Syllabus and Scheme of Examination

for

B.Sc. Chemistry (Honours)
& B.Sc. Chemistry

Fakir Mohan University, Balasore

Under

Choice Based Credit System (CBCS)

(Applicable from the Academic Session 2016-17 onwards)

Choice Based Credit System in B.Sc. Courses of Chemistry (Honours & B.Sc. Chemistry, G.E, AEC & SEC

1. B.Sc. (Pass & Honours) Degree course consists of six semesters in a consecutive of three academic sessions from first admission. Each academic session consists of two semesters i.e. odd semester & even semesters.
2. Marks, credit, no. of theory & lab papers for chemistry (Hons.) for six semesters are given below.

Total Marks	2400	Total Papers-48	
Total Credits	140		
Honours Theory Papers	14	Marks 1400	Credits 84
Honours Lab Papers	14		
DSE Theory Papers	4	400	24
DSE Lab Papers	4		
GE Theory Papers	4	400	24
GE Lab Papers	4		
AEC Theory Papers	2	100	4
SEC Theory Papers	2	100	4
		2400	140

For Semester-I

Sl.No.	Courses	Paper Name	Marks	Credits	Total Marks
1	AEC-I	MIL	Mid Sem-10 End Sem-40	2	50
2	HONS. C-I	Inorganic Chem-I	Mid Sem-15 End Sem-60	4	
3	Hons. C-I Lab.	Inorganic Chem-I Lab	Lab-25	2	100
4	Hons C-II	Physical Chem-I	Mid Sem-15 End Sem-60	4	
5	Hons. C-II Lab	Physical Chem-II Lab	Lab-25	2	100
6	Generic Elective,	GE-I(Th.)	Mid Sem-15 End Sem-60	4	
7	Generic Elective	GE-I Lab	Lab-25	2	100
			Total Credits	20	350 Marks

For Semester-II

Sl.No.	Courses	Paper Name	Marks	Credits	Total Marks
1	AEC-II	Environmental Science	Mid Sem-10 End Sem-40	2	50
2	HONS. C-III	Organic Chem-I	Mid Sem-15 End Sem-60	4	
3	Hons. C-III Lab.	Organic Chem-I Lab	Lab-25	2	100
4	Hons C-IV	Physical Chem-II	Mid Sem-15 End Sem-60	4	
5	Hons. C-IV Lab	Physical Chem-II Lab	Lab-25	2	100
6	Generic Elective-2	GE-2(Th.)	Mid Sem-15 End Sem-60	4	
7	Generic Elective-2	GE-2 Lab	Lab-25	2	100
			Total Credits	20	350 Marks

3. Marks, Credit, number of theory & Lab papers for B.Sc. Chemistry students for six semesters are given below.

Total Marks-2100
Total Credits-120
Total Papers-42

1. Discipline specific courses for three subjects including chemistry 1200 marks, Each subject 400 marks.
   Total Credits-72 for Chemistry-24 Credits
   For Chemistry-Theory Papers -04] 400 marks
   (DSC-2A, 2B, 2C & 2D), Lab Papers-04]
2. DSE-600 marks, Each Subject-200 marks
   Total Credits-36, for Chemistry-200 marks, for chemistry-12 credits
   For Chemistry-(DSE-1 & DSE-2)
   Theory Papers-02] 200 Marks
   Lab Papers-02]
3. Ability enhancement courses (Compulsory)
   Two subjects-Two Theory Papers-100 marks
   AEC-I=MIL/Communicative English
   AEC-II=Environmental Science
   Each Paper- 50 marks - 2 Credits
   Total Credits-04
4. Skill Enhancement courses (SEC)
   Subject- Chemistry- Four Theory papers-200 marks- Total Credits-08
   Each paper – 50 marks – 2 Credits

Papers- SEC-I, SEC-2, SEC-3, SEC-4

For Semester-I

Sl.No.	Courses	Paper Name	Marks	Credits	Total Marks
1	Chemistry DSC (TH.)	DSC-2A	Mid Sem-15 End Sem-60	4	
2	Chemistry DSC Lab.	DSC-2A Lab.	Lab-25	2	100
3	Other subject DSC (Th)	DSC-1A	Mid Sem-15 End Sem-60	4	
4	Other subject DSC Lab	DSC-1A Lab	Lab-25	2	100
5	Another subject DSC (TH)	DSC-3A	Mid Sem-15 End Sem-60	4	
6	Another Subject DSC Lab	DSC-3A Lab	Lab-25	2	100
7	Generic Elective-2	GE-2 Lab	Lab-25	2	50
			Total Credits	20	350 Marks

For Semester-I

Sl.No.	Courses	Paper Name	Marks	Credits	Total Marks
1	Chemistry DSC (TH.)	DSC-2B	Mid Sem-15 End Sem-60	4	
2	Chemistry DSC Lab.	DSC-2B Lab.	Lab-25	2	100
3	Other subject DSC (Th)	DSC-1B	Mid Sem-15 End Sem-60	4	
4	Other subject DSC Lab	DSC-1B Lab	Lab-25	2	100
5	Another subject DSC (TH)	DSC-3B	Mid Sem-15 End Sem-60	4	
6	Another Subject DSC Lab	DSC-3B Lab	Lab-25	2	100
7	AEC-2	Environmental Science (Th)	Mid Sem-10 End Sem-40	2	50
			Total Credits	20	350 Marks

