry, catalysis and their applications.
6. The theoretical and experimental aspects of chemical kinetics including basic theories of reaction rates and methods of determining order.
7. Electrochemistry dealing with electrolytes in solution. Conductance measurements and applications. Concept of ionic mobility and their determination.

**Course outcomes:** After the completion of this course, the student would be able to

1. Predict the nature of the bond formed between different elements
2. Identify the possible type of arrangements of ions in ionic compounds
3. Write Born - Haber cycle for different ionic compounds
4. Relate different energy parameters like, lattice energy, entropy, enthalpy and solvation energy in the dissolution of ionic solids
5. Explain covalent nature in ionic compounds
6. Write the M.O. energy diagrams for simple molecules
7. Differentiate bonding in metals from their compounds
8. Learn important laws of thermodynamics and their applications to various thermodynamic systems
9. Understand adsorption processes and their mechanisms and the function and purpose of a catalyst

10. Apply adsorption as a versatile method for waste water purification.
11. Understand the concept of rate of a chemical reaction, integrated rate equations, energy of activation and determination of order of a reaction based on experimental data
12. Know different types of electrolytes, usefulness of conductance and ionic mobility measurements
13. Determine the transport numbers

## Unit - I

**Structure and Bonding -I**

The ionic bond :Structures of ionic solids

Radius ratio rules, Calculation of some limiting radius ratio values, Coordination number 3 (planar triangle), Coordination number 4 (tetrahedral and square planar), Coordination number 6 (octahedral), Close packing. **3hrs**

**Classification of ionic structures**:

Ionic compounds of the type AX (ZnS, NaCl, CsCl)

Ionic compounds of the type $AX_2$ (Calcium fluoride (fluorite) and Rutile structure

Limitations of radius ratio concept **2 hrs**

Lattice energy and Born-Haber cycle, Born-Lande equation and itsdrawbacks, Kapustinskii equation (No derivation), solvation energy and solubility of ionic solids, polarizing power and polarizability, Fajan's rules with applications.

Numerical problems **5 hrs**

**Covalent bond**: Valence bond theory, The Lewis theory,The octet rule, Exceptions to the octet rule, Sidgwick- Powell theory. Valence shell electron pair repulsion (VSEPR) theory, Effect of lone pairs, electronegativity, isoelectronic principle, Examples using VSEPR theory: $BF_3$ and $BF_4^-$, $NH_3$and $NH_4^+$, $H_2O$, $PCl_5$, $ClF_3$, $SF_4$, $SF_6$, and $IF_7$.

Limitations of VSEPR. **4 hrs**

## Unit - II

**Structure and Bonding -II**

Concept of resonance, resonance energy, hybridisation, types of hybridization, sp, $sp^2$, $sp^3$ $dsp^2$ $dsp^3$, $d^2sp^3$, $sp^3d^2$ with one example each, and energetics of hybridization. Bent's rule, Limitations of Valence Bond Theory.

**3 hrs**

**Molecular Orbital theory**:

LCAO concept: s-s, s-p and p-p combinations of orbitals, bonding, nonbonding and antibonding molecular orbitals, non-bonding combinations of orbitals, Rules for linear combination of atomic orbitals

Examples of molecular orbital treatment for homonuclear diatomic molecules $H_2$ molecule, $H^+_2$, $He_2$ molecule, $He^+_2$ molecule ion, $Li_2$ molecule, $Be_2$ molecule $B_2$ molecule, $C_2$ molecule, $N_2$ molecule, $N_2^+$, $O_2$ molecule, $O_2^-$ and $O_2^{2-}$.
M.O. energy diagrams of heteronuclear diatomic molecules with examples (NO, $NO^+$ CO and HCl). Calculation of bond order, relationship between bond order, bond energy and bond length, magnetic properties based on MOT. **7 hrs**

**Metallic Bonding**:

General properties of metals : Conductivity, Lustre, Malleability and ductility. Crystal structures of metals and Bond lengths

Theories of bonding in metals:

Free electron theory,Valence bond theory, Molecular orbital or band theory of solids Prediction of conducting properties of conductors. insulators and semiconductors, extrinsic and intrinsic semiconductors using M.O. theory. **4 hrs**

## UNIT III

**First Law of Thermodynamics**

Thermodynamic Processes, Reversible and Irreversible Processes, Nature of Heat and Work,Internal Energy, First Law of Thermodynamics, Enthalpy of a System,Work done in isothermal and adiabatic expansion of an ideal gas, Numerical problems, Joule -Thomson Expansion, Relation between Joule-Thomson coefficient and other thermodynamic parameters.

