

SYLLABUS FOR UNDER GRADUATE (UG)  
COURSE IN CHEMISTRY  
(HONOURS )  
UNDER  
CHOICE BASED CREDIT SYSTEM

2015

GENERAL INSTRUCTIONS TO THE STUDENTS

Under Choice Based Credit System in B.Sc. Courses of Chemistry (Honours & Pass, G.E, AEC & SEC) admitted in 2015-16 admission batch.

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, credits, no of Theory & Lab papers for Chemistry (Hons.) students for six semesters are given below.

Total Marks -	2400	Total papers-48	
Total Credits-	140		
Honours Theory Papers	14	Marks	Credits
Honours Lab Papers	14	1400	84
DSE Theory Papers	04	400	24
DSE Lab Papers	04		
GE Theory Papers	04	400	24
GE Lab Papers	04		
AEC Theory Papers	02	100	04
SEC Theory Papers	02	100	04
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		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	100
3	Hons. C-I Lab.	Inorganci Chem-I Lab	Lab-25	2	
4	Hons. C-II	Physical Chem.-I	Mid Sem.-15 End Sem.-60	4	100
5	Hons. C-II Lab	Physical Chem.-II Lab.	Lab-25	2	
6	Generic Elective,	GE-I (Th.)	Mid Sem.-15 End Sem.-60	4	100
7	Generic Elective,	GE-I Lab.	Lab-25	2	
		<b>Total Credits</b>		<b>20</b>	<b>350 marks</b>

**For Semester –II**

Sl no	Course	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	100
3	Hons. C-III Lab.	organci Chem-I Lab	Lab-25	2	
4	Hons. C-IV	Physical Chem.-II	Mid Sem.-15 End Sem.-60	4	100
5	Hons. C-IV Lab	Physical Chem.-II Lab.	Lab-25	2	
6	Generic Elective-2	GE-2 (Th.)	Mid Sem.-15 End Sem.-60	4	100
7	Generic Elective-2	GE-2 Lab.	Lab-25	2	
<b>Total</b>			<b>Total Credits= 20</b>		<b>350</b>

3. Marks, Credits, number of Theory & Lab Papers for B.Sc. (Pass) 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  
( DSC – 2A, 2B, 2C & 2D.) , Lab Papers } - 400 Marks

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  
Lab Papers -02 } 200 Marks

3. Ability enhancement courses (Compulsory)  
Two Subjects – Two Theory Papers – 100 marks  
AEC-I = MIL.  
AEC-II = Environmental Science.  
Each paper – 50 marks – 2 Credits.  
Total Credits – 04

4. Skill Enchantment courses (SEC)  
Subject- Chemistry – Four Theory papers – 200 marks - Total Credits – 08  
Each paper -50 marks – 2 Credits.

**For SEMESTER-I**

<b>Sl no</b>	<b>Courses</b>	<b>Paper name</b>	<b>Marks</b>	<b>Credits</b>	<b>Total Marks</b>
1	Chemistry DSC (TH.)	DSC-2A	Mid Sem-15 End Sem-60	4	100
2	Chemistry DSC Lab.	DSC 2A Lab	Lab-25	2	
3	Other subject DSC (TH)	DSC -1A	Mid Sem-15 End Sem-60	4	100
4	Other subject DSC Lab	DSC -1A Lab	Lab-25	2	
5	Another Subject DSC (TH)	DSC-3A	Mid Sem-15 End Sem-60	4	100
6	Another Subject DSC Lab	DSC-3A Lab	Lab - 25	2	
7	AEC-1	MIL	Mid Sem-10 End Sem-40	2	50
			<b>Total Credits</b>	<b>20</b>	<b>350 marks</b>

**For SEMESTER-II**

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

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 m\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 asemerster 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 theory 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.

**SEMESTER- I**  
**CHEMISTRY HONOURS**

**CHEMISTRY-C I: INORGANIC CHEMISTRY-I**

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

**Theory: 60 Lectures**

**End Sem-60 marks**

**Mid Sem- 15 marks**

**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  $\psi$  and  $\psi^2$ . 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) Ionic 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 ( $\sigma$  and  $\pi$  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  $\text{KMnO}_4$  solution.
- (ii) Estimation of oxalic acid and sodium oxalate in a given mixture.

