

Vidyasagar University

Curriculum for B.Sc. Honours in Chemistry [Choice Based Credit System]

Semester-I

Sl.No.	Name of the Subject	Nature	Code	Teaching Scheme in hour per week			Credit	Marks
				L	T	P		
C1	C1T: Organic Chemistry-I	Core Course-1		4	0	0	6	75
	C1P: Organic Chemistry-I Lab	Core Course1 [Practical]		0	0	4		
C2	C2T: Physical Chemistry-I	Core Course-2		4	0	0	6	75
	C2P: Physical Chemistry-I Lab	Core Course-2 [Practical]		0	0	4		
GE-1	GE-1	GE					4/5	75
	GE-1	GE					2/1	
AECC	English	AECC					2	50
Total Credits = 20								

L=Lecture, T=Tutorial, P=Practical

AECC- Ability Enhancement Compulsory Course: English /Modern Indian Language .

Interdisciplinary/Generic Elective (GE) from other Department

[Four papers are to be taken and each paper will be of 6 credits]:

[Papers are to be taken from any of the following discipline (**GE-1 from Mathematics**)]: **Mathematics/**

Physics /Computer Sc/Statistics/Geology/Electronics/ zoology/Botany/Microbiology /Physiology

/Biotechnology/Nutrition

Semester-1

Core Course

CC-1 :ORGANIC CHEMISTRY-I

Credits 06

(Credits: Theory-04, Practicals-02)

C1T1 : ORGANIC CHEMISTRY-I

Credits 04

Theory: 60 Lectures

Basics of Organic Chemistry

Bonding and Physical Properties

(25 Lectures)

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 (sp^3 , sp^2 , sp : C-C, C-N & C-O systems and *s-cis* and *s-trans* geometry for suitable cases).

Electronic displacements: inductive effect, field effect, mesomeric effect, resonance energy; bond polarization and bond polarizability; electromeric effect; steric effect, steric inhibition of resonance.

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 of chemical reactivity in terms of FMO interactions; sketch and energy levels of π MOs of i) acyclic p orbital system (C=C, conjugated diene, triene, allyl and pentadienyl 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-membered ring); concept of antiaromaticity and homoaromaticity; non-aromatic molecules; Frost diagram; elementary idea about α and β ; measurement of delocalization energies in terms of β for buta-1,3-diene, cyclobutadiene, hexa-1,3,5-triene and benzene.

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 solubility of 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 of combustion and heat of formation.

General Treatment of Reaction Mechanism I

(10 Lectures)

Mechanistic classification: ionic, radical and pericyclic (definition and example);

reaction type: addition, elimination and substitution reactions (definition and example); nature of bond cleavage and bond formation: homolytic and heterolytic bond fission, homogenic and

heterogenic bond formation; curly arrow rules in representation of mechanistic steps; reagent type: electrophiles and nucleophiles (elementary idea); electrophilicity and nucleophilicity in terms of FMO approach.

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

Stereochemistry I

(25 Lectures)

Bonding geometries of carbon compounds and representation of molecules: tetrahedral nature of carbon and concept of asymmetry; Fischer, sawhorse, flying-wedge and Newman projection formulae and their inter translations.

Concept of chirality and symmetry: symmetry elements and point groups (C_{∞} , C_{nh} , C_{nv} , C_n , $D_{\infty h}$, D_{nh} , D_{nd} , D_n , S_n (C_s , C_i); 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-chiral centre(s) (AA, AB, ABA and ABC types).

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 intermediates); resolution of acids, bases and alcohols via diastereomeric salt formation; optical purity and enantiomeric excess; invertomerism of chiral trialkylamines.

Reference Books

1. Clayden, J., Greeves, N. & Warren, S. *Organic Chemistry*, Second edition, Oxford University Press, 2012.
2. Keeler, J., Wothers, P. *Chemical Structure and Reactivity – An Integrated approach*, Oxford University Press.
3. Sykes, P. *A guidebook to Mechanism in Organic Chemistry*, Pearson Education, 2003.
4. Smith, J. G. *Organic Chemistry*, Tata McGraw-Hill Publishing Company Limited.
5. Carey, F. A., Giuliano, R. M. *Organic Chemistry*, Eighth edition, McGraw Hill Education, 2012.
6. Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*, Wiley: London, 1994.
7. Nasipuri, D. *Stereochemistry of Organic Compounds*, Wiley Eastern Limited.
8. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)
10. Fleming, I. *Molecular Orbitals and Organic Chemical Reactions*, Reference/Student Edition, Wiley, 2009.

11. James, J., Peach, J. M. *Stereochemistry at a Glance*, Blackwell Publishing, 2003.
12. Robinson, M. J. T., *Stereochemistry*, Oxford Chemistry Primer, Oxford University Press, 2005.

CC1P1 - CHEMISTRY LAB- I

Credits 02

(60 Lectures)

1. Separation, based upon solubility, by using common laboratory reagents like water (cold, hot), dil. HCl, dil. NaOH, dil. NaHCO_3 , 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*-Nitrotoluene/*p*-Anisidine; etc.

2. 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, succinic acid, resorcinol, urea, glucose, cane sugar, benzoic acid and salicylic acid

Liquid Compounds: formic acid, acetic acid, methyl alcohol, ethyl alcohol, acetone, aniline, dimethylaniline, benzaldehyde, chloroform and nitrobenzene

Reference Books

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).
5. Dutta, S, B. Sc. *Honours Practical Chemistry*, Bharati Book Stall.

