WEST BENGAL STATE UNIVERSITY

DRAFT SYLLABUS IN CHEMISTRY (GENERAL)

UNDER

CHOICE BASED CREDIT SYSTEM

2018

Scheme for CBCS Curriculum for BSc. Chemistry

Credit Distribution across Courses

Credits				
Course Type		Total Papers	Theory + Practical	
Core Courses	4 papers each from 3 disciplines of choice	12	12X4 =48 12X2 =24	
Elective Courses	2 papers each from 3 discipline of choice including interdisciplinary papers	6	6X4=24 6X2=12	
Ability Enhancement Language Courses		2	2X2=4	
Skill Enhancement Courses		4	4X2=8	
Totals		24	120	

Scheme for CBCS Curriculum

Semester	Course Name	Course Detail	Credits	Marks
I	Ability Enhancement Compulsory Course–I	English communication / Environmental Science	2	25
	Core course–I	**CEMGCOR01T**	4	50
	Core course–I Practical	**CEMGCOR01P**	2	25
	Core course–II	Core Course 2A from other chosen discipline	4	50
	Core course–II Practical	Core Course 2A Practical from other chosen discipline	2	25
	Core course – III	Core Course 3A from other chosen discipline	4	50
	Core course – III Practical	Core Course 3A Practical from other chosen discipline	2	25

II	Ability Enhancement Compulsory Course–II	English communication / Environmental Science	2	25
	Core course–IV	**CEMGCOR02T**	4	50
	Core course–IV Practical	**CEMGCOR02P**	2	25
	Core course–V	Core Course 2B from other chosen discipline	4	50
	Core course– V Practical	Core Course 2B Practical from other chosen discipline	2	25
	Core course – VI	Core Course 3B from other chosen discipline	4	50
	Core course – VI Practical	Core Course 3B Practical from other chosen discipline	2	25
III	Core course VII	**CEMGCOR03T**	4	50
	Core course–VII Practical	**CEMGCOR03P**	2	25
	Core course – VIII	Core Course 2C from other chosen discipline	4	50
	Core course – VIII Practical	Core Course 2C Practical from other chosen discipline	2	25
	Core course–IX	Core Course 3C from other chosen discipline	4	50
	Core course–IX Practical	Core Course 3C Practical from other chosen discipline	2	25
	Skill Enhancement Course–1		2	25
IV	Core course–X	**CEMGCOR04T**	4	50
	Core course – X Practical	**CEMGCOR04P**	2	25
	Core course–XI	Core Course 2D from other chosen discipline	4	50
	Core course–XI Practical	Core Course 2D Practical from other chosen discipline	2	25
	Core course–XII	Core Course 3D from other chosen discipline	4	50
	Core course–XII Practical	Core Course 3D Practical from other chosen discipline	2	25
	Skill Enhancement Course-2		2	25
V	Skill Enhancement Course – 3		2	25
	Discipline Specific Elective 1	**DSE** is to be chosen from **CEMGDSE01T and CEMGDSE02T**	4	50

	Discipline Specific Elective 1 Practical	**DSE** is to be chosen from **CEMGDSE01P and CEMGDSE02P**	2	25
	Discipline Specific Elective 2	DSE 2A from other chosen discipline	4	50
	Discipline Specific Elective 2 Practical	DSE 2A Practical from other chosen discipline	2	25
	Discipline Specific Elective 3	DSE 3A from other chosen discipline	4	50
	Discipline Specific Elective 3 Practical	DSE 3A Practical from other chosen discipline	2	25
VI	Skill Enhancement Course – 4		2	25
	Discipline Specific Elective 4	**DSE** is to be chosen from **CEMGDSE03T and CEMGDSE04T**	4	50
	Discipline Specific Elective 4 Practical	**DSE** is to be chosen from **CEMGDSE03P and CEMGDSE04P**	2	25
	Discipline Specific Elective 5	DSE 2B from other chosen discipline	4	50
	Discipline Specific Elective 5 Practical	DSE 2B Practical from other chosen discipline	2	25
	Discipline Specific Elective 6	DSE 3B from other chosen discipline	4	50
	Discipline Specific Elective 6 Practical	DSE 3B Practical from other chosen discipline	2	25
		Total	**120**	**1500**

Discipline Specific Elective papers (Credit: 06 each) (DSE 1, DSE 2):

Chemistry

1. **CEMGDSE01T** : Polymer Chemistry (4)
   CEMGDSE01P : Polymer Chemistry Lab (2)
2. **CEMGDSE02T**: Green Chemistry (4)
   CEMGDSE02P: Green Chemistry Lab (2)
3. **CEMGDSE03T:** Inorganic Materials of Industrial Importance (4)
   CEMGDSE03T: Inorganic Materials of Industrial Importance Lab (2)
4. **CEMGDSE04:** ORGANOMETALLICS, BIOINORGANIC CHEMISTRY, POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY (4)
   CEMGDSE04: ORGANOMETALLICS, BIOINORGANIC CHEMISTRY, POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY Lab (2)

SEMESTER-I

CEMGCOR01T: ATOMIC STRUCTURE, CHEMICAL PERIODICITY, ACIDS AND BASES,REDOX REACTIONS, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures Marks: 50

Section A: Inorganic Chemistry-I

(30 Lectures) Marks: 25

Atomic Structure (10 Lectures)

Bohr's theory for hydrogen atom (simple mathematical treatment), atomic spectra of hydrogen and Bohr's model, Sommerfeld's model, quantum numbers and their significance, Pauli's exclusion principle, Hund's rule, electronic configuration of many-electron atoms, *Aufbau* principle and its limitations.