Estimation of Fe(II) with  $\text{K}_2\text{Cr}_2\text{O}_7$  using internal (diphenylamine, anthranilic acid) and external indicator.

**Reference text:**

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

## **CHEMISTRY- C II : PHYSICAL CHEMISTRY- I**

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

**Theory: 60 Lectures**

**End Sem – 60 marks**

**Mid Sem- 15 marks**

### **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  $\sigma$  from  $\eta$ ; 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 der Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dieterici); 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.

- Determine the surface tension by (i) drop number (ii) drop weight method.
- Study the variation of surface tension of detergent solutions with concentration.

#### 2. Viscosity measurement using Ostwald's viscometer.

- Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
- Study the variation of viscosity of sucrose solution with the concentration of solute.

#### 3. pH metry

- Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
- Preparation of buffer solutions of different pH i. Sodium acetate-acetic acid ii. Ammonium chloride-ammonium hydroxide
- pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
- 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).

## SEMESTER –II

**CHEMISTRY-C - III: ORGANIC CHEMISTRY I**  
**(Credits: Theory-04, Practicals-02)**  
**Theory: 60 Lectures**

**End Sem- 60marks**  
**Mid Sem- 15marks**

### **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; Nucleophilicity 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 benzylic bromination 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 II 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)

## SEMESTER- II

**CHEMISTRY -C IV: PHYSICAL CHEMISTRY II**  
**(Credits: Theory-04, Practicals-02)**  
**Theory: 60 Lectures**

**End Sem- 60marks**  
**Mid Sem- 15 marks**  
**Time- 3hrs**

### 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; Gibbs-Duhem 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  $K_p$ ,  $K_c$  and  $K_x$ . 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 Mc Graw 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  $\Delta H$ .

### 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).

## SEMESTER- I

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

### GE- I (Theory)

## GE: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

End Sem- 60marks

Mid Sem- 15 marks

Time- 3hrs

### 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  $\psi$  and  $\psi^2$ , Schrödinger equation for hydrogen atom. Radial and angular parts of the hydrogenic wavefunctions (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  $m_l$  and  $m_s$ . Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number ( $s$ ) and magnetic spin quantum number ( $m_s$ ).

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, 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  $\text{NO}^+$ . 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.  $\text{KMnO}_4$ ) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymercuration-demercuration, Hydroboration-oxidation.

**Alkynes:** (Upto 5 Carbons) Preparation: Acetylene from  $\text{CaC}_2$  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  $\text{KMnO}_4$ , ozonolysis and oxidation with hot alk.  $\text{KMnO}_4$ .

(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 Alexander: 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.

**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  $\text{KMnO}_4$ .
3. Estimation of water of crystallization in Mohr's salt by titrating with  $\text{KMnO}_4$ .
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**

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  $R_f$  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.



## SEMESTER- II

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

### GE- II (Theory)

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

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures Time- 3hrs

End Sem- 60marks

Mid Sem- 15 marks

### 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  $\Delta G$  and  $\Delta G^\circ$ , Le Chatelier's principle. Relationships between  $K_p$ ,  $K_c$  and  $K_x$  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).

### 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: KNH<sub>2</sub>/NH<sub>3</sub> (or NaNH<sub>2</sub>/NH<sub>3</sub>).

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<sup>o</sup>, 2<sup>o</sup> and 3<sup>o</sup> 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<sub>4</sub>, acidic dichromate, conc. HNO<sub>3</sub>). Oppeneauer oxidation Diols: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

**Phenols:** (Phenol case) Preparation: Cumene hydroperoxide 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):** (Formaldehyde, acetaldehyde, acetone and benzaldehyde)

Preparation: from acid chlorides and from nitriles.

Reactions – Reaction with HCN, ROH, NaHSO<sub>3</sub>, NH<sub>2</sub>-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley 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.
- Arun Bahl 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 Cengage Lening 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- DSC 2B 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<sub>3</sub>, NH<sub>4</sub>Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of  $\Delta H$ .

#### **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