CC-2: PHYSICAL CHEMISTRY-I

Credits 06

(Credits: Theory-04, Practicals-02)

C2 T2 : PHYSICAL CHEMISTRY-I

Credits 04

(Theory: 60 Lectures)

Kinetic Theory and Gaseous state

(20 Lectures)

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

Maxwell's distribution of speed and energy: 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 $\geq \epsilon$, Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases

Real gas and virial equation: 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, 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)

Chemical Thermodynamics

(25 Lectures)

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 van der Waals) under isothermal and adiabatic conditions; Joule's experiment and its consequence.

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

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 $\oint dQ/T$ 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.

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

c) Chemical kinetics

(15 Lectures)

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 first order)

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)

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

Reference Books:

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. Engel, T. & Reid, P. *Physical Chemistry*, Pearson
5. Levine, I. N. *Physical Chemistry*, Tata McGraw-Hill
6. Maron, S. & Prutton *Physical Chemistry*
7. Ball, D. W. *Physical Chemistry*, Thomson Press
8. Mortimer, R. G. *Physical Chemistry*, Elsevier
9. Laidler, K. J. *Chemical Kinetics*, Pearson
10. Glasstone, S. & Lewis, G.N. *Elements of Physical Chemistry*
11. Rakshit, P.C., *Physical Chemistry* Sarat Book House
12. Zemansky, M. W. & Dittman, R.H. *Heat and Thermodynamics*, Tata-McGraw-Hill
13. Rastogi, R. P. & Misra, R.R. *An Introduction to Chemical Thermodynamics*, Vikas
14. Clauze & Rosenberg, *Chemical Thermodynamics*

C 2P2 : CHEMISTRY LAB-II

Credits 04

(60 Lectures)

Experiment 1: Determination of pH of unknown solution (buffer), by color matching method

Experiment 2: Determination of heat of neutralization of a strong acid by a strong base

Experiment 3: Study of kinetics of acid-catalyzed hydrolysis of methyl acetate

Experiment 4: Study of kinetics of decomposition of H_2O_2

Experiment 5: Determination of heat of solution of oxalic acid from solubility measurement

Reference Books

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

Generic Elective Syllabus

GE-1 [Interdisciplinary for other department]

GE-1 : ATOMIC STRUCTURE, CHEMICAL PERIODICITY, ACIDS AND BASES, REDOX REACTIONS, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS. Credits 06

GE1 T1 : ATOMIC STRUCTURE, CHEMICAL PERIODICITY, ACIDS AND BASES, REDOX REACTIONS, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS. Credits 04
Theory: 60 Lectures

Section A: Inorganic Chemistry-I (30 Lectures)

Atomic Structure (10 Lectures)

Bohr's theory for hydrogen atom (simple mathematical treatment), atomic spectra of 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.

Chemical Periodicity (05 Lectures)

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.

Acids and bases (10 Lectures)

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.

Redox reactions (05 Lectures)

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

Section B: Organic Chemistry-I (30 Lectures)

Fundamentals of Organic Chemistry (5 Lectures)

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.

Stereochemistry (8 Lectures)

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.

Nucleophilic Substitution and Elimination Reactions (5 Lectures)

Nucleophilic substitutions: S_N1 and S_N2 reactions; eliminations: E1 and E2 reactions (elementary mechanistic aspects); Saytzeff and Hofmann eliminations; elimination vs substitution.

Aliphatic Hydrocarbons

(12 Lectures)

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

Alkanes: (up to 5 Carbons). *Preparation:* catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. *Reactions:* mechanism for free radical substitution: halogenation.

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) with mechanism, addition of HX [Markownikoff's (with mechanism) and anti-Markownikoff's addition], hydration, ozonolysis, oxymercuration-demercuration and hydroboration-oxidation reaction.

Alkynes: (up to 5 Carbons). *Preparation:* acetylene from CaC₂ and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO₄, ozonolysis and oxidation with hot alkaline KMnO₄.

Reference Books:

1. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Cotton, F.A., Wilkinson, G. & Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons.
4. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education India, 2006.
5. Sethi, A. *Conceptual Organic Chemistry*; New Age International Publisher.
6. Parmar, V. S. *A Text Book of Organic Chemistry*, S. Chand & Sons.
7. Madan, R. L. *Organic Chemistry*, S. Chand & Sons.
8. Wade, L. G., Singh, M. S., *Organic Chemistry*.
9. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
10. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
11. Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*, Wiley: London, 1994.
12. Sen Gupta, Subrata. *Basic Stereochemistry of Organic molecules*.
13. Kalsi, P. S. *Stereochemistry Conformation and Mechanism*, Eighth edition, New Age International, 2014.
14. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.

GE1 P1: LAB: ATOMIC STRUCTURE, CHEMICAL PERIODICITY, ACIDS AND BASES, REDOX REACTIONS, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

Credits 02

60 Lectures

Section A: Inorganic Chemistry –LAB

(30 Lectures)

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with KMnO_4 .
3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO_4 .
4. Estimation of Fe (II) ions by titrating it with $\text{K}_2\text{Cr}_2\text{O}_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $\text{Na}_2\text{S}_2\text{O}_3$.

Section B: Organic Chemistry- LAB

(30 Lectures)

Qualitative Analysis of Single Solid Organic Compound(s)

Experiment A: Detection of special elements (N, Cl, and S) in organic compounds.

