

**Choice Based Credit System**  
**S. Y. B. Sc.**  
**Chemistry Syllabus**  
**To be implemented from the Academic year 2017-2018**

**Course Content**  
**Semester III**

Course Code	Unit	Topics	Credits	L/Week
USCH301	I	Chemical Thermodynamics-II, Electrochemistry	2	1
	II	Chemical Bonding		1
	III	Reactions and reactivity of halogenated hydrocarbons, alcohols, phenols and epoxides		1
USCH302	I	Chemical Kinetics-II, Solutions	2	1
	II	Selected topics on p block elements		1
	III	Carbonyl Compounds		1
USCH303	I	Intorduction to Analytical Chemistry and Statistical Treatment of analytical data-I	2	1
	II	Classical Methods of Analysis.		1
	III	Instrumental Methods-I		1
USCHP1		Chemistry Practicals I	1	3
USCHP2		Chemistry Practicals II	1	3
USCHP3		Chemistry Practicals III	1	3

**Semester IV**

Course Code	Unit	Topics	Credits	L/Week
USCH401	I	Electrochemistry-II, Phase Equilibria	2	1
	II	Comparative Chemistry of the transition metals & Coordination Chemistry		1
	III	Carboxylic acids and their derivatives, Sulphonic acids		1
USCH402	I	Solid state, Catalysis	2	1
	II	Ions in aqueous medium & Uses and Environmental Chemistry of volatile Oxides and oxo-acids		1
	III	Amines, Diazonium salts, Heterocyclic compounds		1
USCH403	I	Separation Techniques in Analytical Chemistry	2	1
	II	Instrumental Methods-II		1
	III	Statistical Treatment of analytical data --II		1
USCHP4		Chemistry Practicals I	1	3
USCHP5		Chemistry Practicals II	1	3
USCHP6		Chemistry Practicals III	1	3

**Semester III**  
**Paper I**  
**Theory: 45 Lectures**

**Unit I: Physical Chemistry**

**1.1 Chemical Thermodynamics-II(8L)**

1.1.1 Free Energy Functions: Helmholtz Free Energy, Gibb's Free Energy, Variation of Gibb's

free energy with Pressure and Temperature.

1.1.2 Gibbs-Helmholtz equation, van't Hoff reaction isotherm and van't Hoff reaction isochore.

(Numericals expected).

1.1.3 Thermodynamics of Open System: Partial Molal Properties, Chemical Potential and its variation with Pressure and Temperature, Gibb's Duhem equation.

1.1.4 Concept of Fugacity and Activity

**1.2 Electrochemistry: (7L)**

1.2.1 Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes.

1.2.2 Kohlrausch law of independent migration of ions.

1.2.3 Applications of conductance measurements: determination of degree of ionization and ionization constant of weak electrolyte, solubility and solubility product of sparingly soluble salts, ionic product of water. (Numericals expected).

1.2.4 Transference number and its experimental determination using Moving boundary method. (Numericals expected). Factors affecting transference number.

**Unit-II**

**Chemical Bonding**

**2.1 Non-Directional Bonding (4L)**

2.1.1 Ionic Bond: Conditions for the Formation of Ionic Bond.

2.1.2 Types of Ionic Crystals

2.1.3 Radius Ratio Rules

2.1.4 Lattice Energy, Born-Landé Equation

2.1.5 Kapustinski Equation

2.1.6 Born-Haber Cycle and its Application

**2.2. Directional Bonding: Orbital Approach. (6L)**

2.2.1 Covalent Bonding The Valence Bond Theory- Introduction and basic tenets.

- 2.2.2 Interaction between two hydrogen atoms and the Potential energy diagram of the resultant system.
- 2.2.3 Corrections applied to the system of two hydrogen atoms- Formation of H<sub>2</sub>
- 2.2.4 Homonuclear diatomic molecules from He<sub>2</sub> to Ne<sub>2</sub>
- 2.2.5 Resonance and the concept of Formal Charge; Rules for Resonance or Canonical structures.
- 2.2.6 Bonding in Polyatomic Species: The role of Hybridization. And types of hybrid orbitals-*sp*, *sp*<sup>2</sup>, *sp*<sup>3</sup>, *sp*<sup>3</sup>*d*, *sp*<sup>2</sup>*d*<sup>2</sup> and *sp*<sup>2</sup>*d* *sp*<sup>3</sup>*d*<sup>2</sup>.
- 2.2.7 Equivalent and Non-Equivalent hybrid orbitals
- 2.2.8 Contribution of a given atomic orbital to the hybrid orbitals (with reference to *sp*<sup>3</sup> hybridisation as in CH<sub>4</sub>, NH<sub>3</sub> and H<sub>2</sub>O and series like NH<sub>3</sub>, PH<sub>3</sub>, AsH<sub>3</sub>, BiH<sub>3</sub>)

