COURSE OBJECTIVES & OUTCOMES OF 3/4 YEAR UNDER GRADUATE CURRICULUM IN CHEMISTRY

NISTARINI COLLEGE, PURULIA

AFFILIATED TO

SIDHO-KANHO-BIRSHA UNIVERSITY, PURULIA, WEST BENGAL

CHEMISTRY UG SYLLABUS FOR NEP 2020

SYLLABUS FOR CHEMISTRY OF SEMESTER –I

MAJOR – 1

COURSE TITLE: Inorganic Chemistry – I

COURSE CODE: BCEMMJ01C

CREDIT: 6 (THEORY: 4 + PRACTICAL: 2)

THEORY:

(i) ATOMIC STRUCTURE: (15L)

Bohr's theory, its limitations and atomic spectrum of hydrogen atom; Sommerfeld's Theory, de Broglie equation, Heisenberg's Uncertainty Principle, Photoelectric Effect, A brief introduction to wave mechanical model of atomic structure (Schrodinger Equation only) Auf-Bau Principle, Hund's Rule of Maximum Spin Multiplicity, Pauli's Exclusion Principle, Electronic configuration of elements (upto Z = 30). Determination of Ground State Term Symbols of elements and ions (upto Z=30).

(ii) **PERIODIC PROPERTIES: (20L)**

Modern IUPAC Periodic table, Effective nuclear charge, screening effects andpenetration, Slater's rules, atomic radii, ionic radii. Ionization potential, electron affinity andelectronegativity (Pauling's, Mulliken's and Allred- Rochow's scales). Group trends and periodic trends in these properties in respect of s-, p-block elements.

(iii) **CONCEPT OF ACID-BASE THEORIES: (15L)**

Acid-Base concept: Arrhenius concept, theory of solvent system (in H2O, NH3,SO2 and HF), Bronsted-Lowry's concept, relative strength of acids, Pauling's rules.Lux-Flood concept, Lewis concept, HSAB principle. Thermodynamic acidity parameters, Drago-Wayland equation.

(iv) **REDOX CHEMISTRY: (10L)**

Ion-electron method of balancing equation of redox reaction. Elementary idea onstandard redox potentials with sign conventions, Nernst equation (without derivation).

Influence of complex formation, precipitation and change of pH onredox potentials;formal potential. Feasibility of a redox titration, redox potential at theequivalencepoint, redox indicators. Redox potential diagram (Latimer and Frost diagrams) ofcommon elements and their applications. Disproportionation and comproportionationreactions (typical examples).

Solubility product principle, common ion effect and their applications to theprecipitation and separation of common metallic ions as hydroxides, sulfides,phosphates, carbonates, sulfates and halides.

READING REFERENCES:

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

3. Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford UniversityPress (2010).
4. Cotton, F.A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry 3rdEd.; Wiley India.
5. Sharpe, A.G., Inorganic Chemistry, 4th Indian Reprint (Pearson Education), 2005.
6. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principlesof Structure andReactivity 4th Ed., Harper Collins 1993, Pearson,2006.
7. Das, Asim. K.; Fundamentals Concepts of Inorganic Chemistry, Vol 1-7, 3rdEd., CBS Publishers.

PRACTICALS:

1. Estimation of carbonate and hydroxide present together in mixture.
2. Standardization of $KMnO_4$ by Oxalic acid.
3. Estimation of Fe(II) using standardized $KMnO_4$ solution.
4. Estimation of Fe(II) using standardized $K_2Cr_2O_7$ solution.

REFERENCES FOR PRACTICALS:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Mukherjee, G. N., University Handbook of Undergraduate Chemistry Experiments, University of Calcutta, 2003.
3. Nad, Mahapatra and Ghoshal, An Advance Course in Practical Chemistry, New Central Book Agency, Kolkata.

COURSE OBJECTIVE OF MAJOR - 1:

The syllabus of Major -1 has been designed to provide the students with the basic ideas of General Inorganic and Physical Chemistry. The four modules consisting of Atomic Structure, Periodic Properties, Acid-Base and Redox reactions will provide the fundamental understandings of chemistry, inevitable for higher learning.

COURSE OUTCOMES OF MAJOR – 1:

CO-1.1 Gather an in-depth knowledge about atomic structure.

CO-1.2 Understand the periodic properties of the elements.

CO-1.3 Understand the concepts of a redox reaction.

CO- 1.4 Explain various phenomenon of redox reactions using Nernst Equation.

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END OF SEMESTER - I

SYLLABUS FOR CHEMISTRY OF SEMESTER – II

MAJOR – 2

COURSE TITLE: Organic Chemistry – I

COURSE CODE: BCEMMJ02C

CREDIT: 6 (THEORY: 4 + PRACTICAL: 2)

THEORY:

BONDING AND HYBRIDIZATION IN THE LIGHT OF ORGANIC CHEMISTRY: (25L)

(i) VALENCE BOND THEORY:

Concept of hybridisation, shapes of molecules, resonance (including hyperconjugation); calculation of formal charges and double bond equivalent (DBE); orbital pictures of bonding (sp3, sp2, sp: C-C, C-N & C-O systems and s-cis and s-trans geometry for suitable cases).

(ii) ELECTRONIC DISPLACEMENTS: Inductive effect, field effect, mesomeric effect,resonance energy; bond polarization and bond polarizability; electromeric effect; steric effect, steric inhibition of resonance.

(iii) MO THEORY: qualitative idea about molecular orbitals, bonding and antibonding interactions, idea about σ, σ*, π, π *, n – MOs; basic idea about Frontier MOs (FMO); concept of HOMO, LUMO and SOMO; interpretation ofchemical reactivity in terms of FMO interactions; sketch and energy levels of πMOs of acyclic p orbital system (C=C, conjugated diene, triene, allyl andpentadienyl systems) ii) cyclic p orbital system (neutral systems: [4], [6]-annulenes; charged systems: 3-,4-,5-membered ring systems); Hückel's rules for aromaticity up to [10]-annulene (including mononuclear heterocyclic compounds up to 6-memberedring); concept of antiaromaticity and homoaromaticity; non-aromatic molecules; Frostdiagram; elementary idea about α and β; measurement of delocalization energies interms of β for buta-1,3-diene, cyclobutadiene, hexa-1,3,5-triene and benzene.

(iv) PHYSICAL PROPERTIES: Influence of hybridization on bond properties: bond dissociation energy (BDE) and bond energy; bond distances, bond angles; concept of bond angle strain (Baeyer's strain theory); melting point/boiling point and solubilityof common organic compounds in terms of covalent & non-covalent intermolecular forces; polarity of molecules and dipole moments; relative stabilities of isomeric hydrocarbons in terms of heat of hydrogenation, heat ofcombustion and heat of formation.

BASIC STEREOCHEMISTRY-I: (20L)

Bonding geometries of carbon compounds and representation of molecules: Tetrahedral nature of carbon and concept of asymmetry; Fischer, sawhorse, flyingwedgeand Newman projection formulae and their inter translations.

2. Concept of chirality and symmetry: symmetryelements and point groups (Cv, Cnh, Cnv, Cn, Dh, Dnh, Dnd, Dn, Sn(Cs,Ci); molecular chirality and centre of chirality; asymmetric and dissymmetric molecules; enantiomers and diastereomers; concept of epimers; concept of stereogenicity,

chirotopicity and pseudoasymmetry; chiral centres and number of stereoisomerism: systems involving 1/2/3-chiralcentre(s) (AA, AB, ABA and ABC types).

3. Relative and absolute configuration: D/L and R/S descriptors; erythro/threo and meso nomenclature of compounds; syn/anti nomenclatures for aldols; E/Z descriptors for C=C, conjugated diene, triene, C=N and N=N systems; combination of R/S- and E/ Z- isomerisms: Optical activity of chiral compounds: optical rotation, specific rotation and molar rotation; racemic compounds, racemisation (through cationic, anionic, radical intermediates and through reversible formation of stable achiral ntermediates); resolution of acids, bases and alcohols via diastereomeric salt formation; optical purity and enantiomeric excess; invertomerism of chiral trialkylamines.

GENERAL REACTION MECHANISM-I: (15L)

1. Mechanistic classification: ionic, radical and pericyclic (definition and example);reaction type: addition, elimination and substitution reactions (definition andexample); nature of bond cleavage and bond formation: homolytic and heterolytic bond fission, homogenic and heterogenic bond formation; curly arrow rules inrepresentation of mechanistic steps; reagent type: electrophiles and nucleophiles(elementary idea); electrophilicity and nucleophilicity in terms of FMO approach.

2. Reactive intermediates: carbocations (carbenium and carbonium ions), carbanions,carbon radicals, carbenes: generation and stability, structure using orbital picture andelectrophilic/nucleophilic behavior of reactive intermediates (elementary idea).

READING REFERENCES:

1. Clayden, J., Greeves, N. & Warren, S. Organic Chemistry, Second edition, Oxford University Press, 2012.
2. Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited.
3. Nasipuri, D. Stereochemistry of Organic Compounds, Wiley Eastern Limited.
4. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd., (Pearson Education).
6. Fleming, I. Molecular Orbitals and Organic Chemical Reactions, Reference/Student Edition, Wiley, 2009.
7. James, J., Peach, J. M. Stereochemistry at a Glance, Blackwell Publishing, 2003.
8. Robinson, M. J. T., Stereochemistry, Oxford Chemistry Primer, Oxford University Press, 2005.

PRACTICALS:

1. Separation

Based upon solubility, by using common laboratory reagents like water (cold, hot),dil. HCl, dil. NaOH, dil. NaHCO3, etc., of components of a binary solid mixture; purification of any one of the separated components by crystallization and determination of its melting point. The composition of the mixture may be of the following types: Benzoic acid/p-Toluidine; p-Nitrobenzoic acid/p-Aminobenzoic acid; p-Nitrotolune/p-Anisidine; etc.

2. Determination of boiling point

Determination of boiling point of common organic liquid compounds e.g., ethanol, cyclohexane, chloroform, ethyl methyl ketone, cyclohexanone, acetylacetone, anisole, crotonaldehyde, mesityl oxide, etc. [Boiling point of the chosen organic compounds should preferably be less than 160°C]

3. Identification of a Pure Organic Compound

Solid compounds: oxalic acid, tartaric acid, citric acid, succinicacid, resorcinol, urea, glucose, cane sugar, benzoic acid and salicylic acidLiquid Compounds: formic acid, acetic acid, methyl alcohol, ethyl alcohol,acetone, aniline, dimethylaniline, benzaldehyde, chloroform and nitrobenzene.

REFERENCES FOR PRACTICALS:

1. Bhattacharyya, R. C, A Manual of Practical Chemistry.
2. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, CBS Publishers and Distributors.
3. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
4. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. Practical Organic Chemistry,5th Ed., Pearson (2012).

COURSE OBJECTIVE OF MAJOR - 2:

The syllabus of Major -2 has been designed to provide the students with the basic ideas of bonding and hybridization and fundamental understanding of stereochemistry. The five modules consisting of valence bond theory, electronic displacements, MO Theory, physical properties and basic stereochemistry -**I** will provide the fundamental understandings of organic chemistry, inevitable for higher learning.

COURSE OUTCOMES OF MAJOR – 2:

CO- 2.1 Understand the valence bond theory.

CO- 2.2 Understand the basics of electronic displacements.

CO- 2.3 Understand the concepts of a Molecular Orbital theory.

CO- 2.4 Understand the physical properties of the organic molecules.

CO- 2.5 Understand the basic concept of stereochemistry of organic molecules.

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END OF SEMESTER - II

SYLLABUS FOR CHEMISTRY OF SEMESTER – III

MAJOR – 3

COURSE TITLE: Physical Chemistry – I

COURSE CODE: BCEMMJ03C

CREDIT: 6 (THEORY: 4 + PRACTICAL: 2)

THEORY:

THERMODYNAMICS –I (12L)

1. Zeroth and 1st law of Thermodynamics: Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics; Concept of heat, work, internal energy and statement of first law; enthalpy, H; relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and vander Waals) under isothermal and adiabatic conditions; Joule's experiment and its consequence.

2. Thermochemistry: Standard states; Heats of reaction; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; Laws of thermochemistry; bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchhoff's equations and effect of pressure on enthalpy of reactions; Adiabatic flame temperature; explosion temperature.

THERMODYNAMICS –II (30 L)

1. Second Law: Need for a Second law; statement of the second law of thermodynamics; Concept of heat reservoirs and heat engines; Carnot cycle; Physical concept of Entropy; Carnot engine and refrigerator; Kelvin – Planck and Clausius statements and equivalence of the two statements with entropic formulation; Carnot's theorem; Values of dQ/T and Clausius inequality; Entropy change of systems and surroundings for various processes and transformations; Entropy and unavailable work; Auxiliary state functions (G and A) and their variation with T, P and V. Criteria for spontaneity and equilibrium.

2. Thermodynamic relations: Maxwell's relations; Gibbs- Helmholtz equation, Joule-Thomson experiment and its consequences; inversion temperature; Joule-Thomson coefficient for a vander Waals gas; General heat capacity relations.

3. Partial properties and Chemical potential: Chemical potential and activity, partial molar quantities, relation between Chemical potential and Gibb's free energy and other thermodynamic state functions; variation of Chemical potential (μ) with temperature and pressure; Gibbs-Duhem equation; fugacity and fugacity coefficient; Variation of thermodynamic functions for systems with variable composition; Equations of states for these systems, Change in G,S H and V during mixing for binary solutions.

4. Chemical Equilibrium: Thermodynamic conditions for equilibrium, degree of advancement; van't Hoff's reaction isotherm (deduction from chemical potential); Variation of free energy with degree of advancement; Equilibrium constant and standard Gibbs free energy change; Definitions of KP, KC and KX; van't Hoff's reaction isobar and isochore from different standard states; Shifting of

equilibrium due to change in external parameters e.g. temperature and pressure; variation of equilibrium constant with addition to inert gas; Le-Chatelier's principle and its derivation.

5. Dissociation of weak electrolyte. Solubility equilibrium.

6. Nernst's distribution law; Application- (finding out Keq using Nernst distribution lawfor KI+I2 = KI3 and dimerization of benzene.

CHEMICAL KINETICS: (18 L)

Rate law, order and molecularity: Introduction of rate law, Extent of reaction; rate constants, order; Forms of rates of First, second and nth order reactions; Pseudo first order reactions (example using acid catalyzed hydrolysis of methyl acetate); Determination of order of a reaction by half-life and differential method; Opposing reactions, consecutive reactions and parallel reactions (with explanation of kinetic and thermodynamic control of products; all steps of first order).

READING REFERENCES:

1. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford University Press
2. Castellan, G. W. Physical Chemistry, Narosa
3. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press
4. Levine, I. N. Physical Chemistry, Tata McGraw-Hill
5. Laidler, K. J. Chemical Kinetics, Pearson
6. Glasstone, S. & Lewis, G.N. Elements of Physical Chemistry
7. Rakshit, P.C., Physical Chemistry Sarat Book House
8. Rastogi, R. P. & Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas
9. Bera, N. K., Ghosh, S., Ghosh, P., Vol-II& III, Physical Chemistry Concepts & Models, Techno World, Kolkata
10. Ashish Kumar Nag, Physical Chemistry (Vol-I & II), McGraw Hill Education (India) Pvt. Ltd.
11. K. L. Kapoor, A Textbook of Physical Chemistry, Vol-I to Vol-V, Macmillan Publishers India Ltd. 2004.
12. Ghoshal, A. Numerical Problems on Physical Chemistry, Books & Allied Pvt. Ltd. Kolkata.

PRACTICALS:

1. Determination of heat of neutralization of a strong acid by a strong base.
2. Study of kinetics of acid-catalyzed hydrolysis of methyl acetate.
3. Study of kinetics of decomposition of H2O2by $FeCl_3$ and Neutral KI method.
4. Determination of partition coefficient for the distribution of I2 between waterand $CHCl_3$.

