

RANCHI WOMEN'S COLLEGE

RANCHI

(Autonomous College)



Constituent Unit

Of

Ranchi University, Ranchi

Syllabus of Chemistry for UG

Under Choice Based Credit System (CBCS)

2018

Sem I and Sem II

**PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM IN  
B. Sc. Honours (Chemistry)**

	<b>CORE COURSE (14)</b>	<b>Ability Enhancement Compulsory Course (AECC) (2)</b>	<b>Ability Enhancement Elective Course (AEEC) (2) (Skill Based)</b>	<b>Elective: Discipline Specific DSE (4)</b>	<b>Elective: Generic (GE) (4)</b>
I	Inorganic I: Atomic Structure & Chemical Bonding-I (4+4) Physical I: States of Matter & Ionic Equilibrium (4+2)	(English Communication/MIL)/Environmental Science			GE-1
II	Organic Basics Hydrocarbons (4+4) Physical Chemical Thermodynamics & its Applications (4+4)	I: Environmental & Science/ (English/MIL Communication) II:			GE-2
III	Inorganic II: s- and p-Block Elements (4+4) Organic II: Oxygen Containing Functional Groups (4+4) Physical III: Phase Equilibria & Chemical Kinetics (4+4)		SEC -1		GE-3
IV	Inorganic III: Coordination Chemistry (4+4) Organic III: Heterocyclic Chemistry (4+4)		SEC -2		GE-4

	Physical IV: Electrochemistry (4+4)				
V	Organic IV: Biomolecules (4+4)			DSE-1	
	Physical V: Quantum Chemistry & Spectroscopy (4+4)			DSE -2	
VI	Inorganic IV: Organometallic Chemistry (4+4)			DSE -3	
	Organic V: Chemistry Spectroscopy (4+4)			DSE -4	

SEMESTER	COURSE OPTED	COURSE NAME	Credits
I	Ability Enhancement Compulsory Course-I	English Communications/ Environmental Science	2
	Core Course-I	Inorganic Chemistry-I	4
	Core Course-I Practical	Inorganic Chemistry-I Lab	2
	Core Course-II	Physical Chemistry-I	4
	Core Course-II Practical	Physical Chemistry-I Lab	2
	Generic Elective -1	GE-1	4/5
	Generic Elective -1 Practical/Tutorial		2/1
II	Ability Enhancement Compulsory Course-II	English Communications/ Environmental Science	2
	Core Course-III	Organic Chemistry-I	4
	Core Course-III Practical/Tutorial	Organic Chemistry-I Lab	2
	Core Course-IV	Physical Chemistry-II	4
	Core Course-IV Practical/Tutorial	Physical Chemistry-II Lab	2
	Generic Elective -2	GE-2	4/5
	Generic Elective -2 Practical/Tutorial		2/1
III	Core Course-V	Inorganic Chemistry-II	4
	Core Course-V Practical/Tutorial	Inorganic Chemistry-II Lab	2
	Core Course-VI	Organic Chemistry-II	4
	Core Course-VI Practical/Tutorial	Organic Chemistry-II Lab	2
	Core Course-VII	Physical Chemistry-III	4
	Core Course-VII Practical/Tutorial	Physical Chemistry-III Lab	2
	Skill Enhancement Course -1	SEC-1	2

	Generic Elective -3	GE-3	4/5
	Generic Elective -3 Practical/Tutorial		2/1
IV	Core Course-VIII	Inorganic Chemistry-III	4
	Course-VIII Practical/Tutorial	Inorganic Chemistry-III Lab	2
	Core Course-IX	Organic Chemistry-III	4
	Course-IX Practical/Tutorial	Organic Chemistry-III Lab	2
	Core Course-X	Physical Chemistry-IV	4
	Course-X Practical/Tutorial	Physical Chemistry-IV Lab	2
	Skill Enhancement Course -2	SEC -2	2
	Generic Elective -4	GE-4	4/5
	Generic Elective -4 Practical		2/1
V	Core Course-XI	Organic Chemistry-IV	4
	Core Course-XI Practical/Tutorial	Organic Chemistry-IV Lab	2
	Core Course-XII	Physical Chemistry-V	4
	Core Course-XII Practical/Tutorial	Physical Chemistry-V Lab	2
	Discipline Specific Elective -1	DSE-1	4
	Discipline Specific Elective -1 Practical/Tutorial	DSE-1 Lab	2
	Discipline Specific Elective -2	DSE-2	4
	Discipline Specific Elective- 2 Practical/Tutorial	DSE-2 Lab	2
VI	Core Course-XIII	Inorganic Chemistry-IV	4
	Core Course-XIII Practical/Tutorial	Inorganic Chemistry-IV Lab	2
	Core Course-XIV	Organic Chemistry-V	4
	Core Course-XIV Practical/Tutorial	Organic Chemistry-V Lab	2
	Discipline Specific Elective -3	DSE-3	4
	Discipline Specific Elective -3 Practical/Tutorial	DSE-3 Lab	2
	Discipline Specific Elective-4	DSE-4	4
	Discipline Specific Elective -4 Practical/Tutorial	DSE-4 Lab	2
<b>Total Credits</b>			<b>140</b>

**Core Papers (C): (Credit: 06 each)** (1 period/week for tutorials or 4 periods/week for practical)

1. Inorganic Chemistry I: Atomic Structure & Chemical Bonding (4 + 4)
2. Physical Chemistry I: States of Matter & Ionic Equilibrium (4 + 4)
3. Organic Chemistry I: Basics and Hydrocarbons (4 + 4)
4. Physical Chemistry II: Chemical Thermodynamics and its Applications (4 + 4)
5. Inorganic Chemistry II: s- and p-block Elements (4 + 4)
6. Organic Chemistry II: Oxygen Containing Functional Groups (4 + 4)
7. Physical Chemistry III: Phase Equilibria and Chemical Kinetics (4 + 4)
8. Inorganic Chemistry III: Coordination Chemistry (4 + 4)
9. Organic Chemistry III: Heterocyclic Chemistry (4 + 4)