**Second law of Thermodynamics**

Concept of entropy, thermodynamic scale of temperature, Statements of the Second Law of Thermodynamics, molecular and statistical interpretation of entropy, Calculation of entropy change for reversible and irreversible processes, Free Energy Functions: Gibbs and Helmholtz energy, Variation of S, G, A with T, V and P, Numerical problems, Free energy change and spontaneity, Gibbs-Helmholtz equation.

**Third Lawof Thermodynamics**

Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules. **10 Hrs**

**Surface Chemistry**

**Adsorption**

Types of adsorption isotherms. Freundlich adsorption isotherm (only equation), its limitations. Langmuir adsorption isotherm (derivation to be done) and BET equation (derivation not included).

**Catalysis**

Types of Catalysis and theories with examples (intermediate compound theory and adsorption theory), Theory of acid base catalysis, Michaelis-Menten equation. Heterogeneous catalysis: surface reactions, unimolecular, bimolecular surface reactions. Autocatalysis with examples. Applications: Design process to removal of toxic compounds from industrial wastewater and treatment of portable water requirements.

**4Hrs**

**UNIT IV**

**Chemical Kinetics**

Differential and integrated form of rate expressions up to second order reactions, Derivation of expression of rate constant of second order reaction (a=b ), Problems on rate constant (a=b), Methods of determination of order of a reaction, temperature dependence of reaction rates; Arrhenius equation, activation energy, Numerical problems on Arrhenius equation in calculating energy of activation and rate constants. Collision theory of reaction rates, Lindemann's mechanism, qualitative treatment of the theory of absolute reaction rates. Experimental determination of kinetics of (i) inversion of cane sugar by polarimetric method (ii) spectrophotometric method for the reaction between potassium persulphate and potassium iodide. **7 Hrs**

**Electrochemistry – I**

Arrhenius theory of electrolytic dissociation. Merits and Demerits, Conductance, Specific conductance, equivalent and molar conductivity and their variation with dilution. Molar conductivity at infinite dilution. Numerical problems.

Kohlrausch's law of independent migration of ions and its applications, Debye-Hückel-Onsager equation. Ionic mobilities and their determinations, transference numbers and their relation to ionic mobility's, determination of transference numbers using Hittorf(non attachable electrode) and Moving Boundary methods.

Applications of conductance measurement: (i) degree of dissociation of weak electrolytes (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts (iv) conductometric titrations (acid base titrations only) and (v) Hydrolysis constants of salts. Numerical problems. **7 Hrs**

**Reference Books**


1. Peter Atkins & Julio De Paula, Physical Chemistry, 9th Ed., Oxford University Press (2010)
2. G W Castellan, Physical Chemistry, 4th Ed., Narosa (2004)
3. R G Mortimer, Physical Chemistry 3rd Ed., Elsevier: Noida, UP (2009)
4. B R Puri, L R Sharma and M S Pathania, Principal of Physical Chemistry, Vishal Publishing Co.
5. B S Bahl, G D Tuli and Arun Bahl, Essentials of Physical chemistry, S Chand & Company Ltd.
6. A S Negi and S C Anand, A textbook of Physical Chemistry, New Age International Publishers.
7. B N Bajpai, Advanced Physical chemistry, S Chand and Company ltd.
8. R L Madan, Chemistry for Degree Students, Semester I, II, III and IV, S Chand and Company Ltd.
9. P L Soni, O P Dharmarha and U N Dash, Textbook of Physical Chemistry, Sultan Chand and Sons.


