UNDERGRADUATE SYLLABUS

Of

CHEMISTRY

Under

CHOICE BASED CREDIT SYSTEM (CBCS)

Department of Chemistry

JAGANNATH BAROOAH COLLEGE

(An Autonomous College Affiliated to Dibrugarh University)

BARPATRA ALI, JORHAT – 785001 (ASSAM)

COURSE STRUCTURE:CHEMISTRY (CORE)

Semester	Course No.	Paper Code	Paper Title	Course Type	Marks Distribution				Total Marks
					Theory	Theory IA	Practical	Practical IA	
SEM-I	CORE-01	CHMC-101	Inorganic Chemistry-I	Theory + Practical	50	15	30	5	100
	CORE-02	CHMC-102	Physical Chemistry-I	Theory + Practical	50	15	30	5	100
SEM-II	CORE-03	CHMC-201	Organic Chemistry-I	Theory + Practical	50	15	30	5	100
	CORE-04	CHMC-202	Physical Chemistry-II	Theory + Practical	50	15	30	5	100
SEM-III	CORE-05	CHMC-301	Inorganic Chemistry-II	Theory + Practical	50	15	30	5	100
	CORE-06	CHMC-302	Organic Chemistry-II	Theory + Practical	50	15	30	5	100
	CORE-07	CHMC-303	Physical Chemistry-III	Theory + Practical	50	15	30	5	100
	SEC-01	CHMS-301	Pharmaceutical Chemistry	Theory + Practical	25	0	15	10	50
SEM-IV	CORE-08	CHMC-401	Inorganic Chemistry-III	Theory + Practical	50	15	30	5	100
	CORE-09	CHMC-402	Organic Chemistry-III	Theory + Practical	50	15	30	5	100
	CORE-10	CHMC-403	Physical Chemistry-IV	Theory + Practical	50	15	30	5	100
	SEC-02	CHMS-401	Chemistry of Cosmetics & Perfumes	Theory + Practical	25	0	15	10	50
SEM-V	CORE-11	CHMC-501	Organic Chemistry-IV	Theory + Practical	50	15	30	5	100
	CORE-12	CHMC-502	Physical Chemistry-V	Theory + Practical	50	15	30	5	100
	DSE-01	CHMD-501	Green Chemistry	Theory + Practical	50	15	30	5	100
	DSE-02	CHMD-502	Inorganic Materials of Industrial Importance	Theory + Practical	50	15	30	5	100
SEM-VI	CORE-13	CHMC-601	Inorganic Chemistry-IV	Theory + Practical	50	15	30	5	100
	CORE-14	CHMC-602	Organic Chemistry-V	Theory + Practical	50	15	30	5	100
	DSE-03	CHMD-601	Industrial Chemicals and Environment	Theory + Practical	50	15	30	5	100
	DSE-04	CHMD-602	Project Work	Project Report			**80****	20	100

** Report: 50 marks; Presentation & Viva: 30 marks

/0/

COURSE STRUCTURE (GENERIC ELECTIVE)

Semester	Course No.	Paper Code	Paper Title	Course Type	Marks Distribution				Total Marks
					Theory	Theory IA	Practical	Practical IA	
SEM-I	GE-01	CHMG-101	Atomic Structure, Bonding, Organic Chemistry and Aliphatic Compounds	Theory + Practical	50	15	30	5	100
SEM-II	GE-02	CHMG-201	Chemical Energetics, Equilibria and Functional Organic Chemistry	Theory + Practical	50	15	30	5	100
SEM-III	GE-03	CHMG-301	Solutions, Phase Equilibria, Electrochemistry and Functional Group Organic Chemistry	Theory + Practical	50	15	30	5	100
SEM-IV	GE-04	CHMG-401	Transition Metal and Coordination Chemistry, States of Matters and Chemical Kinetics	Theory + Practical	50	15	30	5	100

COURSE STRUCTURE (AUDIT)

Semester	Course No.	Paper Code	Paper Title	Course Type	Marks Distribution				Total Marks
					Theory	Theory IA	Practical	Practical IA	
SEM-I	AC-01	CHMA-101	Atomic Structure, Bonding, Organic Chemistry and Aliphatic Compounds	Theory + Practical	50	15	30	5	100
SEM-II	AC-02	CHMA-201	Chemical Energetics, Equilibria and Functional Organic Chemistry	Theory + Practical	50	15	30	5	100
SEM-III	AC-03	CHMA-301	Solutions, Phase Equilibria, Electrochemistry and Functional Group Organic Chemistry	Theory + Practical	50	15	30	5	100
SEM-IV	AC-04	CHMA-401	Inorganic & Physical Chemistry	Theory + Practical	50	15	30	5	100

DETAILED SYLLABUS

FOR

CORE COURSE

B.Sc. (Honours) Chemistry

DETAILED SYLLABUS FOR CORE COURSE
B.Sc. (Honours) Chemistry

SEMESTER-I

Paper Title : **INORGANIC CHEMISTRY-I (THEORY)**
Paper Code : **CHMC-101**
Course No : C- 01
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

[**Course Objectives**: *To understand the important features of the quantum mechanical model of atom. To study the various approaches of bonding and shape of molecules. To apply the electrode potential in redox reactions and redox principle in volumetric analysis*]

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) Marks: 12

Unit-II: 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. Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table; Atomic radii (van der Waals), Ionic and crystal radii, Covalent radii (octahedral and tetrahedral), Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy, Electron gain enthalpy, trends of electron gain enthalpy. 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) Marks: 14

Unit-III: Chemical Bonding: ***Ionic Bonding****:* 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**.** ***Covalent Bonding****:* 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 N2, 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. ***Metallic***

***Bonding**:* Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids. ***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) Marks: 20

Unit-IV: Oxidation-Reduction: Redox equations, Standard Electrode Potential and its application to inorganic reactions. Principles involved in volumetric analysis to be carried out in class.

(04 Lectures) Marks: 04

INORGANIC CHEMISTRY-I (PRACTICAL)

Unit-I: Acid-Base Titrations

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

Unit-II: Oxidation-Reduction Titrimetry

1. Estimation of Fe (II) and oxalic acid using standardized $KMnO_4$ solution.
2. Estimation of oxalic acid and sodium oxalate in a given mixture.
3. Estimation of Fe (II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Reference Books:

1. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry* Oxford, 1970
3. Atkins, P.W. & Paula, J. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014
4. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
5. Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
6. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009

****$$$****

Paper Title	:	**PHYSICAL CHEMISTRY-I (THEORY)**
Paper Code	:	**CHMC-102**
Course No	:	C- 02
Credits	:	06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks:		65 (End Semester: 50; In Semester: 15)
Total Practical Marks:		35 (End Semester: 30; In Semester: 05)

(**Course Objectives**: *To impart basic knowledge of the three states of matter and the principles governing interaction of ions*.)

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 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) Marks: 15

Unit-II: 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) Marks: 5

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) Marks: 12

Unit-IV: 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) Marks: 18

PHYSICAL CHEMISTRY-I (PRACTICAL)

Unit-I: Surface Tension and Viscosity

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.

