Semester –IV; CHEMISTRY: DSC-4: Chemistry-IV

Number of Theory Credits	Number of lecture hrs/semester	Number of practical Credits	Number of practical hrs/ sem
4	56	**2**	**56**
Content of Theory Course 4			**56Hrs**

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

Syllabus

Unit-I Separation methods **14 hrs**

Fundamentals of chromatography: General description, definition, terms and parameters used in chromatography, classification of chromatographic methods, criteria for selection of stationary and mobile phase, 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. **5 hrs**

Paper chromatography: Theory and applications

Thin layer chromatography (TLC): Mechanism, $R_f$value, efficiency of TLC plates, development, spray reagents, identification and detection, qualitative applications **2 hrs**

Solvent Extraction: Types-batch, continuous, efficiency, selectivity, distribution coefficient, 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,). **3hrs**

Unit-II Structure and Bonding-II **14hrs**

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. **4hrs**

Molecular Orbital theory-II:

Calculation of bond order, relationship between bond order, bond energy and bond length. Magnetic properties based on MOT. Examples of molecular orbital treatment for homonulcear diatomic molecules: He_2, Li_2, Be_2, B_2, C_2, N_2, N_2^+, and O_2^{2-} **5hrs**

Metallic Bonding:

General properties of metals: Conductivity, Lustre, Malleability and cohesive force, 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. **5hrs**

Unit III Reaction Intermediates and methods of identification **14hrs**

Reaction Intermediates: Generation, Stability and Reactions of,

i) Carbocations: Dienone-phenol; and Pinacol-Pinacolone Rearrangement.
ii) Carbanions: Perkin Reaction, Aldol condensation,
iii) Free Radicals: Sandmeyer Reaction
iv) Carbenes and Nitrenes: Singlet and Triplet states, their relative stability and reactions
v) Arynes: Formation and detection **9hrs**

Methods for Identifying Reaction Mechanism:

Product analysis, Isolation and identification of intermediates, stereochemical evidences, crossover experiments, isotopic studies, kinetic studies **5 hrs**

UNIT-IV Kinetics and Electrochemistry 14hrs

Chemical Kinetics-II

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. **5 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 mobility and its determinations, transference numbers and their relation to ionic mobility's, determination of transference numbers using Hittorf 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. **9hrs**

Reference Books

1. Peter Atkins & Julio De Paula, Physical Chemistry, 9th Ed., Oxford University Press(2010)
2. GWCastellan,PhysicalChemistry,4thEd.,Narosa(2004)
3. RGMortimer,PhysicalChemistry3rdEd.,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 ArunBahl, 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. BN 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: 25marks
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. Carry out the separation of cations into groups and understand the 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-microanalysis of mixtures containing 2anions 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^+.

Anions: CO_3^{2-},Cl^-,Br^-,I^-,NO_3^-,,SO_4^{2-}, S^{-2}(Sulphide)

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. Determination of velocity constant for acid catalysed hydrolysis of methylacetate.
3. Determination of equivalent conductivity of strong electrolyte and verification of DHO equation.
4. Determination of dissociation constant of weak acid by conductivity method.
5. Conductometric titration of strong acid and strong base.
6. Conductometric titration of weak acid and strong base.

Examination

In the practical examination, a batch of maximum 15 (Fifteen) students may be made. Anyone experiment from Part-A or B can be given by selection done by the students based on lots. **Viva questions must be asked on any of the experiments prescribed in the practical syllabus.**

Part A: Distribution of Marks:

Preliminary tests and presentation - 04 marks,
Anions (group test + C.T +ionic reactions) (1+1+1)×2=6 marks,
Cations (group test + C.T+ ionic reactions) (1+3+1)×2=10 marks,
Viva-Voce-5 marks,
Total=25 marks.

Part B: Distribution of marks

1. Accuracy: 12 Marks
2. Technique and presentation: 03 Marks
3. Graphs and Calculations: 05 Marks
4. Viva: 05 Marks

Total 25 Marks

Deduction of marks for accuracy: Error up to 5% - 12 marks, 6 - 10% 09 marks, 11-15% 6 marks, 16 or above 3 marks.