Experiment B: Solubility and Classification (solvents: H_2O , dil. HCl , dil. NaOH)

Experiment C: Detection of functional groups: Aromatic- NO_2 , Aromatic- NH_2 , - COOH , carbonyl (no distinction of $-\text{CHO}$ and $>\text{C}=\text{O}$ needed), -OH (phenolic) in solid organic compounds.

Experiments A - C with unknown (at least 6) solid samples containing not more than two of the above type of functional groups should be done.

Reference Books:

1. *University Hand Book of Undergraduate Chemistry Experiments*, edited by Mukherjee, G. N., University of Calcutta, 2003.
2. Das, S. C., Chakraborty, S. B., *Practical Chemistry*.
3. Mukherjee, K. S. *Text book on Practical Chemistry*, New Oriental Book Agency.
4. Ghosal, Mahapatra & Nad, *An Advanced course in practical Chemistry*, New Central Book Agency.
5. Vogel, A. I. *Elementary Practical Organic Chemistry*, Part 2: *Qualitative Organic Analysis*, CBS Publishers and Distributors.
6. 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.
7. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.

Vidyasagar University

Curriculum for B.Sc. Honours in Chemistry [Choice Based Credit System]

Semester-II

Sl. No.	Name of the Subject	Nature	Code	Teaching Scheme in hour per week			Credit	Marks
				L	T	P		
C3	C3T: Inorganic Chemistry-I	Core Course-3		4	0	0	6	75
	C3P: Inorganic Chemistry-I Lab	Core Course-3 [Practical]		0	0	4		
C4	C4T: Organic Chemistry-II	Core Course-4		4	0	0	6	75
	C4P: Organic Chemistry-II Lab	Core Course-4 [Practical]		0	0	4		
GE-2	GE-2	GE					4/5	75
	GE-2	GE					2/1	
AEC C-2	Environmental Studies	AECC					4	100
Total Credits = 22								

L=Lecture, T=Tutorial, P=Practical

AECC- Ability Enhancement Compulsory Course: Environmental Studies.

Interdisciplinary/Generic Elective (GE) from other Department

[Four papers are to be taken and each paper will be of 6 credits]:

[Papers are to be taken from any of the following discipline (GE-2 from Mathematics)]:

Mathematics/Physics /Computer Sc/Statistics/Geology/Electronics/ zoology/Botany /Microbiology /Physiology/Biotechnology/Nutrition

Semester-II
Core Course

Core-3

CC-3: INORGANIC CHEMISTRY-I
(Credits: Theory-04, Practicals-02)

Credits 06

C3T: INORGANIC CHEMISTRY-I
Theory: 60 Lectures

Credits 04

Extra nuclear Structure of atom

(18 Lectures)

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

Chemical periodicity

(8 Lectures)

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

Acid-Base reactions

(16 Lectures)

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, group characteristics of Lewis acids, solvent levelling and differentiating effects. Thermodynamic acidity parameters, Drago-Wayland equation. Superacids, Gas phase acidity and proton affinity; HSAB principle. Acid-base equilibria in aqueous solution (Proton transfer equilibria in water), pH, buffer. Acid-base neutralisation curves; indicator, choice of indicators.

Redox Reactions and precipitation reactions

(18 Lectures)

Ion-electron method of balancing equation of redox reaction. Elementary idea on standard redox potentials with sign conventions, Nernst equation (without derivation). Influence of complex formation, precipitation and change of pH on redox potentials; formal potential. Feasibility of a redox titration, redox potential at the equivalence point, redox indicators. Redox potential diagram (Latimer and Frost diagrams) of common elements and their applications. Disproportionation and comproportionation reactions (typical examples)

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

Reference Books

1. Lee, J. D. *Concise Inorganic Chemistry*, 5th Ed., Wiley India Pvt. Ltd., 2008.
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).

C3P: CHEMISTRY (LAB)

Credits 02

60 Lectures

Acid and Base Titrations:

1. Estimation of carbonate and hydroxide present together in mixture
2. Estimation of carbonate and bicarbonate present together in a mixture.
3. Estimation of free alkali present in different soaps/detergents.

Oxidation-Reduction Titrimetric

1. Estimation of Fe(II) using standardized KMnO_4 solution
2. Estimation of oxalic acid and sodium oxalate in a given mixture
3. Estimation of Fe(II) and Fe(III) in a given mixture using $\text{K}_2\text{Cr}_2\text{O}_7$ solution.
4. Estimation of Fe(III) and Mn(II) in a mixture using standardized KMnO_4 solution
5. Estimation of Fe(III) and Cu(II) in a mixture using $\text{K}_2\text{Cr}_2\text{O}_7$.
6. Estimation of Fe(III) and Cr(III) in a mixture using $\text{K}_2\text{Cr}_2\text{O}_7$.

Reference Books

Mendham, J., A. I. *Vogel's Quantitative Chemical Analysis* 6th Ed., Pearson, 2009.

Core-4

CC-4: ORGANIC CHEMISTRY-II

Credits 06

(Credits: Theory-04, Practicals-02)

C4T ORGANIC CHEMISTRY-II

Credits 02

Theory: 60 Lectures

Stereochemistry II

(20 Lectures)

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

Concept of prostereoisomerism: prostereogenic centre; concept of (*pro*)ⁿ-*chirality*: 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.

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, 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*).

General Treatment of Reaction Mechanism II

(22 Lectures)

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

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

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

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

Substitution and Elimination Reactions

(18 Lectures)

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

Nucleophilic substitution reactions: substitution at sp^3 centre: mechanisms (with evidence), relative rates & stereochemical features: S_N1 , S_N2 , S_N2' , S_N1' (allylic rearrangement) and S_{Ni} ; 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].