Unit-II: pH Metry

1. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures
2. Preparation of buffer solutions of different pH**: (i)** Sodium acetate-acetic acid **(ii)** Ammonium chloride-ammonium hydroxide
3. 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:

1. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 10th Ed., Oxford University Press (2014).
2. Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
3. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
4. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009).
5. Engel, T. & Reid, P. *Physical Chemistry* 3rd Ed. Pearson (2013).
6. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011)
7. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003)
8. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

****$$$****

DETAILED SYLLABUS FOR CORE COURSE
B.Sc. (Honours) Chemistry

SEMESTER-II

Paper Title	:	**ORGANIC CHEMISTRY-I (THEORY)**
Paper Code	:	**CHMC-201**
Course No	:	C- 03
Credits	:	06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks:		65 (End Semester: 50; In Semester: 15)
Total Practical Marks:		35 (End Semester: 30; In Semester: 05)

(**Course Objectives**: *To introduce with a variety of structural aspects of organic molecules that are designed to lay the foundations for the study of the organic molecules.*)

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.

(10 Lectures) Marks: 10

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.

(14 Lectures) Marks: 12

Unit-III: Chemistry of Aliphatic Hydrocarbons:

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

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

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) Marks: 22

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) Marks: 6

ORGANIC CHEMISTRY-I (PRACTICAL)

1. **Purification of organic compound and determination of melting point:** Purification of organic compounds by crystallization using the following solvents: Water**,** Alcohol**,** Alcohol-Water
2. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
3. **Chromatography:** Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
   Separation of a mixture of two sugars by ascending paper chromatography
   Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

Reference Books:

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
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. Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*, Wiley: London, 1994.
5. Kalsi, P. S. *Stereochemistry Conformation and Mechanism*, New Age International, 2005.
6. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
7. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
8. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)

****$$$****

Paper Title : **PHYSICAL CHEMISTRY-II (THEORY)**
Paper Code : **CHMC-202**
Course No : C- 04
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

(**Course Objectives**: *To discuss the role of energy in chemistry. To discuss equilibrium and the direction of natural change in chemistry.*)

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.

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) Marks: 24

Unit-II: 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) Marks: 6

Unit-III: 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.

(8 Lectures) Marks: 10

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.

(8 Lectures) Marks: 10

PHYSICAL CHEMISTRY-II (PRACTICAL)

Thermochemistry

1. 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).
2. Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Calculation of the enthalpy of ionization of ethanoic acid.
4. Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
5. 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
6. Determination of enthalpy of hydration of copper sulphate.
7. Study of the solubility of benzoic acid in water and determination of ΔH.

Reference Books

1. Peter, A. & Paula, J. de. *Physical Chemistry* 10th Ed., Oxford University Press (2014).
2. Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa (2004).
3. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
4. McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* Viva Books Pvt. Ltd.:New Delhi (2004).
5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics.* CRC Press: NY (2011).

6. Levine, I .N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill (2010).
7. Metz, C.R. *2000 solved problems in chemistry,* Schaum Series (2006).
8. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry,* R. Chand Co.: New Delhi (2011)
9. Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry* New Age International: New Delhi (2001).

****$$$****

DETAILED SYLLABUS FOR CORE COURSE
B.Sc. (Honours) Chemistry

SEMESTER-III

Paper Title : **INORGANIC CHEMISTRY-II (THEORY)**
Paper Code : **CHMC-301**
Course No : C- 05
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

(**Course Objectives**: *To understand Inorganic Chemistry in the form of materials science. To understand the occurrence of metals based on electrode potential, To classify substances as acids or bases according to Bronsted-Lowry and Lewis concepts, To understand Hard and Soft Acids and Bases (HSAB) principle and its application, To know the role of solvent in acidity or basicity of substances, To know the general chemistry of s & p block elements and basic idea on inorganic polymers*)

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 Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

(6 Lectures) Marks: 5

Unit-II: Acids and Bases: Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.

(8 Lectures) Marks: 7

Unit-III: Chemistry of s and p Block Elements: 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. 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.

(30 Lectures) Marks: 24

Unit-IV: Noble Gases: Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_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) Marks: 7

Unit-V: 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) Marks: 7**

INORGANIC CHEMISTRY-II (PRACTICAL)

Unit-I: Iodo / Iodimetric Titrations

(i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution iodimetrically.
(ii) Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically
(iii) Estimation of available chlorine in bleaching powder iodometrically.

Unit-II: **Inorganic Preparations**

(i) Cuprous Chloride, Cu_2Cl_2
(ii) Preparation of Manganese(III) phosphate, $MnPO_4.H_2O$
(iii) Preparation of Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash Alum) or Chrome alum.

Reference Books:

1. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.
4. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
5. Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010.
6. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.

****$$$****

Paper Title	:	**ORGANIC CHEMISTRY-II (THEORY)**
Paper Code	:	**CHMC-302**
Course No	:	C- 06
Credits	:	06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks:		65 (End Semester: 50; In Semester: 15)
Total Practical Marks:		35 (End Semester: 30; In Semester: 05)

(**Course Objectives**: *To impart basic knowledge on the chemistry of certain classes of organic compounds viz halogenated hydrocarbons, alcohols, phenols, ethers, carbonyl compounds, carboxylic acids and their derivatives).*

Unit-I: Chemistry of Halogenated Hydrocarbons:

Alkyl Halides: Methods of preparation, nucleophilic substitution reactions - S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl Halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; S_NAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

(16 Lectures) Marks: 14

Unit-II: Alcohols, Phenols, Ethers and Epoxides:

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; 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, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism; ***Ethers and Epoxides***: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$. ***Thiols & Thioethers***: Preparation and reactions

(16 Lectures) Marks: 12

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, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC); 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) Marks: 14

Unit-IV: Carboxylic Acids and their Derivatives:

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic sustitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann-bromamide degradation and Curtius rearrangement.

(14 Lectures) Marks: 10

ORGANIC CHEMISTRY-II (PRACTICAL)

Unit -I: Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.

Unit-II: Organic Preparations:

A. Acetylation of one of the following compounds: amines (aniline, o-, m -, p- toluidines and o-, m-, p-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: (i) Using conventional method (ii) Using green approach
B. Benzolyation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and one of the following phenols (β-naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction.

C. Oxidation of ethanol/ isopropanol (Iodoform reaction).
D. Bromination of any one of the following: (i) Acetanilide by conventional methods (ii) Acetanilide using green approach (Bromate-bromide method)
E. Nitration of any one of the following: (i) Acetanilide/nitrobenzene by conventional method (ii) Salicylic acid by green approach (using ceric ammonium nitrate).
F. Selective reduction of metadinitrobenzene to m-nitroaniline.
G. Reduction of p-nitrobenzaldehyde by sodium borohydride.
H. Hydrolysis of amides and esters.
I. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
J. S-Benzylisothiouronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).
K. Aldol condensation using either conventional or green method.
L. Benzil-Benzilic acid rearrangement.

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

Reference Books:

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
4. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
5. Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).
6. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. Practical Organic Chemistry, 5th Ed. Pearson (2012)
7. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
8. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)

****$$$****

Paper Title : **PHYSICAL CHEMISTRY-III (THEORY)**
Paper Code : **CHMC-303**
Course No : C- 07
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

(**Course Objectives**: *To understand phase diagram which summarize the behavior of substances under different condition. To introduce the principles of the study of reaction rates).*

Unit-I: Phase Equilibria: 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, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. 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 nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

(18 Lectures) Marks: 14

Unit-II: 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 rate laws, 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, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

(18 Lectures) Marks: 16

Unit-III: Catalysis: Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

(8 Lectures) Marks: 6

Unit-IV: Surface Chemistry: Physical adsorption, chemisorption, adsorption isotherms- Langmure & Freundlich. nature of adsorbed state.

(6 Lectures) Marks: 6

Unit-V: Photochemistry: Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitized reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

(10 Lectures) Marks: 8

PHYSICAL CHEMISTRY-III (PRACTICAL)

Unit-I: Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.