10. Physical Chemistry IV: Electrochemistry (4 + 4)
11. Organic Chemistry IV: Biomolecules (4 + 4)
12. Physical Chemistry V: Quantum Chemistry & Spectroscopy (4 + 4)
13. Inorganic Chemistry IV: Organometallic Chemistry (4 + 4)
14. Organic Chemistry V: Spectroscopy (4 + 4)

**Discipline Specific Elective Papers: (Credit: 06 each) (4 papers to be selected)- DSE 1-4**

1. Analytical Methods in Chemistry (4) + Lab (4)
  2. Polymer Chemistry (4) + Lab (4)
  3. Green Chemistry (4) + Lab (4)
  4. Industrial Chemicals & Environment (4) + Lab (4)
  5. Application of Computers in Chemistry (4) + Lab (4)
- Dissertation

**Other Discipline (Four papers of any one discipline)- GE 1 to GE 4**

1. Mathematics (5) + Tut (1)
2. Physics (4) + Lab (4)
3. Botany (4) + Lab (4)
4. Zoology (4) + Lab (4)

**Skill Enhancement Courses (Any 02 papers) (Credit: 02 each)- SEC1 to SEC4**

1. Chemistry of Cosmetics & Perfumes
2. Pesticide Chemistry
3. Fuel Chemistry
4. Basic Analytical Chemistry

**Generic Elective Papers (GE) (Minor-Chemistry) (any four) for other Departments/Disciplines: (Credit: 06 each)**

1. Atomic Structure, Bonding, General Organic Chemistry, Aliphatic Hydrocarbons + Lab.
2. Chemical Energetics, Equilibria and Functional Organic Chemistry + Lab.
3. Chem of s and p block elements, state of matter and chemical kinetics + Lab.
4. Chem. of d block elements, Molecules of life + Lab.

OR

Solution, Phase Equilibria, Conductance, Electrochemistry & Functional group Organic Chemistry -II

## CORE COURSE (HONOURS IN CHEMISTRY)

---

### Semester I

---

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

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

**Theory: 60 Lectures**

##### **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.

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)**

##### **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* and *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)**

## Chemical Bonding:

(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.

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

(iv) *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.

(26 Lectures)

## Oxidation-Reduction:

Redox equations, Standard Electrode Potential and its application to inorganic reactions.

Principles involved in volumetric analysis to be carried out in class.

(4 Lectures)

## Reference Books:

- Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
- Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry* Oxford, 1970
- Atkins, P.W. & Paula, J. *Physical Chemistry*, 10<sup>th</sup> Ed., Oxford University Press, 2014.
- Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
- Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.

---

## CHEMISTRY LAB- C I LAB:

60 Lectures

### (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.
- (iii) 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. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis* 6<sup>th</sup> Ed., Pearson, 2009.
- 

## CHEMISTRY -C II: PHYSICAL CHEMISTRY-I

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

#### 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)

#### **Liquid state:**

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.

(6 Lectures)

#### **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)

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

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.

(20 Lectures)

#### **Reference Books:**

- Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 10<sup>th</sup> Ed., Oxford University

- Press (2014).
- Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
  - Castellan, G. W. *Physical Chemistry* 4<sup>th</sup> Ed. Narosa (2004).
  - Mortimer, R. G. *Physical Chemistry* 3<sup>rd</sup> Ed. Elsevier: NOIDA, UP (2009).
  - Engel, T. & Reid, P. *Physical Chemistry* 3<sup>rd</sup> Ed. Pearson (2013).
- 

## CHEMISTRY LAB-C II LAB

### 60 Lectures

1. **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.
2. **Indexing of a given powder diffraction pattern of a cubic crystalline system.**
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.

*Any other experiment carried out in the class.*

#### 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* 8<sup>th</sup> Ed.; McGraw-Hill: New York (2003).
  - Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry* 3<sup>rd</sup> Ed.; W.H. Freeman & Co.: New York (2003).
-

## Semester II

### CHEMISTRY-C III: ORGANIC CHEMISTRY- I

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

#### 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.

(6 Lectures)

#### 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)

#### Chemistry of Aliphatic Hydrocarbons

##### A. Carbon-Carbon sigma bonds

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

##### B. 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, hydroboration-oxidation, 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

*Reactions of alkynes:* Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

### C. 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.

(24 Lectures)

### 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.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7<sup>th</sup> Ed. Cengage Learning India Edition, 2013.

---

### CHEMISTRY LAB-C II LAB

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. Detection of extra elements  
Functional group test for nitro, amine and amide groups.  
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, 5<sup>th</sup> Ed.*, Pearson (2012)
- 

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

#### **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.

*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 relations; thermodynamic equation of state.

(36 Lectures)

#### **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.

(8 Lectures)

#### **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.

(8 Lectures)

#### **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.

(8 Lectures)

#### **Reference Books**

- Peter, A. & Paula, J. de. *Physical Chemistry* 10<sup>th</sup> Ed., Oxford University Press (2014).
  - Castellan, G. W. *Physical Chemistry* 4<sup>th</sup> Ed., Narosa (2004).
  - Engel, T. & Reid, P. *Physical Chemistry* 3<sup>rd</sup> 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* 6<sup>th</sup> Ed., Tata Mc Graw Hill (2010).
  - Metz, C.R. *2000 solved problems in chemistry*, Schaum Series (2006).
-

## CHEMISTRY LAB- C IV LAB

### 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. 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  $\Delta H$ .

*Any other experiment carried out in the class.*

### 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).