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 $C=C$.

Reference Books

1. Clayden, J., Greeves, N., Warren, S. *Organic Chemistry*, Second edition, Oxford University Press 2012.
2. Sykes, P. *A guidebook to Mechanism in Organic Chemistry*, Pearson Education, 2003.
3. Smith, J. G. *Organic Chemistry*, Tata McGraw-Hill Publishing Company Limited.
4. Carey, F. A. & Giuliano, R. M. *Organic Chemistry*, Eighth edition, McGraw Hill Education, 2012.
5. Loudon, G. M. *Organic Chemistry*, Fourth edition, Oxford University Press, 2008.
6. Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*, Wiley: London, 1994.
7. Nasipuri, D. *Stereochemistry of Organic Compounds*, Wiley Eastern Limited.
8. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Finar, I. L. *Organic Chemistry (Volume 1)* Pearson Education.
10. Graham Solomons, T.W., Fryhle, C. B. *Organic Chemistry*, John Wiley & Sons, Inc.
11. James, J., Peach, J. M. *Stereochemistry at a Glance*, Blackwell Publishing, 2003.
12. Robinson, M. J. T., *Stereochemistry*, Oxford Chemistry Primer, Oxford University Press, 2005.
13. Maskill, H., *Mechanisms of Organic Reactions*, Oxford Chemistry Primer, Oxford University Press.

C4P: CHEMISTRY (LAB)

Credits 02

(60 Lectures)

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
11. Selective reduction of *m*-dinitrobenzene to *m*-nitroaniline

Students must also calculate percentage yield, based upon isolated yield (crude) and theoretical yield.

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

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

Reference Books

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.

Generic Elective Syllabus

GE-2 [Interdisciplinary for other department]

GE-2 : STATES OF MATTER & CHEMICAL KINETICS, CHEMICAL BONDING & MOLECULAR STRUCTURE, p-BLOCK ELEMENTS

Credits 06

(Credits: Theory-04, Practicals-02)

**GE2 T : STATES OF MATTER & CHEMICAL KINETICS, CHEMICAL BONDING
& MOLECULAR STRUCTURE, p-BLOCK ELEMENTS** Credits 04
Theory: 60 Lectures

Section A: Physical Chemistry-I (30 Lectures)

Kinetic Theory of Gases and Real gases (10 Lectures)

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 of effusion

Nature of distribution of velocities, Maxwell's distribution of speed and kinetic energy; 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

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

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

Liquids (06 Lectures)

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)

Solids (06 Lectures)

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.

Chemical Kinetics (08 Lectures)

Introduction of rate law, Order and 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 Temperature dependence of rate constant; Arrhenius equation, energy of activation; Collision

theory; Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment)

Reference Books:

1. Barrow, G.M. *Physical Chemistry* Tata McGraw- Hill (2007).
2. Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi (2009).
4. Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
5. Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
6. Chugh, K.L., Agnish, S.L. *A Text Book of Physical Chemistry* Kalyani Publishers
7. Bahl, B.S., Bahl, A., Tuli, G.D., *Essentials of Physical Chemistry* S. Chand & Co.ltd.
8. Palit, S. R., *Elementary Physical Chemistry* Book Syndicate Pvt. Ltd.
9. Mandal, A. K. *Degree Physical and General Chemistry* Sarat Book House
10. Pahari, S., *Physical Chemistry* New Central Book Agency
11. Pahari, S., Pahari, D., *Problems in Physical Chemistry* New Central Book Agency

Section B: Inorganic Chemistry-II

(30 Lectures)

Chemical Bonding and Molecular Structure

(16 Lectures)

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Concept of resonance and resonating structures in various inorganic and organic compounds. MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods. (including idea of *s-p* mixing) and heteronuclear diatomic molecules such as CO, NO and NO⁺. Comparison of VB and MO approaches.

Comparative study of p-block elements:

(14 Lectures)

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

Reference Books:

1. Cotton, F.A. & Wilkinson, G. *Basic Inorganic Chemistry*, Wiley.
2. Shriver, D.F. & Atkins, P.W. *Inorganic Chemistry*, Oxford University Press.
3. Wulfsberg, G. *Inorganic Chemistry*, Viva Books Pvt. Ltd.
4. Rodgers, G.E. *Inorganic & Solid State Chemistry*, Cengage Learning India Ltd., 2008.

GE2 P-LAB: STATES OF MATTER & CHEMICAL KINETICS, CHEMICAL BONDING & MOLECULAR STRUCTURE, p-BLOCK ELEMENTS (60 Lectures) Credits 02

Section A: Physical Chemistry-LAB (15x2=30 Lectures)

(Minimum five experiments to complete)

(I) Surface tension measurement (use of organic solvents excluded)

- a) Determination of the surface tension of a liquid or a dilute solution using a Stalagmometer
- b) Study of the variation of surface tension of a detergent solution with concentration

(II) Viscosity measurement (use of organic solvents excluded)

- a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer
- b) Study of the variation of viscosity of an aqueous solution with concentration of solute

(III) Study the kinetics of the following reactions

- a) Initial rate method: Iodide-persulphate reaction
- b) Integrated rate method:
 - (i) Acid hydrolysis of methyl acetate with hydrochloric acid
 - (ii) Compare the strengths of HCl and H₂SO₄ by studying kinetics of hydrolysis of methyl acetate

Reference Books:

1. *University Hand Book of Undergraduate Chemistry Experiments*, edited by Mukherjee, G. N., University of Calcutta, 2003.
2. Palit, S.R., *Practical Physical Chemistry* Science Book Agency
3. Mukherjee, N.G., *Selected Experiments in Physical Chemistry* J. N. Ghose & Sons
4. Dutta, S.K., *Physical Chemistry Experiments* Bharati Book Stall

Section B: Inorganic Chemistry-LAB (30 Lectures)

Qualitative semimicro analysis of mixtures containing three radicals. Emphasis should be given to the understanding of the chemistry of different reactions.