Unit-II: Phase Equilibria: Construction of the phase diagram using cooling curves or ignition tube method: (i) Simple eutectic and (ii) Congruently melting systems.

Unit-III: Distribution of acetic/ benzoic acid between water and cyclohexane.

Unit-IV: Study the equilibrium of at least one of the following reactions by the distribution method:

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

(ii) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n$

Unit-V: Study the kinetics of the following reactions.

A. Initial rate method: Iodide-persulphate reaction

B. Integrated rate method: (i) Acid hydrolysis of methyl acetate with hydrochloric acid. (ii) Saponification of ethyl acetate.

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

Unit-VI: **Adsorption**: Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Reference Books:

1. Peter Atkins & Julio De Paula, Physical Chemistry 10th Ed., Oxford University Press (2014).
2. Castellan, G. W. Physical Chemistry, 4th Ed., Narosa (2004).
3. McQuarrie, D. A. & Simon, J. D., Molecular Thermodynamics, Viva Books Pvt. Ltd.: New Delhi (2004).
4. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
6. Zundhal, S.S. Chemistry concepts and applications Cengage India (2011).
7. Ball, D. W. Physical Chemistry Cengage India (2012).
8. Mortimer, R. G. Physical Chemistry 3rd Ed.,Elsevier: NOIDA, UP (2009).
9. Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
10. Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009).
11. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
12. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
13. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

****$$$****

DETAILED SYLLABUS FOR SKILL BASED COURSE
B.Sc. (Honours) Chemistry

SEMESTER-III

Paper Title	:	**PHARMACEUTICAL CHEMISTRY (THEORY)**
Paper Code	:	**CHMS-301**
Course No	:	SEC- 01
Credits	:	02 (Theory + Practical/Project) No. of Classes: 30
Total Theory Marks:		25 (End Semester: 25; In Semester: 00)
Total Practical Marks:		15 (End Semester: 10; In Semester: 05)

(**Course Objectives**: *To understand basic chemistry of various drugs and their mechanism as well as their preparation)*

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

(20 Lectures) Marks: 12

Unit-II: Fermentation: Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B_2, Vitamin B_{12} and Vitamin C.

(10 Lectures) Marks: 8

PHARMACEUTICAL CHEMISTRY (PRACTICALS)

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

Reference Books:

1. Patrick, G. L. *Introduction to Medicinal Chemistry, Oxford University* Press, UK, 2013.
2. Singh, H. & Kapoor, V.K. *Medicinal and Pharmaceutical Chemistry,* Vallabh Prakashan, Pitampura, New Delhi, 2012
3. Foye, W.O., Lemke, T.L. & William, D.A.: *Principles of Medicinal Chemistry*, 4th ed., B.I. Waverly Pvt. Ltd. New Delhi.

****$$$****

DETAILED SYLLABUS FOR CORE COURSE
B.Sc. (Honours) Chemistry

SEMESTER-IV

Paper Title	:	**INORGANIC CHEMISTRY-III (THEORY)**
Paper Code	:	**CHMC-401**
Course No	:	C- 08
Credits	:	06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks:		65 (End Semester: 50; In Semester: 15)
Total Practical Marks:		35 (End Semester: 30; In Semester: 05)

(Course Objectives: *To understand bonding in coordination compounds. To have a basic knowledge of the properties of d and f block elements and to understand the role of metals in our body)*

UNIT-I: Coordination Chemistry: Werner's theory, Valence Bond Theory (Inner and Outer Orbital Complexes), Electro-neutrality principle and back bonding. Crystal Field Theory, Measurement of 10 Dq (Δo), CFSE in Weak and Strong Fields, Pairing Energies, Factors Affecting the Magnitude of 10 Dq (Δo, Δt). Octahedral vs. Tetrahedral Coordination, Tetragonal Distortions from Octahedral Geometry, Jahn-Teller Theorem, Square Planar Geometry, Qualitative Aspect 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, polynuclear complexes, Labile and inert complexes.

(26 Lectures, Marks: 25)

UNIT-II: Transition Elements: General group trends with special reference to electronic configuration, colour, variablevalency, magnetic and catalytic properties, ability to form complexes. Stability of variousoxidation states and e.m.f. (Latimer & Bsworth diagrams).Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy)

(18 Lectures, Marks: 12)

UNIT-III: Lanthanoids and Actinoids: Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).

(6 Lectures, Marks: 5)

UNIT-IV: Bioinorganic Chemistry: Metal ions present in biological systems, classification of elements according to their actionin biological system. Geochemical effect on the distribution of metals.Sodium / 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 inmedicine.Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.

(10 Lectures, Marks: 8)

INORGANIC CHEMISTRY-III (PRACTICAL)

UNIT-I: 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 $Al(oxine)_3$

UNIT-II: Inorganic Preparations:

i. Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$
ii. *Cis* and *trans* $K[Cr(C_2O_4)_2.(H_2O)_2]$ Potassium dioxalatodiaquachromate (III)
iii. Tetraamminecarbonatocobalt (III) ion $[Co(NH_3)_4(CO_3)]^+$
iv. Potassium tris(oxalate)ferrate (III) $K_3[Fe(C_2O_4)_3]$

U**NIT-III**: **Chromatography of Metal Ions:**
Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

i. Ni (II) and Co (II)
ii. Fe (III) and Al (III

Reference Books:

1. Purcell, K.F & Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977.
2. Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.
3. Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
4. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry Wiley-VCH, 1999
5. Basolo, F, and Pearson, R.C. Mechanisms of Inorganic Chemistry , John Wiley & Sons, NY, 1967
6. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,Pearson, 2009.

****$$$****

Paper Title	:	**ORGANIC CHEMISTRY-III (THEORY)**
Paper Code	:	**CHMC-402**
Course No	:	C- 09
Credits	:	06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks:		65 (End Semester: 50; In Semester: 15)
Total Practical Marks:		35 (End Semester: 30; In Semester: 05)

(Course Objectives: *To deal in detail the different aspects of the chemistry of heterocyclic compounds, polynuclear hydrocarbons, alkaloids, terpenoids etc.)*

Unit-I: Nitrogen Containing Functional Groups: Preparation and important reactions of nitro compounds, nitriles and isonitriles Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3°amines with Hinsberg reagent and nitrous acid.

Diazonium Salts: Preparation and their synthetic applications.

(16 Lectures) Marks: 12

Unit-II: Polynuclear Hydrocarbons: Structure, preparation and reactions of Reactions of naphthalene phenanthrene and anthracene.

(6 Lectures) Marks: 6

Unit-III: Heterocyclic Compounds: Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction,

(16 Lectures) Marks: 12

Unit-IV: Alkaloids: Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

(7 Lectures) Marks: 7

Unit-V: Terpenes : Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral, Neral and α-terpineol.

(5 Lectures) Marks: 5

Unit-VI: Pharmaceutical Compounds: Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

(10 Lectures) Marks: 8

ORGANIC CHEMISTRY-III (PRACTICAL)

Unit-I: Detection of extra elements.

Unit-II: Functional group test for nitro, amine and amide groups.