## PRACTICALS

**Credit Points: 2** **Teaching Hours:4Hrs**

**Evaluation : Continuous Internal Assessment : 25 marks**

**Semester End Examination : 25 marks**

### Course objective:

**To attain practical knowledge about:**

1. Analytical skills in detecting the constituents present in unknown samples by systematically carrying out the qualitative analysis.
2. The methods of determining rates of chemical reactions.
3. Designing electrochemical cells and making measurements related to it.
4. Determination of physical characteristics of electrolytes using conductivity measurements in solution.
5. Adsorption phenomenon, mechanism and basic models to explain adsorption.
6. Simple techniques like conductometry to obtain physicochemical parameters of electrolytes.

**Course outcomes:** At the end of the course student would be able to

1.Understand the chemical reactions involved in the detection of cations and anions.
2. Explain basic principles involved in classification of ions into groups in semi-micro qualitative analysis of salt mixture
3. Carryout the separation of cations into groups and understandthe concept of common ion effect.

4. Understand the choice of group reagents used in the analysis.
5. Analyse a simple inorganic salt mixture containing two anions and cations
6. Use instruments like conductivity meter to obtain various physicochemical parameters.
7. Apply the theory about chemical kinetics and determine the velocity constants of various reactions.
8. Learn about the reaction mechanisms.
9. Interpret the behaviour of interfaces, the phenomena of physisorption and chemisorptions and their applications in chemical and industrial processes.
10. Learn to fit experimental data with theoretical models and interpret the data

## Part A- Inorganic Chemistry Practicals

Qualitative semi-micro analysis of mixtures containing 2 anions and 2 cations.
Emphasis should be given to the understanding of different reactions.
The following cations and anions are suggested.
Cations: $NH_4^+$, $Pb^{2+}$, $Bi^{3+}$, $Cu^{2+}$, $Al^{3+}$, $Fe^{3+}$, $Co^{2+}$, $Cr^{3+}$, $Ni^{2+}$, $Zn^{2+}$, $Mn^{2+}$, $Ba^{2+}$, $Ca^{2+}$, $Sr^{2+}$, $Mg^{2+}$, $Na^+$, $K^+$ and $Li^+$.
Anions: $CO_3^{2-}$, $CH_3COO^-$, $Cl^-$, $Br^-$, $I^-$, $NO_3^-$, $BO_3^{3-}$, $SO_4^{2-}$, $C_2O_4^{2-}$ and $PO_4^{3-}$
Spot tests and flame tests to be carried out wherever possible.

### Part B- Physical Chemistry Practicals

1. Determination of the enthalpy of neutralization of a strong acid with strong base.
2. Verification of Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.
3. The study of kinetics of potassium persulphate and potassium iodide volumetrically.
4. Determination of velocity constant for acid catalyzed hydrolysis of methyl acetate.
5. Determination of velocity constant for the saponification of ethyl acetate ($a = b$) volumetrically.
6. Determination of equivalent conductivity of strong electrolyte and verification of DHO equation.
7. Determination of dissociation constant of weak acid by conductivity method.
8. Conductometric titration of strong acid and strong base.
9. Conductometric titration of weak acid and strong base.
10. Determination of solubility product of sparingly soluble salt conductometrically.

**References**

1. Vogel's Qualitative analysis, Revised by G. Svehla, Pearson education, 2002
2. J B Yadav, Advanced Physical Chemistry, Krishna Prakashan Media (P) Ltd, Meerut.
3. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
4. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
5. Halpern, A. M. &McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

**Semester 4**

**B Sc / B Sc (Honors)**

Title of the Course: **Open Elective: Electrochemistry, Corrosion and Metallurgy**

| Number of Theory Credits | Number of lecture hours/semester |
|---|---|
| 3 | 42 |

**Evaluation Scheme for Theory:**

Continuous Internal Assessment (CIA) – 40 Marks
Semester End Examination (SEE) – 60 marks

This course provides a broad introduction to the fundamental principles of Electrochemistry, Corrosion and Metallurgy. The student will gain an understanding of basic and practical applications in various fields of Electrochemistry, Corrosion and Metals and Alloy behaviour and manufacturing processes. This course is a valuable prerequisite for taking more technically challenging courses that will be required for career development.