Chemical Periodicity (05 Lectures)

Classification of elements on the basis of electronic configuration: general characteristics of s-, p-, d- and f-block elements. Positions of hydrogen and noble gases. Atomic and ionic radii, ionization potential, electron affinity, and electronegativity; periodic and group-wise variation of above properties in respect of s- and p- block elements.

Acids and bases (10 Lectures)

Brönsted–Lowry concept, conjugate acids and bases, relative strengths of acids and bases, effects of substituent and solvent, differentiating and levelling solvents. Lewis acid-base concept, classification of Lewis acids and bases, Lux-Flood concept and solvent system concept. Hard and soft acids and bases (HSAB concept), applications of HSAB process.

Redox reactions (05 Lectures)

Balancing of equations by oxidation number and ion-electron method oxidimetry and reductimetry.

Section B: Organic Chemistry-I

(30 Lectures) Marks: 25

Fundamentals of Organic Chemistry (5 Lectures)

Electronic displacements: inductive effect, resonance and hyperconjugation; cleavage of bonds: homolytic and heterolytic; structure of organic molecules on the basis of VBT; nucleophiles electrophiles; reactive intermediates: carbocations, carbanions and free radicals.

Stereochemistry (8 Lectures)

Different types of isomerism; geometrical and optical isomerism; concept of chirality and optical activity (up to two carbon atoms); asymmetric carbon atom; elements of symmetry (plane and centre); interconversion of Fischer and Newman representations; enantiomerism and diastereomerism, *meso* compounds; *threo* and *erythro,* D and L, *cis* and *trans* nomenclature; CIP Rules: *R/S* (upto 2 chiral carbon atoms) and *E/Z* nomenclature.

Nucleophilic Substitution and Elimination Reactions (5 Lectures)

Nucleophilic substitutions: S_N1 and S_N2 reactions; eliminations: E1 and E2 reactions (elementary mechanistic aspects); Saytzeff and Hofmann eliminations;elimination *vs* substitution.

Aliphatic Hydrocarbons (12 Lectures)

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

Alkanes:(up to 5 Carbons). *Preparation:* catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. *Reactions:* mechanism forfree radical substitution: halogenation.

Alkenes:(up to 5 Carbons). *Preparation:* elimination reactions: dehydration of alcohols and dehydrohalogenation of alkyl halides; *cis* alkenes (partial catalytic hydrogenation) and *trans* alkenes (Birch reduction). *Reactions: cis*-addition (alkaline $KMnO_4$) and *trans*-addition (bromine) with mechanism, addition of HX [Markownikoff's (with mechanism) and antiMarkownikoff's addition], hydration, ozonolysis, oxymercuration-demercuration and hydroboration-oxidation reaction.

Alkynes: (up to 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 alkaline $KMnO_4$.

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 InorganicChemistry*, 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. Sethi, A. *Conceptual Organic Chemistry;* New Age International Publisher.
6. Parmar, V. S. *A Text Book of Organic Chemistry*, S. Chand & Sons.
7. Madan, R. L. *Organic Chemistry*, S. Chand & Sons.

8. Wade, L. G., Singh, M. S., *Organic Chemistry*.
9. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
10. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
11. Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*, Wiley: London, 1994.
12. Sen Gupta, Subrata. *Basic Stereochemistry of Organic molecules.*
13. Kalsi, P. S. *Stereochemistry Conformation and Mechanism*, Eighth edition, New Age International, 2014.
14. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.

CEMGCOR01P: ATOMIC STRUCTURE, CHEMICAL PERIODICITY, ACIDS AND BASES, REDOX REACTIONS, GENERAL ORGANIC CHEMISTRY & ALIPHATIC

HYDROCARBONS LAB

(60 Lectures/Contact Hours) Marks: 25

Section A: Inorganic Chemistry –LAB ***(30 Lectures)***

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- LAB **(30 Lectures)**

Qualitative Analysis of Single Solid Organic Compound(s)

Experiment A: Detection of special elements (N, Cl, and S) in organic compounds.

Experiment B: Solubility and Classification (solvents: H_2O, dil. HCl, dil. NaOH)

Experiment C: Detection of functional groups: Aromatic-NO_2, Aromatic -NH_2, -COOH, carbonyl (no distinction of –CHO and >C=O needed), -OH (phenolic) in solid organic compounds.