Unit-III: Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)

Reference Books:

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
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. Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds,John Welly & Sons (1976).
5. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
6. McMurry, J.E. Fundamentals of Organic Chemistry , 7th Ed. Cengage Learning India Edition, 2013.
7. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
8. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
9. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Pragati Parakashan (2010).
10. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
11. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
12. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
13. Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

****$$$****

Paper Title	:	**PHYSICAL CHEMISTRY-IV (THEORY)**
Paper Code	:	**CHMC-403**
Course No	:	C- 10
Credits	:	06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks:		65 (End Semester: 50; In Semester: 15)
Total Practical Marks:		35 (End Semester: 30; In Semester: 05)

(Course Objectives: To understand the theories governing the flow of electric current in solution and the working of Galvanic cell.*)*

Unit-I: Conductance: 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-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. 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) Marks: 12

Unit-II: Electrochemistry: Quantitative aspects of Faraday's 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 different kinds of half-cells. Application of EMF measurements in determining (i) free

energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb2O3 electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

(18 Lectures) Marks: 16

Unit-III: Electrical & Magnetic Properties of Atoms and Molecules: Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

(10 Lectures) Marks: 8

Unit-IV: Polymer Chemistry: Introduction and classification including di-block, tri-block and amphiphilic polymers; Number average molecular weight, Weight average molecular weight, Degree of polymerization, Polydispersity Index. Polymerisation reactions -Addition and condensation - Mechanism of cationic, anionic and free radical addition polymerization.

(16 Lectures) Marks: 14

PHYSICAL CHEMISTRY-IV (PRACTICAL)

Unit-I: Conductometry

1. Determination of cell constant
2. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

Unit-II: Conductometric Titrations

a. Strong acid vs. strong base
b. Weak acid vs. strong base
c. Mixture of strong acid and weak acid vs. strong base
d. Strong acid vs. weak base

Unit-III: Potentiometry

i. Strong acid vs. strong base
ii. Weak acid vs. strong base
iii. Dibasic acid vs. strong base
iv. Potassium dichromate vs. Mohr's salt

Reference Books:

1. Atkins, P.W & Paula, J.D. Physical Chemistry, 10th Ed., Oxford University Press (2014).
2. Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
3. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009)
4. Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
5. Engel, T. & Reid, P. Physical Chemistry3rd Ed., Prentice-Hall (2012).
6. Rogers, D. W. Concise Physical Chemistry Wiley (2010).
7. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).
8. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011)

9. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
10. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.;W.H. Freeman & Co.: New York (2003).

****$$$****

DETAILED SYLLABUS FOR SKILL BASED COURSE
B.Sc. (Honours) Chemistry

SEMESTER-IV

Paper Title : **CHEMISTRY OF COSMETICS & PERFUMES (THEORY)**
Paper Code : **CHMS-401**
Course No : SEC- 02
Credits : 02 (Theory + Practical/Project) No. of Classes: 30
Total Theory Marks: 25 (End Semester: 25; In Semester: 00)
Total Practical Marks: 15 (End Semester: 10; In Semester: 05)

(Course Objectives: To provide general overview on cosmetics and perfumes)

Unit-I: A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

(30 Lectures) Marks: 20

CHEMISTRY OF COSMETICS & PERFUMES (PRACTICALS)

1. Preparation of talcum powder.
2. Preparation of shampoo.
3. Preparation of enamels.
4. Preparation of hair remover.
5. Preparation of face cream.
6. Preparation of nail polish and nail polish remover.

Reference Books:

1. Stocchi, E. *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK (1990).
2. Jain, P.C. & Jain, M. *Engineering Chemistry* Dhanpat Rai & Sons, Delhi.
3. Sharma, B.K. & Gaur, H. *Industrial Chemistry,* Goel Publishing House, Meerut, (1996).

****$$$****

DETAILED SYLLABUS FOR CORE COURSE
B.Sc. (Honours) Chemistry

SEMESTER-V

Paper Title	:	**ORGANIC CHEMISTRY-IV (THEORY)**
Paper Code	:	**CHMC-501**
Course No	:	C- 11
Credits	:	06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks:		65 (End Semester: 50; In Semester: 15)
Total Practical Marks:		35 (End Semester: 30; In Semester: 05)

(**Course Objectives**: *To understand the biochemistry and biological process of our body)*

Unit-I: Nucleic Acids: Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

(9 Lectures) Marks: 7

Unit-II: Amino Acids, Peptides and Proteins: Amino acids, Peptides and their classification. α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, pKa values, isoelectric point and electrophoresis; Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups - Solid-phase synthesis

(14 Lectures) Marks: 12

Unit-III: Enzymes: Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

(10 Lectures) Marks: 8

Unit-IV: Lipids: Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenntion of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

(6 Lectures) Marks: 5

Unit-V: Concept of Energy in Biosystems: Cells obtain energy by the oxidation of foodstuff (organic molecules). Introduction to metabolism (catabolism, anabolism). ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change. Agents for transfer of electrons in biological redox systems: NAD^+, FAD. Conversion of food to energy: Outline of catabolic pathways of carbohydrate- glycolysis, fermentation, Krebs cycle.

(7 Lectures) Marks: 6

Unit-VI: Carbohydrates: Occurrence, classification and their biological importance. Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and

Ruff degradation; Disaccharides – Structure elucidation of maltose, lactose and sucrose. Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

(14 Lectures) Marks: 12

ORGANIC CHEMISTRY-IV (PRACTICAL)

1. Estimation of glycine by Sorenson's formalin method.
2. Study of the titration curve of glycine.
3. Estimation of proteins by Lowry's method.
4. Study of the action of salivary amylase on starch at optimum conditions.
5. Effect of temperature on the action of salivary amylase.
6. Saponification value of an oil or a fat.
7. Determination of Iodine number of an oil/ fat.
8. Isolation and characterization of DNA from onion/ cauliflower/peas.

Reference Books:

1. Berg, J.M., Tymoczko, J.L. & Stryer, L. (2006) Biochemistry. 6th Ed. W.H. Freeman and Co.
2. Nelson, D.L., Cox, M.M. & Lehninger, A.L. (2009) Principles of Biochemistry. IV Edition.W.H. Freeman and Co.
3. Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange Medical Books/ McGraw-Hill.
4. Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
5. Arthur, I. V. Quantitative Organic Analysis, Pearson.

****$$$****

Paper Title : **PHYSICAL CHEMISTRY-V (THEORY)**
Paper Code : **CHMC-502**
Course No : C- 12
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

(Course Objectives: *To understand quantum mechanics, mathematical approaches in quantum mechanics and calculation of different forms of energy relative to chemical bonding, To understand the basic theory and application of various types of spectroscopy)*

Unit-I: Quantum Chemistry: Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy. Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy. Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution. Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final

energy expression). Average and most probable distances of electron from nucleus. Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom). Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H2+. Bonding and antibonding orbitals. Qualitative extension to H_2 .

Comparison of LCAO-MO and VB treatments of H2 (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH).

(30 Lectures) Marks: 25

Unit-II: Molecular Spectroscopy: Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation. **Rotation Spectroscopy**: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution. **Vibrational Spectroscopy**: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations , anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. **Vibration-rotation Spectroscopy**: diatomic vibrating rotator, P, Q, R branches. **Raman Spectroscopy**: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion. **Electronic Spectroscopy**: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model. **Nuclear Magnetic Resonance (NMR) Spectroscopy**: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra. **Electron Spin Resonance (ESR) Spectroscopy**: Its principle, hyperfine structure, ESR of simple radicals.

(30 Lectures) Marks: 25

PHYSICAL CHEMISTRY-IV (PRACTICAL)

Unit-I: UV/Visible spectroscopy

1. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λmax values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).
2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$
3. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

Unit-II: Colourimetry

1. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration
2. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
3. Study the kinetics of iodination of propanone in acidic medium.