**Course Objectives**

**This course will deal with**

1. Types of conductance, concept of electrolytes, electrolysis, redox reactions and EMF
2. Concept of different types of electrochemical cells, Types of electrodes and electrode potential. Application of electrochemical series.
3. Basic principles and applications of conductometric, potentiometric and pH titrations.
4. Different types of Batteries their principle construction and working - lead-acid storage and lithium ion battery. Study of Fuels cells.
5. Concept of corrosion, types of corrosion and its prevention by different methods. Introduction to electroplating.
6. Introduction to ores and minerals, extraction of metals from their ores, and purification. Eg., Manganese, Titanium and Uranium.
7. Study of alloys, classification, production and uses of alloys.

**Expected Course Outcomes**

Upon completion of the course students will be able to

1. Understand the concept of conductance in electrolytic solutions, electrolysis and redox reactions involved in electrode reactions.

2. Learn the different types of electrochemical cells, their symbolical representation and application of electrochemical series.
3. Apply conductometric, potentiometric and pH titrations
4. Know the principle, construction and working of batteries
5. Understand different types of corrosion and its prevention by different methods
6. Learn the methods of extraction of metals from their ores and purification

**UNIT I**

**Electrochemistry**

Conductance, specific and molar conductance Types of Electrolytes, Conductivity in electrolytic solution, Electrolysis, Kohlrausch's law and its application, Equivalent Conductance of Weak electrolyte at Infinite dilution.

Oxidation -reduction reactions, electrode potential, EMFof an electrochemical cell, cell reaction, Daniel cell, dry Cells - electrolytic and Galvanic cell, Representation of a cell. Standard electrode potential, Nernst equation (No derivation) and its application to chemical cell, Electrochemical series and its importance. Types of Electrodes.

Basic Principles of (i) Conductometric titrations- HCl Vs NaOH, $CH_3COOH$ Vs NaOH
(ii) Potentiometric titrations: Acid-base titration HCl Vs NaOH, Redox titration (FAS Vs $K_2Cr_2O_7$)
Determination of $P^H$ using glass electrode. **12 hrs**

**Batteries**- Primary and Secondary batteries, Battery components and their role. Working of the following Batteries- Lead acid, Lithium Storage, Batteries, Fuel cells. **2 hrs**

**UNIT II**

**Corrosion**: Introduction, definition, Types of Corrosion, Corrosion rate, Factors affecting corrosion rate, Metallic factor-purity, electrode potential of metal, hydrogen over voltage, natureof corrosion product. Environmental Factors-Temperature, pH of the medium, humidity, presence of impurities, electrical conductivity of the medium, velocity of the medium, concentration of the medium.

**Prevention of Corrosion**: Material selection - Metals and alloys, metal purification, non-metallic, Alteration of environment - Changing media, inhibitors, Design-wall thickness, design rules, Coating-Metallic and other inorganic coatings, organic coating.

**Electroplating:** Introduction, Electroplating of chromium (hard and decorative). Electro less plating: Introduction, distinction between electroplating and electroless plating processes. Electroless plating of copper. **14 hrs**

## UNIT III

**Metallurgy**

**Introduction:** Ore, minerals, important ores of some common elements in India, General Principles of pyrometallurgy, roasting, Calcination, Gangue, Smelting, Flux, Gravity separation, Froth flotation process, leaching. Techniques employed for Purification of metal (Distillation process, Bessemerization, Electro-refining, Van Arkel and De Boer's Filament.

**6 hrs**

**Extraction of metals:** Extraction of Manganese (Pyrolusite), Titanium (Ilmanite) and Uranium.

**4 hrs**

**Alloys:** Introduction, Classification of alloys, commercially important alloys, gold karats,Production of Ferro alloys; Ferrochrome, Ferro Manganese, Uses of alloys. **4 hrs**