4. Duration of odd semesters (SEM-1,3 & 5) is from June to November and even Semesters (SEMS-2,4 & 6) is from December to May in each academic session.
5. Each theory paper consists of Mid Sem and End Sem Examinations.
6. Each lab paper will be held only in End Sem examinations.
7. Mid Sem Examinations of all theory papers of a semester will be conducted during the period of that semester by the college. Marks secured by each student in each paper will be sent to University for computation.
8. End Sem examinations of theory papers and lab papers will be conducted by the University at the end of respective semesters.
9. For each theory paper, marks for mid sem examination is -
    Papers with Practical components – 15 marks
    Papers without practical components- 10/20 marks
10. There shall be no mid sem examinations for lab papers.
11. Full marks for each thoey papers in end sem examinations is-
    Papers with Practical components – 60 marks
    Papers without practical components- 40/80 marks
12. Each theory paper of end sem examinations of Chemistry (Hons., Pass, DSE, DSC & GE) papers has four units. Students have to answer four questions out of four sets of alternative questions covering all the units given in the examinations.

CORE COURSE ; SEMESTER- I B.SC.- CHEMISTRY(HONOURS)
CHEMISTRY-CC- I (Th.) : INORGANIC CHEMISTRY-I
Time – 3 hrs. F.M. – 100 [60(Sem) +15 (Int.) + 25 (Pr.)](Credits: -04(Th.) +02(Pr.)
Lectures – 60 [40(Th.) + (Pr.)

Unit-I
ATOMIC STRUCTURE:

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. 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. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number**.** **(14 Lectures)**

Unit-II
PERIODICITY OF ELEMENTS

Periodicity of Elements: s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to s & p-block. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. (b) Atomic radii (van der Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral) (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. (f) Electron gain enthalpy, trends of electron gain enthalpy. (g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio. **(16 Lectures)**

Unit-III
CHEMICAL BONDING-I

(i) lonic bond: General characteristics, types of ions, size effects, radius ratio rule and its 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. (ii) Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

(16 Lectures)

Unit-IV
CHEMICAL BONDING:-II

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

(ii) Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process**. (16 Lectures)**

(iii) **OXIDATION-REDUCTION:**

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Principles involved in volumetric analysis to be carried out in class. **(14 Lectures)**

Reference Books:

• Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.

• Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970

• Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.

• Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.

CHEMISTRY LAB- C- I LAB:

(F.M=25)

(Expt. -15, Viva Voce- 6 & Lab. Record- 4) **Time – 3hrs**

(A) Titrimetric Analysis

(i) Calibration and use of apparatus

(ii) Preparation of solutions of different Molarity/Normality of titrants

(B) Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized KMnO4 solution.

(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.

Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Reference text:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.

CORE COURSE ; SEMESTER- I B.SC.- CHEMISTRY(HONOURS)

CHEMISTRY-CC- II (Th.) : : PHYSICAL CHEMISTRY- I

Time – 3 hrs. F.M. – 100 [60(Sem) +15 (Int.) + 25 (Pr.)](Credits: -04(Th.) +02(Pr.)

Lectures – 60 [40(Th.) + (Pr.)

Unit-I GASEOUS STATE

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure.

Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. van 12 der Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states. **(18 Lectures)**

Unit-II LIQUID STATE

(i) Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water.

IONIC EQUILIBRIA- I

(ii) 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; dissociation constants of mono-, di-and triprotic acids (exact treatment). **(12 Lectures)**

Unit- III SOLID STATE

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals. **(16 Lectures)**

Unit-IV Ionic equilibria - II:

Salt hydrolysis- calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations.

Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

(14 Lectures)

Reference Books:

• Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 13 (2006).

• Ball, D. W. Physical Chemistry Thomson Press, India (2007).

• Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004). • Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).

CHEMISTRY LAB-(C-II LAB)

(F.M=25)

(Expt. -15, Viva Voce- 6 &Lab. Record- 4) **Time – 3hrs**

1. Surface tension measurements.

a. Determine the surface tension by (i) drop number (ii) drop weight method.

b. Study the variation of surface tension of detergent solutions with concentration.

2. Viscosity measurement using Ostwald's viscometer.

a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.

b. Study the variation of viscosity of sucrose solution with the concentration of solute.

3. **pH metry**

a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.

b. Preparation of buffer solutions of different pH i. Sodium acetate-acetic acid ii. Ammonium chloride-ammonium hydroxide

c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.

d. Determination of dissociation constant of a weak acid.

Reference Books

• Khosla, B. D.; Garg, V. C. &Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

• Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).

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

CORE COURSE ; SEMESTER- II - B.SC.- CHEMISTRY(HONOURS)

CHEMISTRY-CC- III (Th.) : ORGANIC CHEMISTRY

Time – 3 hrs. F.M. – 100 [60(Sem) +15 (Int.) + 25 (Pr.)](Credits: -04(Th.) +02(Pr.)

Lectures – 60 [40(Th.) + (Pr.)

Unit -I

BASICS OF ORGANIC CHEMISTRY:

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.

Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

CARBON-CARBON SIGMA BONDS

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.**(12 Lectures)**

Unit - II
STEREOCHEMISTRY

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations. **(18 Lectures)**

Unit – III
CHEMISTRY OF ALIPHATIC HYDROCARBONS

A. Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylicbromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. 15 Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

B. Cycloalkanes and Conformational Analysis

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams. **(18 Lectures)**

Unit - IV
AROMATIC HYDROCARBONS

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.**(12 Lectures)**

Reference Books:

• Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

• Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

• Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

• Eliel, E. L. &Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.

• Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.