REFERENCES FOR PRACTICALS:

1. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G N., University of Calcutta.
2. Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
3. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd.
4. Saharay, S. K. &Basu, A. S. A Guide to Practical Physical Chemistry, University of Burdwan.
5. Concise Practical Chemistry, Karmakar, P., Sarkar(Sain), R., Ray, S., Ghosh, A. K., The New Book Stall, Kolkata

Course Objective of Major-3:

The syllabus of Major-3 has been designed to provide the students with in-depth ideas on two of the most important aspects of Physical Chemistry: Chemical Thermodynamics and Chemical Kinetics. The three major modules consisting of Thermodynamics I, Thermodynamics II, and Chemical Kinetics will build up the basic understandings of Physical Chemistry, which are inevitable for higher learning. The details of the course objectives are as follows:

CO- 3.1: Introduce the basic definitions of Thermodynamics and the concepts of heat, energy, work, and their interrelationship.

CO- 3.2: To understand the details of two major Thermodynamic Laws along with their applicability for predicting the feasibility and nature of chemical reactions.

CO- 3.3: To understand the basic principles of Chemical Kinetics and its basic differences with chemical thermodynamics.

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END OF SEMESTER - III

SYLLABUS FOR CHEMISTRY OF SEMESTER – IV

MAJOR – 4

COURSE TITLE: Inorganic Chemistry – II

COURSE CODE: BCEMMJ04C

CREDIT: 6 (THEORY: 4 + PRACTICAL: 2)

THEORY:

CHEMICAL BONDING-I: (20 L)

1. Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its application and limitations. Packing of ions in crystals. Born-Landé equation with derivationn for lattice energy, Madelung Constant, Born-Haber cycle and its application, Solvation energy. Defects in solids (elemementary idea). Solubility energetics of dissolution process.

2. Covalent bond: Polarizing power and polarizability, ionic potential, Fajan's rules. Lewis structures, formal charge. Valence Bond Theory. The hydrogen molecule (Heitler-London approach), directional character of covalent bonds, hybridizations, equivalent and non- equivalent hybrid orbitals, Bent's rule, Dipole moments, VSEPR theory, shapes of molecules and ions containing lone pairs and bond pairs (examples from main groups chemistry) and multiple bonding (σ and π bond approach).

Chemical Bonding-II (25L)

1. Molecular orbital concept of bonding (The approximations of the theory, Linear combination of atomic orbitals (LCAO)) (elementary pictorial approach): sigma and pi- bonds and delta interaction, multiple bonding. Orbital designations: gerade, ungerade, HOMO, LUMO. Orbital mixing,. MO diagrams of H2, Li2, Be2, B2, C2, N2, O2, F2, and their ions wherever possible; Heteronuclear molecular orbitals: CO, NO, NO+, CN-, HF, BeH2, CO2 and H2O. Bond properties: bond orders, bond lengths.

2. Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

3. Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Intermolecular forces: Hydrogen bonding (theories of hydrogen bonding, valence bond treatment), receptor-guest interactions, Halogen bonds. Effects of chemical force, melting and boiling points.

CO-ORDINATION CHEMISTRY-I: (15 L)

Coordinate bonding: double and complex salts. Werner's theory of coordination complexes, Classification of ligands, Ambidentate ligands, chelates, Coordination numbers, IUPAC nomenclature of coordination complexes (up to two metal centers), Isomerism in coordination compounds, constitutional and stereoisomerism, Geometrical and optical isomerism in square planar and octahedral complexes.

READING REFERENCES:

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. Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).
4. Cotton, F.A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry 3rd Ed.; Wiley India.
5. Sharpe, A.G., Inorganic Chemistry, 4th Indian Reprint (Pearson Education), 2005.
6. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure andReactivity 4th Ed., Harper Collins 1993, Pearson,2006.
7. Das, Asim. K.; Fundamentals Concepts of Inorganic Chemistry, Vol 1-7, 3rd Ed., CBS Publishers.
8. Miessler, G. L., Fischer, P. J., Tarr, D. A., Inorganic Chemistry, Pearson, 5th Edition.

PRACTICALS:

1. Estimation of Cu(II) by Iodometric method.
2. Determination of available Chlorine in bleaching powder by Iodometric method.
3. Estimation of Oxalic acid and Sodium oxalate by KMnO4.
4. Estimation of Fe(III) & Cu(II) by K2Cr2O7.

REFERENCES FOR PRACTICALS:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Mukherjee, G. N., University Handbook of Undergraduate Chemistry Experiments, University of Calcutta, 2003.
3. Nad, Mahapatra and Ghoshal, An Advance Course in Practical Chemistry, New Central Book Agency, Kolkata.

COURSE OBJECTIVE OF MAJOR - 4:

The syllabus of Major -4 has been designed to provide the students with in-depth knowledge of Chemical bonding, including Ionic bonding, Covalent Bonding, Co-ordinate covalent bonding and other weak bonding interactions. This course will also give the students some idea about the drawbacks of Valence Bond Theory leading to the advent of the Molecular Orbital Theory. Students will be taught the Molecular Orbital Theory to some extent, exemplified by Molecular Orbital diagrams of simple homodiatomic and heterodiatomic molecules.

Apart from the concept of the different bonding theories, the students will also learn the basic concepts of Co-ordination Compounds, Werner's Theory and associated ideas and they will also get an overall idea about the developments of bonding theories from the very preliminary to an advanced level of understanding.

COURSE OUTCOMES OF MAJOR – 4:

CO- 4.1	**Thorough understanding of Chemical Bonding with special Emphasis on Ionic, Covalent bonding and Concepts of weak bonds like Hydrogen Bond, van der Waals bond.**
CO- 4.2	**Understanding the concepts of Molecular Orbital Theory.**
CO- 4.3	**Metallic bonding and concepts of semi-conductors.**
CO- 4.4	**Thorough understanding of Co-ordination Chemistry.**
CO- 4.5	**Isomerism of Inorganic Compounds.**
CO- 4.6	**IUPAC nomenclature of Inorganic compounds.**

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MAJOR – 5

COURSE TITLE: Organic Chemistry – II

COURSE CODE: BCEMMJ05C

CREDIT: 6 (THEORY: 4 + PRACTICAL: 2)

THEORY:

FUNDAMENTALS OF ORGANIC REACTION MECHANISM: (16 L)

1. Free-radical substitution reaction: halogentaion of alkanes, mechanism (with evidence) and stereochemical features; reactivity-selectivity principle in the light of Hammond's postulate.

2. Nucleophilic substitution reactions: substitution at sp3 centre: mechanisms (with evidence), relative rates & stereochemical features: SN1, SN2, SN2', SN1' (allylic rearrangement) and SNi; effects of solvent, substrate structure, leaving group and nucleophiles (including ambident nucleophiles, cyanide & nitrite); substitutions involving NGP; role of crown ethers and phase transfer catalysts; [systems: alkyl halides, allyl halides, benzyl halides, alcohols, ethers, epoxides].

3. Elimination reactions: E1, E2, E1cB and Ei (pyrolytic syn eliminations); formation of alkenes and alkynes; mechanisms (with evidence), reactivity, regioselectivity (Saytzeff/Hofmann) and stereoselectivity; comparison between substitution and elimination; importance of Bredt's rule relating to the formation of C=C.

BASIC STEREOCHEMISTRY-II (22 L)

1. Chirality arising out of stereoaxis: stereoisomerism of substituted cumulenes with even and odd number of double bonds; chiral axis in allenes, spiro compounds, alkylidene cycloalkanes and biphenyls; related configurational descriptors (Ra/Sa and P/M); atropisomerism; racemisation of chiral biphenyls; buttressing effect.

2. Concept of prostereoisomerism: prostereogenic centre; concept of (pro)nchirality: topicity of ligands and faces (elementary idea); pro-R/pro-S, pro-E/pro-Z and Re/Si descriptors; pro-r and pro-s descriptors of ligands on propseudoasymmetric centre.

3. Conformation: conformational nomenclature: eclipsed, staggered, gauche, syn and anti; dihedral angle, torsion angle; Klyne-Prelog terminology; P/M descriptors; energy barrier of rotation, concept of torsional and steric strains; relative stability of conformers on the basis of steric effect, dipole-dipole interaction and H-bonding; butane gauche interaction; conformational analysis of ethane, propane, n-butane, 4. 2-methylbutane and 2,3-dimethylbutane; haloalkane, 1,2-dihaloalkanes and 1,2-diols (up to four carbons); 1,2-halohydrin; conformation of conjugated systems (s-cis and s-trans).

REACTION MECHANISM –II (22 L)

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

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

3. Tautomerism: prototropy (keto-enol, nitro - aci-nitro, nitroso-oximino, diazoamino 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 ketoenol tautomerism; application of thermodynamic principles in tautomeric equilibria.

4. 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 isotopic effect (kH /kD); principle of microscopic reversibility; Hammond's postulate.

READING REFERENCES:

1. Clayden, J., Greeves, N. & Warren, S. Organic Chemistry, Second edition, Oxford University Press, 2012.
2. Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited.
3. Nasipuri, D. Stereochemistry of Organic Compounds, Wiley Eastern Limited.
4. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd., (Pearson Education).
6. Fleming, I. Molecular Orbitals and Organic Chemical Reactions, Reference/Student Edition, Wiley, 2009.
7. James, J., Peach, J. M. Stereochemistry at a Glance, Blackwell Publishing, 2003.
8. Robinson, M. J. T., Stereochemistry, Oxford Chemistry Primer, Oxford University Press, 2005.

PRACTICALS:

Organic Preparations

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

6. Side chain oxidation of aromatic compounds

7. Diazo coupling reactions of aromatic amines

8. Bromination of anilides using green approach (Bromate-Bromide method)

9. Redox reaction including solid-phase method

10. Green ‘multi-component-coupling’ reaction.

REFERENCES FOR PRACTICALS:

1. Vogel, A. I. Elementary Practical Organic Chemistry, Part 1: Small scale Preparations, CBS Publishers and Distributors.
2. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003.
3. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
4. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. Practical Organic Chemistry, 5th Ed. Pearson (2012).
5. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry:Preparation and Quantitative Analysis, University Press (2000).
6. Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.

COURSE OBJECTIVE OF MAJOR - 5:

The syllabus of Major -5 has been designed to provide the students with the basic ideas of organic reaction mechanism and few concepts of organic stereochemistry. The later part includes concepts chiral axis, prostereoisomerism and conformation. The organic reaction mechanism part consists of substitution reactions, elimination reactions, reaction thermodynamics, concepts of organic acids and bases, tautomerism and reaction kinetics.

COURSE OUTCOMES OF MAJOR – 5:

CO- 5.1 Understand the aliphatic substitution reactions.

CO- 5.2 Understand the basics of elimination reaction.

CO- 5.3 Understand the concepts of a Molecular Orbital theory.

CO- 5.4 Understand few concepts of organic stereochemistry involvingchiral axis, prostereoisomerism and conformation.

CO- 5.5 Understand the basic concept of reaction thermodynamics.

CO- 5.6 Understand basic ideas of organic acids and bases.

CO- 5.7 Understand basic concept of tautomerism.

CO- 5.8 Understand basic ideas of reaction kinetics.

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END OF SEMESTER - IV

SYLLABUS FOR CHEMISTRY OF SEMESTER – V

MAJOR – 6

COURSE TITLE: Physical Chemistry – II

COURSE CODE: BCEMMJ06C

CREDIT: 6 (THEORY: 4 + PRACTICAL: 2)

THEORY:

KINETIC THEORY OF GASES: (20 L)

1. Kinetic Theory of gases: Concept of pressure and temperature; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules); Wall collision and rate of effusion.

2. Maxwell's distribution of speed and energy (without derivation): Nature of distribution of velocities, Maxwell's distribution of speeds in one, two and three dimensions; Kinetic energy distribution in one, two and three dimensions, calculations of average, root mean square and most probable values in each case; Calculation of number of molecules having energy $\geq \varepsilon$.

3. Real gas and virial equation: Deviation of gases from ideal behavior; compressibility factor; Boyle temperature; Andrew's and Amagat's plots; vander Waals equation and its features; its derivation and application in explaining real gas behaviour, other equations of state (Berthelot, Dietrici); Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states; virial equation of state; van der Waals equation expressed in virial form and significance of second virial coefficient; Intermolecular forces (Debye, Keesom and London interactions; Lennard-Jones potential - elementary idea). Equipartition principles.

APPLICATION OF THERMODYNAMICS-II: (20 L)

1. Binary mixture: Chemical potential of individual components. Thermodynamic parameters of mixing ideal solution; Colligative properties: Vapour pressure of solution; Ideal solutions, ideally diluted solutions and colligative properties; Raoult's law; Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) Osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution; Abnormal colligative properties.

2. Phase rule: Definitions of phase, component and degrees of freedom; Phase rule and its derivations; Definition of phase diagram; Phase diagram for water, CO2, Sulphur.

3. First order phase transition and Clapeyron equation; Clausius-Clapeyron equation - derivation and use; Liquid vapour equilibrium for two component systems; Phenol-water system.

4. Binary solutions: Ideal solution; Positive and negative deviations from ideal behaviour; Principle of fractional distillation; Duhem-Margules equation; Henry's law; Konowaloff's rule; Azeotropic solution; Liquid-liquid phase diagram using phenol- water system; Solid-liquid phase diagram; Eutectic mixture.

APPLICATION OF THERMODYNAMICS-III: (12 L)

1. Electromotive Force: Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation /reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry; Chemical cells, reversible and irreversible cells with examples; Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinine-hydroquinone, glass and SbO/Sb2O3 electrodes.
2. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers; Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

TRANSPORT PROCESS-I: (8 L)

1. Diffusion; Fick's law: Flux, force, phenomenological coefficients & their interrelationship(general form), different examples of transport properties.

2. Viscosity: General features of fluid flow (streamline flow and turbulentflow);Newton's equation, viscosity coefficient; Poiseuille's equation;principle ofdetermination of viscosity coefficient of liquids by falling sphere method, Viscosity of gasesand effect of temperature and pressure on coefficient of viscosity (qualitative treatment only),Temperature variation of viscosity of liquids and comparison with that of gases.

READING REFERENCES:

1. Castellan, G. W. Physical Chemistry, Narosa.
2. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford University Press
3. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press
4. Levine, I. N. Physical Chemistry, Tata McGraw-Hill
5. Moore, W. J. Physical Chemistry, Orient Longman
6. Glasstone, S. & Lewis, G.N. Elements of Physical Chemistry
7. Rakshit, P.C., Physical Chemistry Sarat Book House
8. Bera, N. K., Ghosh, S., Ghosh, P., Vol-(I, II & III), Physical Chemistry Concepts & Models, Techno World, Kolkata.
9. Mortimer, R. G. Physical Chemistry, Elsevier
10. Denbigh, K. The Principles of Chemical Equilibrium Cambridge University Press
11. Engel, T. & Reid, P. Physical Chemistry, Pearson
12. Rastogi, R. P. & Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas
13. Ashish Kumar Nag, Physical Chemistry (Vol-I & II), McGraw Hill Education (India) Pvt. Ltd.
14. K. L. Kapoor, A Textbook of Physical Chemistry, Vol-I to Vol-V, Macmillan Publishers India Ltd. 2004.
15. Ghoshal, A. Numerical Problems on Physical Chemistry, Books & Allied Pvt. Ltd. Kolkata
16. Klotz, I.M., Rosenberg, R. M. Chemical Thermodynamics:Basic Concepts and Methods Wiley
17. Glasstone, S. An Introduction to Electrochemistry, East-West Press.
18. Reddy, A. K., Bockris, John O'M.; Modern Electrochemistry: An Introduction to an Interdisciplinary Area, Springer, 1995.

PRACTICALS:

1. Determination of Keq for KI + I2 = KI3, using partition coefficient betweenwater and CHCl3.
2. Study of viscosity of unknown liquid (glycerol, sugar) with respect to water.
3. Potentiometric titration: (a) weak acid vs. base, (b) Redox, determination of E^0.
4. Determination of strength of unknown HCl by NaOH pH-metrically.

REFERENCES FOR PRACTICALS:

1. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G N., University of Calcutta.
2. Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
3. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd.
4. Saharay, S. K. &Basu, A. S. A Guide to Practical Physical Chemistry, University of Burdwan.
5. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009)
6. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson
7. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007).