Experiments A - C with unknown (at least 6) solid samples containing not more than two of the above type of functional groups should be done.

Reference Books:

1. *University Hand Book of Undergraduate Chemistry Experiments*, edited by Mukherjee, G. N., University of Calcutta, 2003.
2. Das, S. C., Chakraborty, S. B., *Practical Chemistry.*
3. Mukherjee, K. S. *Text book on Practical Chemistry*, New Oriental Book Agency.
4. Ghosal, Mahapatra & Nad, *An Advanced course in practical Chemistry,* New Central Book Agency.
5. Vogel, A. I. *Elementary Practical Organic Chemistry,* Part 2: *Qualitative Organic Analysis,* CBS Publishers and Distributors.
6. 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.
7. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.

SEMESTER-II

CEMGCOR02T: STATES OF MATTER & CHEMICAL KINETICS, CHEMICAL BONDING & MOLECULAR STRUCTUR, p-BLOCK ELEMENTS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures **Marks: 50**

Section A: Physical Chemistry-I

(30 Lectures) **Marks: 25**

Kinetic Theory of Gases and Real gases **(10 Lectures)**

Concept of pressure and temperature; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules); Rate of effusion

Nature of distribution of velocities, Maxwell's distribution of speed and kinetic energy; Average velocity, root mean square velocity and most probable velocity; Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases

Deviation of gases from ideal behavior; compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features; its derivation and application in explaining real gas behaviour; Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states

Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only)

Liquids **(06 Lectures)**

Definition of Surface tension, its dimension and principle of its determination using stalagmometer; Viscosity of a liquid and principle of determination of coefficient of viscosity using Ostwald viscometer; Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only)

Solids **(06 Lectures)**

Forms of solids, crystal systems, unit cells, Bravais lattice types, Symmetry elements; Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices; Miller indices

of different planes and interplanar distance, Bragg's law; Structures of NaCl, KCl and CsCl (qualitative treatment only); Defects in crystals; Glasses and liquid crystals.

Chemical Kinetics **(08 Lectures)**

Introduction of rate law, Order and molecularity; Extent of reaction; rate constants; Rates of First, second and nth order reactions and their Differential and integrated forms (with derivation); Pseudo first order reactions; Determination of order of a reaction by half-life and differential method; Opposing reactions, consecutive reactions and parallel reactions

Temperature dependence of rate constant; Arrhenius equation, energy of activation; Collision theory; Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment)

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. Chugh, K.L., Agnish, S.L. *A Text Book of Physical Chemistry* Kalyani Publishers7.Bahl, B.S., Bahl, A., Tuli, G.D., *Essentials of Physical Chemistry* S. Chand & Co. ltd.
8. Palit, S. R., *Elementary Physical Chemistry* Book Syndicate Pvt. Ltd.
9. Mandal, A. K. *Degree Physical and General Chemistry* Sarat Book House
10. Pahari, S., *Physical Chemistry* New Central Book Agency
11. Pahari, S., Pahari, D., *Problems in Physical Chemistry* New Central Book Agency

Section B: Inorganic Chemistry-II

(30 Lectures) **Marks: 25**

Chemical Bonding and Molecular Structure **(16 Lectures)**

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionicbonding, 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, BornHaber 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 basisof 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.

Comparative study of p-block elements: (14 Lectures)

Group trends in electronic configuration, modification of pure elements, common oxidation states, inert pair effect, and their important compounds in respect of the following groups of elements:

i)B-Al-Ga-In-Tl
ii)C-Si-Ge-Sn-Pb
iii)N-P-As-Sb-Bi
iv)O-S-Se-Te v)F-
Cl-Br-I

Reference Books:

1. Cotton, F.A. & Wilkinson, G. *Basic Inorganic Chemistry,* Wiley.
2. Shriver, D.F. & Atkins, P.W. *Inorganic Chemistry*, Oxford University Press.
3. Wulfsberg, G. *Inorganic Chemistry,* Viva Books Pvt. Ltd.
4. Rodgers, G.E. *Inorganic & Solid State Chemistry,* Cengage Learning India Ltd., 2008.

CEMGCOR02P: STATES OF MATTER & CHEMICAL KINETICS, CHEMICAL BONDING & MOLECULAR STRUCTUR, p-BLOCK ELEMENTS LAB

(60 Lectures/Contact Hours) Marks: 25

Section A: Physical Chemistry-LAB **(15x2=30 Lectures)**

(Minimum **five** experiments to complete)

(I) Surface tension measurement (use of organic solvents excluded)

a) Determination of the surface tension of a liquid or a dilute solution using a Stalagmometer

b) Study of the variation of surface tension of a detergent solution with concentration

(II) Viscosity measurement (use of organic solvents excluded)

a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer

b) Study of the variation of viscosity of an aqueous solution with concentration of solute

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

Reference Books:

1. *University Hand Book of Undergraduate Chemistry Experiments*, edited by Mukherjee, G. N., University of Calcutta, 2003.
2. Palit, S.R., *Practical Physical Chemistry* Science Book Agency
3. Mukherjee, N.G., *Selected Experiments in Physical Chemistry* J. N. Ghose & Sons
4. Dutta, S.K., *Physical Chemistry Experiments* Bharati Book Stall

Section B: Inorganic Chemistry-LAB **(30 Lectures)**

Qualitative semimicro analysis of mixtures containing three radicals. Emphasis should be given to the understanding of the chemistry of different reactions.