CHEMISTRY LAB-C III LAB

(F.M=25)

(Expt. -15, Viva Voce- 6 & Lab. Record- 4) **Time – 3hrs**

1. Checking the calibration of the thermometer
2. Purification of organic compounds by crystallization using the following solvents:
   a. Water
   b. Alcohol
   c. Alcohol-Water
3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)
6. Chromatography
   a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
   b. Separation of a mixture of two sugars by ascending paper chromatography
   c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

Reference Books

• Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
• Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)

CORE COURSE ; SEMESTER- II - B.SC.- CHEMISTRY(HONOURS)

CHEMISTRY-CC- IV (Th.) : PHYSICAL CHEMISTRY II

Time – 3 hrs. F.M. – 100 [60(Sem) +15 (Int.) + 25 (Pr.)](Credits: -04(Th.) +02(Pr.)

Lectures – 60 [40(Th.) + (Pr.)

Unit-I

CHEMICAL THERMODYNAMICS:

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

First law: Concept of heat, q, work, w, internal energy, U, 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.

Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature. **(14 Lectures)**

Unit-II

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell 17 relations; thermodynamic equation of state. **(14 Lectures)**

Unit-III

SYSTEMS OF VARIABLE COMPOSITION

Partial molar quantities, dependence of thermodynamic parameters on composition; GibbsDuhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

CHEMICAL EQUILIBRIUM

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants Kp, Kc and Kx. Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase. **(18 Lectures)**

Unit-IV

Solutions and Colligative Properties: Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. 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. **(14 Lectures)**

Reference Books

• Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).
• Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
• Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
• McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
• Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
• Levine, I .N. Physical Chemistry 6th Ed., Tata McGraw Hill (2010).
• Metz, C.R. 2000 solved problems in chemistry, Schaum Series (2006

CHEMISTRY LAB- C IV LAB

(F.M=25)

(Expt. -15, Viva- 6 & Lab. Record- 4) **Time – 3hrs**

THERMOCHEMISTRY

(a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
(c) Calculation of the enthalpy of ionization of ethanoic acid.
(d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
(e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
(f) Determination of enthalpy of hydration of copper sulphate.
(g) Study of the solubility of benzoic acid in water and determination of ΔH.

Reference Books

• Khosla, B. D.; Garg, V. C. &Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
• Athawale, V. D. &Mathur, P. Experimental Physical Chemistry New Age International: New Delhi (2001).

GENERIC ELECTIVE; SEMESTER- I / III B.SC. CHEMISTRY(Inter-disciplinary)

B.Sc. Hons. Students other than Chemistry Hons. will opt. four Chemistry GE Papers

CHEM. GE: I (tTh.)- ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

Time – 3 hrs. F.M. – 100 [60(Sem) +15 (Int.) + 25 (Pr.)](Credits: -04(Th.) +02(Pr.)
Lectures – 60 [40(Th.) + (Pr.)

SECTION A: INORGANIC CHEMISTRY-1

(30 Periods)

Unit-I
Atomic Structure

Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.
What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2 , Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenicwavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers ml and ms. Shapes of

s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations. **(14 Lectures)**

Unit-II

Chemical Bonding and Molecular Structure

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, trigonalbipyramidal 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. **(16 Lectures)**

Section B: Organic Chemistry-1

Unit- III **(30 Periods)**

Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule. **(8 Lectures)**

Stereochemistry

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; cis - trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems). **(10 Lectures)**

Unit- IV

Aliphatic Hydrocarbons

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

Alkanes: (Upto 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.

Alkenes: (Upto 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. $KMnO_4$) and

trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5 Carbons) Preparation: Acetylene from CaC_2 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 $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$. **(12 Lectures)**

Reference Books:

• J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
• F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
• Douglas, McDaniel and Alexader: Concepts and Models in Inorganic Chemistry, John Wiley.
• James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
• T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
• Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
• E. L. Eliel: Stereochemistry of Carbon Compounds, Tata McGraw Hill.• I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
• R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
• ArunBahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand

GE- I- LAB: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

(F.M=25)

(Expt. -15, Viva- 6 & Lab. Record- 4) **Time – 3hrs**

Section A: Inorganic Chemistry- Volumetric Analysis

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 $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Section B:Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
2. Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given)
   (a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography
   (b) Identify and separate the sugars present in the given mixture by paper chromatography.

Reference Books:

• Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
• Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
• Textbook of Practical Organic Chemistry, A.I. Vogel , Prentice Hall, 5th edition.
• Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960.

GENERIC ELECTIVE; SEMESTER- II/ IV B.SC. CHEMISTRY(Inter-disciplinary

CHEM. GE: II (tTh.)- CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY

Time – 3 hrs. F.M. – 100 [60(Sem) +15 (Int.) + 25 (Pr.)](Credits: -04(Th.) +02(Pr.)
Lectures – 60 [40(Th.) + (Pr.)
(B.Sc. Hons. Students other than Chemistry Hons. will opt. 2 GE Papers)

Section A: Physical Chemistry-1(30 Lectures)

Unit-I

Chemical Energetics

Review of thermodynamics and the Laws of Thermodynamics.
Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation.Statement of Third Law of thermodynamics and calculation of absolute entropies of substances. **(10 Lectures)**

Chemical Equilibrium:

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^o , Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases. **(8 Lectures)**

Unit- II

Ionic Equilibria:

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. **(12 Lectures)**

Section B: Organic Chemistry-2 (30 Lectures)

Unit- III

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

Aromatic hydrocarbons

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.
Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene). **(8 Lectures)**

Alkyl and Aryl Halides

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions.
Preparation: from alkenes and alcohols.
Reactions: hydrolysis, nitrite & nitro formation, nitrile &isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.
Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer&Gattermann reactions.

Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH2/NH3 (or NaNH2/NH3).
Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides. **(8 Lectures)**

Unit- IV

Alcohols, Phenols and Ethers (Upto 5 Carbons)

Alcohols: Preparation: Preparation of 1^0 , 2^0 and 3^0 alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation Diols: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case) Preparation: Cumenehydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. ReimerTiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation,Schotten – Baumann Reaction.

Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

Aldehydes and ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde)

Preparation: from acid chlorides and from nitriles.

Reactions – Reaction with HCN, ROH, $NaHSO_3$, NH2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-PondorffVerley reduction.**(14 Lectures)**

Reference Books:

• T. W. Graham Solomons: Organic Chemistry, John Wiley and Sons.
• Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
• I.L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
• R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
• ArunBahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
• G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
• G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).
• J. C. Kotz, P. M. Treichel& J. R. Townsend: General Chemistry CengageLening India Pvt. Ltd., New Delhi (2009).
• B. H. Mahan: University Chemistry 3rd Ed. Narosa (1998).
• R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).

GE- II LAB- LAB: CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY-I

(F.M=25)

(Expt. -15, Viva- 6 & Lab. Record- 4) **Time – 3hrs**

Section A: Physical Chemistry

Thermochemistry

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 integral enthalpy of solution of salts (KNO_3, NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of ΔH.

Ionic equilibria

pH measurements

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.

b) Preparation of buffer solutions:

(i) Sodium acetate-acetic acid

(ii) Ammonium chloride-ammonium hydroxide Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation. 2. Criteria of Purity: Determination of melting and boiling points.

3. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(a) Bromination of Phenol/Aniline

(b) Benzoylation of amines/phenols

(c) Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone

Reference Books

• A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.

• F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).

• B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co

DISCIPLINE SPECIFIC CORE ; Semester I- B.SC. CHEMISTRY

CHEM. : DSC-I (Th.) - ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS
Time – 3 hrs. F.M. – 100 [60(Sem) +15 (Int.) + 25 (Pr.)](Credits: -04(Th.) +02(Pr.)
Lectures – 60 [40(Th.) + (Pr.)

Unit- I
Section A: INORGANIC CHEMISTRY-1

(30 Periods)

ATOMIC STRUCTURE

Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom.Radial and angular parts of the hydogenicwavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers mland ms. Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations. **(14 Lectures)**

Unit- II

CHEMICAL BONDING AND MOLECULAR STRUCTURE

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, trigonalbipyramidal 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, nonbondingcombination 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. **(16 Lectures)**

Unit- III

Section B: Organic Chemistry-1

FUNDAMENTALS OF ORGANIC CHEMISTRY (30 Periods)

Physical Effects, Electronic Displacements: Inductive Effect, ElectromericEffect,Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factorsaffecting pK values. Aromaticity: Benzenoids and Hückel's rule. **(08 Lectures)**

Stereochemistry

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality(upto two carbon atoms). Configuration: Geometrical and Optical isomerism;Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; cis - trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems). **(10 Lectures)**

Unit- IV

ALLIPHATIC HYDROCARBONS

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

Alkanes: (Upto 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction,Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.

Alkenes: (Upto 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration- oxidation.

Alkynes: (Upto 5 Carbons) Preparation: Acetylene from CaC2 and conversion intohigher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$,ozonolysis and oxidation with hot alk. $KMnO_4$. **(12 Lectures)**

References Books:

• J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
• F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
• Douglas, McDaniel and Alexader: Concepts and Models in Inorganic Chemistry,
• James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
• T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
• Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient
• E. L. Eliel: Stereochemistry of Carbon Compounds, Tata McGraw Hill.
• I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
• R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
• ArunBahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand

CHEMISTRY LAB: DSC-I LAB: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

(F.M=25)

(Expt. -15, Viva Voce- 6 & Lab. Record- 4) **Time – 3hrs**

SECTION A: INORGANIC CHEMISTRY - VOLUMETRIC ANALYSIS

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with KMnO4.
3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO4.
4. Estimation of Fe (II) ions by titrating it with K2Cr2O7 using internal indicator.
5. Estimation of Cu (II) ions iodometrically using Na2S2O3.

SECTION B: ORGANIC CHEMISTRY

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto
2. Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given)

(a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography.

(b) Identify and separate the sugars present in the given mixture by paperchromatography.

References Books:

• Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
• Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
• Textbook of Practical Organic Chemistry, A.I. Vogel , Prentice Hall, 5th edition.
• Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman,

DISCIPLINE SPECIFIC CORE ; Semester II- B.SC. CHEMISTRY

CHEM. : DSC-II (Th.) CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY

Time – 3 hrs. F.M. – 100 [60(Sem) +15 (Int.) + 25 (Pr.)](Credits: -04(Th.) +02(Pr.)

Lectures – 60 [40(Th.) + (Pr.)

SECTION A: PHYSICAL CHEMISTRY-1

Unit- I (30 Lectures)

Chemical Energetics

Review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation.

Statement of Third Law of thermodynamics and calculation of absolute entropies of substances. **(10 Lectures)**

Chemical Equilibrium

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^o , Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases. **(8 Lectures)**

Unit- II

Ionic Equilibria

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. **(12 Lectures)**

SECTION B: ORGANIC CHEMISTRY-II

Unit- III (30 Lectures)

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

Aromatic hydrocarbons

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene). **(8 Lectures)**

Alkyl and Aryl Halides

Alkyl Halides(Upto 5 Carbons) Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions.

Preparation: from alkenes and alcohols.

Reactions: hydrolysis, nitrite & nitro formation, nitrile &isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.

Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer&Gattermann reactions.

Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH2/NH3 (or NaNH2/NH3).

Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides. **(8 Lectures)**

Unit- IV

Alcohols, Phenols and Ethers (Upto 5 Carbons)

Alcohols: Preparation: Preparation of 1^0 , 2^0 and 3^0 alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation Diols: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case) Preparation: Cumenehydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten – Baumann Reaction.

Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

Aldehydes and ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde)

Preparation: from acid chlorides and from nitriles.

Reactions – Reaction with HCN, ROH, NaHSO3, NH2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-PondorffVerley reduction. **(14 Lectures)Reference Books:**

• T. W. Graham Solomons: Organic Chemistry, John Wiley and Sons.
• Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
• I.L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
• R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
• ArunBahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
• G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
• G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).
• J. C. Kotz, P. M. Treichel& J. R. Townsend: General Chemistry CengageLening India Pvt. Ltd., New Delhi (2009).
• B. H. Mahan: University Chemistry 3rd Ed. Narosa (1998).
• R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).

CHEMISTRY LAB- DSC -II LAB: CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY

(F.M=25)

(Expt. -15, Viva Voce- 6 & Lab. Record- 4) **Time – 3hrs**

Section A: Physical Chemistry

Thermochemistry

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 integral enthalpy of solution of salts (KNO_3, NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of ΔH.

Ionic equilibria

pH measurements

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.

b) Preparation of buffer solutions:

(i) Sodium acetate-acetic acid

(ii) Ammonium chloride-ammonium hydroxide

Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.
3. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(a) Bromination of Phenol/Aniline

(b) Benzoylation of amines/phenols

(c) Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone

Reference Books

• A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.

• F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).

• B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

SEMESTER-III

C-5: INORGANIC CHEMISTRY-II
(Credits-6: Theory-4, Practical-2)-Max. Marks: 100
THEORY (Each class 1 hr.): Marks-75
PRACTICAL (Each class 2 hrs.): Marks-25
Lectures: 60 (40 Theory + 20 Practical classes)

UNIT-I: General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Re-duction, Hydrometallurgy. Methods of puri_cation of metals: Electrolytic process, Parting process,
van Arkel-de Boer process and Monds process, Zone re_ning. (8 Lectures)

Acids and Bases

Brnsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of
acid-base reactions, Lewis acid-base concept, Classi_cation of Lewis acids, Hard and Soft Acids and
Bases (HSAB) Application of HSAB principle. (8 Lectures)

UNIT-II: Chemistry of s and p Block Elements-I

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements. Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate. (14 Lectures)

UNIT-III: Chemistry of s and p Block Elements-II

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes. Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens. (14 Lectures)

UNIT-IV: Noble Gases

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and proper-ties of XeF_2;XeF_4andXeF_6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2). Molecular shapes of noble gas compounds (VSEPR theory). (8 Lectures)

Inorganic Polymers:

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates. (8 Lectures)

Reference Books:

- Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
- Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
- Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.

- Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
- Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010.
- Shriver & Atkins, Inorganic Chemistry 5th Ed.

PRACTICAL: C-5 LAB.

(A) Iodo / Iodimetric Titrations

(i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).

(ii) Estimation of available chlorine in bleaching powder iodometrically.

(B) Inorganic preparations

(i) Cuprous chloride, Cu_2Cl_2:

(ii) Preparation of manganese(III) phosphate, $MnPO_4$:H_2O:

(iii) Preparation of aluminium potassium sulphate K_2SO_4:$Al_2(SO_4)_2$:$24H_2O$ (Potash alum).

Reference Books:

- Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS. 1978

C-6: ORGANIC CHEMISTRY-II
(Credits-6: Theory-4, Practical-2)-Max. Marks: 100
THEORY (Each class 1 hr.): Marks-75
PRACTICAL (Each class 2 hrs.): Marks-25
Lectures: 60 (40 Theory + 20 Practical classes)

UNIT-I: Chemistry of Halogenated Hydrocarbons

Alkyl halides: Methods of preparation, nucleophilic substitution reactions SN1, SN2 and SNi mech-anisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination. Aryl halides: Preparation, including preparation from diazonium salts, nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and arylhalides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li Use in synthesis of organic compounds. (16 Lectures)

UNIT-II: Alcohols, Phenols, Ethers and Epoxides

Alcohols: preparation, properties and relative reactivity of 1, 2, 3 alcohols, Bouvaelt-Blanc Re-duction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement; Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, eimerTiemann and KolbesSchmidt Reactions, Fries and Claisen rearrangements with mechanism; Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and LiAlH4 (16 Lectures)

UNIT-III: Carbonyl Compounds

Structure, reactivity and preparation: Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation,Knoevenagel condensation, Perkin, Cannizzaro and Wittig reaction, Beckmann rearrangements,haloform reaction and Baeyer Villiger oxidation, - substitution reactions, oxidations and reductions (Clemmensen, Wol_-Kishner, LiAlH4, NaBH4, MPV.; Addition reactions of unsaturated carbonyl
compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate. (14 Lectures)

UNIT-IV: Carboxylic Acids and their Derivatives

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicar-boxylic acids, hydroxy acids and unsaturated acids: succinic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Compar-ative study of nucleophilic sustitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann-bromamide degrada- tion and Curtius rearrangement. (10 Lectures)

Sulphur containing compounds

Preparation and reactions of thiols, thioethers. (4 Lectures)

Reference Books:

- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
-

PRACTICAL: C-6 LAB.