Course Objective of Major-6:

The syllabus of Major-6 is divided into four modules: (1) Kinetic theory of gases; (2) Applications of Thermodynamics-II; (3) Applications of Thermodynamics-II; and (4) Transport Process-I. The first module deals with the theories involved in explaining the properties of gaseous states of matter. The second and third modules are applications of the thermodynamic laws, discussed in Major 3, in different contexts. The fourth module discusses the Physical Chemistry of the fluids in motion. Students taking this course will get an almost complete idea of classical physical chemistry, which is essential for further higher studies in Physical Chemistry. After completion of the course, it is expected that the students will be able to answer the basic questions on the following topics:

CO - 6.1: Kinetic Theory of Gases, Behaviour of Real Gases, and Related Theories

CO - 6.2: Thermodynamic rationale of the behaviour of solutions and mixtures, the thermodynamics of different phases of matter, and phase transitions. The module is designed to impart knowledge of the basic chemistry of binary solutions and their deviation from ideality. A discussion on the principle of fractional distillation is given to make the students realize the application of the theoretical knowledge to practical utilization.

CO - 6.3: Understanding the thermodynamics involved in the working principles of different kinds of cells, the phenomenon of electrolysis, the concept of electromotive force, etc.

CO - 6.4: Concept of diffusion and viscosity of fluids. After taking the course, students will be able to answer the basic questions on fluids in motion.

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MAJOR – 7

COURSE TITLE: Organic Chemistry – III

COURSE CODE: BCEMMJ07C

CREDIT: 6 (THEORY: 4 + PRACTICAL: 2)

THEORY:

CHEMISTRY OF ALEKENES & ALKYNES: (12 L)

1. Addition to C=C: mechanism (with evidence wherever applicable), reactivity, regioselectivity (Markownikoff and anti-Markownikoff additions) and stereoselectivity; reactions: hydrogenation, halogenations, iodolactonisation, hydrohalogenation, hydration, oxymercuration-demercuration, hydroborationoxidation,epoxidation, syn and anti-hydroxylation, ozonolysis, addition of singlet and triplet carbenes; electrophilic addition to diene (conjugated dienes and allene); radical addition: HBr addition; mechanism of allylic and benzylic bromination incompetition with brominations across C=C; use of NBS; Birch reduction of benzenoid aromatics; interconversion of E - and Z - alkenes; contra-thermodynamic isomerization of internal alkenes.

2. Addition to C≡C (in comparison to C=C): mechanism, reactivity, regioselectivity (Markownikoff and anti-Markownikoff 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.

AROMATIC REACTIONS: (10 L)

1. 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, Vilsmeyer-Haack, Reimer-Tiemann, Kolbe-Schmidt); Ipso substitituion.

2. Nucleophilic aromatic substitution: addition-elimination mechanism and evidences in favour of it; SN1 mechanism; cine substitution (benzyne mechanism), structure of benzyne.

Carbonyl and Related Compounds (30L)

1. Addition to C=O: structure, reactivity and preparation of carbonyl compounds; mechanism (with evidence), reactivity, equilibrium and kinetic control; Burgi-Dunitz trajectory in nucleophilic additions; formation of hydrates, cyanohydrins and bisulphite add nucleophilic addition-elimination reactions with alcohols, thiols and nitrogen- based nucleophiles; reactions: benzoin condensation, Cannizzaro and Tischenko reactions, reactions with ylides: Wittig and Corey-Chaykovsky reaction; Rupe rearrangement, oxidations and reductions: Clemmensen, Wolff-Kishner,LiAlH4, NaBH4, MPV, Oppenauer, Bouveault-Blanc, acyloin condensation;oxidation of alcohols with PDC and PCC; periodic acid and lead tetraacetateoxidation of 1,2-diols.

2. Exploitation of acidity of α-H of C=O: formation of enols and enolates; kineticand thermodynamic enolates; reactions (mechanism with evidence): halogenation ofcarbonyl compounds under acidic and basic conditions, Hell-Volhard-Zelinsky (H. V.Z.) reaction, nitrosation, SeO2 (Riley) oxidation; condensations (mechanism withevidence): Aldol, Tollens', Knoevenagel, Claisen-Schmidt, Claisen ester includingDieckmann, Stobbe; Mannich reaction, Perkin reaction, Favorskii rearrangement;alkylation of active methylene compounds; preparation and synthetic applicationsof diethyl malonate and ethyl acetoacetate; specific enol equivalents (lithiumenolates, enamines, aza-enolates and silyl enol ethers) in connection with alkylation,acylation and aldol type reaction.

3. Elementary ideas of Green Chemistry: Twelve (12) principles of green chemistry;planning of green synthesis; common organic reactions and their counterparts:reactions: Aldol, Friedel-Crafts, Michael, Knoevenagel, Cannizzaro, benzoin condensation and Dieckmann condensation.

4. Nucleophilic addition to α,β-unsaturated carbonyl system: generalprinciple and mechanism (with evidence); direct and conjugate addition, addition of enolates (Michael reaction), Stetter reaction, Robinson annulation.

5. Substitution at sp2 carbon (C=O system): mechanism (with evidence): BAC2,AAC2, AAC1, AAL1 (in connection to acid and ester); acid derivatives: amides, anhydrides & acyl halides (formation and hydrolysis including comparison).

Organometallics: (8L)

Grignard reagent; Organolithiums; Gilman cuprates: preparation and reactions (mechanism with evidence); addition of Grignard and organolithium to carbonyl compounds; substitution on -COX; directed ortho metalation of arenes using organolithiums, conjugate addition by Gilman cuprates; Corey-House synthesis; abnormal behavior of Grignard reagents; comparison of reactivity among Grignard, organolithiums and organocopper reagents; Reformatsky reaction; Blaise reaction; concept of umpolung and base-nucleophile dichotomy in case of organometallic reagents.

READING REFERENCES:

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.

PRACTICALS:

Qualitative Analysis of Single Solid Organic Compounds

1. Detection of special elements (N, S, Cl, Br) by Lassaigne's test.

2. Solubility and classification (solvents: H2O, 5% HCl, 5% NaOH and 5%NaHCO3).

3. Detection of the following functional groups by systematic chemical tests:

4. Aromatic amino (-NH_2), aromaticnitro (-NO_2), amido (-$CONH_2$, including imide),phenolic – OH, carboxylic acid (-COOH), carbonyl (-CHO and >C=O); only one testfor each functional group is to be reported.

5. Melting point of the given compound

6. Preparation, purification and melting point determination of a crystalline derivative of the given compound.

7. Identification of the compound through literature survey.

Each student, during laboratory session, is required to carry out qualitative chemical tests for all the special elements and the functional groups with relevant derivatization in known and unknown (at least six) organic compounds.

REFERENCES FOR PRACTICALS:

1. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, CBS Publishers and Distributors.
2. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G.N. University of Calcutta, 2003.
3. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
4. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. Practical Organic Chemistry, 5th Ed.,Pearson (2012).
5. Clarke, H. T., A Handbook of Organic Analysis (Qualitative and Quantitative), Fourth Edition, CBS Publishers and Distributors (2007).

COURSE OBJECTIVE OF MAJOR - 7:

The syllabus of Major -7 has been designed to provide the students with in-depth knowledge of addition reactions of alkenes and alkynes, including aromatic electrophilic and nucleophilic substitution reactions, various reactions involving carbonyl and related compounds, few elementary ideas of green chemistry, nucleophilic addition to α,β-unsaturated carbonyl system,Substitution at sp^2 carbon and organometallic reactions.

COURSE OUTCOMES OF MAJOR – 7:

CO- 7.1 Thorough understanding of addition reactions involving alkenes and alkynes.

CO- 7.2 Detailed study of various aromatic electrophilic and nucleophilic reactions .

CO- 7.3 Detailed study of reactions involving carbonyl and related compounds

CO- 7.4 Understanding the elementary ideas of Green Chemistry.

CO- 7.5 Understanding the substitution at sp^2 carbon.

CO- 7.6 Through understanding of the organic reactions involving organometallic reagents.

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END OF SEMESTER – V

SYLLABUS FOR CHEMISTRY OF SEMESTER – VI

MAJOR – 8

COURSE TITLE: Inorganic Chemistry – III

COURSE CODE: BCEMMJ08C

CREDIT: 6 (THEORY: 4 + PRACTICAL: 2)

THEORY:

Coordination Chemistry-II (24L)

VB description and its limitations. Elementary Crystal Field Theory: splitting of d^n configurations in octahedral, square planar and tetrahedral fields, crystal field stabilization energy (CFSE) in weak and strong fields; pairing energy. Spectrochemical series. Jahn- Teller distortion. Octahedral site stabilization energy (OSSE). Metal-ligand bonding (MO concept, elementary idea), sigma- and pi bonding in octahedral complexes (qualitative pictorial approach) and their effects on the oxidation states of transitional metals (examples). Magnetism and Colour: Orbital and spin magnetic moments, spin only moments of dn ions and their correlation with effective magnetic moments, including orbital contribution; quenching of magnetic moment: super exchange and antiferromagnetic interactions (elementary idea with examples only); d-d transitions; L-S coupling; qualitative Orgel diagrams for $3d^1$ to $3d^9$ ions. Selection rules for electronic spectral transitions; spectrochemical series of ligands; charge transfer spectra (elementary idea).

REACTION KINETICS & MECHANISM: (10 L)

Introduction to inorganic reaction mechanisms. Substitution reactions in square planarcomplexes, Trans- effect and its application in complex synthesis, theories of trans-effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligandfield effects and reaction rates, Mechanism of substitution in octahedral complexes.

RADIOACTIVITY: (10L)

Nuclear Stability and binding Energy, Nuclear Models and Elementary Idea, Magic Number. Artificial Radioactivity, Transmutation, Fission, Fusion, Spallation, Uses of Radioactivity.

NOBLE GASES: (4L)

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2 and XeF_4). Xenon oxygen compounds. Molecular shapes of noble gas compounds (VSEPR theory).

GROUP CHEMISTRY OF S- AND P-BLOCK ELEMENTS: (12 L)

Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Beryllium hydrides and halides.

Boric acid and borates, boron nitrides, borohydrides (diborane) and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, phosphorus, sulphur and chlorine. Interhalogen compounds, polyhalide ions, pseudohalogens, fluorocarbons and basic properties of halogens.

READING REFERENCES:

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. Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).
4. Cotton, F.A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry 3rd Ed.; Wiley India.
5. Sharpe, A.G., Inorganic Chemistry, 4th Indian Reprint (Pearson Education), 2005.
6. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson,2006.
7. Das, Asim. K.; Fundamentals Concepts of Inorganic Chemistry, Vol 1-7, 3rd Ed., CBS Publishers.
8. Miessler, G. L., Fischer, P. J., Tarr, D. A., Inorganic Chemistry, Pearson, 5th Edition.

PRACTICALS:

1. Standardization of Na_2EDTA by Zn(II).

2. Determination of Hardness of water due to Calcium and Magnesium.

3. Preparation of Tris-(ethylenediamine) nickel(II) chloride.

4. Preparation of $[Fe(acac)_3]$.

REFERENCES FOR PRACTICALS:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Mukherjee, G. N., Advanced Experiments in Inorganic Chemistry, U. N. Dhur & Sons Private Ltd, Kolkata – 700073.
3. Mukherjee, G. N., University Handbook of Undergraduate Chemistry Experiments, University of Calcutta, 2003.
4. Nad, Mahapatra and Ghoshal, An Advance Course in Practical Chemistry, New Central Book Agency, Kolkata.

COURSE OBJECTIVE OF MAJOR - 8:

The syllabus of Major -8 has been designed to provide the students with thorough understanding of the Crystal Field Theory, its advantages over VBT, its challenges, and its achievements. After completing this course, a student will be able to explain the CFSE, OSSE, Geometries of various co-ordination complexes, their colours, and their magnetic properties.

The module concerning the Reaction Kinetics will augment the understanding of the rate of formation of complex compounds, and methods to carry out selective substitution reactions.

The students will get an idea of Radioactivity and its associated applications.

The module concerning the group chemistry of s- and p- block elements, including the Noble Gases will impart a vivid application of the basic concepts of chemistry taught in the earlier Major Papers and reactions of the elements of s-, p- elements as well as the Noble Gases.

COURSE OUTCOMES OF MAJOR – 8:

CO- 8.1	**Thorough understanding of Co-ordination chemistry in the light of VBT, CFT, LFT.**
CO- 8.2	**Understanding of the colour and spectra of co-ordination Compounds and their magnetic properties.**
CO- 8.3	**Understanding inorganic reaction mechanism and kinetics.**
CO- 8.4	**Understanding of Radioactivity.**
CO- 8.5	**Detailed study of the Noble gases.**
CO-8.6	**Detailed knowledge of s- and p- block elements and their reactions.**

MAJOR – 9

COURSE TITLE: Physical Chemistry – III

COURSE CODE: BCEMMJ09C

CREDIT: 6 (THEORY: 4 + PRACTICAL: 2)

THEORY:

FOUNDATION OF QUANTUM MECHANICS: (16 L)

Beginning of Quantum Mechanics: Wave-particle duality, light as particles: photoelectric and Compton effects; electrons as waves and the de Broglie hypothesis; Uncertainty relations (without proof).

1. Wave function: Schrodinger time-independent equation; nature of the equation, acceptability conditions imposed on the wave functions and probability interpretations of wave function.

2. Concept of Operators: Elementary concepts of operators, eigenfunctions and eigenvalues; Linear operators; Commutation of operators, commutator and uncertainty relation; Expectation value; Hermitian operator; Postulates of Quantum Mechanics.

3. Particle in a box: Setting up of Schrodinger equation for one-dimensional box and its solution; Comparison with free particle eigenfunctions and eigenvalues. Properties of PB wave functions (normalisation, orthogonality, probability distribution); Expectation values of x, x2, px and px2 and their significance in relation to the uncertainty principle; Extension of the problem to two and three dimensions and the concept of degenerate energy levels.

4. Simple Harmonic Oscillator: setting up of the Schrodinger stationary equation, energy expression (without derivation), expression of wave function for $n = 0$ and $n = 1$ (without derivation) and their characteristic features.

5. Hydrogen atom problem, Schrodinger Equation, Concept of Quantum Numbers, Radial Distribution Function, Shape of orbitals, Concept of Angular Momentum and Spin Angular Momentum, Ground State Term Symbols.

MOLECULAR SPECTROSCOPY: (15 L)

1. Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.

2. Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

3. Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies; Diatomic vibrating rotator, P, Q, R branches.

4. Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

PHOTOCHEMISTRY: (10 L)

1. Lambert-Beer's law: Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients; Laws of photochemistry, Stark-Einstein law of photochemical equivalence quantum yield, actinometry, examples of low and high quantum yields.

2. Photochemical Processes: Potential energy curves (diatomic molecules), Frank- Condon principle and vibrational structure of electronic spectra; Bond dissociation and principle of determination of dissociation energy (ground state); Decay of excited states by radiative and non-radiative paths; Predissociation; Fluorescence and phosphorescence, Jablonskii diagram.

3. Rate of Photochemical processes: Photochemical equilibrium and the differential rate of photochemical reactions, Photostationary state; HI decomposition, H2-Br2 reaction, dimerisation of anthracene; photosensitized reactions, quenching; Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

Symmetry and group theory- I: (10 L):

Point symmetry operations, groups and group multiplication tables, similarity transformation and conjugate classes, identification of point groups and stereographic projection, representation of symmetry operators and groups; characters of symmetry operators in a representation, invariance of character under similarity transformation, symmetry elements and symmetry operations of the Platonic solids.

Chemical Kinetics-II: (9 L)

Role of T and theories of reaction rate: Temperature dependence of rate constant; Arrhenius equation, energy of activation; Rate-determining step and steady-state approximation – explanation with suitable examples; Collision theory; Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment).

READING REFERENCES:

1. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford University Press
2. Castellan, G. W. Physical Chemistry, Narosa
3. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press
4. Levine, I. N. Physical Chemistry, Tata McGraw-Hill
5. Laidler, K. J. Chemical Kinetics, Pearson
6. Levine, I. N. Quantum Chemistry, PHI
7. Atkins, P. W. Molecular Quantum Mechanics, Oxford
8. Banwell, C. N. and McCash, E.M. Fundamentals of Molecular Spectroscopy, Edn. 4th, Tata McGraw-Hill, New Delhi.