**Reference Books**


1. Barrow. G.M, Physical Chemistry, Tata McGraw-Hill, (2007)
2. An introduction to electrochemistry, Samuel Glasstone, East-West edition New Delhi,(1942)
3. Text book of physical chemistry, Samuel Glasstone, 2nd Edition, Mac Millan India Ltd,(1991)
4. Principles and applications of Electrochemistry, D. R. Crow, 3rd edition, ChapmanhallLondon, (1988)
5. Fundamentals of electrochemical deposition, Milan Paunovic and MordechaySchlesinger, Wiley Interscience Publications, New York, (1998)
6. Engineering Chemistry, V R Kulkarni and K Ramakrishna Reddy, New Age International,(2015)
7. Electrochemistry and Corrosion Science, Nestor Perez, Springer (india) Pvt. Ltd., (2004)
8. Principles and Prevention of Corrosion, D. A. Jones, Macmillan Publ. Co., (1996)
9. Essential of Materials Science and Engineering, Donald R. Askeland, Thomson Learning,5th Edition, (2006)
10. Introduction to Engineering Materials, B. K. Agarwal, Tata McGraw Hill, 1st Edition
11. Material Science and Engineering, V. Raghavan, PHI Learning, 5th Edition
12. Engineering Materials and Metallurgy, R. K. Rajput, S. Chand - 1st Edition, (2011)

# OPEN ELECTIVES

## I SEM Non-Science Students

## Environmental Chemistry

**Unit I**

**Environmental Chemistry**

Vertical temperature and vertical structure of atmosphere, Heat/ radiation budget of the earth: Energy balance of earth, Bio Geo Chemical Cycles in environment: Oxygen, Carbon, Nitrogen, Phosphorous, Sulphur Cycle, Bio distribution of elements

**Ozone layer**

Ozone layer- Earth's protective umbrella: Formation & depletion, Ozone hole over Antarctica, harmful effects of Chlorofluoro Carbons (CFC),

**Acid rain:** Introduction, Theories of acid rain, adverse effects of acid rain, control of acid rain

21 Hours

**Unit II**

**Environmental Pollution**

Air pollution dealing with Particles, ions and radicals. Important photochemical reactions in atmosphere, Major sources of Air pollution, Aerosols and their effects, Effects of particulate matter, indoor and occupational pollutants, Air Quality standards

**Vehicular pollution**

Automobile emissions, Fuels: Diesel vs CNG, biofuels, prevention and control of vehicular pollution, gobal efforts in reducing vehicular pollution

**Smog:** Definition, mechanism of smog formation, examples of London Smog, Los Angeles Smog

21 Hours

References


1. Environmental Chemistry, Dr H Kaur, Pragathi Prakashan, 2016
2. Environmental Chemistry by Colin Baird and Michael Cann | 2012
3. A Textbook Of Environmental Chemistry 2020 by V. Subramanian

**II SEM Non-Science Students**

**Green Chemistry and clean energy sources**

**Unit I**

Principles and goals of Green Chemistry, Green chemicals, Green reagents, Green catalysts, Green solvents.

Emerging Green technologies, Microwave chemistry, Sono chemistry, Photo chemistry and Electro chemistry

Use of pesticides synthesized by Green chemistry route

21 Hours

**Unit II**

Growing energy demands, Resources of energy, Conventional sources of energy with example of hydroelectric power/ thermal power plants, nonconventional sources of energy: solar, wind, geothermal energy, ocean energy and tidal power

Fossil fuel based energy: coal, methanol, petroleum, natural gas, biomass energy, biogas

Hydrogen as an alternate source of energy. Energy consumption and conservation

Environmental impact assessment and environmental laws in India

21 Hours

References:

1.Green Chemistry for Beginners, , Anju Srivastava**,** Rakesh K Sharma, Tayler and Francis 2022.

2.Green Chemistry, Fundamentals and Applications, *Suresh C. Ameta, Rakshit Ameta,* Tayler and Francis 2022.2021

**III SEM Non-Science Students**

**Effects of Radioactivity**

**Unit I**

Introduction, Radiation, Natural and manmade sources of radioactive pollution, effects of radioactive pollution, biological effects of radiation, radiation effects on plants

Precautions to be taken in the event of nuclear war, preventive measures and control of radiation from nuclear power plants, atom bomb disaster in Hiroshima, three mile island disaster, Chernobyl : world's worst nuclear disaster

21 Hours

**Unit II**

Disposal of hazardous radioactive waste

Radioactive waste, environmental problems and management of nuclear waste, disposal methods of radioactive waste, recent methods to dispose critically dangerous radioactive waste