1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
2. Organic preparations:

(i) Acetylation of one of the following compounds: amines (aniline, o-, m-, p-toluidines and o-, m-,p-anisidine) and phenols (-naphthol, vanillin, salicylic acid) by any one method:
(a) Using conventional method.
(b) Using green approach.
(ii) Benzolyation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and one of the following phenols (-naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction.
(iii) Bromination of any one of the following:
(a) Acetanilide by conventional methods.
(b) Acetanilide using green approach (Bromate-bromide method).
(iv) Nitration of any one of the following:
(a) Acetanilide/nitrobenzene by conventional method.
(b) Salicylic acid by green approach (using ceric ammonium nitrate).

The above derivatives should be prepared using 0.5-1gm. of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.

Reference Books:

- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

C-7: PHYSICAL CHEMISTRY-III
(Credits-6: Theory-4, Practical-2)-Max. Marks: 100
THEORY (Each class 1 hr.): Marks-75
PRACTICAL (Each class 2 hrs.): Marks-25
Lectures: 60 (40 Theory + 20 Practical classes))

UNIT-I:Phase Equilibria-I

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquidvapour and solid-vapour equilibria, phase diagram for one component systems, with applications (H_2O and sulphur system). Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions (Pb-Ag system, desilverisation of lead)
(14 Lectures)

UNIT-II: Phase Equilibria-II

Three component systems, water-chloroform-acetic acid system, triangular plots. Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications. (14 Lectures)

UNIT-III: Chemical Kinetics

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of orders, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.
Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, qualitative treatment of the theory of absolute reaction rates. (18 Lectures)

UNIT-IV: Catalysis

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and effciency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis. (8 Lectures)

Surface chemistry

Physical adsorption, chemisorption, adsorption isotherms (Langmuir, Freundlich and Gibbs isotherms), nature of adsorbed state. (6 Lectures)

Reference Books:

- Peter Atkins & Julio De Paula, Physical Chemistry 9th Ed., Oxford University Press (2010).
- Castellan, G. W. Physical Chemistry, 4th Ed., Narosa (2004).
- McQuarrie, D. A. & Simon, J. D., Molecular Thermodynamics, Viva Books Pvt. Ltd.: New Delhi (2004).

- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S.
- Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
- Zundhal, S.S. Chemistry concepts and applications Cengage India (2011).
- Ball, D. W. Physical Chemistry Cengage India (2012).
- Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
- Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
- Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009).

PRACTICAL: C-7 LAB.

I. Distribution of acetic/ benzoic acid between water and cyclohexane.
II. Study the equilibrium of at least one of the following reactions by the distribution method:

$I_2(aq) + I^- \rightarrow I_3^-(aq)$

$Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)n$:

III. Study the kinetics of the following reactions.
(1) Integrated rate method:
a. Acid hydrolysis of methyl acetate with hydrochloric acid.
b. Saponification of ethyl acetate.
(2) Compare the strengths of HCl and H2SO4 by studying kinetics of hydrolysis of methyl acetate.

Adsorption

Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co. New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

SEMESTER- IV

C-8: INORGANIC CHEMISTRY-III
(Credits-6: Theory-4, Practical-2)-Max. Marks: 100
THEORY (Each class 1 hr.): Marks-75
PRACTICAL (Each class 2 hrs.): Marks-25
Lectures: 60 (40 Theory + 20 Practical classes)

UNIT-I: Coordination Chemistry

Werners theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of CFSE weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq in octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry, Jahn-Teller

theorem, square planar geometry. Qualitative as affpect of ligand field and MO Theory. IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, Labile and inert complexes. (20 Lectures)

UNIT-II: Transition Elements-I

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series. (12 Lectures)

UNIT-III: Transition Elements-II

Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy). (12 Lectures)

UNIT-IV: Lanthanoids and Actinoids

Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide con-traction, separation of lanthanides (ion-exchange method only). General features of actinoids, separation of Np, Pm, Am from U. (6 Lectures)

Bioinorganic Chemistry

Metal ions present in biological systems, classification of elements according to their action in bilogical system. Na/K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron. (10 Lectures)

Reference Books:

- Purcell, K.F & Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977.
- Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.
- Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
- Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry. Wiley-VCH, 1999.
- Basolo, F, and Pearson, R.C., Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
- Greenwood, N.N. & Earnshaw A., Chemistry of the Elements, Butterworth-Heinemann, 1997.

PRACTICAL: C-8 LAB.

Gravimetric Analysis:

i. Estimation of nickel(II) using Dimethylglyoxime (DMG).

ii Estimation of copper as CuSCN.

iii. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$:

iv. Estimation of Al(III) by precipitating with oxine and weighing as Al(oxine)3 (aluminium oxinate).Chromatography of metal ions

Principals involved in chromatographic separations. Paper chromatographic separation of following metal ions:

i. Ni(II) and Co(II)

ii. Fe(III) and Al(III)

Reference Book:

- Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.