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⁺.

Reference Books:

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
2. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).

Vidyasagar University

Curriculum for B.Sc (Honours) in Chemistry [Choice Based Credit System]

Semester-III

Course	Course Code	Name of the Subjects	Course Type/ Nature	Teaching Scheme in hour per week			Credit	Marks
				L	T	P		
CC-5		C5T: Physical Chemistry-II	Core Course - 5	4	0	0	6	75
		C5P: Physical Chemistry-II		0	0	4		
CC-6		C6T: Inorganic Chemistry-II	Core Course - 6	4	0	0	6	75
		C6P: Inorganic Chemistry-II		0	0	4		
CC-7		C7T: Organic Chemistry-III	Core Course - 7	4	0	0	6	75
		C7P: Organic Chemistry-III		0	0	4		
GE-3		TBD	Generic Elective -3				6	75
SEC-1		SEC1T: Analytical Clinical Biochemistry SEC1P: Analytical Clinical Biochemistry Or SEC1T: Pharmaceutical Chemistry SEC1P: Pharmaceutical Chemistry	Skill Enhancement Course-1	1	0	2	2	50
Semester Total							26	350

L=Lecture, T= Tutorial, P=Practical, CC = Core Course, GE= Generic Elective, SEC = Skill Enhancement Course, TBD = to be decided

Generic Elective (GE) (Interdisciplinary) from other Department [Four papers are to be taken and each paper will be of 6 credits]:

Papers are to be taken from any of the following discipline: **Mathematics/Physics /Computer Sc/Statistics/Geology/Electronics/zoology/Botany /Microbiology /Physiology/Biotechnology/Nutrition**

Modalities of selection of Generic Electives (GE): A student shall have to choose **04** Generic Elective (GE1 to GE4) strictly from **02** subjects / disciplines of choice taking exactly

02 courses from each subjects of disciplines. Such a student shall have to study the curriculum of Generic Elective (GE) of a subject or discipline specified for the relevant semester.

Semester-III
Core Course (CC)

CC-5: Physical Chemistry-II

Credits 06

C5T: Physical Chemistry-II

Credits 04

Theory: 60 Lectures

a) Transport processes

(15 Lectures)

Fick's law: Flux, force, phenomenological coefficients & their inter-relationship (general form), different examples of transport properties

Viscosity: General features of fluid flow (streamline flow and turbulent flow); Newton's equation, viscosity coefficient; Poiseuille's equation; principle of determination of viscosity coefficient of liquids by falling sphere method; Temperature variation of viscosity of liquids and comparison with that of gases

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 for strong 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; Ostwald's dilution law; Ionic mobility; Application of conductance measurement (determination of solubility product and ionic product of water); Conductometric titrations

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

b) Applications of Thermodynamics – I

(25 Lectures)

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

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 K_P , K_C and K_X ; 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

Nernst's distribution law; Application- (finding out K_{eq} using Nernst dist law for $KI + I_2 = KI_3$ and dimerization of benzene)

Chemical potential and other properties of ideal substances- pure and mixtures: a) Pure ideal gas-its Chemical potential and other thermodynamic functions and their changes during a change of; Thermodynamic parameters of mixing; Chemical potential of an ideal gas in an ideal gas mixture; Concept of standard states and choice of standard states of ideal gases

b) Condensed Phase – Chemical potential of pure solid and pure liquids, Ideal solution – Definition, Raoult's law; Mixing properties of ideal solutions, chemical potential of a component in an ideal solution; Choice of standard states of solids and liquids

c) Foundation of Quantum Mechanics

(20 Lectures)

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)

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

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

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 , x^2 , p_x and p_x^2 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

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

Reference Books:

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. Rakshit, P.C., *Physical Chemistry*, Sarat Book House
6. Moore, W. J. *Physical Chemistry*, Orient Longman
7. Mortimer, R. G. *Physical Chemistry*, Elsevier
8. Denbigh, K. *The Principles of Chemical Equilibrium* Cambridge University Press

9. Engel, T. & Reid, P. *Physical Chemistry*, Pearson
10. Levine, I. N. *Quantum Chemistry*, PHI
11. Atkins, P. W. *Molecular Quantum Mechanics*, Oxford
12. Zemansky, M. W. & Dittman, R.H. *Heat and Thermodynamics*, Tata-McGraw-Hill
13. Rastogi, R. P. & Misra, R.R. *An Introduction to Chemical Thermodynamics*, Vikas
14. Klotz, I.M., Rosenberg, R. M. *Chemical Thermodynamics: Basic Concepts and Methods* Wiley
15. Glasstone, S. *An Introduction to Electrochemistry*, East-West Press

C5P: Physical Chemistry-II Lab

Credits 02

LAB

(60 Lectures)

Experiment 1: Study of viscosity of unknown liquid (glycerol, sugar) with respect to water

Experiment 2: Determination of partition coefficient for the distribution of I_2 between water and CCl_4

Experiment 3: Determination of K_{eq} for $KI + I_2 = KI_3$, using partition coefficient between water and CCl_4

Experiment 4: Conductometric titration of an acid (strong, weak/ monobasic, dibasic) against base strong

Experiment 5: Study of saponification reaction conductometrically

Experiment 6: Verification of Ostwald's dilution law and determination of K_a of weak acid

Suggested Readings :

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

CC-6: Inorganic Chemistry-II

Credits 06

C6T: Inorganic Chemistry-II

Credits 04

Theory: 60 Lectures

Chemical Bonding-I

(24 Lectures)

(i) *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 derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. Defects in solids (elementary idea). Solubility energetics of dissolution process.