Acid Radicals: Cl^-, Br^-, I^-, NO_2^-, NO_3^-,S^{2-}, SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, H_3BO_3. Basic Radicals: Na^+, K^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Cr^{3+}, Mn^{2+}, Fe^{3+}, Ni^{2+}, Cu^{2+}, NH_4^+.

Reference Books:

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
2. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).

SEMESTER-III

CEMGCOR03T: CHEMICAL ENERGETICS, EQUILIBRIA, ORGANIC CHEMISTRY-II

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures Marks: 50

Section A: Physical Chemistry-II

(30 Lectures) Marks: 25

Chemical Energetics (14 Lectures)

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics; Concept of heat, work, internal energy 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

Standard states; Heats of reaction; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; Laws of thermochemistry; bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchhoff's equations and effect of pressure on enthalpy of reactions; Adiabatic flame temperature; explosion temperature

Statement of the second law of thermodynamics; Concept of heat reservoirs and heat engines; Carnot cycle; Physical concept of Entropy; Carnot engine, refrigerator and efficiency; Entropy change of systems and surroundings for various processes and transformations; Auxiliary state functions (G and A) and Criteria for spontaneity and equilibrium.

Chemical Equilibrium: (08 Lectures)

Thermodynamic conditions for equilibrium, degree of advancement; Variation of free energy with degree of advancement; Equilibrium constant and standard Gibbs' free energy change; Definitions of K_P, K_C and K_X and relation among them; van't Hoff's reaction isotherm, isobar and isochore from different standard states; Shifting of equilibrium due to change in external parameters e.g. temperature and pressure; variation of equilibrium constant with addition to inert gas; Le Chatelier's principle

Ionic Equilibria: (08 Lectures)

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

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. Ekambaram, S. *General Chemistry*, Pearson.
6. Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
7. Chugh, K.L., Agnish, S.L. *A Text Book of Physical Chemistry* Kalyani Publishers8.Bahl, B.S., Bahl, A., Tuli, G.D., *Essentials of Physical Chemistry* S. Chand & Co. ltd.
9. Palit, S. R., *Elementary Physical Chemistry* Book Syndicate Pvt. Ltd.
10. Mandal, A. K. *Degree Physical and General Chemistry* Sarat Book House
11. Pahari, S., *Physical Chemistry* New Central Book Agency
12. Pahari, S., Pahari, D., *Problems in Physical Chemistry* New Central Book Agency

Section-B: Organic Chemistry-II

(30 Lectures) Marks: 25

Functional group app roach for the following reactions (preparations & reactions) to be studied in context to their structures.

Aromatic Hydrocarbons 06 Lectures)

Benzene:Preparation: from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. *Reactions*: electrophilic substitution (general mechanism); nitration (with mechanism), halogenations (chlorination and bromination), sulphonation and Friedel-Craft's reaction (alkylation and acylation) (up to 4 carbons on benzene); side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

Organometallic Compounds (2 Lectures)

Introduction; *Grignard reagents*: *Preparations* (from alkyl and aryl halide); concept of *umpolung;* Reformatsky reaction.

Aryl Halides (3 Lectures)

Preparation: (chloro-, bromo- and iodobenzene): from phenol, Sandmeyer reactions. *Reactions (Chlorobenzene):* nucleophilic aromatic substitution (replacement by –OH group) and effect of nitro substituent (activated nucleophilic substitution).

Alcohols, Phenols and Ethers (11 Lectures)

Alcohols:(up to 5 Carbons). *Preparation:* 1°-, 2°- and 3°- alcohols: using Grignard reagent, reduction of aldehydes, ketones, carboxylic acid and esters; *Reactions:* With sodium, HX (Lucas test), oxidation (alkaline $KMnO_4$, acidic dichromate, concentrated HNO_3);

Oppenauer oxidation;

Diols: Preparation (with OsO_4); pinacol- pinacolone rearrangement (with mechanism) (*with symmetrical diols* only).

Phenols:Preparation: cumene hydroperoxide method, from diazonium salts; acidic nature of phenols; *Reactions:* electrophilic substitution: nitration and halogenations; Reimer -Tiemann reaction, Houben–Hoesch condensation, Schotten –Baumann reaction, Fries rearrangement and Claisen rearrangement.

Ethers:Preparation: Williamson's ether synthesis; *Reaction*: cleavage of ethers with HI.