C-9: ORGANIC CHEMISTRY-III
(Credits-6: Theory-4, Practical-2)-Max. Marks: 100
THEORY (Each class 1 hr.): Marks-75
PRACTICAL (Each class 2 hrs.): Marks-25
Lectures: 60 (40 Theory + 20 Practical classes)

UNIT-I: Nitrogen Containing Functional Groups

Preparation and important reactions of nitro and compounds, nitriles. Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel hthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmanns exhaustive methylation, Hofmann-elimination reaction; Dis- tinction between 1, 2 and 3 amines with Hinsberg reagent and nitrous acid. (14 Lectures)

UNIT-II: Diazonium Salts

Preparation and their synthetic applications.Polynuclear Hydrocarbons Reactions of naphthalene and anthracene Structure, Preparation and structure elucidation and im- portant derivatives of naphthalene and anthracene. Polynuclear hydrocarbons. (12 Lectures)

UNIT-III: Heterocyclic Compounds

Classi_cation and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings con-taining one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine. Fischer indole synthesis and Madelung synthesis, structure of
quinoline and isoquinoline. Derivatives of furan: Furfural and furoic acid (preparation only). (18 Lectures)

UNIT-IV: Alkaloids

Natural occurrence, General structural features, Isolation and their physiological action Hoffmanns exhaustive methylation, Emdes modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine. (8 Lectures)

Terpenes Occurrence, classi_cation, isoprene rule; Elucidation of stucture and synthesis of Citral, Neral and -terpineol. (8 Lectures)

Reference Books:

- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons (1976).
- Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
- Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.

- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
- Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Parakashan (2010).

PRACTICAL: C-9 LAB.

1. Detection of extra elements (N, X, S).
2. Functional group test for nitro, amine and amide groups.
3. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds).

Reference Books:

- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

C-10: PHYSICAL CHEMISTRY-IV

(Credits-6: Theory-4, Practical-2)-Max. Marks: 100
THEORY (Each class 1 hr.): Marks-75
PRACTICAL (Each class 2 hrs.): Marks-25
Lectures: 60 (40 Theory + 20 Practical classes)

UNIT-I: Conductance-I

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hckel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Waldens rules. (12 Lectures)

UNIT-II: Conductance-II

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts. (16 Lectures)

UNIT-III: Electrochemistry-I

Quantitative aspects of Faradays 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 diferent kinds of half- cells. Application of EMF measurements in determining free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass electrodes. (18 Lectures)

UNIT-IV: Electrochemistry-II

Concentration cells with and without transference, liquid junction potential; determination of activity coeficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation). Electrical properties of atoms and molecules Basic ideas of electrostatics, Electrostatics of dielectric media. Clausius-Mosotti equation and Lorenz-Laurentz equation (no
derivation), Dipole moment and molecular polarizabilities and their measurements. (14 Lectures)

Reference Books:

- Atkins, P.W & Paula, J.D. Physical Chemistry, 9th Ed., Oxford University Press (2011).
- Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
- Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
- Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- Rogers, D. W. Concise Physical Chemistry Wiley (2010).Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).

PRACTICAL: C-10 LAB.

Conductometry

I. Determination of cell constant.

II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

III. Perform the following conductometric titrations:

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

iii. Strong acid vs. weak base

Potentiometry

I. Perform the following potentiometric titrations:

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

iii. Dibasic acid vs. strong base

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

SKILL ENHANCEMENT COURSES (SEC)

SEMESTER- IV

SEC-II: PESTICIDE CHEMISTRY

(Credits: 02)- Max. Marks: 50

30 Lectures(Each Lecture 1 hr.)

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).

Practical

- To calculate acidity/alkalinity in given sample of pesticide formulations as per BIS speci_cations.
- Preparation of simple organophosphates, phosphonates and thiophosphates.

Reference Book:

- R. Cremlyn: Pesticides, John Wiley.

SEMESTER-III

DSC-III(2C): SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC CHEMISTRY-II

(Credits:6 Theory-04, Practicals-02)

THEORY (Each class 1 hour):75 Marks

PRACTICAL (Each class 2 hours):25 Marks

Lectures: 60(40 Theory + 20 Practical classes)

Section A: Physical Chemistry-2 (30 Lectures)

UNIT-I: Solutions

Thermodynamics of ideal solutions: Ideal solutions and Raoults law, deviations from Raoults law non-ideal solutions. Vapour pressure-composition and temperaturecomposition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes.Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction. (8 Lectures)

Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems

(water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$ -H_2O and Na-K only). (7 Lectures).

UNIT-II: Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base). (7 Lectures)

Electrochemistry

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernstequation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treat-ment (acid-base and oxidation-reduction only). (8 Lectures)

Section B: Organic Chemistry-3 (30 Lectures)

UNIT-III: Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Carboxylic acids and their derivatives.

Carboxylic acids (aliphatic and aromatic)

Preparation: Acidic and Alkaline hydrolysis of esters.

Reactions: Hell Vohlard - Zelinsky Reaction.

Carboxylic acid derivatives (aliphatic): (Upto 5 carbons)

Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion.

Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation. (6 Lectures).

Amines and Diazonium Salts

Amines (Aliphatic and Aromatic): (Upto 5 carbons) Preparation: from alkyl halides, Gabriels Ph-thalimide synthesis, Hofmann bromamide reaction. Reactions: Hofmann vs. Saytze_ elimination, Carbylamine test, Hinsberg test, with HNO2, Schotten Baumann Reaction. Electrophilic substi-tution (case aniline): nitration, bromination, sulphonation. Diazonium salts: Preparation: from aromatic amines. Reactions: conversion to benzene, phenol, dyes. (6 Lectures)

UNIT-IV: Amino Acids, Peptides and Proteins:

Preparation of Amino Acids: Strecker synthesis using Gabriels phthalimide synthesis. Zwitterion,Isoelectric point and Electrophoresis. Reactions of Amino acids: ester of COOH group, acetylation of NH2 group, complexation with Cu2+ ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

Determination of Primary structure of Peptides by degradation Edmann degradation (Nterminal) and Cterminal (thio-hydantoin and with carboxypeptidase enzyme). Synthesis of

simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis. (10 Lectures).
Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

Reference Books:

- G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
- G. W. Castellan: Physical Chemistry 4th Ed. Narosa (2004).
- J. C. Kotz, P. M. Treichel, J. R. Townsend, General Chemistry, Cengage Learning India Pvt. Ltd.:New Delhi (2009).
- B. H. Mahan: University Chemistry, 3rd Edn. Narosa (1998).
- R. H. Petrucci, General Chemistry, 5th Edn., Macmillan Publishing Co.: New York (1985).
- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nelson, D. L. & Cox, M. M. Lehningers Principles of Biochemistry 7th Ed., W. H. Freeman.
- Berg, J. M., Tymoczko, J. L. & Stryer, L. Biochemistry 7th Ed., W. H. Freeman.