(ii) *Covalent bond*: Polarizing power and polarizability, ionic potential, Fazan'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

(24 Lectures)

- (i) 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 H_2 , Li_2 , Be_2 , B_2 , C_2 , N_2 , O_2 , F_2 , and their ions wherever possible; Heteronuclear molecular orbitals: CO, NO, NO^+ , CN^- , HF, BeH_2 , CO_2 and H_2O . Bond properties: bond orders, bond lengths.
- (ii) *Metallic Bond*: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.
- (iii) *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.

Radioactivity

(12 Lectures)

Nuclear stability and nuclear binding energy. Nuclear forces: meson exchange theory. Nuclear models (elementary idea): Concept of nuclear quantum number, magic numbers. Nuclear Reactions: Artificial radioactivity, transmutation of elements, fission, fusion and spallation. Nuclear energy and power generation. Separation and uses of isotopes. Radio chemical methods: principles of determination of age of rocks and minerals, radio carbon dating, hazards of radiation and safety measures.

Suggested Readings :

1. Lee, J. D. *Concise Inorganic Chemistry*, 5th Ed., Wiley India Pvt. Ltd., 2008.
2. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles of*

- Structure and Reactivity 4th Ed.*, Harper Collins 1993, Pearson, 2006.
3. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry* Oxford, 1970.
 4. Porterfield, H. W., *Inorganic Chemistry*, Second Edition, Academic Press, 2005.
 5. Purecell, K.F. and Kotz, J.C., *An Introduction to Inorganic Chemistry*, Saunders: Philadelphia, 1980.
 6. Cotton, F.A., Wilkinson, G., & Gaus, P.L. *Basic Inorganic Chemistry 3rd Ed.*; Wiley India.
 7. Gillespie, R. J. and Hargittai, I., *The VSEPR Model of Molecular Geometry*, Prentice Hall (1992).
 8. Albright, T., *Orbital interactions in chemistry*, John Wiley and Sons (2005).
 9. Mingos, D.M.P., *Essential trends in inorganic chemistry*. Oxford University Press (1998).
 10. Miessler, G. L., Fischer, P. J., Tarr, D. A., *Inorganic Chemistry*, Pearson, 5th Edition.
 11. Kaplan, I., *Nuclear Physics*, Addison-Wesley Publishing Company Inc. London, 1964.
 12. Friedlander, G., Kennedy, J. W., Macias, E. S. And Miller, J. M., *Nuclear and Radiochemistry*, Wiley, 1981.

C6P: Inorganic Chemistry-II -Lab

Credits 02

Inorganic Chemistry-II (LAB)

(60 Lectures)

Iodo-/ Iodimetric Titrations

1. Estimation of Cu(II)
2. Estimation of Vitamin C
3. Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically
4. Estimation of available chlorine in bleaching powder.

Estimation of metal content in some selective samples

1. Estimation of Cu in brass.
2. Estimation of Cr and Mn in Steel.
3. Estimation of Fe in cement.

Suggested Readings :

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis* 6th Ed., Pearson, 2009.

CC-7: Organic Chemistry-III

Credits 06

C7T: Organic Chemistry-III

Credits 04

Theory: 60 Lectures

Chemistry of alkenes and alkynes

(15 Lectures)

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, hydroboration-oxidation, 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 in competition 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.

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 Substitution

(10 Lectures)

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

Nucleophilic aromatic substitution: addition-elimination mechanism and evidences in favour of it; S_N1 mechanism; cine substitution (benzyne mechanism), structure of benzyne.

Carbonyl and Related Compounds

(30 Lectures)

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, cyano hydrins and bisulphite adduct; 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 tetraacetate oxidation of 1,2-diols.

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

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.

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

Substitution at sp^2 carbon ($C=O$ system): mechanism (with evidence): B_{AC2} , A_{AC2} , A_{AC1} , A_{AL1} (in connection to acid and ester); acid derivatives: amides, anhydrides & acyl halides (formation and hydrolysis including comparison).

Organometallics

(5 Lectures)

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.

Suggested Readings:

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., Giuliano, 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.
13. Ahluwalia, V. K. *Strategies for Green Organic Synthesis*, ANE Books Pvt. Ltd.

C7P: Organic Chemistry-III –Lab

Credits 02

LAB (60 Lectures)

Experiment -1: Qualitative Analysis of Single Solid Organic Compounds

- a) Detection of special elements (N, S, Cl, Br) by Lassaigne's test
- b) Solubility and classification (solvents: H_2O , 5% HCl , 5% $NaOH$ and 5% $NaHCO_3$)

- c) Detection of the following functional groups by systematic chemical tests: aromatic amino ($-\text{NH}_2$), aromatic nitro ($-\text{NO}_2$), amido ($-\text{CONH}_2$, including imide), phenolic $-\text{OH}$, carboxylic acid ($-\text{COOH}$), carbonyl ($-\text{CHO}$ and $>\text{C}=\text{O}$); only one test for each functional group is to be reported.
- d) Melting point of the given compound
- e) Preparation, purification and melting point determination of a crystalline derivative of the given compound
- f) 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 derivatisation in known and unknown (**at least six**) organic compounds.