9. Atomic and Molecular Spectroscopy: Basic Concepts and Applications, Rita Kakkar Cambridge University Press, 2015.
10. Moore, W. J. Physical Chemistry, Orient Longman.
11. Glasstone, S. & Lewis, G.N. Elements of Physical Chemistry
12. Bera, N. K., Ghosh, S., Ghosh, P., Vol-II, Physical Chemistry Concepts & Models, Techno World, Kolkata.
13. Rakshit, P.C., Physical Chemistry Sarat Book House.
14. Mortimer, R. G. Physical Chemistry, Elsevier.
15. Engel, T. & Reid, P. Physical Chemistry, Pearson.
16. Rastogi, R. P. & Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas.
17. Ashish Kumar Nag, Physical Chemistry (Vol-I & II), McGraw Hill Education (India) Pvt. Ltd.
18. K. L. Kapoor, A Textbook of Physical Chemistry, Vol-I to Vol-V, Macmillan Publishers India Ltd. 2004.
19. Ghoshal, A. Numerical Problems on Physical Chemistry, Books & Allied Pvt. Ltd. Kolkata.
20. Klotz, I.M., Rosenberg, R. M. Chemical Thermodynamics:Basic Concepts and Methods Wiley.
21. F. A. Cotton, Chemical Applications of Group Theory, 3rd Edn Reprint, John Wiley and Sons.
22. L. Pauling and E. B. Wilson, Introduction to Quantum Mechanics, McGraw-Hill, 1939.
23. H. Eyring, J. Walter and G. F. Kimball, Quantum Chemistry, Wiley, New York, 1944.

PRACTICALS:

1. Verification of Beer and Lambert's Law for $KMnO_4$.

2. Verification of Beer and Lambert's Law for $K_2Cr_2O_7$.

3. Study of kinetics of $K_2S_2O_8$ + KI reaction, spectrophotometrically.

REFERENCES FOR PRACTICALS:

1. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta.
2. Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
3. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd.
4. Saharay, S. K. &Basu, A. S. A Guide to Practical Physical Chemistry, University of Burdwan.
5. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009).
6. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson
7. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007).

Course Objective and Learning Outcome of Major 9:
The syllabus of Major 9 has been designed to make the students learn the most modern aspects of Physical Chemistry, such as Quantum Mechanics, Molecular Spectroscopy, Photochemistry, Symmetry and Group Theory and classical theories of Chemical Kinetics. Students taking this course are expected to achieve the following module-wise objectives:

CO - 9.1: This module will be helpful in understanding the Fundamentals of Quantum Mechanics, which include the Postulates of Quantum Mechanics, the Concept of Wave Function, the Probabilistic Nature of Quantum Particles, and exactly solvable problems.

CO - 9.2: The aim of this module is to make the students learn the basic concepts involved in molecular spectroscopy, which include rotational, vibrational, and Raman spectroscopy. The module is designed to impart these concepts in such a way that the students taking the course will be able to answer the questions based on a fundamental understanding of molecular spectroscopy and subsequently apply the knowledge to unknown and complicated systems.

CO - 9.3: This chapter is aimed at understanding the basic principles of Photochemistry and photochemical reactions and thereby studying the kinetics of various photochemical reactions. It is expected that the students will be able to realize that the interaction of radiation with matter opens up the way to alternative routes of synthesis. Thus, they will get a taste of the rich Physical Chemistry involved in this field.

CO - 9.4: By going through this module, students will learn that the symmetry in molecules can be used to predict several properties of molecules; the symmetry properties can be used to derive spectroscopic selection rules; simplify secular determinants in molecular calculations; identify the normal modes of vibration as infrared or Raman active; and so on. The learners will understand that the mathematical tool required for utilizing symmetry is Group theory. In this introductory chapter, students will be taught to construct the Group Multiplication Table that can be used to predict the conjugate classes present within a given point group. The identification of point groups is the main topic of this chapter. Similarity transformation and invariance of character under similarity transformation are two other important topics. The chapter ended with knowledge of symmetry operations that are possible within Platonic solids.

CO - 9.5: The main aim of this chapter is to help the students understand the Role of Temperature and Related Theories of Reaction Rates, the Concept of Unimolecular Reactions, the Basics of Transition State Theory, and the energy profile. After the completion of the course, the students will be able to answer the relevant questions related to the temperature dependence of reaction rates and the reason behind it. They will also be able to rationalize the chemistry at the molecular level in the course of a reaction.

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MAJOR – 10

COURSE TITLE: Organic Chemistry – IV

COURSE CODE: BCEMMJ10C

CREDIT: 6 (THEORY: 4 + PRACTICAL: 2)

THEORY:

Nitrogen compounds (12L)

1. Amines: Aliphatic & Aromatic: preparation, separation (Hinsberg's method)and identification of primary, secondary and tertiary amines; reaction (withmechanism): Eschweiler–Clarke methylation, diazo coupling reaction, Mannich reaction; formation and reactions of phenylenediamines, diazomethane anddiazoacetic ester.
2. Nitro compounds (aliphatic and aromatic): preparation and reaction (withmechanism): reduction under different conditions; Nef carbonyl synthesis,Henry reaction and conjugate addition of nitroalkane anion.
3. Alkylnitrile and isonitrile: preparation and reaction (with mechanism): Thorpe nitrile condensation, von Richter reaction.
4. Diazonium salts and their related compounds: reactions (with mechanism) involving replacement of diazo group; reactions: Gomberg, Meerwein, Japp-Klingermann.

Rearrangements (16L)
Mechanism with evidence and stereochemical features for the following:
1. Rearrangement to electron-deficient carbon: Wagner-Meerwein rearrangement, pinacol rearrangement, dienone-phenol; Wolff rearrangement in Arndt-Eistertsynthesis, benzil- benzilic acid rearrangement, Demjanov rearrangement, Tiffeneau–Demjanov rearrangement.
2. Rearrangement to electron-deficient nitrogen: rearrangements: Hofmann, Curtius, Lossen, Schmidt and Beckmann.
3. Rearrangement to electron-deficient oxygen: Baeyer-Villiger oxidation, Cumene hydroperoxide-phenol rearrangement and Dakin reaction.
4. Aromatic rearrangements: Migration from oxygen to ring carbon: Friesrearrangement and Claisen rearrangement.
5. Migration from nitrogen to ring carbon: Hofmann-Martius rearrangement, Fischer-Hepp rearrangement, N-azo to C-azo rearrangement, Bambergerrearrangement, Orton rearrangement and benzidine rearrangement.
6. Rearrangement reactions by green approach: Fries rearrangement, Claisen rearrangement, Beckmann rearrangement, Baeyer-Villiger oxidation.

The Logic of Organic Synthesis (12L)
1. Retrosynthetic analysis: disconnections; synthons, donor and acceptor synthons; natural reactivity and umpolung; latent polarity in bifunctional compounds:
consonant and dissonant polarity; illogical electrophiles and nucleophiles; synthetic equivalents; functional group interconversion and addition (FGI and FGA); C-C disconnections and synthesis: one-group and two-group (1,2- to 1,5-dioxygenated compounds), reconnection (1,6-dicarbonyl); protection-deprotection strategy (alcohol, amine, carbonyl, acid).

2. Strategy of ring synthesis: thermodynamic and kinetic factors; synthesis of large rings, application of high dilution technique.
3. Asymmetric synthesis: stereoselective and stereospecific reactions; diastereoselectivity and enantioselectivity (only definition); enantioselectivity, kinetically controlled MPV reduction; diastereoselectivity: addition of nucleophiles toC=O adjacent to a stereogenic centre: Felkin-Anh and Zimmermann-Traxler models.

Organic Spectroscopy (20L)

1. UV Spectroscopy: introduction; types of electronic transitions, end absorption; transition dipole moment and allowed/forbidden transitions; chromophores andauxochromes; Bathochromic and Hypsochromic shifts; intensity of absorptions (Hyper-/Hypochromic effects); application of Woodward's Rules for calculation of λmax for the following systems: conjugated diene, α,β-unsaturated aldehydes and ketones (alicyclic, homoannular and heteroannular); extended conjugated systems (dienes, aldehydes and ketones); relative positions of λmax considering conjugative effect, steric effect, solvent effect, effect of pH; effective chromophore concentration: keto-enol systems; benzenoid transitions.

2. IR Spectroscopy: introduction; modes of molecular vibrations (fundamental and non-fundamental); IR active molecules; application of Hooke's law, force constant; fingerprint region and its significance; effect of deuteration; overtone bands;vibrational coupling in IR; characteristic and diagnostic stretching frequencies of CH,N-H, O-H, C-O, C-N, C-X, C=C (including skeletal vibrations of aromatic compounds), C=O, C=N, N=O, C≡C, C≡N; characteristic/diagnostic bending vibrations are included; factors affecting stretching frequencies: effect of conjugation, electronic effects, mass effect, bond multiplicity, ring- size, solvent effect, H-bondingon IR absorptions; application in functional group analysis.

3. NMR Spectroscopy: introduction; nuclear spin; NMR active molecules; basic principles of Proton Magnetic Resonance; equivalent and non-equivalent protons; chemical shift and factors influencing it; ring current effect; significance of the terms: up-/downfield, shielded and deshielded protons; spin coupling and coupling constant (1st order spectra); relative intensities of first-order multiplets: Pascal's

triangle; chemical and magnetic equivalence in NMR ; elementary idea about non first-order splitting; anisotropic effects in alkene, alkyne, aldehydes and aromatics;NMR peak area, integration; relative peak positions with coupling patterns ofcommon organic compounds (both aliphatic and benzenoid-aromatic); rapid proton exchange; interpretation of NMR spectra of simple compounds.

4. Applications of IR, UV and NMR spectroscopy for identification of simple organic molecules.

READING REFERENCES:

1. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
3. Norman, R.O. C., Coxon, J. M. Principles of Organic Synthesis, Third Edition, Nelson Thornes, 2003.
4. Clayden, J., Greeves, N., Warren, S., Organic Chemistry, Second edition, Oxford University Press 2012.

5. Silverstein, R. M., Bassler, G. C., Morrill, T. C. Spectrometric Identification of Organic Compounds, John Wiley and Sons, INC, Fifth edition.
6. Kemp, W. Organic Spectroscopy, Palgrave.
7. Pavia, D. L. et al. Introduction to Spectroscopy, 5th Ed. Cengage Learning India Ed. (2015).
8. Dyer, J. Application of Absorption Spectroscopy of Organic Compounds, PHI Private Limited
9. March, J. Advanced Organic Chemistry, Fourth edition, Wiley.
10. Harwood, L. M., Polar Rearrangements, Oxford Chemistry Primer, Oxford University Press.
11. Bailey, Morgan, Organonitrogen Chemistry, Oxford Chemistry Primer, Oxford University Press.
12. Warren, S. Organic Synthesis the Disconnection Approach, John Wiley and Sons.
13. Warren, S., Designing Organic Synthesis, Wiley India, 2009.
14. Carruthers, W. Modern methods of Organic Synthesis, Cambridge University Press.
15. Willis, C. A., Wills, M., Organic Synthesis, Oxford Chemistry Primer, Oxford University Press.

PRACTICALS:

1. Estimation of glycine by Sörensen's formol method.
2. Estimation of glucose by titration using Fehling's solution.
3. Estimation of sucrose by titration using Fehling's solution.
4. Estimation of vitamin-C (reduced).
5. Estimation of aromatic amine (aniline) by bromination (Bromate-Bromide)method.
6. Estimation of phenol by bromination (Bromate-Bromide) method.
7. Estimation of formaldehyde (Formalin).
8. Estimation of acetic acid in commercial vinegar.

REFERENCES FOR PRACTICALS:

1. Arthur, I. V. Quantitative Organic Analysis, Pearson
2. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G.N., University of Calcutta

COURSE OBJECTIVE OF MAJOR - 10:

The syllabus of Major -10 has been designed to provide the students with in-depth knowledge of nitrogen compounds, rearrangement reactions, the logic of organic synthesis i.e, retrosynthetic analysis of organic compounds, organic spectroscopy which includes UV-visible, Infra-red and nuclear magnetic resonance spectroscopy.

COURSE OUTCOMES OF MAJOR – 10:

CO- 10.1 **Thorough understanding of reactions involving nitrogen compounds.**

CO- 10.2 **Detailed study of rearrangement reactions , which includes several organic name reactions.**

CO- 10.3 **Detailed study of basics and various strategies of retrosynthetic analysis, strategies of large ring synthesis and asymmetric synthesis.**

CO- 10.4 **Understanding UV-visible, IR and ^{1}H-NMR spectroscopy and applications of these spectroscopies for the identification of simple organic compounds.**

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END OF SEMESTER - VI

SYLLABUS FOR CHEMISTRY OF SEMESTER – VII

MAJOR – 11

COURSE TITLE: Organic Chemistry – V

COURSE CODE: BCEMMJ11C

CREDIT: 6 (THEORY: 4 + PRACTICAL: 2)

THEORY:

CARBOCYCLES AND HETEROCYCLES: (15 L)

1. Polynuclear hydrocarbons and their derivatives: synthetic methods include Haworth, Bardhan-Sengupta, Bogert-Cook and other useful syntheses (withmechanistic details); fixation of double bonds and Fries rule; reactions (withmechanism) of naphthalene, anthracene, phenanthrene and their derivatives.

2. Heterocyclic compounds: 5- and 6-membered rings with one heteroatom; reactivity, orientation and important reactions (with mechanism) of furan, pyrrole, thiophene and pyridine; synthesis (including retrosynthetic approach and mechanistic details): pyrrole: Knorr synthesis, Paal-Knorr synthesis, Hantzsch; furan: Paal-Knorr synthesis, Feist- Benary synthesis and its variation; thiophenes: Paal-Knorr synthesis, Hinsberg synthesis; pyridine: Hantzsch synthesis; benzo-fused 5- and 6-membered rings with one heteroatom: reactivity, orientation and important reactions (with mechanistic details) of indole, quinoline and isoquinoline;synthesis (including retrosynthetic approach and mechanistic details): indole: Fischer, Madelung and Reissert; quinoline: Skraup, Doebner- Miller, Friedlander;isoquinoline: Bischler-Napieralski synthesis.

CYCLIC STEREOCHEMISTRY: (10 L)

Alicyclic compounds: concept of I-strain; conformational analysis: cyclohexane, mono and disubstituted cyclohexane; symmetry properties and optical activity; topomerisation; ring-size and ease of cyclisation; conformation & reactivity in cyclohexane system: consideration of steric and stereoelectronic requirements; elimination (E2, E1), nucleophilicsubstitution (SN1, SN2, SNi, NGP), merged substitution-elimination; rearrangements; oxidation of cyclohexanol, esterification, saponification, lactonisation,epoxidation, pyrolytic syn elimination and fragmentation reactions.

PERICYCLIC REACTIONS: (10 L)

Mechanism, stereochemistry, regioselectivity in case of

1. Electrocyclic reactions: FMO approach involving 4π- and 6π-electrons (thermal and photochemical) and corresponding cycloreversion reactions.

2. Cycloaddition reactions: FMO approach, Diels-Alder reaction,photochemical [2+2] cycloadditions.

3. Sigmatropic reactions: FMO approach, sigmatropic shifts and their order; [1,3]-and [1,5]- H shifts and [3,3]-shifts with reference to Claisen and Coperearrangements.

CARBOHYDRATES: (10 L)

1. Monosaccharides: Aldoses up to 6 carbons; structure of D-glucose & D-fructose(configuration & conformation); ring structure of monosaccharides (furanoseand pyranose forms): Haworth representations and non-planar conformations;anomeric effect (including stereoelectronic explanation); mutarotation; epimerization;reactions (mechanisms in relevant cases): Fischer glycosidation, osazone formation,bromine-water oxidation, HNO3 oxidation, selective oxidation of terminal $–CH_2OH$of aldoses, reduction to alditols, Lobryde Bruyn-van Ekenstein rearrangement;stepping–up (Kiliani-Fischer method) and stepping–down (Ruff's & Wohl'smethods) of aldoses; end-group-interchange of aldoses; acetonide (isopropylidene)and benzylidene protections; ring-size determination; Fischer's proof ofconfiguration of (+)-glucose.

2. Disaccharides: Glycosidic linkages, concept of glycosidic bond formation byglycosyl donor-acceptor; structure of sucrose, inversion of cane sugar.