### 2.3 Molecular Orbital Theory (5L)

- 2.3.1. Comparing Atomic Orbitals and Molecular Orbitals.
- 2.3.2. Linear combination of atomic orbitals. to give molecular orbitals LCAO-MO approach for diatomic homonuclear molecules).
- 2.3.4. Wave mechanical treatment for molecular orbitals (H<sub>2</sub><sup>+</sup> and H<sub>2</sub>)
- 2.3.4 Molecular orbital Theory and Bond Order and magnetic property: with reference to O<sub>2</sub>, O<sub>2</sub><sup>+</sup>, O<sub>2</sub><sup>-</sup>, O<sub>2</sub><sup>2-</sup>

(Problems and numerical problems expected wherever possible)

## Unit III: Organic Chemistry

### 3.1.1. Reactions and reactivity of halogenated hydrocarbons: [4L]

- 3.1.1. **Alkyl halides:** Nucleophilic substitution reactions: S<sub>N</sub>1, S<sub>N</sub>2 and S<sub>N</sub>i mechanisms with stereochemical aspects and factors affecting nucleophilic substitution reactions- nature of substrate, solvent, nucleophilic reagent and leaving group.
- 3.1.2. **Aryl halides:** Reactivity of aryl halides towards nucleophilic substitution reactions. Nucleophilic aromatic substitution (S<sub>N</sub>Ar) addition-elimination mechanism and benzyne mechanism.
- 3.1.2. **Organomagnesium and organolithium compounds: [3L]**  
Nomenclature, nature, type and reactivity of carbon-metal bond. Preparation using alkyl / aryl halide. Structure, stability and reactions with compounds containing acidic hydrogen, carbonyl compounds, CO<sub>2</sub>, cyanides and epoxides.

### 3.2 Alcohols, phenols and epoxides: [8L]

- 3.2.1.**Alcohols:** Nomenclature, Preparation: Hydration of alkenes, hydrolysis of alkyl halides, reduction of aldehydes and ketones, using Grignard reagent. Properties: Hydrogen bonding, types and effect of hydrogen bonding on different properties. Acidity of alcohols, Reactions of alcohols
- 3.2.2.**Phenols:** Preparation, physical properties and acidic character. Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols.
- 3.2.3.**Epoxides:** Nomenclature, methods of preparation and reactions of epoxides: reactivity, ring opening reactions by nucleophiles (a) In acidic conditions: hydrolysis, reaction with halogen halide, alcohol, hydrogen cyanide. (b) In neutral or basic conditions: ammonia, amines, Grignard reagents, alkoxides.

## Semester IV

### Paper I

#### Unit I: Physical Chemistry

##### 1.1 Electrochemistry-II: (8 L)

- 1.1.1 Electrochemical conventions, Reversible and irreversible cells.
- 1.1.2 Nernst equation and its importance, Types of electrodes, Standard electrode potential, Electrochemical series (Numericals expected).
- 1.1.3 Thermodynamics of a reversible cell, calculation of thermodynamic properties:  $\Delta G$ ,  $\Delta H$  and  $\Delta S$  from EMF data. (Numericals expected)
- 1.1.4 Calculation of equilibrium constant from EMF data. (Numericals expected)
- 1.1.5 Concentration cells with transference and without transference. Liquid junction potential and salt bridge.
- 1.1.6 pH determination using hydrogen electrode and quinhydrone electrode. (Numericals expected)

##### 1.2 Phase Equilibria: (7L)

- 1.2.1 Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation.
- 1.2.2 Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. (numericals expected)
- 1.2.3 Phase diagrams of one-component systems (water and sulphur).
- 1.2.4 Two component systems involving eutectics, congruent and incongruent melting points (lead-silver system).

#### Unit-II

##### 2.1 Comparative Chemistry of the transition metals (9 L)

- 2.1.1 Position in the periodic table; Natural occurrence principal ores and minerals;
- 2.1.2 Significance of special stability of  $d^0$ ,  $d^5$  and  $d^{10}$  leading to variable oxidation states; Unusual oxidation states and their stabilities in aqueous solutions (with special reference to vanadium, and chromium.)

- 2.1.3 Origin of colour for transition metals and their compounds: such as reflectivity, surface coatings, particle size, packing density for metals and nature of d-orbitals, number of electrons in the d-orbitals, geometry, and ability for charge transfer).
- 2.1.4 Magnetic properties of transition metal compounds: Origin of magnetism-spin and orbital motion of electrons; equation for spin only and spin-orbital magnetism in terms of Bohr magnetons (No derivation of relevant equations expected); Reasons for quenching of orbital moments.
- 2.1.5 Chemistry of Titanium and vanadium: properties of Oxides and chlorides; use in titrimetric analysis
- 2.1.6 Qualitative tests for transition metal ions: General considerations in devising tests (with reference to Chromium, Manganese, iron, Cobalt Nickel and Copper)

## 2.2 Coordination Chemistry : (6 L)

### 2.2.1 Introduction to Chemistry of Coordination Compounds

- i. Historical perspectives: Early ideas on coordination compounds
- ii. Basic terms and nomenclature.
- iii. Types of ligands
- iv. Isomerism :General Types with special reference to stereoisomerism of coordination compounds (C.N=6)
- v. Evidence for the formation of coordination compounds,

### 2.2.2. Theories of coordination compounds

- i. Werner's Theory of coordination compounds,
- ii. Effective atomic number rule.
- iii. Eighteen electron Rule