Suggested Readings:

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).
6. *Practical Workbook Chemistry (Honours)*, UGBS, Chemistry, University of Calcutta, 2015.

Skill Enhancement Course (SEC)

SEC-1: Analytical Clinical Biochemistry

Credits: 02

SEC1T: Analytical Clinical Biochemistry

Credits: 01

THEORY: 30 Lectures

Basic understanding of the structures, properties and functions of carbohydrates, lipids and proteins:

Review of concepts studied in the core course:

Carbohydrates: Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle.

Isolation and characterization of polysaccharides.

Proteins: Classification, biological importance; Primary and secondary and tertiary structures of proteins: α -helix and β -pleated sheets, Isolation, characterization, denaturation of proteins.

Enzymes: Nomenclature, Characteristics (mention of Ribozymes), Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes, Coenzymes and cofactors, Enzyme inhibitors, Introduction to Biocatalysis: Importance in "Green Chemistry" and Chemical Industry.

Lipids: Classification. Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications. Lipoproteins. Properties, functions and biochemical functions of steroid hormones.

Biochemistry of peptide hormones.

Structure of DNA (Watson-Crick model) and RNA, Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation, Introduction to Gene therapy.

Enzymes: Nomenclature, classification, effect of pH, temperature on enzyme activity, enzyme inhibition.

Biochemistry of disease: A diagnostic approach by blood/ urine analysis.

Blood: Composition and functions of blood, blood coagulation. Blood collection and preservation of samples. Anaemia, Regulation, estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol and bilirubin.

Urine: Collection and preservation of samples. 6. Formation of urine. Composition and estimation of constituents of normal and pathological urine.

SEC1P: Analytical Clinical Biochemistry

Credits: 01

Practicals:

Identification and estimation of the following:

1. Carbohydrates – qualitative and quantitative.
2. Lipids – qualitative.
3. Determination of the iodine number of oil.
4. Determination of the saponification number of oil.
5. Determination of cholesterol using Liebermann- Burchard reaction.
6. Proteins – qualitative.

7. Isolation of protein.
8. Determination of protein by the Biuret reaction.
9. Determination of nucleic acids

Reference Books:

- Cooper, T.G. *Tool of Biochemistry*. Wiley-Blackwell (1977).
- Wilson, K. & Walker, J. *Practical Biochemistry*. Cambridge University Press (2009).
- Varley, H., Gowenlock, A.H & Bell, M.: *Practical Clinical Biochemistry*, Heinemann, London (1980).
- Devlin, T.M., *Textbook of Biochemistry with Clinical Correlations*, John Wiley & Sons, 2010.
- Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002.
- Talwar, G.P. & Srivastava, M. *Textbook of Biochemistry and Human Biology*, 3rd Ed. PHI Learning.
- Nelson, D.L. & Cox, M.M. *Lehninger Principles of Biochemistry*, W.H. Freeman, 2013.
- O. Mikes, R.A. Chalmers: *Laboratory Handbook of Chromatographic Methods*, D. Van Nostrand & Co., 1961.

Or

SEC-1: Pharmaceutical Chemistry

Credits: 02

SEC1T: Pharmaceutical Chemistry

Credits: 01

Theory: 30 Lectures

Drugs & Pharmaceuticals

Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, antiinflammatoryagents (Aspirin, paracetamol, Ibuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

Fermentation

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

SEC1P: Pharmaceutical Chemistry

Credits: 01

Practicals:

1. Preparation of Aspirin and its analysis.
2. Preparation of magnesium bisilicate (Antacid).

Reference Books:

- Patrick, G. L. *Introduction to Medicinal Chemistry*, Oxford University Press, UK,

2013.

- Singh, H. & Kapoor, V.K. *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan, Pitampura, New Delhi, 2012.
- Foye, W.O., Lemke, T.L. & William, D.A.: *Principles of Medicinal Chemistry*, 4th ed., B.I. Waverly Pvt. Ltd. New Delhi.

Generic Elective Syllabus

GE-3 [Interdisciplinary for other department]

GE3: Chemical Energetics, Equilibria, Organic Chemistry-II

Credits 06

GE3T: Chemical Energetics, Equilibria, Organic Chemistry-II

Credits 04

Theory: 60 Lectures

Section A: Physical Chemistry-II (30 Lectures)

Chemical Energetics

(14 Lectures)

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 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 Statement of the second law of thermodynamics; Concept of heat reservoirs and heat engines; Carnot cycle; Physical concept of Entropy; Carnot engine, refrigerator and efficiency; Entropy change of systems and surroundings for various processes and transformations; Auxiliary state functions (G and A) and Criteria for spontaneity and equilibrium.