Carbonyl Compounds (08 Lectures)

Aldehydes and Ketones (aliphatic and aromatic):(Formaldehye, acetaldehyde, acetone and benzaldehyde): *Preparation:* from acid chlorides, from nitriles and from Grignard reagents; general properties of aldehydes and ketones; *Reactions:* with HCN, ROH, $NaHSO_3$, NH_2-G derivatives and with Tollens' and Fehling's reagents; iodoform test; aldol condensation (with mechanism); Cannizzaro reaction (with mechanism), Wittig reaction, benzoin condensation; Clemmensen reduction, Wolff- Kishner reduction and Meerwein-Pondorff-Verley (MPV) reduction.

Reference Books:

1. Sethi, A. *Conceptual Organic Chemistry;* New Age International Publisher.
2. Parmar, V. S. *A Text Book of Organic Chemistry*, S. Chand & Sons.
3. Madan, R. L. *Organic Chemistry*, S. Chand & Sons.
4. Wade, L. G., Singh, M. S., *Organic Chemistry, Pearson*.
5. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.

CEMGCOR03P: CHEMICAL ENERGETICS, EQUILIBRIA, ORGANIC CHEMISTRY LAB

(60 Lectures/Contact Hours) Marks: 25

Section A: Physical Chemistry-LAB **(15x2=30 Lectures)**

(Minimum **five** experiments to complete)

(I) Thermochemistry (Any **three**)

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 enthalpy of hydration of copper sulphate

(II) Ionic Equilibria (Any **two**)

a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter and compare it with the indicator method

b) Preparation of buffer solutions and find the pH of an unknown buffer solution by colour matching method (using following buffers)
   (i) Sodium acetate-acetic acid
   (ii) Ammonium chloride-ammonium hydroxide

c)Study of the solubility of benzoic acid in water

Reference Books:

1. *University Hand Book of Undergraduate Chemistry Experiments*, edited by Mukherjee, G. N., University of Calcutta, 2003.
2. Palit, S.R., *Practical Physical Chemistry* Science Book Agency
3. Mukherjee, N.G., *Selected Experiments in Physical Chemistry* J. N. Ghose & Sons
4. Dutta, S.K., *Physical Chemistry Experiments* Bharati Book Stall

Section B: Organic Chemistry-LAB

Identification of a pure organic compound

Solid compounds: oxalic acid, tartaric acid, succinic acid, resorcinol, urea, glucose, benzoic acid and salicylic acid.

Liquid Compounds: methyl alcohol, ethyl alcohol, acetone, aniline, dimethylaniline, benzaldehyde, chloroform and nitrobenzene

Reference Books:

1. Bhattacharyya, R. C, *A Manual of Practical Chemistry.*
2. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbookof Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.

SEMESTER-IV

CEMGCOR04T: SOLUTIONS, PHASE EQUILIBRIA, CONDUCTANCE,

ELECTROCHEMISTRY & ANALYTICAL AND ENVIORNMETAL CHEMISTRY-I

(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures Marks: 50

Section A: Physical Chemistry-III
(30 Lectures) Marks: 25

Solutions **(06 Lectures)**

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

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

Phase Equilibria **(08 Lectures)**

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 (leadsilver, $FeCl_3$-H_2O and Na-K only)

Conductance **(08 Lectures)**

Conductance, cell constant, specific conductance and molar conductance; Variation of specific and equivalent conductance with dilution for strong and weak electrolytes; Kohlrausch's law of independent migration of ions; Equivalent and molar conductance at infinite dilution and their determination for strong and weak electrolytes; Ostwald's dilution law; Application of conductance measurement (determination of solubility product and ionic product of water); Conductometric titrations (acid-base)

Transport Number and principles of Hittorf's and Moving-boundary method

Electromotive force **(08 Lectures)**

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; Electrochemical series;

Thermodynamics of a reversible cell, calculation of thermodynamic properties: *G*, *H* and *S* from EMF data

Concentration cells with and without transference, liquid junction potential; pH determination using hydrogen electrode and quinhydrone; Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation)

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. Chugh, K.L., Agnish, S.L. *A Text Book of Physical Chemistry* Kalyani Publishers7.Bahl, B.S., Bahl, A., Tuli, G.D., *Essentials of Physical Chemistry* S. Chand & Co. ltd.
8. Palit, S. R., *Elementary Physical Chemistry* Book Syndicate Pvt. Ltd.
9. Pahari, S., *Physical Chemistry* New Central Book Agency
10. Pahari, S., Pahari, D., *Problems in Physical Chemistry* New Central Book Agency

Section B: Analytical and Environmental Chemistry
(30 Lectures) Marks: 25

Chemical Analysis (15 Lectures)

Gravimetric analysis: solubility product and common ion effect; requirements of gravimetry; gravimetric estimation of chloride, sulphate, lead, barium, nickel, copper and zinc.

Volumetric analysis: primary and secondary standard substances; principles of acid-base, oxidation –reduction and complexometric titrations; indicators: acid-base, redox and metal ion; principles of estimation of mixtures: $NaHCO_3$ and Na_2CO_3 (by acidimetry); iron, copper, manganese and chromium (by redox titration); zinc, aluminum, calcium and magnesium (by complexometric EDTA titration).