3. Polysaccharides: starch (structureand its use as an indicator in titrimetricanalysis).

BIOMOLECULES: (15 L)

1. Amino acids: synthesis with mechanistic details: Strecker, Gabriel, acetamidomalonic ester, azlactone, Bücherer hydantoin synthesis, synthesis involvingdiketopiperazine; isoelectric point, zwitterions; electrophoresis, reaction (withmechanism): ninhydrin reaction, Dakin-West reaction; resolution of racemic aminoacids.

2. Peptides: peptide linkage and its geometry; syntheses (with mechanisticdetails) of peptides using N-protection & C-protection, solid-phase (Merrifield)synthesis; peptide sequence: C-terminal and N-terminal unit determination (Edman,Sanger & 'dansyl' methods); partial hydrolysis; specific cleavage of peptides: use ofCNBr.

3. Nucleic acids: pyrimidine and purine bases (only structure & nomenclature);nucleosides and nucleotides corresponding to DNA and RNA; mechanism for acidcatalysed hydrolysis of nucleosides (both pyrimidine and purine types); comparisonof alkaline hydrolysis of DNA and RNA; elementary idea of double helical structureof DNA (Watson-Crick model); complimentary base–pairing in DNA.

READING REFERENCES:

1. Clayden, J., Greeves, N., Warren, S. Organic Chemistry, Second edition, Oxford University Press, 2012.
2. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London.
3. Nasipuri, D. Stereochemistry of Organic Compounds, Wiley Eastern Limited.
4. Sen Gupta, Subrata. Basic Stereochemistry of Organic molecules.
5. Kalsi, P. S. Stereochemistry Conformation and Mechanism, Eighth edition, New Age International, 2014.
6. Fleming, I. Molecular Orbitals and Organic Chemical reactions, Reference/Student Edition, Wiley, 2009.
7. Fleming, I. Pericyclic Reactions, Oxford Chemistry Primer, Oxford University Press.
8. Gilchrist, T. L. & Storr, R. C. Organic Reactions and Orbital symmetry, Cambridge University Press.

9. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
10. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
11. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
12. Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press.
13. James, J., Peach, J. M. Stereochemistry at a Glance, Blackwell Publishing, 2003.
14. Robinson, M. J. T., Stereochemistry, Oxford Chemistry Primer, Oxford University Press, 2005.
15. Davis, B. G., Fairbanks, A. J., Carbohydrate Chemistry, Oxford Chemistry Primer, Oxford, University Press.
16. Joule, J. A. Mills, K. Heterocyclic Chemistry, Blackwell Science.
17. Acheson, R.M. Introduction to the Chemistry.

PRACTICALS:

Chromatographic Separations

1. TLC separation of a mixture containing 2/3 amino acids.

2. TLC separation of a mixture of dyes (fluorescein and methylene blue).

3. Column chromatographic separation of leaf pigments fromspinach leaves.

4. Paper chromatographic separation of a mixture containing 2/3 amino acids.

Spectroscopic Analysis of Organic Compounds

1. Assignment of labelled peaks in the 1H NMR spectra of the known organiccompounds explaining the relative δ-values and splitting pattern.

2. Assignment of labelled peaks in the IR spectrum of the same compoundexplaining the relative frequencies of the absorptions (C-H, O-H, N-H, C-O, C-N, CX,C=C, C=O, N=O, C≡C, C≡N stretching frequencies; characteristic bendingvibrations are included).

3. The students must analyze full spectra of at least 10 (ten) compoundsfrom the following list:

a. 4-Bromoacetanilide

b. 2-Bromo-4'-methylacetophenone c. Vanillin

d. 2-Methoxyacetophenone e. 4-Aminobenzoic acid

f. Salicylamide

g. 2-Hydroxyacetophenone h. 1,3-Dinitrobenzene

i. Benzylacetate

j. trans-4-Nitrocinnamaldehyde k. Diethyl fumarate

l. 4-Nitrobenzaldehyde

m. 4-Methylacetanilide

n. Mesityl oxide

o. 2-Hydroxybenzaldehyde

p. 4-Nitroaniline

q. 2-Hydroxy-3-nitrobenzaldehyde r. 2,3-Dimethylbenzonitrile

REFERENCES FOR PRACTICALS:

1. S. Perry, Practical Liquid Chromatography, 2012
2. C.F. Poole, S.A. Schuette, Contemporary Practice of Chromatography, · 2012
3. Ivor Smith, J. W. T. Seakins, Paper and Thin Layer Chromatography, · 2013
4. B. Ravindranath · Principles and Practice of Chromatography,1989.
5. Rosaleen J. Anderson, David J. Bendell, Paul W. Groundwater, Organic Spectroscopic Analysis,2004.

COURSE OBJECTIVE OF MAJOR - 11:

The syllabus of Major -11 has been designed to provide the students with in-depth knowledge of carbocycles and heterocycles, cyclic stereochemistry, pericyclic reactions, carbohydrates and biomolecules.Discussion of biomolecules includes amino acids, peptides and nucleic acids.

COURSE OUTCOMES OF MAJOR – 11:

CO- 11.1 **Thorough understanding ofcarbocycle and heterocycle systems and corresponding reactions.**

CO- 11.2 **Detailed study of stereochemistry of alicyclic compound s and corresponding reactions viz, elimination, substitution, rearrangement, esterification, epoxidation and fragmentation reactions.**

CO- 11.3 **Detailed study of various pericyclic reactions including electrocyclic, cycloaddition and sigmatropic reactions.**

CO- 11.4 **Detailed discussion of carbohydrate chemistry and related reactions.**

CO- 11.5 **Detailed discussion of various biomolecules including amino acids, peptides and nucleic acids.**

MAJOR – 12

COURSE TITLE: Inorganic Chemistry – IV

COURSE CODE: BCEMMJ12C

CREDIT: 6 (THEORY: 4 + PRACTICAL: 2)

THEORY:

Bioinorganic Chemistry: (15L)

Elements of life: essential and beneficial elements, major, trace and ultratrace elements. Basic chemical reactions in the biological systems and the role of metal ions (specially Na^+, K^+, Mg^{2+}, Ca^{2+}, $Fe^{3+}/^{2+}$, $Cu^{2+/+}$, and Zn^{2+}). Metal ion transport across biological membrane Na+/ K+-ion pump (Basic Idea). Dioxygen molecule in life. Dioxygen management proteins: Haemoglobin, Myoglobin, Hemocyanine and Hemerythrin.

Electron transfer proteins: Cytochromes and Ferredoxins. Hydrolytic enzymes: carbonate bicarbonate buffering system and carbonic anhydrase and carboxyanhydrase A. Biological nitrogen fixation (Basic Idea).

Photosynthesis: Photosystem-I andPhotosystem-II (Basic Idea). Toxic metal ions and their effects, chelation therapy (examples only), Pt and Au complexes as drugs (examples only), metal dependent diseases (examples only).

ORGANOMETALLIC CHEMISTRY: (10L)

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. 18-electron and 16-electron rules (pictorial MO approach). Applications of 18-electron rule to metal carbonyls, nitrosyls, cyanides. General methods of preparation of mono and binuclear carbonyls of 3d-series. Structures of mononuclear and binuclear carbonyls. Pi-acceptor behaviour of CO, synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation, structure, evidences of synergic effect. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation); Applications based on MO diagram of Ferrocene, Structure of Ferrocene.

ORGANOMETALLIC CATALYSIS: (15 L)

1. Alkene hydrogenation (Wilkinson's Catalyst)
2. Hydroformylation
3. Wacker Process
4. Synthetic gasoline (Fischer Tropsch reaction)
5. Monsanto Acetic Acid Process.
6. Ziegler-Natta catalysis for olefin polymerization.

Reactions of organometallic complexes: substitution, oxidative addition, reductive elimination and insertion reactions.

d & f- BLOCK CHEMISTRY: (20 L)

Transition Elements:

General comparison of 3d, 4d and 5d elements in term of electronic configuration, oxidation states, redox properties, coordination chemistry.

Lanthanoids and Actinoids:

General Comparison on Electronic configuration, oxidation states, colour, spectral andmagnetic properties; lanthanide contraction, separation of lanthanides (ion-exchangemethod only).

READING REFERENCES:

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. Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).
4. Cotton, F.A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry 3rd Ed.; Wiley India.
5. Sharpe, A.G., Inorganic Chemistry, 4th Indian Reprint (Pearson Education), 2005.
6. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure andReactivity 4th Ed., Harper Collins 1993, Pearson,2006.
7. Das, Asim. K.; Fundamentals Concepts of Inorganic Chemistry, Vol 1-7, 3rd Ed., CBS Publishers.
8. Miessler, G. L., Fischer, P. J., Tarr, D. A., Inorganic Chemistry, Pearson, 5th Edition.
9. Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
10. Bertini, I., Gray, H. B., Lippard, S.J., Valentine, J. S., Viva, 2007.
11. Basolo, F, and Pearson, R.C. Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
12. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
13. Collman, J. P. et al. Principles and Applications of Organotransition Metal Chemistry. Mill Valley, CA: University Science Books, 1987.
14. Crabtree, R. H. The Organometallic Chemistry of the Transition Metals. New York, NY: JohnWiley, 2000.

PRACTICALS:

Qualitative semi-micro analysis

Qualitative semimicro analysis of mixtures containing four radicals. Emphasis should be given to the understanding of the chemistry of different reactions and to assign the most probable composition.

Cation Radicals: Na^+, K^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Al^{3+}, Cr^{3+}, Mn^{2+}/Mn^{4+}, Fe^{3+},Co^{2+}/Co^{3+}, Ni^{2+}, Cu^{2+}, Zn^{2+}, Pb^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}/Sn^{4+}, As^{3+}/As^{5+}, $Sb^{3+}/^{5+}$, NH^{4+}, Mg^{2+}.

Anion Radicals: F^-, Cl^-, Br^-, BrO_3^-, I^-, IO_3^-, SCN^-, S^{2-}, SO_4^{2-}, NO_3^-, NO_2^-, PO_4^{3-} , AsO_4^{3-}, BO_3^{3-}, CrO_4^{2-} / $Cr_2O_7^{2-}$, $[Fe(CN)_6]^{4-}$, $[Fe(CN)_6]^{3-}$.

Insoluble Materials: Al_2O_3(ig), Fe_2O_3(ig), Cr_2O_3(ig), SnO_2, $SrSO_4$, $BaSO_4$, CaF_2, $PbSO_4$.

REFERENCES FOR PRACTICALS:

1. Svehla, G., Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mukherjee, G. N., Semi-Micro Qualitative Inorganic Analysis, University of Calcutta, 2008.
3. Bhattacharya, R. C., A Manual of Practical Chemistry for degree classes (Vol. I & II) for Honours Students, Biswas Book Stall, Calcutta.

COURSE OBJECTIVE OF MAJOR - 12:

The syllabus of Major -12 has been designed to provide the students with thorough understanding of the Electron Transport System in Biological Systems, mechanism of Na+ / K+ pumps, photosysthesis process and most importantly, the explanation of the mentioned processes from Chemistry point of view.

The module concerning the Organometallic chemistry will impart a so-called inter-disciplinary idea of inorganic and organic chemistry, commonly known as the Organometallic Chemistry, especially in the arena of Inorganic Synthesis and Catalysis. The module will provide fundamental concepts like EAN rule and its applications, formation of non-conventional bonds with special reference to Zeise Salt, Ferrocene and other metallocenes.

Using the basic concepts of the previous module, the students will learn the use of organometallic complexes as catalysts and the concepts of Oxidative Addition, Reductive Elimination, Insertion reactions as well as the catalytic cycle of well-known Catalysts as described in the syllabus.

The module concerning the group chemistry of d- and f- block elements, will impart the knowledge of the differences of transition metals with s- & p-block elements.

COURSE OUTCOMES OF MAJOR – 12:

CO- 12.1 Developing the idea and concepts of Bio-inorganic chemistry.

CO- 12.2 Understanding of Organometallic chemistry from Inorganic point of view.

CO- 12.3 Study of catalysis by organometallic compounds.

CO- 12.4 Detailed study of d- and f- transition elements with emphasis on Lanthanides.

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MAJOR – 13

COURSE TITLE: Physical Chemistry – IV

COURSE CODE: BCEMMJ13C

CREDIT: 6 (THEORY: 4 + PRACTICAL: 2)

THEORY:

Crystal Structure: (8L)

1. Bravais Lattice and Laws of Crystallography: Concept of lattice, basis, primitive cell. Types of solid, Bragg's law ofdiffraction; Laws of crystallography (Haüy's law and Steno's law); Permissible symmetry axes in crystals; Lattice, space lattice, Cubical systems (SC, BCC, FCC).

2. Crystal planes: Distance between consecutive planes [cubic, tetragonal and orthorhombic lattices]; Indexing of planes, Miller indices; calculation of d_{hkl}; Relation between molar mass and unit cell dimension for cubic system;

3. Diffraction of X-ray by crystals, Braggequation, determination of crystal structure: Powder method; Structure of NaCland KCl crystals, elementary idea of structure factor.

STATISTICAL THERMODYNAMICS: (10 L)

1. Configuration: Macrostates, microstates and configuration; calculation with harmonic oscillator; variation of W with E; equilibrium configuration.

2. Boltzmann distribution: Thermodynamic probability, entropy and probability, Boltzmann distribution formula (with derivation); Applications to barometric distribution.

3. Partition function: molecular partition function and thermodynamic properties, Maxwell's speed distribution; Gibbs' paradox. Nature of particles and concept of other distribution formula (FD, BE).

3rd LAW OF THERMODYNAMICS: (12 L)

Specific heat of solid: Coefficient of thermal expansion, thermal compressibility of solids; Dulong – Petit's law; Equipartition theorem and heat capacities; Perfect Crystal model, Einstein's theory – derivation from partition function, limitations; Debye's T3 law – analysis at the two extremes. 1. 3rd law: Absolute entropy, Plank's law, Calculation of entropy, Nernst heat Theorem.

2. Adiabatic demagnetization: Approach to zero Kelvin.

APPLICATION OF THERMODYNAMICS-IV: (10 L)

Ionic equilibria: Chemical potential of an ion in solution; Activity and activity coefficients of ions in solution; Debye-Huckel limiting law-brief qualitative description of the postulates involved, qualitative idea of the model, the equation (without derivation) for ion-ion atmosphere interaction potential. Estimation of activity coefficient for electrolytes using Debye-Huckel limiting law; Mean ionic activity coefficient; Applications of the Debye-Huckel equation and its limitations.

TRANSPORT PROCESS-II: (8 L)

1. Conductance and transport number: Ion conductance; Conductance and measurement of conductance, cell constant, specific conductance and molar conductance; Variation of specific and equivalent conductance with dilution forstrong and weak electrolytes; Kohlrausch's law of independent migration of ions; Equivalent and molar conductance at infinite dilution and their determination for strong and weak electrolytes; Debye –Huckel theory of Ion atmosphere (qualitative)-asymmetric effect, relaxation effect and electrophoretic effect; Ionic mobility; Application of conductance measurement(determination of solubility product and ionic product of water);Conductometric titrations.

4. Transport number, Principles of Hittorf's and Moving-boundary method; Wieneffect, Debye-Falkenhagen effect, Walden's rule.

SURFACE CHEMISTRY & COLLOIDS: (12 L)

1. Surface tension and energy: Surface tension, surface energy, excess pressure, capillary rise and surface tension; Work of cohesion and adhesion, spreading ofliquid over other surface; Vapour pressure over curved surface; Temperature dependence of surface tension.

2. Adsorption: Physical and chemical adsorption; Freundlich and Langmuir

adsorption isotherms; multilayer adsorption and BET isotherm (no derivation required); Gibbs adsorption isotherm and surface excess; Heterogenous catalysis (single reactant); Zero order and fractional order reactions.

3. Colloids: Lyophobic and Lyophilic sols, Origin of charge and stability of Lyophobic colloids, Coagulation and Schultz-Hardy rule, Zeta potential and Stern double layer (qualitative idea), Tyndall effect; Electrokinetic phenomena(qualitative idea only); Determination of Avogadro number by Perrin's method; Stability of colloids and zeta potential; Micelle formation.