Classification of hazardous waste, management of hazardous waste, treatment and disposal of hazardous chemicals

21 Hours

References:


4. Environmental Chemistry, Dr H Kaur, Pragathi Prakashan, 2016
5. Environmental Chemistry by Colin Baird and Michael Cann | 2012
6. A Textbook Of Environmental Chemistry 2020 by V. Subramanian

## IV SEM Non-Science Students

## Water

**Unit I**

Introduction: Water quality parameters, standards and laws, Hard and Soft water, softening of water, demineralisation of waste water, purification of water for municipal purposes, chlorination and dechlorination, fluoridation and deflouridation, potability of water

Control of water pollution-minimisation, functions of central and state pollution control boards, recycling of waste water

21 Hours

**Unit II**

Analysis of water pollutants, objectives of water analysis, chemical substances affecting water quality: colour, odour, turbidity, conductivity, pH, acidity, alkalinity, etc, chemicals substances in water affecting health.

Definitions of following terms: Dissolved oxygen, COD(Chemical Oxygen Demand), BOD(Biological Oxygen Demand), and Total organic carbon content.

21 Hours

References:

1.Monitoring Water Quality Pollution Assessment, Analysis, and Remediation, Satinder Ahuja, Elsevier 2013.

2.Environmental Chemistry, Dr H Kaur, Pragathi Prakashan, 2016

# Mangalore University

## Scheme of Practical Examinations for B.Sc Chemistry Practicals

## (As per the New Education Policy)

**III Semester Chemistry Practical III**

**Duration: 4 hrs** **Max.marks:25**

**PART A**

Q.1 Any one of the following experiments may be set for the actual experimental work. The distribution of experiments is to be done such that more than four students do not get the same experiment. **10Marks**

1.Colorimetric determination of Copper using ammonia solution.

2.Colorimetric determination of Iron using Thiocyanate solution.

3.Colorimetric determination of Nickel using DMG solution.

4.Colorimetric determination of Titanium using hydrogen peroxide.

5.Colorimetric determination of Phosphate as Ammonium phosphomolybdate.

6.Colorimetric determination of Nitrite in a water sample ( diazo coupling reaction/Griers reagent).

7.Determination of Rf values of two or three component systems by TLC.

VALUATION SCHEME

The practical class records certified by the teacher in charge and head of the chemistry department should be produced at the time of examination.

EXPERIMENT

**I Colorimetric Determinations:**

i) Graph (good plot) with four points - 4 marks

Other plots -1 mark

ii) Error in concentration:

| | |
|---|---|
| ± 0.2mM | 6 Marks |
| ±0.3mM | 5 Marks |
| ± 0.4mM | 2 Marks |
| Any other value | 1 Mark |

II Chromatography:

i) Error in Rf volue

| | | |
|---|---|---|
| | Error upto ± 5% | 8Marks |
| | ± 6% to10% | 6Marks |
| | ± 11 % to 15% | 4Marks |
| | Any other value | 2Marks |
| ii | Calculation | 2Marks |

## PART B

## Organic Analysis 15 marks

**I Any one of the following organic compounds may be given for an analysis**

1)Salycilic acid, p-Nitro benzoic acid, Antranilicacid, p-Chloro benzoic acid 2) o-Cresol,p-Cresol, Resorcinol, o- Nitrophenol, p-nitophenol 3)o-Nitro aniline, p-Nitroaniline, p-Toluidine, p-Chloroaniline, p-Bromoaniline, 4)Ethyl Salicylate, Salicylaldehyde, Acetophenone, p-Dichlorobenzene, p-Nitro toluene, Benzamide.