Chromatography: chromatographic methods of analysis: column chromatography and thin layer chromatography.

Environmental Chemistry (15 Lectures)

The Atmosphere: composition and structure of the atmosphere; troposphere, stratosphere, mesosphere and thermosphere; ozone layer and its role; major air pollutants: CO, SO_2, NO_x and particulate matters – their origin and harmful effects; problem of ozone layer depletion; green house effect; acid rain and photochemical smog; air pollution episodes: air quality

standard; air pollution control measures: cyclone collector, electrostatic precipitator, catalytic converter.

The Hydrosphere: environmental role of water, natural water sources, water treatment for industrial, domestic and laboratory uses; water pollutants; action of soaps and detergents, phosphates, industrial effluents, agricultural runoff, domestic wastes; thermal pollution, radioactive pollution and their effects on animal and plant life; water pollution episodes: water pollution control measures : waste water treatment; chemical treatment and microbial treatment; water quality standards: DO, BOD, COD, TDS and hardness parameters; desalination of sea water : reverse osmosis, electrodialysis.

The Lithosphere: water and air in soil, waste matters and pollutants in soil, waste classification, treatment and disposal; soil pollution and control measures.

Reference Books:

1. Banerjee, S. P. *A Text Book of Analytical Chemistry*, The New Book Stall.
2. Gangopadhyay, P. K. *Application Oriented Chemistry*, Book Syndicate.
3. Mondal, A. K & Mondal, S. *Degree Applied Chemistry*, Sreedhar Publications.
4. Banerjee, S. P. *A Text Book of Analytical Chemistry*, The New Book Stall.

CEMGCOR04P: SOLUTIONS, PHASE EQUILIBRIA, CONDUCTANCE,

ELECTROCHEMISTRY & FUNCTIONAL ORGANIC CHEMISTRY-II LAB

(60 Lectures/Contact Hours) Marks: 25

Section A: Physical Chemistry-LAB **(15x2=30 Lectures)**

(Minimum **six** experiments to complete)

(I) Distribution Law (Any **one**)

Study of the equilibrium of **one of the following reactions** by the distribution method:

$$I_2(aq) + I^-(aq) = I_3^-(aq)$$

$$Cu^{2+}(aq) + xNH_2(aq) = [Cu(NH_3)_x]^{2+}$$

(II) Phase equilibria (Any **one**)

a) Construction of the phase diagram of a binary system (simple eutectic) using cooling curves

b) Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it

(III) Conductance

a) Determination of dissociation constant of a weak acid (cell constant, equivalent conductance are also determined)

b) Perform the following conductometric titrations: (Any **one**)
   (i) Strong acid vs. strong base
   (ii) Weak acid vs. strong base

(IV) Potentiometry

Perform the following potentiometric titrations:
   (i) Weak acid vs. strong base
   (ii) Potassium dichromate vs. Mohr's salt

Reference Books:

1. *University Hand Book of Undergraduate Chemistry Experiments*, edited by Mukherjee, G. N., University of Calcutta, 2003.
2. Palit, S.R., *Practical Physical Chemistry* Science Book Agency

3. Mukherjee, N.G., *Selected Experiments in Physical Chemistry* J. N. Ghose & Sons
4. Dutta, S.K., *Physical Chemistry Experiments* Bharati Book Stall

Section B: Analytic and Environmental Chemistry-LAB (30 Lectures)

1. To find the total hardness of water by EDTA titration.
2. To find the PH of an unknown solution by comparing color of a series of HCl solutions + 1 drop of methyl orange, and a similar series of NaOH solutions + 1 drop of phenolphthalein.
3. To determine the rate constant for the acid catalysed hydrolysis of an ester.
4. Determination of the strength of the H_2O_2 sample.
5. To determine the solubility of a sparingly soluble salt, e.g. KHTa (one bottle)

Reference Books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Ghosal, Mahapatra & Nad, *An Advanced Course in Practical Chemistry,* New Central Book Agency.
3. *University Hand Book of Undergraduate Chemistry Experiments*, edited by Mukherjee, G. N. University of Calcutta, 2003.
4. Das, S. C., Chakraborty, S. B., *Practical Chemistry.*

Discipline Specific Electives

CHEMISTRY-DSE I-IV (ELECTIVES)

CEMGDSE01T: POLYMER CHEMISTRY

(Credits: Theory-06, Practicals-02)

Theory: 60 Lectures Marks:50

Introduction and history of polymeric materials:

(4 Lectures) Marks:04

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of polymers.

Functionality and its importance:

(8 Lectures) Marks:06

Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bi-functional systems, Poly-functional systems.

Kinetics of Polymerization:

(8 lectures) Marks:06

Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

Crystallization and crystallinity:

(4 Lectures) Marks:04

Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

Nature and structure of polymers-

(2 Lectures) Marks:04

Structure Property relationships.