READING REFERENCES:

1. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford University Press
2. Castellan, G. W. Physical Chemistry, Narosa
3. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press
4. Levine, I. N. Physical Chemistry, Tata McGraw-Hill
5. Laidler, K. J. Chemical Kinetics, Pearson
6. Levine, I. N. Quantum Chemistry, PHI
7. Atkins, P. W. Molecular Quantum Mechanics, Oxford
8. McQuarrie, D. A. Statistical Mechanics, Viva Books Pvt. Ltd. 2003, New Delhi
9. Banwell, C. N. and McCash, E.M. Fundamentals of Molecular Spectroscopy, Edn. 4th, Tata McGraw-Hill, New Delhi.
10. Nash, L. K. Elements of Statistical Thermodynamics, Dover
11. Atomic and Molecular Spectroscopy: Basic Concepts and Applications, Rita Kakkar Cambridge University Press, 2015.
12. Moore, W. J. Physical Chemistry, Orient Longman
13. Glasstone, S. & Lewis, G.N. Elements of Physical Chemistry

14. Bera, N. K., Ghosh, S., Ghosh, P., Vol-(I, II and III), Physical Chemistry Concepts & Models, Techno World, Kolkata.
15. Rakshit, P.C., Physical Chemistry Sarat Book House
16. Mortimer, R. G. Physical Chemistry, Elsevier
17. Engel, T. & Reid, P. Physical Chemistry, Pearson
18. Rastogi, R. P. & Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas
19. Ashish Kumar Nag, Physical Chemistry (Vol-I & II), McGraw Hill Education (India) Pvt. Ltd.
20.K. L. Kapoor, A Textbook of Physical Chemistry, Vol-I to Vol-V, Macmillan Publishers India Ltd. 2004
21. Ghoshal, A. Numerical Problems on Physical Chemistry, Books & Allied Pvt. Ltd. Kolkata
Klotz, I.M., Rosenberg, R. M. Chemical Thermodynamics:Basic Concepts and Methods Wiley.

PRACTICALS:

1. Determination of surface tension of a liquid using Stalagmometer.

2. Determination of solubility of sparingly soluble salt in water, in electrolyte with common ions and in neutral electrolyte (using common indicator).

3. Conductometric titration of a strong / weak acid by strong base.

4. Conductometric titration of a dibasic acid by strong base.

REFERENCES FOR PRACTICALS:

1. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G N., University of Calcutta
2. Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
3. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd.
4. Saharay, S. K. &Basu, A. S. A Guide to Practical Physical Chemistry, University of Burdwan.
5. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009)
6. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson
7. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007)

Course Outcome of Major-13

The objectives of the present major course are manyfold. There are six modules in this course, and the objectives of the modules can be stated as below:

CO - 13.1 This module is designed to provide students with molecular- or atomic-level ideas of crystal structure and its influence on the properties of the solid concerned. A brief theoretical knowledge of X-ray crystallography has been given, so that the learners can apply this knowledge in future studies.

CO - 13.2 The chapter discusses the applicability of thermodynamic laws at the microscopic scale and, at the same time, makes a bridge between the atomic and macroscopic levels of theories. Students taking the course will be able to apply the rules of statistics to understand the thermodynamics of the systems.

CO -13.3 This module discusses the third law of thermodynamics and the phenomena occurring near 0 K. Students taking this course will be able to understand the meaning and definition of entropy at the molecular level.

CO -13.4 This module discusses the application of thermodynamics in the case of solutions, more specifically the ionic equilibrium. Students taking the course will learn the definitions of chemical potential, activity, and activity coefficient of ions in solutions. A description of the Debye-Huckel limiting law and its applications has been given to help the students understand the physical chemistry of ions in solutions.

CO - 13.5 This module will provide the students with details of transport processes taking place in solutions containing electrolytes. This module also gives the idea of applying the conducting property of ions in solutions to determining the various physical or chemical properties of solutions, such as solubility product, etc.

CO- 13.6 This chapter is designed to help the students understand the different physical properties as well as the chemistry of the surface. The topics discussed in this chapter are expected to give the learners a fundamental understanding of surface-related chemistry, which is widely applied in various industrial units.

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END OF SEMESTER - VII

SYLLABUS FOR CHEMISTRY OF SEMESTER – VIII

(Papers with 6 Credits)

MAJOR – 14

COURSE TITLE: Inorganic Chemistry – V

COURSE CODE: BCEMMJ14C

CREDIT: 6 (THEORY: 4 + PRACTICAL: 2)

THEORY:

Qualitative and quantitative aspects of analysis (10L)

Sampling, evaluation of analytical data, errors, accuracy and precision, methods oftheir expression, normal law of distribution if indeterminate errors, statistical test ofdata; F, Q and t test, rejection of data, and confidence intervals, Detection Limit, Least Square Method.

Optical methods of analysis (15L)

1. Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

2. UV-Visible Spectrometry: Basic principles

3. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

4. Infrared Spectrometry: Basic principles

1. Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, and detector, choice of flame and Burner designs. Techniques of atomization and sample introduction;

Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

Thermal methods of analysis (5L)

Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture. DTA, DSC.

Electroanalytical methods: (10L)

Classification of electroanalytical methods, basic principle of pH metric, potentiometric, conductometric, amperometric and coulometric titrations. Techniques used for the determination of equivalence points, Dropping Mercury Electrode (DME), Ilkovich Equation, Polarography, Cyclic Voltametry (CV). Techniques used for the determination of pKa values.

Separation techniques (20L)

1. Solvent extraction: Classification, principle and efficiency of the technique.

Mechanism of extraction: extraction by solvation and chelation.

2. Technique of extraction: batch, continuous and counter current extractions.

3. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media.

4. Chromatography: Classification, principle and efficiency of the technique.

Mechanism of separation: adsorption, partition & ion exchange.

5. Development of chromatograms: frontal, elution and displacement methods.

6. Qualitative and quantitative aspects of chromatographic methods of analysis:

IC, GLC, GPC, TLC and HPLC.

7. Stereoisomeric separation and analysis: Measurement of optical rotation,calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios anddetermination of enantiomeric composition using NMR, Chiral solvents andchiral shift reagents. Chiral chromatographic techniques using chiral columns(GC and HPLC).

8. Role of computers in instrumental methods of analysis.

READING REFERENCES:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson,2009.
2. Willard, H.H. Et al.: Instrumental Methods of Analysis, 7th Ed. WardsworthPublishing Company, Belmont, California, USA, 1988.
3. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York,2004.
4. Harris, D.C.: Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman,2016.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age InternationalPublisher,2009.
6. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis,Cengage Learning India Ed.
7. Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, EllesHarwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
8. Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand, 1974.

PRACTICALS:

1. Determination of Fe(III) content in cement.

2. Chromatographic separation of Amino acids.

3. Chromatographic separation of Ni & Co using Paper Chromatography.

4. Estimation of Ascorbic Acid in Vitamin-C by Iodometric method.

REFERENCES FOR PRACTICALS:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
3. Harris, D.C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
4. Mukherjee, G. N., University Handbook of Undergraduate Chemistry Experiments, University of Calcutta, 2003.
5. Nad, Mahapatra and Ghoshal, An Advance Course in Practical Chemistry, New Central Book Agency, Kolkata.

COURSE OBJECTIVE OF MAJOR - 14:

The syllabus of Major -14 has been designed to provide the students with thorough understanding of Analytical Chemistry. After successfully completing this syllabus, the students should be able to analyze data for accuracy, precision and errors. They will also be able to perform various tests like F, Q and t tests.

The second module will enable the students to carry out various spectroscopic experiments and analyze the data and interpret them for meaningful conclusions.

The third module will enable the students to some standard separation and purification methods, commonly used in chemistry.

COURSE OUTCOMES OF MAJOR – 14:

CO- 14.1 Understanding and application of Sampling & Errors in Quantitative Analysis.

CO- 14.2 Understanding and application of Lambert-Beer's Law.

CO- 14.3 Understanding the basic principles of UV-Vis & IR spectroscopy.

CO- 14.4 Understanding of separation techniques like GC, HPLC, TLC.

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MAJOR – 15

COURSE TITLE: Physical Chemistry – V

COURSE CODE: BCEMMJ15C

CREDIT: 6 (THEORY: 4 + PRACTICAL: 2)

THEORY:

1. **Angular momentum (25L):**

Commutation rules, quantization of square of total angular momentum and z-component; rigid rotator model of rotation of diatomic molecule; Schrödinger equation, transformation to spherical polar coordinates; Separation of variables. Spherical harmonic: Solutions for the stationary states of harmonic oscillator (wave function and operator methods), rigid rotator and the H-atom (with complex and real solutions).

2. **Chemical kinetics-III (15L):**

Theories of reaction rates: applications to uni-, bi-molecular reactions, thermodynamic formulation of reaction rate, and reactions in solution: cage effect, diffusion and activation controlled reactions (elementary idea), dielectric effect on ion-ion reaction; electrostriction; volume of activation; effect of pressure on reaction rate.

3. **Catalysis (10 L):**

Homogeneous catalysis: Homogeneous catalysis with reference to acid-base catalysis; Primary kinetic salt effect; Enzyme catalysis; Michaelis-Menten equation, Lineweaver-Burk plot, turn-over number; Autocatalysis; periodic reactions, Heterogeneous catalysis.

4. **Application of Computers in Chemistry (5L):**

Basic ideas of Computers, Basic idea of Roots of equations, matrix operations, numerical differentiation, integration, Graph plotting tools, Molecular visualization tools, Crystal structure database.

5. **Nanomaterials (5L):**

Importance of nano-systems; confinement and dimensionality with example (dot, wire etc.); Different approaches for preparation of nanomaterials.

READING REFERENCES:

1. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford University Press
2. Castellan, G. W. Physical Chemistry, Narosa
3. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press
4. Levine, I. N. Physical Chemistry, Tata McGraw-Hill
5. Laidler, K. J. Chemical Kinetics, Pearson
6. K. J. Laidler, Reaction Kkinetics, Vols. I & II, Pergamon Press, London, 1970.

7. L. P. Hammett, Physical Organic Chemistry, McGraw-Hill Book Company, New Delhi, 1970.
8. M. R. Wright, Fundamental Chemical Kinetics, Horwood Publishing, 1999.
9. Levine, I. N. Quantum Chemistry, PHI
10. Atkins, P. W. Molecular Quantum Mechanics, Oxford
11. Moore, W. J. Physical Chemistry, Orient Longman
12. Glasstone, S. & Lewis, G.N. Elements of Physical Chemistry
13. Bera, N. K., Ghosh, S., Ghosh, P., Vol-II, Physical Chemistry Concepts & Models, Techno World, Kolkata.
14. Rakshit, P.C., Physical Chemistry Sarat Book House
15. Mortimer, R. G. Physical Chemistry, Elsevier
16. Engel, T. & Reid, P. Physical Chemistry, Pearson
17. Rastogi, R. P. & Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas
18. Ashish Kumar Nag, Physical Chemistry (Vol-I & II), McGraw Hill Education (India) Pvt. Ltd.
19. K. L. Kapoor, A Textbook of Physical Chemistry, Vol-I to Vol-V, Macmillan Publishers India Ltd. 2004.
20. Ghoshal, A. Numerical Problems on Physical Chemistry, Books & Allied Pvt. Ltd. Kolkata
21. Klotz, I.M., Rosenberg, R. M. Chemical Thermodynamics:Basic Concepts and Methods Wiley
22. F. A. Cotton, Chemical Applications of Group Theory, 3rd Edn Reprint, John Wiley and Sons.
23. S. C. Rakshit, Molecular Symmetry Group and Chemistry, The New Book Stall, Kolkata, 1988.
24. L. Pauling and E. B. Wilson, Introduction to Quantum Mechanics, McGraw-Hill, 1939.
25. H. Eyring, J. Walter and G. F. Kimball, Quantum Chemistry, Wiley, New York, 1944.
26. F. L. Pilar, Elementary Quantum Chemistry, Tata McGraw-Hill, 1990.
27. A. K. Chandra, Introductory Quantum Chemistry, Tata McGraw-Hill Publishing Co, New Delhi, 1989.
28. K.K. Choudhary, Nanoscience and Nanotechnology, Narosa Publishing House, New Delhi.
29. A. K. Das & M. Das, An Introduction to Nanomaterials and Nanoscience, CBS Publishers and Distributors Pvt. Ltd.

PRACTICALS:

1. Study of phenol-water phase diagram.
2. Study of The Effect of the PKSE on the kinetics of $K_2S_2O_8$ + KI reaction (bytitrimetric method).
2. Plotting of differential values of data obtained from Conductometric Titration using MS-Excel/Origin.
3. Plotting of differential values of data obtained from Potentiometric Titration using MS-Excel/Origin.
4. Plotting of differential values of data obtained from pH-metric Titration using MS-Excel/ Origin.

REFERENCES FOR PRACTICALS:

1. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G N., University of Calcutta.
2. Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
3. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd.
4. Saharay, S. K. &Basu, A. S. A Guide to Practical Physical Chemistry, University of Burdwan.

5. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009)
6. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson
7. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007)

COURSE OBJECTIVE MAJOR-15

This major has five modules that focus on (1) Angular Momentum, (2) Chemical Kinetics, (3) Catalysis, (4)Application of Computers in chemistry, and (5) Nanomaterials. These seemingly unrelated topics give the students in-depth advance knowledge of the topics already discussed in previous majors. In addition, it introduces some theoretical techniques, like computational chemistry, often used in modern research laboratories. The course objectives of these modules are as follows:

CO - 15.1: This chapter includes the method of constructing the Hamiltonian and Schrodinger Equations for different quantum mechanical systems. Understanding the different mathematical techniques involved in solving the Schrodinger Equation will certainly enable the students to apply the techniques to more complicated systems.

CO - 15.2: The module is framed to make the students understand the elementary laws of chemical kinetics and analyze reaction mechanisms. The learners are expected to get a detailed understanding of the kinetics of reactions in solution and the influence of pressure, ionic strength, and solvent on reaction rates. After completion, the students should be able to explain the potential energy surface, the aspects of reactions in the gas or liquid phase. They will also be able to solve problems on rate and rate constants for (i) elementary and complex reactions and (ii) unimolecular and bimolecular reactions.

CO - 15.3: This chapter includes an overall idea of Catalysis and the related theories. After completion of this course, the students will be able to understand and analyze the different types of catalysis and the physical chemistry of such catalytic activities. They will be able to draw Michaelis-Menten plots, Lineweaver-Burk plots, etc., so that the efficiency of the catalysts can be determined.

CO - 15.4: This module is designed to give the learners a preliminary idea of the application of Computers in Chemistry. Students taking the course will be able to draw simple graphs or do simple calculations using various freely available software programs.

CO - 15.5: This chapter gives a brief idea of nanomaterials, their dimensional analysis, and the chemical methods followed for synthesizing nanomaterials. The aim of this particular module is to make the students aware of the fundamental basis of nanoscience.

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CHEMISTRY MAJOR SYLLABUS FOR 8TH SEMESTER WITH PAPERS OF 4 CREDITS

MAJOR – 16

COURSE TITLE: Inorganic Chemistry – VI

COURSE CODE: BCEMMJ16C

CREDIT: 4 (THEORY: 3 + PRACTICAL: 1)

THEORY:

Spectroscopic Applications: (25 L)

Practical applications of UV-Vis, IR, Mass spectroscopy, EPR and Raman Spectroscopy in Inorganic Chemistry.

Industrial Chemistry: (20 L)

SILICATE INDUSTRIES:

1. Glass: Glassy state and its properties, classification (silicate and non-silicateglasses). Manufacture and processingof glass. Composition and properties of thefollowing types of glasses: Soda lime glass, lead glass, armoured glass, safety glass,borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

2. Ceramics: Important clays and feldspar, ceramic, their types and manufacture.High technology ceramics and their applications, superconducting andsemiconducting oxides, fullerenes carbon nanotubes and carbon fibre.

3. Cements: Classification of cement, ingredients and their role, Manufacture ofcement and the setting process, quick setting cements.

Fertilizers:

Different types of fertilizers. Manufacture of the following fertilizers: Urea,ammonium nitrate, calcium ammonium nitrate, ammonium phosphates;polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride,potassium sulphate.

Surface Coatings:

Objectives of coatings surfaces, preliminary treatment of surface, classificationof surface coatings. Paints and pigments-formulation, composition and relatedproperties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments,Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fireretardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oilpaints, additives, Metallic coatings (electrolytic and electroless), metal spraying andanodizing.