4. Determine the amount of iron present in a sample using 1,10-phenathroline.
5. Determine the dissociation constant of an indicator (phenolphthalein)
6. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
7. Analysis of the given vibration-rotation spectrum of HCl(g)

Reference Books:

1. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001)
3. House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
4. Kakkar, R. Atomic & Molecular Spectroscopy: Concepts & Applications, Cambridge University Press (2015)
5. Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
6. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
7. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
8. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.;W.H. Freeman & Co.: New York (2003).

****$$$****

DETAILED SYLLABUS FOR DISCIPLINE SPECIFIC ELECTIVE COURSE
B.Sc. (Honours) Chemistry

SEMESTER-V

Paper Title : **GREEN CHEMISTRY (THEORY)**
Paper Code : **CHMD-501**
Course No : DSE- 01
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

Unit-I: Introduction to Green Chemistry: What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry

(4 Lectures) Marks: 4

Unit-II: Principles of Green Chemistry and Designing a Chemical synthesis: Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following:

(i) Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products , Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions.

(ii) Prevention/ minimization of hazardous/ toxic products reducing toxicity. risk = (function) hazard × exposure; waste or pollution prevention hierarchy.

(iii) Green solvents– supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents.

(iv) Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy.

(v) Selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups.

(vi) Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.

(vii) Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD "What you don't have cannot harm you", greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.

(viii) Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

(30 Lectures) Marks: 24

Unit-III: Examples of Green Synthesis/ Reactions and some real world cases:

(i) Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)

(ii) Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction

(iii) Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)

(iv) Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO2 for precision cleaning and dry cleaning of garments.

(v) Designing of Environmentally safe marine antifoulant.

(vi) Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments.

(vii) An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

(viii) Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils

(ix) Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting

(16 Lectures) Marks: 14

Unit-IV: Future Trends in Green Chemistry: Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C2S3); Green chemistry in sustainable development.

(10 Lectures) Marks: 8

GREEN CHEMISTRY (PRACTICAL)

1. Safer starting materials: Preparation and characterization of nanoparticles of silver using tea leaves
2. Using renewable resources: Preparation of biodiesel from vegetable/ waste cooking oil.
3. Avoiding waste: Principle of atom economy**,** Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry. Preparation of propene by two methods can be studied

   Triethylamine ion + OH^- → propene + trimethylpropene + water

   1-propanol $-(H_2SO_4/\Delta)\rightarrow$ propene + water

   Other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy.
4. Use of enzymes as catalysts: Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.
5. Alternative Green solvents: Extraction of D-limonene from orange peel using liquid CO2 prepared form dry ice. Mechanochemical solvent free synthesis of azomethines
6. Alternative sources of energy***:*** Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II). Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Reference Books:

1. Ahluwalia, V.K. & Kidwai, M.R. New Trends in Green Chemistry, Anamalaya Publishers (2005).
2. Anastas, P.T. & Warner, J.K.: Green Chemistry - Theory and Practical, Oxford University Press (1998).
3. Matlack, A.S. Introduction to Green Chemistry, Marcel Dekker (2001).
4. Cann, M.C. & Connely, M.E. Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
5. Ryan, M.A. & Tinnesand, M. Introduction to Green Chemistry, American Chemical Society, Washington (2002).
6. Lancaster, M. Green Chemistry: An Introductory Text RSC Publishing, 2nd Edition, 2010.
7. Anastas, P.T & Warner, J.C. Green Chemistry: Theory and Practice, Oxford University Press (1998)
8. Kirchoff, M. & Ryan, M.A. Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington DC (2002)
9. Ryan, M.A. Introduction to Green Chemistry, Tinnesand; (Ed), American Chemical Society, Washington DC (2002)
10. Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi (2013).
11. Cann, M.C. & Connelly, M. E. Real world cases in Green Chemistry American Chemical Society (2008)
12. Lancaster, M. Green Chemistry: An Introductory Text RSC Publishing, 2nd Edition, 2010.
13. Pavia, D.L., Lampman, G.M., Kriz, G.S. & Engel, R.G. Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach, W.B.Saunders, 1995.

****$$$****

Paper Title	:	**INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE (THEORY)**
Paper Code	:	**CHMD-502**
Course No	:	DSE- 02
Credits	:	06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks:		65 (End Semester: 50; In Semester: 15)
Total Practical Marks:		35 (End Semester: 30; In Semester: 05)

(Course Objectives: *To study the basic chemistry of some industrially important compounds)*

Unit-I: Silicate Industries: Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass. **Ceramics:** Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre. **Cements:** Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

(16 Lectures) Marks: 13

Unit-II: Fertilizers: Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

(8 Lectures) Marks: 6

Unit-III: Surface Coatings: Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolytic and electroless), metal spraying and anodizing.

(10 Lectures) Marks: 9

Unit-IV: Batteries: Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

(6 Lectures) Marks: 5

Unit-V: Alloys: Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

(10 Lectures) Marks: 9

Unit-VI: Catalysis: General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts. Phase transfer catalysts, application of zeolites as catalysts.

(6 Lectures) Marks: 5

Unit VII: Chemical explosives: Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.

(4 Lectures) Marks: 3

INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE (PRACTICAL)

1. Determination of free acidity in ammonium sulphate fertilizer
2. Estimation of Calcium in Calcium ammonium nitrate fertilizer.
3. Estimation of phosphoric acid in superphosphate fertilizer.
4. Electroless metallic coatings on ceramic and plastic material.
5. Determination of composition of dolomite (by complexometric titration).
6. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
7. Analysis of Cement.
8. Preparation of pigment (zinc oxide).

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain:Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
7. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
8. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
9. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
10. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi
11. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
12. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
13. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).

****$$$****

DETAILED SYLLABUS FOR CORE COURSE
B.Sc. (Honours) Chemistry

SEMESTER-VI

Paper Title	:	**INORGANIC CHEMISTRY-IV (THEORY)**
Paper Code	:	**CHMC-601**
Course No	:	C- 13
Credits	:	06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks:		65 (End Semester: 50; In Semester: 15)
Total Practical Marks:		35 (End Semester: 30; In Semester: 05)

(Course Objectives: *To understand the separation principle of cations and anions, To focus on* the synthesis, structure and bonding, properties and reactivity of main group organometallics, organotransition metal chemistry and organometallic catalysis.*)*

Unit-I: Theoretical Principles in Qualitative Analysis (H_2S Scheme): Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

(8 Lectures) Marks: 6

Unit-II: Organometallic Compounds: Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls. Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

(26 Lectures) Marks: 20

Unit-III: Reaction Kinetics and Mechanism: Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.

(16 Lectures) Marks: 15

Unit-IV: Catalysis by Organometallic Compounds: Study of the following industrial processes and their mechanism: Alkene hydrogenation (Wilkinsons Catalyst)**,** Hydroformylation (Co salts), Wacker Process, Synthetic gasoline (Fischer Tropsch reaction) and Synthesis gas by metal carbonyl complexes

(10 Lectures) Marks: 8

INORGANIC CHEMISTRY-IV (PRACTICAL)

Unit-I: Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+},, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+},Sr^{2+}, Ca^{2+}, Mg^{2+}

Mixtures should preferably contain one interfering anion, OR Insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) OR Combination of anions e.g. CO_3^{2-}-and SO_3^{2-}, NO_2^- and NO_3^-, Cl^-, and Br^-, $Cl^-$and I^-, $Br^-$and I^-, NO_3^- and Br-, $NO_3^-$and I^-.

Spot tests should be done whenever possible.

Unit-II: Measurement of 10 Dq by spectrophotometric method

Unit-III: Verification of spectrochemical series

Unit-IV: Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.