Determination of molecular weight of polymers

(8 Lectures) Marks:06

(M_n, M_w, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index.

Glass transition temperature (Tg) and determination of Tg,

(8 Lectures) Marks:06

Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg).

Polymer Solution –

(8 Lectures) Marks:06

Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures.

Properties of Polymers

(10 Lectures) Marks:08

(Physical, thermal, flow & mechanical properties).

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes,

Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].

Reference Books:

- Seymour, R.B.& Carraher, C.E. *Polymer Chemistry: An Introduction,* Marcel Dekker, Inc. New York, 1981.
- Odian, G. *Principles of Polymerization*, 4th Ed. Wiley, 2004.
- Billmeyer, F.W. *Textbook of Polymer Science*, 2nd Ed. Wiley Interscience, 1971. Ghosh, P. *Polymer Science & Technology*, Tata McGraw-Hill Education, 1991.
- Lenz, R.W. *Organic Chemistry of Synthetic High Polymers.* Interscience Publishers, New York, 1967.

CEMGDSE01P: POLYMER CHEMISTRY

(60 Lectures/Contact Hours) Marks: 25

1. **Polymer synthesis**

1.Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).

   a. Purification of monomer
   b. Polymerization using benzoyl peroxide (BPO) / 2,2'-azo-bisisobutylonitrile (AIBN)

2. Preparation of nylon 66/6

1.Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein

   a. Preparation of IPC
   b. Purification of IPC
   c. Interfacial polymerization

3. Redox polymerization of acrylamide
4. Precipitation polymerization of acrylonitrile
5. Preparation of urea-formaldehyde resin
6. Preparations of novalac resin/resold resin.
7. Microscale Emulsion Polymerization of Poly(methylacrylate).

Polymer characterization

1. Determination of molecular weight by viscometry:
   (a) Polyacrylamide-aq.$NaNO_2$ solution
   (b) (Poly vinyl proplylidine (PVP) in water
2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).
4. Testing of mechanical properties of polymers.
5. Determination of hydroxyl number of a polymer using colorimetric method.

Polymer analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
2. Instrumental Techniques
3. IR studies of polymers
4. DSC analysis of polymers
5. Preparation of polyacrylamide and its electrophoresis *at least 7 experiments to be carried out.

Reference Books:

- M.P. Stevens, *Polymer Chemistry: An Introduction*, 3rd Ed., Oxford University Press, 1999.
- H.R. Allcock, F.W. Lampe & J.E. Mark, *Contemporary Polymer Chemistry*, 3rd ed. Prentice-Hall (2003)
- F.W. Billmeyer, *Textbook of Polymer Science*, 3rd ed.Wiley-Interscience (1984)
- J.R. Fried, *Polymer Science and Technology*, 2nd ed.Prentice-Hall (2003)
- P. Munk & T.M. Aminabhavi, *Introduction to Macromolecular Science*, 2nd ed.John Wiley & Sons (2002)
- L. H. Sperling, *Introduction to Physical Polymer Science*, 4th ed.John Wiley & Sons (2005)
- M.P. Stevens, *Polymer Chemistry: An Introduction* 3rd ed.Oxford University Press (2005).
- Seymour/ Carraher's Polymer Chemistry, 9th ed.by Charles E. Carraher, Jr. (2013).

CEMGDSE02T: GREEN CHEMISTRY

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures Marks: 50

Introduction to Green Chemistry

(4 Lectures) Marks: 05

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry

Principles of Green Chemistry and Designing a Chemical synthesis

(30 Lectures) Marks: 25

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following:

- 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.

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

- 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.
- Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy.
- Selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups.
- 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.
- 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.
- Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

Examples of Green Synthesis/ Reactions and some real world cases

(16 Lectures) Marks: 12

1. Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)
2. 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
3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction

(Ultrasonic alternative to Iodine)

4 Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments.

5 Designing of Environmentally safe marine antifoulant.

6 Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments.

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

8 Healthier fats and oil by Green Chemistry: Enzymatic interesterification for production of no Trans-Fats and Oils

9 Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting

Future Trends in Green Chemistry

(10 Lectures) Marks: 08

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C^2S^3); Green chemistry in sustainable development.

Reference Books:

- Ahluwalia, V.K. & Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers (2005).
- Anastas, P.T. & Warner, J.K.: *Green Chemistry - Theory and Practical*, Oxford University Press (1998).
- Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).
- Cann, M.C. & Connely, M.E. *Real-World cases in Green Chemistry*, American Chemical Society, Washington (2000).
- Ryan, M.A. & Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, Washington (2002).
- Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition, 2010.

CEMGDSE02P: GREEN CHEMISTRY

(60 Lectures/Contact Hours) Marks: 25

1. Safer starting materials

- Preparation and characterization of nanoparticles of gold 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

(I) Triethylamine ion + $OH^- \rightarrow$ propene + trimethylpropene + water

(II) 1-propanol $\xrightarrow{H_2SO_4/\square}$ 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 CO_2 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:

- Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice,* Oxford University Press (1998).
- Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC (2002).
- Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).
- Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. *Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi*. Bangalore CISBN 978-93-81141-55-7 (2013).
- Cann, M.C. & Connelly, M. E. *Real world cases in Green Chemistry*, American Chemical Society (2008).
- Cann, M. C. & Thomas, P. *Real world cases in Green Chemistry,* American Chemical Society (2008).
- Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition, 2010.
- 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.