**II) Compounds should be distributed among students such that, more than three students do not get same compound.**

### Valuation Scheme

| | |
|---|---|
| Preliminary tests | 1 mark |
| Physical Constant | 1 mark |
| Detection of elements(Nitrogen & Halogen) | 4 marks |
| Determination of Solubility | 3 marks |
| Reactions of functional group (any two) | 4 marks |
| Name and Structure | 2 marks |

**xxxxxxxxx**

**Allotment of Marks for Formative assessment:**

**Maximum marks: 25**

**i)Laboratory Record and Attendance 10Marks**

**ii)Internal Practical Examination 15Marks.**

**Internal Practical Examination should be conducted as per the university examination scheme and maximum marks is to be reduced from 25 to 15.**

xxxxxxxxxxxxx

# Scheme of Practical Examinations and Valuation Procedures for B.Sc. Chemistry Practical as per the New Education Policy

**IV Semester BSc Chemistry Practical – IV**

**Duration: 4Hrs** **Max. Marks: 25**

## Part –A Inorganic chemistry Practical

### Exercise set for inorganic qualitative analysis (12 marks)

1. Inorganic systematic qualitative analysis of the mixture of two simple salts containing two anions and two cations using semi micro technique.

i)A simple powdered mixture of inorganic salts containing two anions and two cations is to be prepared on the spot by examiners from simple salts having the following anions and cations.

Anions: $CO_3^{-2}$, $CH_3COO^-$, $Cl^-$, $Br^-$, $I^-$, $NO_3^-$, $BO_3^{3-}$, $SO_4^{2-}$ $C_2O_4^{-2}$ and $PO_4^-$,

Cations: $NH_4^+$,$Pb^{2+}$, $Bi^{3+}$, $Cu^{2+}$, $Al^{3+}$,$Fe^{+3}$ $Mn^{2+}$, $Zn^{2+}$, $Ba^{2+}$, $Ca^{2+}$, $Sr^{2+}$, $Mg^{2+}$, $Na^+$, $K^+$ and $Li^{+1}$

Note:

1.Mixture requiring elimination of phosphate and borate radicals must be avoided (avoid cations such as $Ba^{2+}$, $Ca^{2+}$, $Sr^{2+}$,$Mg^{2+}$ when borate or phosphate radicals are given).

2. Mixures of salts which on double decomposition form precipitates insoluble in dilute HCl (like $BaSO_4$, $SrSO_4$, $PbSO_4$) should not be given.

3. Combination like $NO_3^-$ and $Br^-$, $NO_3^-$ and $I^-$ ,$Cl^-$ and $Br^-$, $Cl^-$ and $I^-$, $Cl^-$ and $NO_3^-$, $Br^-$ and $I^-$ must be avoided.

4. The cations should belong to different groups. For example a combination of $Ca^{2+}$, and $Sr^{2+}$, $Ba^{2+}$ and $Ca^{2+}$, $Ba^{2+}$ and $Sr^{2+}$, $Mg^{2+}$ and $Na^+$, $Na^+$ and $K^+$, $Mg^{2+}$ and $Na^+$, $Na^+$ and $K^+$, $Mg^{2+}$ and $K^+$, $Al^{3+}$ and $Mn^{2+}$, $Mn^{2+}$ and $Zn^{2+}$, $Bi^{3+}$ and $Cd^{2+}$ must be avoided.

5. AR and GR grade chemicals are used for preparing mixtures.

6. Different mixtures should be prepared and distributed to the candidates (by lots) so that not more than three candidates in a batch get the same mixture.

7. In case of cations, recording of tests are to be done until two cations are detected and confirmed.

**Inorganic qualitative analysis.**

| | |
|---|---|
| Four radicals reported correctly | 12marks |
| Three radicals reported correctly | 09 marks |
| Two radicals reported correctly | 06 marks |
| One radical reported correctly | 03marks |

**Note:**

1. For detecting only the group to which the cations belong, one mark for each correct group should be given.

2. If more than four radicals are reported, reduce three marks for each extra radical reported.

3. In case of anions, confirmatory test is expected.

4. In case of cations confirmatory test is expected only in case of $NH_4^+$.

5. Flame test may be considered as one of the preliminary test only and not as a conclusive test for cation.

6. In case of anions, positive tests should be recorded in detail while the essential negative tests may be recorded in brief.

**Part B- Physical Chemistry Practical (13 marks)**

Any one of the following experiments may be given.

- Determination of the enthalpy of neutralization of a strong acid with a strong base.

