Bachelors with Chemistry as Major
3rd Semester
CHM322J: CHEMISTRY: FUNDAMENTALS OF CHEMISTRY AND CHEMICAL ANALYSIS-III

Credits: Theory-4, Lab-2

Theory (4 credits: 60 Hours) **Max. Marks: 100, Min Marks:** 36

Course Objectives:

- *To understand the chemistry of transition elements.*
- *To understand the chemistry of oxygen bearing compounds.*
- *To understand the fundamentals of electrochemistry.*
- *To understand different theories of kinetics.*
- *To study about rates and mechanisms of chemical reactions.*

Learning outcomes:

On completion of the course, the student should be able to:

- *Appreciate and contrast chemistry of transition elements.*
- *Understanding of electronic, magnetic, spectral and bonding properties of their complexes*
- *Applications of transition elements.*
- *Learn the chemistry of oxygen bearing compounds.*
- *Evaluate fundamentals of conduction and electrochemical cells*
- *Understand the kinetics of chemical processes.*

Unit-I: Transition elements **(15 hours)**

Characteristic properties of Transition elements: variable oxidation states, anomalous electronic configurations. Trends in ionic radii, hydration and lattice energy of 3d series. Standard Electrode Potentials of M^{2+}/M and M^{3+}/M^{2+} systems. Complexing ability, Catalytic properties (. Acidic/Basic character of transition metal compounds in various oxidation states. Stabilization of unusual oxidation states. Chemistry of selected transition metal compounds (Potassium ferricyanide and sodium nitroprusside). Magnetic properties: calculation of magnetic moment value (spin only). Spectral properties (d-d bands and charge transfer transitions).

Unit-II: Reaction Mechanism in Organic Chemistry-III **(15 hours)**

Alcohols: Synthesis of 1, 2 diols and trihydric alcohols (Glycerol). Periodic acid and lead tetra acetate oxidations of 1,2-diols. Reactions of glycerol with Na, PCl_5, Acetylation, Oxalic acid, HI, Dehydration, HCl, and oxidation reactions, Noble Oil.

Phenols: Comparative study of acidic character of substituted phenol and Napthols, Nitration and sulphonation on α and β napthols, Mechanisms of, Kolbe's–Schmidt reactions, Fries and Claisen rearrangements.

Mechanism of Nucleophillic addition reactions of aldehydes/ketones: Reaction with HCN, ROH, $NaHSO_3$ and amines, Aldol, Perkin Condensation, Cannizzaro's and Wittig reaction. Clemensen, Wolff Kishner, Meerwein-Pondorff Verley and Bouvaelt-Blanc Reduction. Baeyer Villeger oxidation.

Unit-III: Chemical Kinetics and Catalysis **(15 hours)**

Reaction Order and Rate constants: Order of reaction, derivation of rate equations for second (two reactants) and third order reactions. Determination of order of reaction by differential rate, integration, half-life period and

isolation methods.
Temperature dependence of reaction rates:-Arrhenius equation, concept of activation energy.
Theories of chemical kinetics*:* Simple collision theory based on hard sphere model, estimation of rate constants of atomic reactions, extension to molecular reactions, limitations.

Catalysis: Introduction, mechanism of action of catalysts, Acid-Base catalysis*:* Generalized and specific acid-base catalysis, pH dependence of reaction rate

Unit-IV: Electrochemistry: (15 hours)

Ionic Conductors: Electrolytes as conductors, Migration of ions and Kohlrausch's law, ionic mobility, Debye-Huckel-Onsager's equation for strong electrolytes (Approximations and predictions, no derivation). Transport number, definition and determination by Hittorf's and moving boundary methods.
Application of conductivity measurements: determination of the degree of dissociation and dissociation constants of acids, solubility product of a sparingly soluble salt, conductometric titrations.

Electrochemical Cells: electrode types, electrode potential and its measurement,
Nernst equation and cell E.M.F and its measurement. Electrochemical series and its significance.

Concentration cells: electrolyte concentration cells without transport.