Alloys:

Classification of alloys, ferrous and non-ferrous alloys, Specific properties ofelements in alloys. Manufacture of Steel (removal of silicon decarbonization,demanganization, desulphurization dephosphorisation) and surface treatment (Ar andheat treatment, nitriding, carburizing).Composition and properties of different types of steels.

READING REFERENCES:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
7. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).

PRACTICALS:

1. Preparation of Zinc Oxide pigment.
2. Estimation of Calcium in Calcium Ammonium Nitrate fertilizer.
3. Analysis of Cement.

REFERENCES FOR PRACTICALS:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
7. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).
8. Mukherjee, G. N., Advanced Experiments in Inorganic Chemistry, U. N. Dhur & Sons, Kolkata.

COURSE OBJECTIVE OF MAJOR - 16:

The syllabus of Major -16 has been designed to provide the students with the industrial application of chemistry. This course will empower the students with the knowledge of preparation of Glass, Ceramics, Cement, Fertilizers, alloys etc and quantitative analysis of cement will also be demonstrated to enable them to work as Quality Management Resources.

The students will also get a thorough knowledge of different spectroscopic analysis with interpretation of the UV-Vis, IR, Raman etc. spectra.

COURSE OUTCOMES OF MAJOR – 16:

CO - 16.1 Understanding the basic principles of UV-Vis, IR, Mass, ESR & Raman spectroscopy.

CO - 16.2 Understanding of preparation of glass, ceramics and silicates.

CO - 16.3 Elementary idea of Fertilizers.

CO - 16.4 Elementary idea of alloys.

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MAJOR – 17

COURSE TITLE: Physical Chemistry – VI

COURSE CODE: BCEMMJ17C

CREDIT: 4 (THEORY: 3 + PRACTICAL: 1)

THEORY:

SPIN RESONANCE SPECTROSCOPY: (5 L)

Principles of NMR/ESR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

Group theory II: (20 lectures)
The Great Orthogonality Theorem: statement and interpretation, proof of important corollaries; construction of character tables: construction of their character tables for abelian and cyclic groups. Direct product groups and construction of their character tables, direct product representations, reduction formula, vanishing of integrals and its applications, invariance of the Hamiltonian operator and eigen functions of H as bases of irreducible representations.
Projection operators (without derivation), application of group theoretical methods for (i) construction of SALC's and their use in calculation of π MO's under the Huckel approximations, (ii) symmetry aspects of molecular vibrations: infrared and Raman activity.

Quantum mechanics (10L):
de Broglie wavelength, Bohr's correspondence principle with examples; properties of wave functions, operators and related theorems.Schrödinger equation, energy-eigenvalue equation, expectation value, eigenvalue and spread of observation, definition of uncertainty; equation of motion, constants of motion; detailed treatment of the particle in a box, including degeneracy; step potential and tunneling.

Atomic spectra: (10 L):
Quantum numbers, orbital and spin angular momenta of electrons, Stern-Gerlach experiment, vector atom model, term symbols (one and two optical electron systems), normal and anomalous Zeeman effect, Paschen back effect.
Introduction to Molecular Term Symbols.

READING REFERENCES:

1. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford University Press
2. Castellan, G. W. Physical Chemistry, Narosa
3. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press
4. Levine, I. N. Physical Chemistry, Tata McGraw-Hill
5. Laidler, K. J. Chemical Kinetics, Pearson
6. Levine, I. N. Quantum Chemistry, PHI
7. Atkins, P. W. Molecular Quantum Mechanics, Oxford
8. Moore, W. J. Physical Chemistry, Orient Longman
9. Glasstone, S. & Lewis, G.N. Elements of Physical Chemistry.

10.Rakshit, P.C., Physical Chemistry Sarat Book House
11.Mortimer, R. G. Physical Chemistry, Elsevier
12.Engel, T. & Reid, P. Physical Chemistry, Pearson
13.Banwell, C. N. and McCash, E.M. Fundamentals of Molecular Spectroscopy, Edn. 4th, Tata McGraw-Hill, New Delhi.
14.Atomic and Molecular Spectroscopy: Basic Concepts and Applications, Rita Kakkar Cambridge University Press, 2015.
15.K. L. Kapoor, A Textbook of Physical Chemistry, Vol-I to Vol-V, Macmillan Publishers India Ltd. 2004.
16.F. A. Cotton, Chemical Applications of Group Theory, 3rd Edn Reprint, John Wiley and Sons.
17.S. C. Rakshit, Molecular Symmetry Group and Chemistry, The New Book Stall, Kolkata, 1988.
18.A. Vincent, Molecular Symmetry and Group Theory, John Wiley and Sons, New York, 1998.
19.V. Heine, Group Theory in Quantum Mechanics: An Introduction to Its Present Usage, Dover Publication.
20.L. Pauling and E. B. Wilson, Introduction to Quantum Mechanics, McGraw-Hill, 1939.
21.H. Eyring, J. Walter and G. F. Kimball, Quantum Chemistry, Wiley, New York, 1944.
22.F. L. Pilar, Elementary Quantum Chemistry, Tata McGraw-Hill, 1990.
23.A. K. Chandra, Introductory Quantum Chemistry, Tata McGraw-Hill Publishing Co, New Delhi,1989.

PRACTICALS:

1.Job's Method using Fe-Phenanthroline/ Fe-Salicylic acid complex by colourimetric / spectrophotometric method.
2. Mole Ratio method using Fe-Phenanthroline/ Fe-Salicylic acid complex by colourimetric / spectrophotometric method.
3. Determination of Rate Constant of Inversion of Cane sugar by polarimetric method.

REFERENCES FOR PRACTICALS:

1. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G N., University of Calcutta
2. Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
3. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd.
4. Saharay, S. K. &Basu, A. S. A Guide to Practical Physical Chemistry, University of Burdwan.
5. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009)
6. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson
7. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007).

Course Objectives of Major – 17

This major has four modules to cover. The following are the individual objectives of the respective modules. This major is, to some extent, an advanced-level course required for the next level of higher studies. The course objectives are:

CO - 17.1: This particular module focuses mainly on the understanding and analysis of NMR/ PMR spectroscopy. The chapter discusses mainly topics like chemical shift and shielding, spin interactions, and equivalent protons pertaining to NMR spectroscopy. Learners taking this course are expected to determine the nature of a proton and the number of equivalent protons in a molecule from proton NMR spectra. They will also be able to analyse the NMR/PMR spectra of simple organic molecules.

CO - 17.2: This chapter consists of the basic principles of group theory. The Great Orthogonality Theorem (GOT) and its important corollaries are the most important parts of the chapter. In this segment of group theory, the procedure for the construction of character tables for Abelian, Cyclic, and Direct product groups has been explained by utilizing the corollaries of GOT. Several applications of the vanishing integral rule have been demonstrated. Actually, this chapter is the gateway to the next higher level of studies involving Group Theory or Applications of Group Theory.

CO - 17.3: This chapter essentially deals with a major part of exactly solvable quantum mechanical problems. The analytical solutions to these problems involve the learning of some major mathematical techniques frequently used in other parts of theoretical chemistry.

CO - 17.4: This module is designed to make the students familiar with the vector model of atoms and term symbols (one and two optical electron systems). This also includes the study of normal and anomalous Zeeman effects and the Paschen Back effect. After the completion of the course, the student is expected to be able to: (1) explain and use the central concepts, theoretical descriptions, and fundamental approximations applied to atoms; (2) treat the quantum mechanical formalism for identical particles and apply these to the structure of atoms; and (3) describe, carry out, and evaluate the various spectroscopic methods used to study atoms.

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MAJOR – 18

COURSE TITLE: Organic Chemistry – VI

COURSE CODE: BCEMMJ18C

CREDIT: 4 (THEORY: 3 + PRACTICAL: 1)

THEORY:

1. Structure-reactivity relationship: (5 L)

The Hammett equation and linear free energy relationship, equilibria and rates in organic reactions, substituent and reaction constants, Taft equation.

2. Application of Spectroscopy: (15 L)

a) NMR Spectroscopy:

Principle, instrumentation and different techniques (CW & FT) of NMR spectroscopy, classification of A4, A3, ABX, AMX, ABC, A2B2 in proton NMR. Introduction to ^{13}C-NMR spectroscopy. Rules for carbon-13 calculations.

b) Mass Spectroscopy:

Instrumentation, methods of ionization: EI, CI, Electronimpact mass spectroscopy, low and high resolution, exact masses of nucleides, molecular ions, isotopeions, mass marking techniques, fragment ions of odd and even electron types, rearrangement of ions, base peak, nitrogen rule, metastable peaks, isotope peaks, isotope effects in chloro and bromo compounds, calculation of molecular formula, factors effecting cleavage patterns. Structure determination of organic compounds by IR, UV-Vis, 1H &^{13}C NMR and Mass spectroscopy.

3. Organic Transformation: (10 L)

Multi-component reactions-early examples, Ugi reaction, Passerini reactions, Biginelli condensation; Baylis-Hillman reaction, Olefin metathesis, Remote functionalisation.

4. Photochemistry: (15 L)

Basic principles, Jablonski diagram, photosensitization and quenching, photochemistry of olefinic compounds, cis-trans isomerisation, Peterno-Buchi reaction, Norrish Type – I and II reactions, photoreduction of ketones, di-π methane rearrangement, photo-induced reactions in organic compounds.

READING REFERENCES:

1. Organic Photochemistry -J. W. Coxon & B. Halton.
2. Elements of Organic Photochemistry -D. O. Cowan & K. L. Drisco.

3. Spectrometric Identification of Organic Compounds – R. M. Silverstein & F. O. Webster; 6th edition.
4. Applications of Nuclear magnetic Resonance Spectroscopy in Organic Chemistry L. M. Jackman.
5. NMR and Chemistry – J. W. Akitt.
6. Organic Spectroscopy – W. Kemp, 3rd Edn.
7. Strategic Applications of Named Reactions in Organic Synthesis By Laszlo Kurti, Barbara Czako · 2005.

PRACTICALS:

Synthesis of organic compounds involving:

1. Nitration, diazotization.

2. Photochemical reaction

3. Sandmayer reaction

4. Pinacol-pinacolone rearrangement, Claisen rearrangement etc.

REFERENCES FOR PRACTICALS:

1. Frederick George Mann, Bernard Charles Saunders - Practical Organic Chemistry.

COURSE OBJECTIVE OF MAJOR - 18:

The syllabus of Major -18 has been designed to provide the students with in-depth knowledge of **Structure-reactivity relationship**, application of spectroscopy including NMR and Mass spectroscopy, organic transformation and photochemistry of organic molecules.

COURSE OUTCOMES OF MAJOR – 18:
CO - 18.1 : Thorough understanding ofStructure-reactivity relationship in the light of Hammett equation and Taft equation.
CO - 18.2 : Detailed study of NMR and Mass spectroscopy. Determination of structure of organic molecules by IR, UV-Vis, 1H &^{13}C NMR and Mass spectroscopic results.
CO - 18.3 : Brief discussion about few organic transformations.
CO - 18.4 : Understanding thoroughly about the photochemistry of organic molecules.

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END OF SEMESTER - VIII

CHEMISTRY UG MINOR SYLLABUS FOR NEP

SYLLABUS FOR CHEMISTRY MINOR OF SEMESTER –I& II

MINOR – 1& 2

COURSE TITLE : General Concepts of Chemistry

COURSE CODE : BCEMMEA11C

CREDIT : 4 (THEORY: 3 + PRACTICAL: 1)

THEORY:

1. ATOMIC STRUCTURE: (10L)

Bohr's theory for hydrogen atom (simple mathematical treatment), atomic spectraof hydrogen and Bohr's model, Sommerfeld's model, quantum numbers and their significance, Pauli's exclusion principle, Hund's rule, electronic configuration of many- electron atoms, Aufbau principle and its limitations.

2. **PERIODIC PROPERTIES OF ELEMENTS –(10 L):**

Classification of elements on the basis of electronic configuration: general characteristics of s-, p-, d- and f-block elements. Positions of hydrogen and noble gases. Atomic and ionic radii, ionization potential, electron affinity, and electronegativity; periodic and group-wise variation of above properties in respect of s- and p- block elements.

3. **CHEMICAL KINETICS – (15 L):**

a. Introduction of rate law, Orderand molecularity; Extent of reaction; rate constants; Rates of First, second and nth order reactions and their Differential and integrated forms (with derivation); Pseudo first order reactions; Determination of order of a reaction by half-life and differential method; Opposing reactions, consecutive reactions and parallel reactions.

b. Temperature dependence of rate constant; Arrhenius equation, energy of activation; Collision theory; Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment).

4. **SOLIDS – (10 L):**

(i) Forms of solids, crystal systems, unit cells, Bravais lattice types, Symmetry elements; Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices; Miller indices of different planes and interplanar distance, Bragg's law; Structures of NaCl, KCl and CsCl (qualitative treatment only); Defects in crystals; Glasses and liquid crystals.

READING REFERENCES:

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. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
4. Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).
5. Cotton, F.A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry 3rd Ed.; Wiley India.
6. Sharpe, A.G., Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005.
7. Huheey, J. E.; Keiter, E.A. &Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson,2006.
8. Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
9. Mingos, D.M.P., Essential trends in inorganic chemistry. Oxford University Press (1998).
10. Winter, M. J., The Orbitron, http://winter.group.shef.ac.uk/orbitron/ (2002). An illustrated gallery of atomic and molecular orbitals.
11. Burgess, J., Ions in solution: basic principles of chemical interactions. Ellis Horwood (1999).
12. Misra, S.; Giri, G. C.; Roy, S. K.; Chanda, G., SnatakRasayan, B.Sc. Semester-I, II, III, IV, Santra Publication.

PRACTICALS:

1. Volumetric estimation of strength of strong / weak acid by a strong base.
2. Standardization of $KMnO_4$ by Oxalic acid.
3. Estimation of Fe(II) using standardized $KMnO_4$ solution.

REFERENCES FOR PRACTICALS:

1. S. P. Dey, SnatakParikhyagareRasayan, Vol-I, Santra Publication, Kolkata.
2. Mukherjee, G. N., University Handbook of Undergraduate Chemistry Experiments, University of Calcutta, 2003.
3. Nad, Mahapatra and Ghoshal, An Advance Course in Practical Chemistry, New Central Book Agency, Kolkata.

COURSE OBJECTIVE OF MINOR – 1& 2:

The syllabus of Minor -1& 2 has been designed to provide the students with the basic ideas of General Inorganic and Physical Chemistry. The four modules consisting of Atomic Structure, Periodic Properties, Chemical Kinetics and Solids will provide the fundamental understandings of chemistry, inevitable for higher learning.

COURSE OUTCOMES OF MINOR – 1& 2:

CO- 1.1: Gather an in-depth knowledge about atomic structure.

CO- 1.2: Understand the periodic properties of the elements.

CO- 1.3: Understand the basic principles of Chemical Kinetics and its basic differences with chemical thermodynamics. This chapter also includes the Role of Temperature and Related Theories of Reaction Rates, the Basics of Transition State Theory, and the energy profile. After the completion of the course, the students will be able to answer the relevant questions related to the temperature dependence of reaction rates and the reason behind it. They will also be able to rationalize the chemistry at the molecular level in the course of a reaction.

CO - 1.4: This module is designed to provide students with molecular- or atomic-level ideas of crystal structure and its influence on the properties of the solid concerned. A brief theoretical background of X-ray crystallography has been given with pertinent examples, so that the learners can apply this knowledge in future studies.

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END OF SEMESTER – I& II

SYLLABUS FOR CHEMISTRY MINOR OF SEMESTER – III & IV

MINOR – 3 & 4

COURSE TITLE : Acid Base Theory and GeneralOrganic Chemistry

COURSE CODE : BCEMMEB23C

CREDIT : 4 (THEORY: 3 + PRACTICAL: 1)

THEORY:

1. ACID-BASE THEORY – (10 L):

Brönsted–Lowry concept, conjugate acids and bases, relative strengths of acids and bases, effects of substituent and solvent, differentiating and levelling solvents. Lewis acid-base concept, classification of Lewis acids and bases, Lux-Flood concept and solvent system concept. Hard and soft acids and bases (HSAB concept), applications of HSAB process.