### 2.2.3. Nature of the Metal-Ligand Bond:

- i. Valence Bond Theory; Hybridisation of the central metal orbitals- $sp^3$ ,  $sd^3/d^3s$ ,  $sp^3d^2/d^2sp^3$ ,  $sp^2d$ ,
- ii. Inner and outer orbital complexes of .(suitable examples of Mn(II) Fe(II),Fe(III),Co(II)/Co(III),Ni(II), Cu(II) Zn(II) complexes with ligands like aqua, ammonia  $CN^-$  and halides may be used)
- iii. Limitations of V.B.T

### 2.2.4. Application of coordination compounds.

## Unit III: Organic Chemistry

### 3.1 Carboxylic Acids and their Derivatives :(11 Lectures)

3.1.1. Nomenclature, structure and physical properties, acidity of carboxylic acids, effects of substituents on acid strength of aliphatic and aromatic carboxylic acids.

3.1.2. Preparation of carboxylic acids: oxidation of alcohols and alkyl benzene, carbonation of Grignard and hydrolysis of nitriles.

3.1.3. Reactions: Acidity, salt formation, decarboxylation, Reduction of carboxylic acids with  $\text{LiAlH}_4$ , diborane, Hell-Volhard-Zelinsky reaction, Conversion of carboxylic acid to acid chlorides, esters, amides and acid anhydrides and their relative reactivity.

3.1.4. Mechanism of nucleophilic acyl substitution and acid-catalysed nucleophilic acyl substitution. Interconversion of acid derivatives by nucleophilic acyl substitution.

3.1.5. Mechanism of Claisen condensation and Dieckmann condensation.

### **3.2 Sulphonic acids: [4L]**

Nomenclature, preparation of aromatic sulphonic acids by sulphonation of benzene (with mechanism), toluene and naphthalene, Reactions: Acidity of arene sulfonic acid, Comparative acidity of carboxylic acid and sulfonic acids. Salt formation, desulphonation. Reaction with alcohol, phosphorous pentachloride, IPSO substitution.

## Reference Books:

### Unit I:

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt.Ltd., New Delhi (2009).
4. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co., New York (1985).
6. K.L.Kapoor A textbook of Physical Chemistry 3<sup>rd</sup> Ed. vol.1,2 Macmillan Publishing Co., New Delhi (2001)

### Unit II:

1. *Practical Inorganic Chemistry* by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972)
2. Inorganic Chemistry – Gary Wulfsberg, Viva Book, First Indian Edition 2002
3. Quantitative Analysis – R.A.Day, A.L. Underwood, sixth edition
4. Vogel's Textbook of quantitative chemical analysis – J Mendham, R C Denny, J D Barnes, M Thomas, B Sivasankar

### 5. References.

6. Bruce H. Mahan, University Chemistry, Narosa publishing house pg. 611 to 683.
7. R. Gopalan , Universities Press India Pvt.Ltd. Inorganic Chemistry for Undergraduates.
8. Chemistry of Transition Elements Pg.- 608 – 679 .
9. J. D. Lee, 4th Edn., Concise Inorganic Chemistry, ELBS, The group III elements Pg. 359- 648.
10. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3rd edition, Oxford University Press (1999) page 325-446.
11. Ramesh Kapoor and R.S. Chopra, Inorganic Chemistry, R. Chand publishers, New Delhi.
12. CNR Rao edited, University General Chemistry, 513-578.
13. James E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity,
14. Emeleus and Anderson, Modern Aspects of Inorganic Chemistry, page no. 435-463.
15. Cotton and Wilkinson, Advanced Inorganic Chemistry, 3<sup>rd</sup>. Edition.
16. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt., Ltd. (2002).
17. Puri, Sharma and Kalia, Milestone publishers, Principles of Inorganic Chemistry, page 416-628.
18. Bruce H. Mahan, University Chemistry, Narosa publishing house.
19. R. Gopalan , Universities Press India Pvt.Ltd. Inorganic Chemistry for Undergraduates.
20. J. D. Lee, 4th Edn., Concise Inorganic Chemistry, ELBS
21. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3rd edition, Oxford University Press (1999)
22. Ramesh Kapoor and R.S. Chopra, Inorganic Chemistry, R. Chand publishers, New Delhi.
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24. James E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity,

25. Emeleus and Anderson, Modern Aspects of Inorganic Chemistry
26. Cotton and Wilkinson, Advanced Inorganic Chemistry, 3<sup>rd</sup>. Edition.
27. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt., Ltd. (2002).
28. Puri, Sharma and Kalia, Milestone publishers, Principles of Inorganic Chemistry

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1. Morrison, R. T. and Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).2012
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)
4. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7<sup>th</sup> Ed. Cengage Learning India Edition, 2013.
5. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
6. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
7. Comprehensive Organic Chemistry- The synthesis and reactions of Organic Compounds, Derek barton ,W. David Ollis.
8. Kalsi, P. S. Textbook of Organic Chemistry 1<sup>st</sup> Ed., New Age International (P) Ltd. Pub.
9. Eliel, E. L. and Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
10. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005