Application of EMF measurements: Determination of thermodynamic functions of cell reactions (ΔG, ΔH and K.), potentiometric acid-base titrations (pH and pKa determination).

Books Recommended:

1. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.
2. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.
3. Madan, R.L., "Chemistry for Degree Students, B. Sc. Second Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.
4. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010.
5. Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers, India, 2018, 1st edition. vi. Prakash, S., Tuli, G.D., Basu, S.K. and Madan, R.D., "Advanced Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2000, Vol 1.
6. Advanced General Organic Chemistry: A Modern Approach; S.K. Ghosh; 3rd Revised Edn., New Central, 2010.
7. Organic Chemistry; R.T. Morrison, R.N. Boyd, S. K. Bhattacharjee; 7^{th} Edn., Pearson India, 2011.
8. Advanced Organic Chemistry; Dr. Jagdamba Singh and LDS Yadav; Pragati edition,2017.
9. Principles of Physical Chemistry; B.R. Puri, L.R. Sharma and L.S. Pathania; 47^{th} Edn.,Vishal Pubs & Co, 2017.
10. Physical Chemistry; Barrow, G. M.; 5thed.; McGraw-Hill; International Student edition; 1992.
11. Elements of Physical Chemistry, Peter Atkins and Julio de Paula, 7^{th} Edition, Oxford University Press, 2016.
12. Physical Chemistry, Concepts and Models, Volume III, Nabakumar Bera, Subhasree Ghosh, Paulami Ghosh, Techno world.
13. Atkins' Physical Chemistry, Peter Atkins, Julio de Paula & James Keeler, 11^{th} Edition, Oxford University Press, 2018.

Practical (2 credits: 60 Hours) Max. Marks: 50, Min Marks: 18

Section A: Qualitative Inorganic Analysis

1. Qualitative Analysis: To identify the given Inorganic mixture containing two acidic and two basic radicals (excluding insoluble and interfering radicals) by Macro scale analysis (06 known and 06 unknown mixtures).
2. Paper Chromatography: Separation and identification of metal ions from mixtures containing two cations through ascending and radial methods. (03 exercises)

Section B: Synthesis and Binary Mixture Analysis

1. Separation and Identification of binary mixtures of Organic Compounds using H_2O, $NaHCO_3$ or NaOH.

2. Organic Synthesis (Any two)*
   a) Aspirin via Acetylation of Salicylic acid
   b) Iodoform from acetone
   c) 2,4-dinitrophenylhydrozone formation of aldehydes/ketones
   *Any other feasible single stage synthesis

Section C: Physical Parameter determination

1. Determination of equivalent conductance, degree of dissociation and the dissociation constant of a weak acid.
2. Determination of the concentration of HCl and CH_3COOH by conductometric titration.
3. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
4. Determination of H_3PO_4 content in a given sample of Soft drink.
5. Determination of strength and pKa value of weak acid by titration with an alkali using quinhydrone electrode.
6. Titration of Fe (II) vs. $K_2Cr_2O_7$ and determination of formal redox potential of Fe^{2+} /Fe^{3+}.

Books Recommended:

1. Vogel's; text book of Quantitative Inorganic Analysis (revised); Bassett, J.; Denney, R.C.; Jeffery, G. H and Mendham, J.; 6th ed.; ELBS; 2007.
2. Comprehensive Practical Organic Chemistry: Qualitative analysis Ahluwalia, V.K. &Sunita Dhingra; Universities Press, India, 2004.
3. Advanced Practical Organic Chemistry; N. K. Vishnoi; 3rdEdn; Vikas Publishing, 2009.
4. Advanced Practical Physical Chemistry; J.B. Yadav; Krishna Prakashan Media (P)Limited, 2015.
5. Selected Experiments in Physical Chemistry; Mukherjee N.G.& Ghosh, J.N.; S. Chand & Sons.
6. Advanced Physical Chemistry Experiments; J. N. Gurtu, A. Gurtu, PragatiPrakashan, 2008.
7. Experiments in Physical Chemistry; Das, R. C, and Behra, B.; Tata McGraw Hill.