CEMGDSE03T: INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures Marks: 50

Silicate Industries

(16 Lectures) Marks: 12

*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.

Fertilizers:

(10 Lectures) Marks: 10

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.

Surface Coatings:
(8 Lectures) Marks: 06

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.

Batteries:

(8 Lectures) Marks: 06

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.

Alloys:

(8 Lectures) Marks: 06

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.

Catalysis:

(6 Lectures) Marks: 06

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.

Chemical explosives:

(4 Lectures) Marks: 04

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

Reference Books:

- E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
- R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
- W. D. Kingery, H. K. Bowen, D. R. Uhlmann: *Introduction to Ceramics,* Wiley Publishers, New Delhi.
- J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
- P. C. Jain & M. Jain: *Engineering Chemistry,* Dhanpat Rai & Sons, Delhi.
- R. Gopalan, D. Venkappayya, S. Nagarajan: *Engineering Chemistry,* Vikas Publications, New Delhi.
- B. K. Sharma: *Engineering Chemistry*, Goel Publishing House, Meerut

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CEMGDSE03P:
INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE
(60 Lectures/Contact Hours) Marks: 25

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:

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

CEMGDSE04T:
ORGANOMETALLICS, BIOINORGANIC CHEMISTRY,
POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures Marks: 50

Section A: Inorganic Chemistry-4
(30 Lectures) Marks: 25

Chemistry of 3d metals (6 Lectures)

Oxidation states displayed by Cr, Fe, Co, Ni and Co.

A study of the following compounds (including preparation and important properties);

Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$, $Na_3[Co(NO_2)_6]$.

Organometallic Compounds (12 Lectures)

Definition and Classification with appropriate examples based on nature of metalcarbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. p-

acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies).

Bio-Inorganic Chemistry (12 Lectures)

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump; Role of Mg^{2+} ions in energy production and chlorophyll. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones).

Section B: Organic Chemistry-4
(30 Lectures) Marks: 25

Polynuclear and heteronuclear aromatic compounds: (6 Lectures)

Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene , Furan, Pyrrole, Thiophene, and Pyridine.

Active methylene compounds: (6 Lectures)

Preparation: Claisen ester condensation. Keto-enol tautomerism.

Reactions: Synthetic uses of ethylacetoacetate (preparation of non-heteromolecules having upto 6 carbon).

Application of Spectroscopy to Simple Organic Molecules (18 Lectures)

Application of visible, ultraviolet and Infrared spectroscopy in organic molecules. Electromagnetic radiations, electronic transitions, λ_{max}&ε_{max}, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating l max of conjugated dienes and α,β – unsaturated compounds.

Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

Reference Books:

- James E. Huheey, Ellen Keiter & Richard Keiter: *Inorganic Chemistry: Principles of Structure and Reactivity,* Pearson Publication.
- G.L. Miessler & Donald A. Tarr: *Inorganic Chemistry,* Pearson Publication.
- J.D. Lee: *A New Concise Inorganic Chemistry,* E.L.B.S.
- F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley & Sons.
- I.L. Finar: *Organic Chemistry* (Vol. I & II), E.L.B.S.
- John R. Dyer: *Applications of Absorption Spectroscopy of Organic Compounds,* Prentice Hall.

- R.M. Silverstein, G.C. Bassler & T.C. Morrill*: Spectroscopic Identification of Organic Compounds*, John Wiley& Sons.
- R.T. Morrison & R.N. Boyd: *Organic Chemistry,* Prentice Hall.
- Peter Sykes: *A Guide Book to Mechanism* in *Organic Chemistry,* Orient Longman.
- Arun Bahl and B. S. Bahl: *Advanced Organic Chemistry,* S. Chand.

CEMGDSE04P:

(60 Lectures/Contact Hours) Marks: 25

Section A: Inorganic Chemistry

1. Separation of mixtures by chromatography: Measure the R_f value in each case. (Combination of two ions to be given)

Paper chromatographic separation of Fe^{3+}, $A1^{3+}$ and Cr^{3+} or

Paper chromatographic separation of Ni^{2+}, Co^{2+}, Mn^{2+} and Zn^{2+}

2. Preparation of any two of the following complexes and measurement of their conductivity:

(i) tetraamminecarbonatocobalt (III) nitrate
(ii) tetraamminecopper (II) sulphate
(iii) potassium trioxalatoferrate (III) trihydrate

Compare the conductance of the complexes with that of M/1000 solution of NaCl, $MgCl_2$ and $LiCl_3$.

Section B: Organic Chemistry

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

Reference Books:

- A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel: Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- 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.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