Unit-V: Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}. Find the λmax of the complex

Unit-VI: Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

Reference Books:

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, 7th Edition, Prentice Hall, 1996.
2. Cotton, F.A.G.; Wilkinson & Gaus, P.L. Basic Inorganic Chemistry 3rd Ed.; Wiley India,
3. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed.,Harper Collins 1993, Pearson,2006
4. Sharpe, A.G. Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005
5. Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry 3rd Ed., John Wiley and Sons, NY, 1994.
6. Greenwood, N.N. & Earnshaw, A. Chemistry of the Elements, Elsevier 2nd Ed, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
7. Lee, J.D. Concise Inorganic Chemistry 5th Ed.,John Wiley and sons 2008.
8. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
9. Shriver, D.D. & P. Atkins, Inorganic Chemistry 2nd Ed.,Oxford University Press, 1994.
10. Basolo, F. & Pearson, R. Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution 2nd Ed., John Wiley & Sons Inc; NY.
11. Purcell, K.F. & Kotz, J.C., Inorganic Chemistry, W.B. Saunders Co. 1977
12. Miessler, G. L. & Tarr, D.A. Inorganic Chemistry 4th Ed., Pearson, 2010.
13. Collman, J. P. et al. Principles and Applications of Organotransition Metal Chemistry . Mill Valley, CA: University Science Books, 1987.
14. Crabtree, R. H. The Organometallic Chemistry of the Transition Metals. J New York, NY: John Wiley, 2000.
15. Spessard, G. O. & Miessler, G.L. Organometallic Chemistry. Upper Saddle River, NJ: Prentice-Hall, 1996.
16. Vogel's Qualitative Inorganic Analysis, Revised by G. Svehla. Pearson Education, 2002.
17. Marr & Rockett Practical Inorganic Chemistry. John Wiley & Sons 1972.

****$$$****

Paper Title : **ORGANIC CHEMISTRY-V (THEORY)**
Paper Code : **CHMC-602**
Course No : C- 14
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

(Course Objectives: *To understand spectroscopic techniques use in organic chemistry, To understand the chemistry of dyes and polymers, To understand pericyclic reactins and basic systematic organic synthesis procedures.)*

Unit-I: Organic Spectroscopy: General principles Introduction to absorption and emission spectroscopy.

UV Spectroscopy: Types of electronic transitions, λmax, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λmax for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds.

Mass Spectroscopy: Principle and molecular ion peak.

Applications of IR, UV and NMR for identification of simple organic molecules.

(22 Lectures) Marks: 23

Unit-II: Dyes : Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing; Synthesis and applications of: Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling); Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet; Phthalein Dyes – Phenolphthalein and Fluorescein; Natural dyes –structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

(8 Lectures) Marks: 6

Unit-III: Polymers: Metallocene-based Ziegler-Natta polymerisation of alkenes; **Preparation and applications of plastics** – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene); **Fabrics** – natural and synthetic (acrylic, polyamido, polyester); **Rubbers** – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives; Introduction to liquid crystal polymers; Biodegradable and conducting polymers with examples.

(6 Lectures) Marks: 5

Unit-IV: Pericyclic Reactions: Defination and classification, Orbital symmetry and HOMO-LUMO approach (FMO method), Cycloaddition reactions ([2+2] and [4+2]), electro-cyclic reactions and sigma-tropic rearrangement (Cope and Claisen)

(12 Lectures) Marks: 8

Unit-V: Planning of Organic Synthesis: Disconnection, functional group interchange (FGI), functional group addition (FGA), synthons and synthetic equivalent, simple example of reactions (Corey House, witting and aldol condensation), retrosynthesis of monofunctionalised compounds.

(12 Lectures) Marks: 8

ORGANIC CHEMISTRY-IV (PRACTICAL)

1. Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of urea formaldehyde.
4. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
5. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc
6. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).
7. Preparation of methyl orange.

Reference Books:

1. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
2. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.
4. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub.
5. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
7. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
8. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
9. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Prakashan (2010).
10. Kemp, W. Organic Spectroscopy, Palgrave.
11. Vogel, A.I. Quantitative Organic Analysis, Part 3, Pearson (2012).
12. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
13. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
14. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
15. Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

****$$$****

DETAILED SYLLABUS FOR DISCIPLINE SPECIFIC ELECTIVE COURSE
B.Sc. (Honours) Chemistry

SEMESTER-VI

Paper Title : **INDUSTRIAL CHEMICALS AND ENVIRONMENT (THEORY)**
Paper Code : **CHMD-601**
Course No : DSE- 03
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)

Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

*(**Course Objectives:** To understand the types as well as effect of various industrial gaes in our human body. To understand the environment and ecology)*

Unit I: Industrial Gases and Inorganic Chemicals Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

Inorganic Chemicals: Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

(10 Lectures) Marks: 10

Unit II: Industrial Metallurgy: Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

(4 Lectures) Marks: 4

Unit III: Environment and its segments Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur. Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution. Pollution by SO_2, CO_2, CO, NO_x, H_2S and other foul smelling gases. Methods of estimation of CO, NO_x, SOx and control procedures. Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates. Water Pollution: Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems. Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal. Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

(30 Lectures) Marks: 24

Unit IV: Energy & Environment: Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

(10 Lectures) Marks: 8

Unit V: Biocatalysis: Introduction to biocatalysis: Importance in "Green Chemistry" and Chemical Industry.

(6 Lectures) Marks: 4

INDUSTRIAL CHEMICALS & ENVIRONMENT (PRACTICAL)

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)

3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
6. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.
7. Measurement of dissolved CO_2.
8. Study of some of the common bio-indicators of pollution.
9. Estimation of SPM in air samples.
10. Preparation of borax/ boric acid.

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
4. S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
5. K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
6. S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.
7. S.E. Manahan, Environmental Chemistry, CRC Press (2005).
8. G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
9. A. Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).

****$$$****

Paper Title	:	**RESEARCH PROJECT**
Paper Code	:	**CHMD-602**
Course No	:	DSE- 04
Credits	:	06
Total Marks:		100 (Report: 50; Presentation: 30; In Semester: 20)

[Students will submit a research project report on any relevant topic of chemistry / bio-chemistry etc. under the supervision of any faculty members of the department. Report prepared by the students during their summer/ winter internship programmmes under different schemes of Govt. of India will also be considered as his/ her research project report for Discipline Specific Elective-IV.]

****$$$****

DETAILED SYLLABUS

FOR

GENERIC ELECTIVE COURSE

B.Sc. with Chemistry

DETAILED SYLLABUS FOR GENERIC ELECTIVE COURSE
B.Sc. with Chemistry

SEMESTER-I

Paper Title : **Atomic Structure, Bonding, Organic Chemistry and Aliphatic Compounds (Theory)**
Paper Code : **CHMG-101**
Course No : GE- 01
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

Section-A: (INORGANIC CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

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 $\psi 2$, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wavefunctions (atomic orbitals) and their variations for 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* 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 1*s* and 2*s* 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) Marks: 12

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 NO+. Comparison of VB and MO approaches.

(16 Lectures) Marks: 13

Section-B: (ORGANIC CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

Unit-I: 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 p^{Ka} values. Aromaticity: Benzenoids and Hückel's rule.

(8 Lectures) Marks: 7

Unit-II: 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) Marks: 8

Unit-III: 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) Marks: 10

Atomic Structure, Bonding, Organic Chemistry and Aliphatic Compounds (Practical)

Section A: (INORGANIC CHEMISTRY)
Total Marks: 15

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)
Total Marks: 15

6. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
7. 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 two 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:

1. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Cotton, F.A., Wilkinson, G. & Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons.

4. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education India, 2006.
5. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013
6. Eliel, E.L. *Stereochemistry of Carbon Compounds*, Tata McGraw Hill education, 2000.
7. Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
8. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.
9. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
10. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
11. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.

****$$$****

SEMESTER-II

Paper Title : **Chemical Energetics, Equilibria and Functional Organic Chemistry (Theory)**
Paper Code : **CHMG-201**
Course No : GE- 02
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

Section-A: (PHYSICAL CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

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) Marks: 8

Unit II: Chemical Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔGo, Le Chatelier's principle. Relationships between *Kp, Kc* and *Kx* for reactions involving ideal gases.

(8 Lectures) Marks: 6

Unit III: 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) Marks: 11

Section-A: (ORGANIC CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

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

Unit I: 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) Marks: 6

Unit II: 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_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

(8 Lectures) Marks: 7

Unit III: Alcohols, Phenols and Ethers: ***Alcohols:*** (Upto 5 Carbons) *Preparation:* Preparation of 1o, 2o and 3o 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:* Cumene hydroperoxide 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, $NaHSO_3$, NH_2-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) Marks: 12

Chemical Energetics, Equilibria and Functional Organic Chemistry (Practical)

Section-A: (PHYSICAL CHEMISTRY)
Total Marks: 15

Unit-I: 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.

Unit-II: Ionic Equilibria

pH measurements: 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.

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-A: (ORGANIC CHEMISTRY)
Total Marks: 15

Purification of organic compounds by crystallization (from water and alcohol) and distillation.

Criteria of Purity: Determination of melting and boiling points.

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:

1. Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. *Organic Chemistry,* John Wiley & Sons (2014).
2. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
3. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* Orient Longman, New Delhi (1988).
4. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.
5. Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
6. Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
7. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
8. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
9. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).

****$$$****

SEMESTER-III

Paper Title : **Solutions, Phase Equilibria, Electrochemistry and Functional Group Organic Chemistry (Theory)**
Paper Code : **CHMG-301**
Course No : GE- 03
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

Section-A: (PHYSICAL CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

Unit I: Solutions : Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature-

composition 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) Marks: 7

Unit II: Phase Equilibria: 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).

(8 Lectures) Marks: 6

Unit III: 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).

(6 Lectures) Marks: 5

Unit IV: Electrochemistry: Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS 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 treatment (acid-base and oxidation-reduction only).

(8 Lectures) Marks: 7

Section-A: (PHYSICAL CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

Unit I: 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) Marks: 5

Unit II: Amines and Diazonium Salts Amines (Aliphatic and Aromatic): (Upto 5 carbons): Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation. Diazonium salts: Preparation: from aromatic amines. Reactions: conversion to benzene, phenol, dyes.

(6 Lectures) Marks: 5

Unit III: Amino Acids, Peptides and Proteins: Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis. Reactions

of Amino acids: ester of –COOH group, acetylation of –NH2 group, complexation with Cu^{2+} ions, ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C–terminal (thiohydantoin 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) Marks: 8

Unit IV: 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.

(8 Lectures) Marks: 7

Solutions, Phase Equilibria, Electrochemistry and Functional Group Organic Chemistry (Practical)

Section-A: (PHYSICAL CHEMISTRY)
Total Marks: 15

Unit-I: Distribution: Study of the equilibrium of one of the following reactions by the distribution method:

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

$Cu^{2+}(aq) + Xnh_2(aq) \rightarrow [Cu(NH_3)x]^{2+}$

Unit-II: Phase Equilibria: Construction of the phase diagram of a binary system (simple eutectic) using cooling curves. Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it. Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

Unit-III: Conductance: Determination of cell constant, Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid. Perform the following conductometric titrations:

a. Strong acid vs. strong base

b. Weak acid vs. strong base

Unit-IV: 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)
Total Marks: 15

Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

Separation of amino acids by paper chromatography

Determination of the concentration of glycine solution by formylation method.

Titration curve of glycine

Action of salivary amylase on starch

Effect of temperature on the action of salivary amylase on starch.

Differentiation between a reducing and a nonreducing sugar.

Reference Books:

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
4. Mahan, B.H. University Chemistry, 3rd Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).
6. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed.,
8. Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.
9. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
10. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
11. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011)
12. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

****$$$****

SEMESTER-IV

Paper Title : **Transition Metal and Coordination Chemistry, States of Matters and Chemical Kinetics (Theory)**

Paper Code : **CHMG-401**
Course No : GE- 04
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

Section-A: (INORGANIC CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

Unit I: Transition Elements (3d series): General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu. Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

(12 Lectures) Marks: 10

Unit II: Coordination Chemistry: Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and

stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature.

(8 Lectures) Marks: 7

Unit III: Crystal Field Theory : Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for Oh and Td complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.

(10 Lectures) Marks: 8

Section-A: (PHYSICAL CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

Unit I: 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. Andrews isotherms of CO_2.

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) Marks: 7

Unit II: 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).

(4 Lectures) Marks: 5

Unit III: 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. X–Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

(8 Lectures) Marks: 6

Unit IV: 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). Half–life 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) Marks: 7

Transition Metal and Coordination Chemistry, States of Matters and Chemical Kinetics (Practical)

Section-A: (INORGANIC CHEMISTRY)

Total Marks: 15

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

Cations: NH_4, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Fe^{3+}, Al^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+},Sr^{2+}, Ca^{2+}, K^+

Anions: CO_3^{2-}, S^{2-}, SO_4^{2-}, $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}

(Spot tests should be carried out wherever feasible)

Estimate the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel (II) or aluminium as oximate in a given solution gravimetrically.

Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.

Estimation of total hardness of a given sample of water by complexometric titration

Section-A: (PHYSICAL CHEMISTRY)

Total Marks: 15

Surface tension measurement (use of organic solvents excluded): Determination of the surface tension of a liquid or a dilute solution using a stalagmometer. Study of the variation of surface tension of a detergent solution with concentration.

Viscosity measurement (use of organic solvents excluded): Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer. Study of the variation of viscosity of an aqueous solution with concentration of solute.

Chemical Kinetics: Study the kinetics of the following reactions:

Initial rate method: Iodide-persulphate reaction

Integrated rate method:

Acid hydrolysis of methyl acetate with hydrochloric acid.

Saponification of ethyl acetate.

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

Reference Books:

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
4. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
6. Cotton, F.A. & Wilkinson, G. Basic Inorganic Chemistry, Wiley.
7. Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press.
8. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
9. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.

****$$$****

DETAILED SYLLABUS

FOR

AUDIT COURSE

B.Sc. with Chemistry

DETAILED SYLLABUS FOR AUDIT COURSE
B.Sc. with Chemistry

SEMESTER-I

Paper Title : **Atomic Structure, Bonding, Organic Chemistry and Aliphatic Compounds (Theory)**
Paper Code : **CHMA-101**
Course No : AC- 01
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

Section-A: (INORGANIC CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

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 $\psi 2$, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wavefunctions (atomic orbitals) and their variations for 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* 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 1*s* and 2*s* 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) Marks: 12

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 NO+. Comparison of VB and MO approaches.

(16 Lectures) Marks: 13

Section-B: (ORGANIC CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

Unit-I: 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 p^{Ka} values. Aromaticity: Benzenoids and Hückel's rule.