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

Semester4

BSc/B Sc(Honors)

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

Course	Credits	No. of Classes/ Week	Total No. of Lecture Hours	Duration of Exam in hrs	Internal Assessment Marks	Semester End Exam Marks	Total Marks
Theory	03	03	42	2	40	60	100

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 **14hrs**

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, EMF of 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 $K_2Cr_2O_7$) **12hrs**

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

Unit II Corrosion **14hrs**

Corrosion: Introduction, definition, Types of Corrosion, Corrosion rate, Factors affecting corrosion rate, Metallic factor-purity, electrode potential of metal, hydrogen overvoltage, nature of 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. **7hrs**

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. **4hrs**

Electroplating: Introduction, Electroplating of chromium (hard and decorative). Electro lessplating: Introduction, distinction between electroplating and electroless plating processes. Electroless plating of copper. **3hrs**

Unit III Metallurgy **14hrs**

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 DeBoer's filament **6hrs**

Extraction of metals: Extraction of Manganese (Pyrolusite) Titanium (Ilmanite) and Uranium. **4hrs**

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

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, Chapmanhall London,(1988)
5. Fundamentals of electrochemical deposition, Milan Paunovic and Mordechay Schlesinger,Wiley Interscience Publications,NewYork,(1998)
6. Engineering Chemistry, VR 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. Essentials of Materials Science and Engineering, Donald R.Askeland, Thomson Learning, 5th Edition, (2006)
10. Introduction to Engineering Materials, B.K.Agarwal,TataMcGrawHill,1st Edition
11. Material Science and Engineering,V.Raghavan,PHILearning,5th Edition
12. Engineering Materials and Metallurgy, R.K.Rajput,S.Chand-1st Edition,(2011)

SEMESTER IV

OEC 4 - ANALYTICAL INSTRUMENTATION

[Only For B. Sc. (Sugar Science & Technology) Students]

Credits – 3	Max. Marks: 100
Teaching Hours / week: 4 Hours	Marks: Theory = 60
Theory Examination duration :2 Hours	Internal assessment= 40

Unit – I **14 Hours**

Spectroscopy: General principles of absorption spectroscopy, theory of Colorimetry, Beers & Lambert Law, Instrumentation of Photoelectric Colorimeter, construction of standard curve and applications.

Flame Photometry: General discussion and elementary theory, Instrumentation of flames photometer, monochromators, detectors and applications

Unit – II **14 Hours**

Polarimetry: Introduction, plane polarized light, optical activity, Instrumentation of Polarimeter, types of polarimeter, Laurenzpolarimeter, Industrial polarimeter, white lamp single wedge and double wedge polarimeter, automatic polarimeter, measurement of specific rotation and determination of unknown concentration and other applications in sugar technology.

Refractometry: Introduction, Snell's law, specific refraction, molar refraction, Hand Refractometer, Abbe's Refractometer, experimental techniques and applications.

Unit – III **14 Hours**

pH and Conductivity measurements: Introduction sensors, Electroanalytical Sensors, different types of sensor electrodes, pH meter, standardization and pH measurements, conductivity solutions, specific and equivalent conductivity, equivalent conductivity at infinite dilution, measurement of conductivity/resistivity of solution, Conductometers, conductivity cell applications.

Laboratory equipment calibration process – Brix hydrometer, Thermometer, weight box, lab oven, Polarimeter, Refractometer, pH meter, conductivity meter, TDS meter, spectrophotometer

Unit – IV **14 Hours**

Chromatography: Introduction, Classification of chromatographic methods, introduction of terms used in chromatography,

Thin layer chromatography: Introduction of basic concept and technique, methodology, application,

Gas chromatography: General introduction of terminology, stationary phases, supports used for making GLC column

REFERENCE BOOKS:

1. Vogel's Textbook of quantitative inorganic revised by J. Bassett et al.
2. Instrumental Methods of Chemical Analysis by H. Kaur.
3. Instrumental methods of analysis by Strobel.
4. Practical Physical Chemistry by Findley.
5. Instrumental methods of chemical analysis by Bhal and Tuli.