7. Verification of Freundlich isotherm for adsorption of acetic acid adsorbed onactivated charcoal.
8. The study of kinetics of potassium persulphate and potassium iodidevolumetrically.
9. Determination of velocity constant for acid catalyzed hydrolysis of methyl acetate.
10. Determination of velocity constant for the saponification of ethyl acetate ($a = b$)volumetrically.
11. Determination of equivalent conductivity of sodium chloride and verification ofDHO equation.
12. Determination of dissociation constant of weak acid by conductivity method.
13. Conductometric titration of strong acid and strong base.
14. Conductometric titration of weak acid and strong base.

10. Determination of solubility product of sparingly soluble salt conductometrically

## Valuation Scheme

1. Determination of the enthalpy of neutralization of a strong acid with strong base. 13 Marks

i) Error in enthalpy value

| | |
|---|---|
| Error upto ±10% | 10 Marks |
| ±11% to 15% | 08 Marks |
| ±16% to 20% | 06 Marks |
| ±21% to 25% | 04 Marks |
| Any Other value | 02 Marks |
| Calculation | 03 Marks |

2. Verification of Freundlich isotherm for adsorption of acetic acid on activated charcoal

a) Tabulation and calculation 03 Marks

b) Graph (good plot) 06 Marks
Deduct marks proportionally for variation

c) Calculation of k and n values
Calculation 04 marks

Experiments 3 to 5 (Velocity constant determination Experiments)

i) Error in velocity constant value

| | |
|---|---|
| Error upto ±10% | 10 Marks |
| ±11% to 15% | 08 Marks |
| ±16% to 20% | 06 Marks |
| ±21% to 25% | 04 Marks |
| Any Other value | 02 Marks |

ii) Calculation 03 Marks

6.. Determination of equivalent conductivity of strong electrolyte(sodium chloride) and verification ofDHO equation

a) Graph (good plot) 04Marks
Other plots 02Marks

b) Error in values

| | |
|---|---|
| ± 0.2 ml | 06Marks |
| ± 0.3 ml | 05Marks |
| ± 0.4 ml | 04Marks |
| ± 0.5 ml | 03Marks |
| Other values | 02Marks |

c) Calculation of equivalent conductance 03Marks

7. Determination of dissociation constant of weak acid by conductivity method

a) Graph (good plot) 04 Marks
Other plots 02 Marks
b) Error in values

| | |
|---|---|
| ± 0.2 ml | 06 Marks |
| ± 0.3 ml | 05 Marks |
| ± 0.4 ml | 04 Marks |
| ± 0.5 ml | 03 Marks |
| Any Other value | 02 Marks |

c) Calculation dissociation constant 03 Marks

8. Conductometric titration of a strong acid with a strong base

a) Graph (good plot) 05 Marks
Other plots 02 Marks
b) Error in values

| | |
|---|---|
| ± 0.2 ml | 06 Marks |
| ± 0.3 ml | 05 Marks |
| ± 0.4 ml | 04 Marks |
| ± 0.5 ml | 03 Marks |
| Any Other value | 02 Marks |

c) Calculation 02 Marks

9. Conductometric titration of weak acid and strong base.

a) +Graph (good plot) 05 Marks
Other plots 02 Marks
b) Error in values

| | |
|---|---|
| ± 0.2 ml | 06 Marks |
| ± 0.3 ml | 05 Marks |
| ± 0.4 ml | 04 Marks |
| ± 0.5 ml | 03 Marks |
| Any Other value | 02 Marks |
| Calculation | 02 Marks |

10. Determination of solubility product of sparingly soluble salt conductometrically

i) Error in solubility product value

| | |
|---|---|
| Error upto ±8% | 10 Marks |
| ±9% to 13 % | 08 Marks |
| ±14% to 16% | 06 Marks |
| ±16% to 20% | 04 Marks |

Any Other value 02 Marks

ii) Calculation 03 Marks

**Allotment of Marks or Formative Assessment:**
**Maximum Marks: 25**

**i)Laboratory Record and Attendance 10Marks**
**ii)Internal Practical Examination 15Marks.**

**Internal Practical Examination should be conducted as per the university examination scheme and maximum marks is to be reduced from 25 to 15.**

**xxxxxxxxxx**