Chemical Equilibrium:

(08 Lectures)

Thermodynamic conditions for equilibrium, degree of advancement; Variation of free energy with degree of advancement; Equilibrium constant and standard Gibbs free energy change; Definitions of KP, KC and KX and relation among them; van't Hoff's reaction isotherm, 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

Ionic Equilibria:

(08 Lectures)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water; Ionization of weak acids and bases, pH scale, common ion effect; Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts; Buffer solutions; Solubility and solubility product of sparingly soluble salts – applications of solubility product principle

Suggested Readings :

1. Barrow, G.M. *Physical Chemistry* Tata McGraw Hill (2007).
2. Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi (2009).
4. Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
5. Ekambaram, S. *General Chemistry*, Pearson.
6. Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
7. Chugh, K.L., Agnish, S.L. *A Text Book of Physical Chemistry* Kalyani Publishers
8. Bahl, B.S., Bahl, A., Tuli, G.D., *Essentials of Physical Chemistry* S. Chand & Co. Ltd.
9. Palit, S. R., *Elementary Physical Chemistry* Book Syndicate Pvt. Ltd.
10. Mandal, A. K. *Degree Physical and General Chemistry* Sarat Book House
11. Pahari, S., *Physical Chemistry* New Central Book Agency
12. Pahari, S., Pahari, D., *Problems in Physical Chemistry* New Central Book Agency

Section-B: Organic Chemistry-II

(30 Lectures)

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

Aromatic Hydrocarbons

06 Lectures

Benzene: Preparation: from phenol, by decarboxylation, from acetylene, from Benzene sulphonic acid. *Reactions:* electrophilic substitution (general mechanism); nitration (with mechanism), halogenations (chlorination and bromination), sulphonation and Friedel-Craft's reaction (alkylation and acylation) (up to 4 carbons on benzene); side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

Organometallic Compounds

(2 Lectures)

Introduction; *Grignard reagents: Preparations* (from alkyl and aryl halide); concept of *umpolung*; Reformatsky reaction.

Aryl Halides

(3 Lectures)

Preparation: (chloro-, bromo- and iodobenzene): from phenol, Sandmeyer reactions. *Reactions (Chlorobenzene):* nucleophilic aromatic substitution (replacement by -OH group) and effect of nitro substituent (activated nucleophilic substitution).

Alcohols, Phenols and Ethers

(11 Lectures)

Alcohols: (up to 5 Carbons). *Preparation:* 1°, 2°- and 3°- alcohols: using Grignard reagent, reduction of aldehydes, ketones, carboxylic acid and esters; *Reactions:* With sodium, HX (Lucas test), oxidation (alkaline KMnO₄, acidic dichromate, concentrated HNO₃); Oppenauer oxidation;

Diols: Preparation (with OsO₄); pinacol- pinacolone rearrangement (with mechanism) (*with symmetrical diols only*).

Phenols: Preparation: cumene hydroperoxide method, from diazonium salts; acidic nature of phenols; *Reactions:* electrophilic substitution: nitration and halogenations;

Reimer -Tiemann reaction, Houben–Hoesch condensation, Schotten –Baumann reaction, Fries rearrangement and Claisen rearrangement.

Ethers: Preparation: Williamson's ether synthesis; *Reaction:* cleavage of ethers with HI.

Carbonyl Compounds

(08 Lectures)

Aldehydes and Ketones (aliphatic and aromatic): (Formaldehyde, acetaldehyde, acetone and benzaldehyde); *Preparation:* from acid chlorides, from nitriles and from Grignard reagents; general properties of aldehydes and ketones; *Reactions:* with HCN, ROH, NaHSO₃, NH₂-G derivatives and with Tollens' and Fehling's reagents; iodoform test; aldol condensation (with mechanism); Cannizzaro reaction (with mechanism), Wittig reaction, benzoin condensation; Clemmensen reduction, Wolff- Kishner reduction and Meerwein-Ponndorf- Verley (MPV) reduction.

Suggested Readings:

1. Sethi, A. *Conceptual Organic Chemistry*; New Age International Publisher.
2. Parmar, V. S. *A Text Book of Organic Chemistry*, S. Chand & Sons.
3. Madan, R. L. *Organic Chemistry*, S. Chand & Sons.
4. Wade, L. G., Singh, M. S., *Organic Chemistry*, Pearson.
5. Finar, I. L. *Organic Chemistry (Volume I)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.

GE-3P: LAB: Practicals (60 Lectures)

Credits 02

Practicals:

Section A: Physical Chemistry-LAB (15x2=30 Lectures)

(Minimum **five** experiments to complete)

(I) Thermochemistry (Any **three**)

1. Determination of heat capacity of calorimeter for different volumes
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide
3. Determination of enthalpy of ionization of acetic acid
4. Determination of enthalpy of hydration of copper sulphate

(II) Ionic Equilibria (Any **two**)

- a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter and compare it with the indicator method
- b) Preparation of buffer solutions and find the pH of an unknown buffer solution by colour matching method (using following buffers)
 - (i) Sodium acetate-acetic acid
 - (ii) Ammonium chloride-ammonium hydroxide
- c) Study of the solubility of benzoic acid in water

Suggested Readings:

1. *University Hand Book of Undergraduate Chemistry Experiments*, edited by Mukherjee, G. N., University of Calcutta, 2003.
2. Palit, S.R., *Practical Physical Chemistry* Science Book Agency
3. Mukherjee, N.G., *Selected Experiments in Physical Chemistry* J. N. Ghose & Sons
4. Dutta, S.K., *Physical Chemistry Experiments* Bharati Book Stall

Section B: Organic Chemistry-LAB

Identification of a pure organic compound

Solid compounds: oxalic acid, tartaric acid, succinic acid, resorcinol, urea, glucose, benzoic acid and salicylic acid.

Liquid Compounds: methyl alcohol, ethyl alcohol, acetone, aniline, dimethylaniline, benzaldehyde, chloroform and nitrobenzene

Suggested Readings:

1. Bhattacharyya, R. C, *A Manual of Practical Chemistry*.
2. 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.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.