Syllabus of Chemistry (Major & Minor)
for 3-Year and 4-Year B.Sc. Course

Chemistry Major

Semester-II

Paper Code: CEMMJ-T3 (Organic Chemistry - II) **(Credit:03)**
Total Lectures: 45

1. Chemistry of Alkenes & Alkynes (15L)

Addition To C=C: Mechanism (With Evidence Wherever Applicable), Reactivity, Regioselectivity (Markownikoff And Anti-Markovnikov Additions) And Stereoselectivity; Reactions: Hydrogenation, Halogenation, Hydrohalogenation, Hydration, Oxymercuration- Demercuration, Hydroboration-Oxidation, Epoxidation, Syn And Anti-Hydroxylation, Ozonolysis, Addition Of Singlet And Triplet Carbenes; Simmons-Smith Cyclopropanation Reaction; Electrophilic Addition To Diene (Conjugated Dienes And Allene); Radical Addition: Hbr Addition; Mechanism Of Allylic And Benzylic Bromination In Competition With Brominations Across C=C; Use Of Nbs; Birch Reduction Of Benzenoid Aromatics; Interconversion Of E- & Z- Alkenes; Contra-Thermodynamic Isomerization Of Internal Alkenes.
Addition To C≡C (In Comparison To C=C): Mechanism, Reactivity, Regioselectivity (Markownikoff& Anti-Markovnikov Addition) And Stereoselectivity; Reactions:Hydrogenation, Halogenations, Hydrohalogenation, Hydration, Oxymercuration- Demercuration, Hydroboration-Oxidation, Dissolving Metal Reduction of Alkynes (Birch); Reactions of Terminal Alkynes By Exploring Its Acidity; Interconversion Of Terminal And Non-Terminal Alkynes.

2. Reaction Mechanism-II (15L)

Reaction thermodynamics: Free energy and equilibrium, enthalpy and entropy factor, calculation of enthalpy change via BDE, intermolecular & intramolecular reactions.

Concept of organic acids and bases: Effect of structure, substituent and solvent on acidity andbasicity; proton sponge; gas-phase acidity and basicity; comparison between nucleophilicity and basicity; HSAB principle; application of thermodynamic principles in acid-base equilibria.

Tautomerism: Prototropy (keto-enol, nitro - aci-nitro, nitroso-oximino, diazo- amino and enamine-imine systems); valence tautomerism and ring-chain tautomerism; composition of the equilibrium in different systems (simple carbonyl; 1,2- and 1,3-dicarbonyl systems, phenols and related systems), factors affecting keto-enol tautomerism; application of thermodynamic principles in tautomeric equilibria.

Reaction kinetics: Rate constant and free energy of activation; concept of order and molecularity; free energy profiles for one-step, two-step and three-step reactions; catalyzed reactions: electrophilic and nucleophilic catalysis; kinetic control and thermodynamic control of reactions; isotope effect: primary and secondary kinetic isotope effect (k_H/k_D); principle of microscopic reversibility; Hammond's postulate.

3. Aromatic Substitutions: (8L)

Electrophilic aromatic substitution: mechanisms and evidences in favour of it; orientation and reactivity; reactions: nitration, nitrosation, sulfonation, halogenation, Friedel-Crafts reaction; one-carbon electrophiles (reactions: chloromethylation, Gatterman-Koch, Gatterman, Houben- Hoesch, Vilsmeier-Haack, Reimer-Tiemann, Kolbe-Schmidt); Ipso substitution.

Nucleophilic aromatic substitution: addition-elimination mechanism and evidence in favour of it; S_NAr mechanism; cine substitution (benzyne mechanism), structure of benzyne.

4. Chemistry of Alcohols, Ethers and Phenols (7L)

A. **Alcohols**: (Up To 5 Carbons). Preparation: Monohydric, Dihydric and Trihydric Alcohols: Using Grignard Reagent, Reduction of Aldehydes, Ketones, Carboxylic Acid and Esters; Reactions: With Sodium, Hx (Lucas Test), Oxidation (Alkaline $KMnO_4$, Acidic Dichromate, Concentrated HNO_3); Oppenauer Oxidation;
b. **Dihydric Alcohols**: Preparation (with OsO_4); pinacol- pinacolone rearrangement (with mechanism) (with symmetrical diols only).
c. **Trihydric Alcohols**: Glycerol (Few rexn may be added like Nitration, halogenation, nitration etc)
d. **Phenols**: Preparation: cumene hydroperoxide method, from diazonium salts; acidic nature of phenols; Reactions: electrophilic substitution: nitration and halogenations; Reimer -Tiemann reaction, Houben–Hoesch condensation, Schotten –Baumann reaction, Fries rearrangement and Claisen rearrangement.
e. **Ethers**: Preparation: Williamson's ether synthesis; Reaction: cleavage of ethers with HI.