PRACTICAL: DSE-III(2C) LAB.

Section A: Physical Chemistry
Distribution
Study of the equilibrium of one of the following reactions by the distribution method:

$$I_2(aq) + I^-(aq) \longrightarrow I_{3-}(aq),\ Cu_2 + (aq) + xNH_2(aq) \longrightarrow [Cu(NH_3)_x]^{2+}.$$

Conductance
I. Determination of cell constant.
II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a
weak acid.
III. Perform the following conductometric titrations:
i. Strong acid vs. strong base.
ii. Weak acid vs. strong base.
Potentiometry
Perform the following potentiometric titrations:
i. Strong acid vs. strong base.

ii. Weak acid vs. strong base.
iii. Potassium dichromate vs. Mohr's salt.

Section B: Organic Chemistry
I. Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.
II. Separation of amino acids by paper chromatography.
2. Determination of the concentration of glycine solution by formylation method.
3. Titration curve of glycine.
4. Action of salivary amylase on starch.
5. Effect of temperature on the action of salivary amylase on starch.
6. Differentiation between a reducing/nonreducing sugar.

Reference Books:

- A.I. Vogel: Textbook of Practical Organic Chemistry, Prentice Hall, 5th Edn.
- F. G. Mann & B. C. Saunders: Practical Organic Chemistry, Orient Longman, 1960.
- B.D. Khosla: Senior Practical Physical Chemistry, R. Chand & Co.
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

SEMESTER-IV

DSC-IV(2D): CHEMISTRY OF S- AND P-BLOCK ELEMENTS, STATES OF MATTER & CHEMICAL KINETICS
THEORY (Each class 1 hour):75 Marks
PRACTICAL (Each class 2 hours):25 Marks
Lectures: 60(40 Theory + 20 Practical classes)

Section A: Inorganic Chemistry-2 (30 Lectures)
UNIT-I: General Principles of Metallurgy
Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent. Hydrometallurgy, Methods of purification of metals (Al, Pb, Fe, Cu, Ni, Zn): electrolytic, oxidative refining, Parting process, van Arkel-de Boer process and Monds process. (4 Lectures)
s- and p-Block Elements
Periodicity in s- and p-block elements with respect to electronic con_guration, atomic and ionic size, ionization enthalpy, electronegativity (Pauling & Mulliken scales). Allotropy in C, S, and P. Oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides), inert pair effect, diagonal relationship and anomalous behaviour of first member of each group. (11 Lectures).
UNIT-II: Compounds of s- and p-Block Elements
Hydrides and their classi_cation (ionic, covalent and interstitial), structure and properties with respect to stability of hydrides of p- block elements. Concept of multicentre bonding (diborane). Structure, bonding and their important properties like oxidation/reduction, acidic/basic nature of the following compounds and their applications in industrial, organic and environmental chemistry.
Hydrides of nitrogen (NH_3;N_2H_4;N_3H;NH_2OH)

Oxoacids of P, S and Cl.
Halides and oxohalides: PCl_3; PCl_5; $SOCl_2$: (15 Lectures)

Section B: Physical Chemistry-3 (30 Lectures)
UNIT-III: Kinetic Theory of Gases
Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation derivation not required) and their importance.
Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only). (10 Lectures)
Liquids
Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only). (5 Lectures)
UNIT-IV: Solids
Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. XRay diffraction by crystals, Braggs law. Structures of NaCl, and CsCl (qualitative treatment only). Defects in crystals. (7 Lectures)
Chemical Kinetics
The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Halflife of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).
(8 Lectures)

Reference Books:

- G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
- G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).
- C. Kotz, P. M. Treichel & J. R. Townsend: General Chemistry Cengage Lening India Pvt. Ltd.,New Delhi (2009).
- H. Mahan: University Chemistry 3rd Ed. Narosa (1998).
- R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
- D. Lee: A New Concise Inorganic Chemistry, E.L.B.S.
- F.A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
- F. Shriver and P. W. Atkins: Inorganic Chemistry, Oxford University Press.
- Gary Wulfsberg: Inorganic Chemistry, Viva Books Pvt. Ltd.

PRACTICAL: DSE-IV(2D) LAB.

Section A: Inorganic Chemistry

Semi-micro qualitative analysis using H_2S of mixtures- not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

Cations : $NH^{4+}, Pb^{2+}, Ag^{+}, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}$, $Co, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^{+}$

Actions: $CO_3^2, S*2, SO_3^2, NO_3, Cl, Br, I, NO_3, SO_4^{2-}, PO_4^{3-}, F^{-}$

(Spot tests should be carried out wherever feasible)

Section B: Physical Chemistry

Chemical Kinetics

Study the kinetics of the following reactions.

3. Initial rate method: Iodide-persulphate reaction.
4. Integrated rate method:

a) Acid hydrolysis of methyl acetate with hydrochloric acid.

b) Saponi_cation of ethyl acetate.

c) Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

Reference Books:

- A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn
- A.I. Vogel, Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.