2. **GENERAL ORGANIC CHEMISTRY-I (35 L):**

a) Fundamentals of Organic Chemistry Electronic displacements: inductive effect, resonance and hyperconjugation; cleavage of bonds: homolytic and heterolytic; structure of organic molecules on the basis of VBT; nucleophiles electrophiles;reactive intermediates: carbocations,carbanions and free radicals.

b) Stereochemistry:

Different types of isomerism; geometrical and optical isomerism; concept of chirality and optical activity (up to two carbon atoms); asymmetric carbon atom; elements of symmetry (plane and centre); interconversion of Fischer and Newman representations; enantiomerism and diastereomerism, meso compounds; threo and erythro, D and L, cis and trans nomenclature; CIP Rules: R/S (upto 2 chiral carbon atoms) and E/Z nomenclature.

c) Nucleophilic Substitution and Elimination Reactions:

Nucleophilic substitutions: SN1 and SN2 reactions; eliminations: E1 and E2 reactions (elementary mechanistic aspects); Saytzeff and Hofmann eliminations; elimination vs. substitution.

d) Aliphatic Hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structures.

e) Alkanes: (up to 5 Carbons):

Preparation: catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: mechanism for free radical substitution: halogenation.

f) Alkenes: (up to 5 Carbons):

Preparation: elimination reactions: dehydration of alcohols and dehydrohalogenation of alkyl halides; cis alkenes (partial catalytic hydrogenation) and trans- alkenes (Birch reduction). Reactions: cis-addition (alkaline KMnO4) and trans- addition (bromine) withmechanism,addition of HX [Markownikoff's (with mechanism) and anti-Markownikoff's addition], hydration, ozonolysis, oxymercuration-demercuration and hydroboration-oxidation reaction.

g) Alkynes: (up to 5 Carbons):

Preparation: acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal dihalides.

h) Reactions:

Formation of metal acetylides, addition of bromine and alkaline KMnO4, ozonolysis and oxidation with hot alkaline KMnO4.

READING REFERENCES:

1. Madan, R. L. Organic Chemistry, S. Chand & Sons.
2. Wade, L. G., Singh, M. S., Organic Chemistry.
3. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
6. Sen Gupta, Subrata. Basic Stereochemistry of Organic molecules.
7. Kalsi, P. S. Stereochemistry Conformation and Mechanism, Eighth edition, New Age International, 2014.
8. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.

PRACTICALS:

Qualitative Analysis of Single Solid Organic Compound(s)

1. Detection of special elements (N, Cl, and S) in organic compounds.

2. Solubility and Classification (solvents: H2O, dil. HCl, dil. NaOH)

3. Detection of functional groups:Aromatic-NO2, Aromatic -NH2, -COOH, carbonyl (no distinction of –CHO and >C=O needed), -OH (phenolic) in solid organic compounds.

REFERENCES FOR PRACTICALS:

1. Mukherjee, K. S. Text book on Practical Chemistry, New Oriental Book Agency.
2. Ghosal, Mahapatra&Nad, An Advanced course in practical Chemistry, New Central Book Agency.
3. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, CBS Publishers and Distributors.
4. 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.

COURSE OBJECTIVE OF MINOR –3 & 4:

The syllabus of Minor -3& 4 has been designed to provide the students with the basic ideas of General Inorganic and Physical Chemistry. The two modules consisting of Acid-Base Theory and Organic reaction mechanisms will provide the fundamental understandings of both Inorganic and Organic chemistry.

COURSE OUTCOMES OF MINOR – 3 & 4:

CO- 3.1: Understand the basic principles of Acid-Base Theory; Different definitions of Acid-Base Theories and its applications.

CO- 3.2: Gather basic knowledge about fundamentals of organic chemistry.

CO- 3.3: Gather basic knowledge about organic stereochemistry.

CO- 3.4: Understand the fundamental concepts of nucleophilic substitution and elimination reactions.

CO- 3.5: Gather basic knowledge about aliphatic hydrocarbons.

CO- 3.6: Gather basic knowledge about alkane, alkene, alkyne and corresponding reactions.

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END OF SEMESTER – III & IV

SYLLABUS FOR CHEMISTRY OF SEMESTER – V

MINOR – 5

COURSE TITLE : Inorganic & Physical Chemistry– I

COURSE CODE : BCEMMEA35C

CREDIT : 4 (THEORY: 3 + PRACTICAL: 1)

THEORY:

1. CHEMICAL BONDING – (15 L):

a) Ionic bond: General characteristics, types of ions, size effects, radius ratio ruleand its application and limitations. Born-Landéequation without derivation. Madelung Constant, Born-Haber cycle and its application.

b) Covalent bond: Polarizing power and polarizability, ionic potential, Fajan's rule. Lewis structures, formal charge. Valence Bond Theory. Directional character of covalent bonds,hybridizations, equivalent and non- equivalent hybrid orbitals, Bent's rule,Dipole moments, VSEPR theory, shapes of molecules and ions containing lonepairs and bond pairs (examples from main groups chemistry) and multiple bonding ($\sigma$and π bond approach). MO diagrams of B_2, C_2, N_2 and O_2 molecules and their simple applications.

2. KINETIC THEORY OF GAS – (20 L):

a. Concept of pressure and temperature; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules); Rate ofeffusion.

b. Nature of distribution of velocities, Maxwell's distribution of speed and kineticenergy; Average velocity, root mean square velocity and most probable velocity; Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases.

c. Deviation of gases from ideal behavior; compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features; its derivation and application in explaining real gas behaviour; Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states.

d. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

3. Liquids (10 L):

Definition of Surface tension, its dimension and principle of its determination using stalagmometer; Viscosity of a liquid and principle of determination of coefficient of viscosity using Ostwald viscometer; Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only).

READING REFERENCES:

1. Misra, S.; Giri, G. C.; Roy, S. K.; Chanda, G., SnatakRasayan, B.Sc. Semester-I, II, III, IV, Santra Publication.
2. A. Ghoshal, General and Physical Chemistry, Books and Allied (P) Ltd. Kolkata
3. Physical Chemistry, G. W. Castellan, Narosa Publication House
4. A Text Book of Physical Chemistry, K. L. Kapoor, Vol. 1-5, Macmillan Indian Ltd. New Delhi.
5. Chemical Kinetics, K. J. Laidler, Pearson Education.
6. Physical Chemistry, P. C. Rakshit, Sarat Book House, Kolkata.
7. Physical Chemistry, Hrishikesh Chatterjee, Vol. 1-2, Platinum Publishers.
8. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.
9. Cotton, F.A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry 3rd Ed.; Wiley India.
10. Sharpe, A.G., Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005.

11. R. P. Sarkar, General and Inorganic Chemistry, Part-1 & 2, New Central Book Agency (P) Ltd. Kolkata.

PRACTICALS:

1. Determination of the surface tension of a liquid or a dilute solution using a Stalagmometer.

2. Determination of relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.and $CHCl_3$.

REFERENCES FOR PRACTICALS:

S. P. Dey, SnatakParikhyagareRasayan, Vol-I, Santra Publication, Kolkata.

COURSE OBJECTIVE OF MINOR - 5:

The syllabus of Minor -5 has been designed to provide the students with in-depth knowledge of Chemical bonding, including Ionic bonding, Covalent Bonding, Co-ordinate covalent bonding. This course will also give the students some idea about the drawbacks of Valence Bond Theory leading to the advent of the Molecular Orbital Theory. Students will be taught the Molecular Orbital Theory to some extent, exemplified by Molecular Orbital diagrams of simple homodiatomic and heterodiatomic molecules. There are two modules related to Physical Chemistry of Gases and liquids. The course is designed to make the students understand the fundamentals of fluids. The learning outcome of these modules are as follows:

COURSE OUTCOMES OF MINOR – 5:

CO- 5.1: Thorough understanding of Chemical Bonding with special Emphasis on Ionic, Covalent bonding. Understanding the concepts of Molecular Orbital Theory.

CO- 5.2: This module deals with the theories involved in explaining the properties of gaseous states of matter. After completion of the course, it is expected that the students will be able to answer the basic questions on the kinetic theory of gases, the behaviour of real gases, and related theories.

CO- 5.3: This chapter is designed to help the students understand the concepts of surface tension and the viscosity of fluids. After taking the course, students will be able to answer the basic questions on surface-related chemistry and fluids in motion, which are widely applied in various industrial units.

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END OF SEMESTER – V

SYLLABUS FOR CHEMISTRY MINOR OF SEMESTER – VII

MINOR – 6

COURSE TITLE : Inorganic & Physical Chemistry–II

COURSE CODE : BCEMMEA47C

CREDIT :4 (THEORY: 3 + PRACTICAL: 1)

THEORY:

1. REDOX (10 L):

Balancing of equations by oxidation number and ion-electron method oxidimetry and reductimetry.

2. Group Chemistry (s & p- block only) (20 L):

a.Group trends in electronic configuration, modification of pure elements,common oxidation states, inert pair effect, and their important compounds in respect of the following groups of elements:

i. B-Al-Ga-In-Tl

ii. C-Si-Ge-Sn-Pb

iii. N-P-As-Sb-Bi

iv. O-S-Se-Te

v. F-Cl-Br-I

3. Thermodynamics-I (15 L):

1. Zeroth and 1st law of Thermodynamics: Intensive and extensive variables; stateand path functions; isolated, closed and open systems; zeroth law ofthermodynamics; Concept of heat, work, internal energy and statement of firstlaw; enthalpy, H; relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions; Joule's experiment and its consequence.

READING REFERENCES:

1. Misra, S.; Giri, G. C.; Roy, S. K.; Chanda, G., SnatakRasayan, B.Sc. Semester-I, II, III, IV, Santra Publication.

2. Physical Chemistry, P. C. Rakshit, Sarat Book House, Kolkata.
3. Physical Chemistry, Hrishikesh Chatterjee, Vol. 1-2, Platinum Publishers.
4. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.

5. R. P. Sarkar, General and Inorganic Chemistry, Part-1 & 2, New Central Book Agency (P) Ltd. Kolkata.

PRACTICALS:

Qualitative semi-micro analysis of mixture containing three radicals.

Acid Radicals: Cl-, Br-, I-, NO2-, NO3-, S2-, SO42-, PO43-, BO33-, H3BO3.

Basic Radicals: Na+, K+, Ca2+, Sr2+, Ba2+, Cr3+, Mn2+, Fe3+, Ni2+, Cu2+, NH4+.

REFERENCES FOR PRACTICALS:

1. Svehla, G., Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mukherjee, G. N., Semi-Micro Qualitative Inorganic Analysis, University of Calcutta, 2008.
3. Bhattacharya, R. C., A Manual of Practical Chemistry for degree classes (Vol. I & II) for Honours Students, Biswas Book Stall, Calcutta.
4. A. K. Nad, B. Mahapatra, A. Ghoshal, An Advance Course in Practical Chemistry, New Central Book Agency (P) Ltd. Kolkata.
5. S. P. Dey, SnatakParikhyagareRasayan, Vol-I, Santra Publication, Kolkata.

COURSE OBJECTIVE OF MINOR - 6:

The syllabus of Minor -6 has been designed to provide the students with the concept of Redox reactions will provide the fundamental understandings of chemistry, inevitable for higher learning.

COURSE OUTCOMES OF MINOR – 6:

CO- 6.1: Understand the concepts of a redox reaction.

CO- 6.2: Explain various phenomenon of redox reactions using Nernst Equation.

CO- 6.3: The syllabus of this module has been designed to provide the students with in-depth ideas Chemical Thermodynamics. This includes the introduction to the basic definitions of Thermodynamics and the concepts of heat, energy, work, and their interrelationship. Students taking this course are expected to apply this knowledge in analyzing the nature of chemical reactions.

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END OF SEMESTER – VII

SYLLABUS FOR CHEMISTRY SKILL ENHANCEMENT COURSE (SEC)

SEC – 1

SEMESTER: I / II / III

COURSE TITLE : Skill Enhancing Basic Applications of Chemistry

COURSE CODE : BCEMSEC01T

CREDIT : 3 (THEORY)

1. Volumetric Titration- (10 L):

a) Theory of Acid Base Titrations of Strong acid vs. strong base, strong acid vs. weak base, weak base vs. strong acid and weak acid vs. weak base.

b) Theory of Redox Titration of Oxalic Acid vs. $KMnO_4$, Fe^{2+} vs. $KMnO_4$, Fe^{2+} vs. $K_2Cr_2O_7$.

c) Theory of Complexometric Titration of Ca^{2+} and Mg^{2+} by Na_2EDTA, Hardness of Water.

2. Theory of experiments involving Surface Tension and Viscosity- (5 L)

3. Basis concepts of Computational Chemistry using Microsoft Excel and Microcal Origin – (15 L)

4. Basic concept of Green Chemistry – (15 L)

a) What is Green Chemistry?

b) Twelve principles of Green Chemistry.

c) Discussion about atom economy and calculation of atom economy of the addition, substitution and elimination reactions.

d) Brief introduction about Green solvents.

e) Short introduction about alternative energy resources.

f) Green materials used in ourdaily life viz, marine anti-foulant, healthier fats and oil, poly lactic acid (without any synthesis).

READING REFERENCES:

1. Anastas, P.T. & Warner, J.K.: Green Chemistry - Theory and Practical, Oxford University Press (1998).
2. Matlack, A.S. Introduction to Green Chemistry, Marcel Dekker (2001).

3. Cann, M.C. &Connely, M.E. Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
4. Ryan, M.A. &Tinnesand, M., Introduction to Green Chemistry, American Chemical Society, Washington (2002).
5. Green Chemistry: An Introductory Text RSC Publishing, 2nd Edition, 2010.
6. Lancaster, M., M.Kidwai New Trends in GREEN CHEMISTRY, Kluwer Academic Publishers, 2004.
7. Misra, S.; Giri, G. C.; Roy, S. K.; Chanda, G., SnatakRasayan, B.Sc. Semester-I, II, III, IV, Santra Publication.

COURSE OBJECTIVE OF SEC-1:

In order to augment the employability, the Skill Enhancement Course has been designed by incorporating the theories of the various titrations of Inorganic Chemistry, theories of Surface Tension and Viscosity related experiments, using various softwares for data analysis and graph plotting. The course has also been designed to impart knowledge about Green Chemistry as well.

COURSE OUTCOMES:

CO- 1: Understanding of the theories for quantitative estimation by volumetric titration.

CO- 2: Understanding the theories behind the experiments designed to measure surface tension and the viscosity of fluids.

CO-3: This part is designed to give the learners a preliminary idea of the application of Computers in Chemistry. Students taking the course will be able to draw simple graphs using freely available programmes like Microsoft Excel and/or others.

CO-4: Gather basic knowledge of green chemistry which includes basic principles, atom economy, green solvents, alternative energy resources and green materials.

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END OF SEC SYLLABUS

Please scroll down for Multi-Disciplinary Syllabus

SYLLABUS FOR CHEMISTRY FOR MULTI-DISCIPLINARY COURSE

SEMESTER: III (TO BE OPTED BY STUDENTS WHO DID NOT HAVE CHEMISTRY OR PHYSICS IN THEIR (10+2) LEVEL.

UNIT – 1: CHEMISTRY

COURSE TITLE : Physical Sciences

COURSE CODE : BMDCCEM03T

TOTAL CREDIT : 3 (THEORY).

CREDIT FOR UNIT-1 (CHEMISTRY): 1.5

NUMBER OF LECTURES: 22

1. Symbol of Elements, Valency and formula of simple compounds.
2. Ideal Gas
3. Preliminary concept of acid-base theory (Arrhenius, Bronsted-Lowry).
4. Industrial preparation of Ammonia by Haber's Process.
5. Chemicals of daily use: Washing soda, baking soda, Vinegar, Table salt and sugar.

READING REFERENCES: ANY STANDARD BOOK OF CLASS-X

COURSE OBJECTIVE:

This course is meant for students who did not have Physics or Chemistry in their 10+2 level. The course will give them a flavor of Physical Sciences (Physics & Chemistry), at the very basic level and its applications in everyday life.

CO- 1: The students will learn the Symbols of the elements.

CO- 2: The students will learn the basic concepts of Acid-Base Theory.

CO- 3: The students will learn at least one Industrial Process of Preparation of Ammonia.

CO- 4: The students will learn the chemical properties of some materials of daily use.

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END OF MULTI-DISCIPLINARY SYLLABUS