Reference Books:

1.Clayden, J., Greeves, N., Warren, S. Organic Chemistry, Second edition, Oxford University Press 2012. 2. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003. 3. Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited. 4. Carey, F. A., Guiliano, R. M. Organic Chemistry, Eighth edition, McGraw Hill Education, 2012. 5. Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press, 2008. 6. Norman, R.O. C., Coxon, J. M. Principles of Organic Synthesis, Third Edition, Nelson Thornes, 2003. 7. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 8. Finar,I. L. Organic Chemistry (Volume 1), Pearson Education. 9. Graham Solomons, T.W., Fryhle, C. B. Organic Chemistry, John Wiley & Sons, Inc. 10. March, J. Advanced Organic Chemistry, Fourth edition, Wiley. 11. Jenkins, P. R., Organometallic Reagents in Synthesis, Oxford Chemistry Primer, Oxford University Press. 12. Ward, R. S., Bifunctional Compounds, Oxford Chemistry Primer, Oxford University Press

Paper Code: CEMMJ-P3 (Organic Chemistry - II PRAC) (Credit: 01)

(30 Hours)

List of Practicals

Organic Preparations-I:

A. The following reactions are to be performed, noting the yield of the crude product:

1. Nitration of aromatic compounds
2. Condensation reactions
3. Hydrolysis of amides/imides/esters
4. Acetylation of phenols/aromatic amines
5. Benzoylation of phenols/aromatic amines

B. Purification of the crude product is to be made by crystallization from water/alcohol, crystallization after charcoal treatment, or sublimation, whichever is applicable.

C. Melting point of the purified product is to be noted.

Paper Code: CEMMJ-T4 (Inorganic Chemistry - I) **(Credit: 03)**
Total Lectures: 45

1. Atomic Structure: **(15 L)**

Bohr's theory, its limitations and atomic spectrum of hydrogen atom; Sommerfeld's Theory. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f-orbitals. Pauli's Exclusion Principle, Hund's rules and multiplicity, Exchange energy, Aufbau principle and its limitations, Ground state term symbols of atoms and ions for atomic number up-to 30.

2. Chemical Periodicity: **(15 L)**

Modern IUPAC Periodic table, Effective nuclear charge, screening effects and penetration, Slater's rules, atomic radii, ionic radii (Pauling's univalent), covalent radii, lanthanide contraction. Ionization potential, electron affinity and electronegativity (Pauling's, Mulliken's and Allred Rochow's scales) and factors influencing these properties, group electronegativities. Group trends and periodic trends in these properties in respect of s-, p- and d-block elements. Secondary periodicity, relativistic effect, inert pair effect.

3. Acid and bases: **(15 L)**

Acid-base concept: Arrhenius concept, theory of solvent system (in H_2O, NH_3, SO_2 and HF), Bronsted-Lowry's concept, relative strength of acids, Pauling's rules. Lux-Flood concept, Lewis concept, group characteristics of Lewis acids, solvent levelling and differentiating effects. Thermodynamic acidity parameters, Drago-Wayland equation. Hammett acidity function. Super acids, Gas phase acidity and proton affinity; HSAB principle. Acid-base equilibria in aqueous solution (Proton transfer equilibria in water), pH, buffer, salt hydrolysis. Acid-base neutralization curves; indicator, choice of indicators.

Recommended Text Books and Reference Books:

1. Lee, J. D. Concise Inorganic Chemistry,5th Ed., Wiley India Pvt. Ltd., 2008.
2. Atkins, Overton, Rourke, Weller, Armstrong; Shriver & Atkins' Inorganic Chemistry, 5th Ed., Oxford University Press (2010).
3. G. L. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson India, 2008
4. R. Sarkar, General and Inorganic Chemistry Part-I,New Central Book Agency, 2014
5. A. G. Sharpe, C. E. Housecroft, Inorganic Chemistry 3rd Edition, Pearson India ,2002
6. J. E. Huheey, E. A. Keiter, R. L. Keiter, Okhil K. Medhi, Principles of Structure and Reactivity, 5th Edition,Pearson India,2022
7. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 1 & 3, Second Edition), CBS Publishers & Distributors Pvt. Ltd.
8. Principles of Inorganic Chemistry (33rd Edition), B.R. Puri, L.R. Sharma, K.C. Kalia, Vishal Publishing Co.
9. R. L. Dutta and G. S. De, Inorganic Chemistry, Pt – I, 7th Edn, 2013, The New Book Stall, 2013.