(8 Lectures) Marks: 7

Unit-II: 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) Marks: 8

Unit-III: 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) Marks: 10

Atomic Structure, Bonding, Organic Chemistry and Aliphatic Compounds (Practical)

Section A: (INORGANIC CHEMISTRY)
Total Marks: 15

8. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
9. Estimation of oxalic acid by titrating it with $KMnO_4$.
10. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
11. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
12. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Section B (ORGANIC CHEMISTRY)
Total Marks: 15

13. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
14. 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 two 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:

12. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
13. Cotton, F.A., Wilkinson, G. & Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
14. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons.

15. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education India, 2006.
16. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013
17. Eliel, E.L. *Stereochemistry of Carbon Compounds*, Tata McGraw Hill education, 2000.
18. Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
19. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.
20. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
21. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
22. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.

****$$$****

SEMESTER-II

Paper Title : **Chemical Energetics, Equilibria and Functional Organic Chemistry (Theory)**
Paper Code : **CHMA-201**
Course No : AC- 02
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

Section-A: (PHYSICAL CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

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) Marks: 8

Unit II: Chemical Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔGo, Le Chatelier's principle. Relationships between *Kp, Kc* and *Kx* for reactions involving ideal gases.

(8 Lectures) Marks: 6

Unit III: 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) Marks: 11

Section-A: (ORGANIC CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

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

Unit I: 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) Marks: 6

Unit II: 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_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

(8 Lectures) Marks: 7

Unit III: Alcohols, Phenols and Ethers: ***Alcohols:*** (Upto 5 Carbons) *Preparation:* Preparation of 1o, 2o and 3o 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:* Cumene hydroperoxide 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, $NaHSO_3$, NH_2-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) Marks: 12

Chemical Energetics, Equilibria and Functional Organic Chemistry (Practical)

Section-A: (PHYSICAL CHEMISTRY)
Total Marks: 15

Unit-I: Thermochemistry

7. Determination of heat capacity of calorimeter for different volumes.
8. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
9. Determination of enthalpy of ionization of acetic acid.
10. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).
11. Determination of enthalpy of hydration of copper sulphate.
12. Study of the solubility of benzoic acid in water and determination of ΔH.

Unit-II: Ionic Equilibria

pH measurements: 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.

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-A: (ORGANIC CHEMISTRY)
Total Marks: 15

Purification of organic compounds by crystallization (from water and alcohol) and distillation.

Criteria of Purity: Determination of melting and boiling points.

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:

10. Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. *Organic Chemistry,* John Wiley & Sons (2014).
11. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
12. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* Orient Longman, New Delhi (1988).
13. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.
14. Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
15. Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
16. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
17. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
18. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).

****$$$****

SEMESTER-III

Paper Title : **Solutions, Phase Equilibria, Electrochemistry and Functional Group Organic Chemistry (Theory)**
Paper Code : **CHMA-301**
Course No : AC- 03
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

Section-A: (PHYSICAL CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

Unit I: Solutions : Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature-

composition 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) Marks: 7

Unit II: Phase Equilibria: 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).

(8 Lectures) Marks: 6

Unit III: 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).

(6 Lectures) Marks: 5

Unit IV: Electrochemistry: Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS 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 treatment (acid-base and oxidation-reduction only).

(8 Lectures) Marks: 7

Section-A: (PHYSICAL CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

Unit I: 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) Marks: 5

Unit II: Amines and Diazonium Salts Amines (Aliphatic and Aromatic): (Upto 5 carbons): Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation. Diazonium salts: Preparation: from aromatic amines. Reactions: conversion to benzene, phenol, dyes.

(6 Lectures) Marks: 5

Unit III: Amino Acids, Peptides and Proteins: Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis. Reactions

of Amino acids: ester of –COOH group, acetylation of –NH2 group, complexation with Cu^{2+} ions, ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C–terminal (thiohydantoin 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) Marks: 8

Unit IV: 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.

(8 Lectures) Marks: 7

Solutions, Phase Equilibria, Electrochemistry and Functional Group Organic Chemistry (Practical)

Section-A: (PHYSICAL CHEMISTRY)
Total Marks: 15

Unit-I: Distribution: Study of the equilibrium of one of the following reactions by the distribution method:

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

$Cu^{2+}(aq) + Xnh_2(aq) \rightarrow [Cu(NH_3)x]^{2+}$

Unit-II: Phase Equilibria: Construction of the phase diagram of a binary system (simple eutectic) using cooling curves. Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it. Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

Unit-III: Conductance: Determination of cell constant, Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid. Perform the following conductometric titrations:

a. Strong acid vs. strong base

b. Weak acid vs. strong base

Unit-IV: 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)
Total Marks: 15

Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

Separation of amino acids by paper chromatography

Determination of the concentration of glycine solution by formylation method.

Titration curve of glycine

Action of salivary amylase on starch

Effect of temperature on the action of salivary amylase on starch.

Differentiation between a reducing and a nonreducing sugar.

Reference Books:

13. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
14. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
15. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
16. Mahan, B.H. University Chemistry, 3rd Ed. Narosa (1998).
17. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).
18. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
19. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed.,
20. Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.
21. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
22. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
23. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011)
24. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

****$$$****

SEMESTER-IV

Paper Title : **Transition Metal and Coordination Chemistry, States of Matters and Chemical Kinetics (Theory)**

Paper Code : **CHMA-401**
Course No : AC- 04
Credits : 06 (Theory: 04; Practical: 02) No. of Classes: 90 (60+30)
Total Theory Marks: 65 (End Semester: 50; In Semester: 15)
Total Practical Marks: 35 (End Semester: 30; In Semester: 05)

Section-A: (INORGANIC CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

Unit I: Transition Elements (3d series): General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu. Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

(12 Lectures) Marks: 10

Unit II: Coordination Chemistry: Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and

stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature.

(8 Lectures) Marks: 7

Unit III: Crystal Field Theory : Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for Oh and Td complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.

(10 Lectures) Marks: 8

Section-A: (PHYSICAL CHEMISTRY)
Total Marks: 25 :: Total Lectures: 30

Unit I: 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. Andrews isotherms of CO_2.

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) Marks: 7

Unit II: 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).

(4 Lectures) Marks: 5

Unit III: 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. X–Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

(8 Lectures) Marks: 6

Unit IV: 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). Half–life 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) Marks: 7

Transition Metal and Coordination Chemistry, States of Matters and Chemical Kinetics (Practical)

Section-A: (INORGANIC CHEMISTRY)

Total Marks: 15

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

Cations: NH_4, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Fe^{3+}, Al^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+},Sr^{2+}, Ca^{2+}, K^+

Anions: CO_3^{2-}, S^{2-}, SO_4^{2-}, $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}

(Spot tests should be carried out wherever feasible)

Estimate the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel (II) or aluminium as oximate in a given solution gravimetrically.

Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.

Estimation of total hardness of a given sample of water by complexometric titration

Section-A: (PHYSICAL CHEMISTRY)

Total Marks: 15

Surface tension measurement (use of organic solvents excluded): Determination of the surface tension of a liquid or a dilute solution using a stalagmometer. Study of the variation of surface tension of a detergent solution with concentration.

Viscosity measurement (use of organic solvents excluded): Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer. Study of the variation of viscosity of an aqueous solution with concentration of solute.

Chemical Kinetics: Study the kinetics of the following reactions:

Initial rate method: Iodide-persulphate reaction

Integrated rate method:

Acid hydrolysis of methyl acetate with hydrochloric acid.

Saponification of ethyl acetate.

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

Reference Books:

10. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
11. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
12. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
13. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
14. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
15. Cotton, F.A. & Wilkinson, G. Basic Inorganic Chemistry, Wiley.
16. Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press.
17. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
18. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.

****$$$****