Paper Code: CEMMJ-P4 (Inorganic Chemistry - I PRAC) **(Credit: 01)**
(30 Hours)

List of Practicals

Acid – Base Titration:

1. Estimation of Na_2CO_3 and NaOH in a mixture.
2. Estimation of $NaHCO_3$ and Na_2CO_3 in a mixture.

3. Estimation of alkali content of antacid tablet.
4. Estimation of acetic acid content of commercial vinegar.

Basics Of Qualitative Inorganic Analysis:

Only dry tests and confirmatory tests of simple water soluble single salts like $(NH_4Cl/(NH_4)_2SO_4$, $Pb(NO_3)_2$, $CuSO_4$, $Cr_2(SO_4)_3$, $Al_2(SO_4)_3$, $FeSO_4$, $NiCl_2/NiSO_4$, $ZnSO_4$, $MnCl_2/MnSO_4$, $CoCl_2/CoSO_4$, $CaCl_2$, $BaCl_2/Ba(NO_3)_2$, $SrCl_2/Sr(NO_3)_2$, NaCl, KCl, $MgCl_2/MgSO_4$.

Reference Books:

1. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas and B. Sivasankar, Vogel's Text Book of Quantitative Chemical Analysis (6th Edition), Pearson.
2. Chemistry in Laboratory (New Revised Edition), S. Ghosh, M. Das Sarma, D. Majumdar, S. Manna; Santra Publication Pvt. Ltd.
3. A. K. Nad, B. Mahapatra & A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd.
4. Advanced Practical Chemistry (3rd Edition), S.C. Das.
5. Bhattacharyya, R. C, A Manual of Practical Chemistry.

Paper Code: CEMMJ-SEC-II (IT Skills for Chemists & Introduction to Nanotechnology)

Total Lectures: 45 **(Credit: 03)**

1. Introduction to Computer: **(5L)**

Components, classification, input and output devices, memory unit, storage devices; hardware and software, computer languages (basic idea), operating systems, number systems (conversion of binary, decimal, octal, hexadecimal and their inter-conversion), computer softwares used in basic chemistry (name and uses).

2. Basic Mathematics for Chemists **(10L)**

Basic theory, principles and problems related to chemistry only: Mathematical functions, polynomial expressions, logarithms, the exponential function, constants and variables, basic rules of differentiation, maxima and minima, applications in chemistry, plotting graphs. Exact and inexact differential, Taylor and McLaurin series, Fourier series and Fourier Transform, Laplace transform, partial differentiation.

3.Statistical Methods of Data Analysis: **(12L)**

Errors: Definition, classification, causes and minimization; propagation of errors, accuracy and precision, methods of expressing precision: mean, median, mode, range, standard deviation, relative standard deviation and variance. Test of significance: Student's t-test, F-test, Chi-square test, rejection of a result (Q-test); confidence interval, confidence limits. Distribution of Experimental Results: Gaussian curve, histogram.

4. Background of Nano-Technology: **(3L)**

Emergence of nano-technology, challenges in nanotechnology, carbon age: New forms of carbon (from graphene to CNT).

Nucleation **(6L)**

Influence of nucleation rate on size of the crystals, macroscopic and microscopic crystals and nano crystals, large surface to volume ratio, top-down and bottom-up approaches, self-assembly process, defects in nanocrystals, surface effects on the properties.

Types Of Nano-Structures & Applications: (9L)

Definition of nano system, types of nanocrystals: One dimensional (1D), Two dimensional (2D), Three dimensional (3D). Molecular electronics and nanoelectronics, quantum electronic devices, CNT based transistor and Field Emission Display, biological applications, biochemical sensor, membrane-based water purification

Reference Books

1. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books (2008). 2. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005). 3. Steiner, E. The Chemical Maths Book Oxford University 6. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001) 487 pages. 7. Noggle, J. H. Physical chemistry on a Microcomputer. Little Brown & Co. (1985). 8. Kreyszig Erwin, Advanced Engineering Mathematics, Wiley, 10th Edition. 9. Nabakumar Bera, Subhasree Ghosh, Paulami Ghosh, Mathematics and Statistics for Chemists, Techno World. 10. Essentials of Physical Chemistry; A. Bhal, B.S. Bhal, G.D. Tuli; S. Chand and Company Limited. 11. Analytical Chemistry; G.D. Christian, P.K. Dasgupta, K.A. Schug; An Indian Adaptation (Wiley). 12. Fundamentals of Analytical Chemistry (Ninth Edition); D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch; Brooks/Cole Ceange Learning. 13. An Introduction to Nanomaterials and Nanoscience; A.K. Das, M. Das; CBS Publishers & Distributors Pvt. Ltd.