UNIVERSITY OF NORTH BENGAL

Syllabus for B. Sc. General
under revised new course structure
for Part - I, Part - II and Part - III

in

CHEMISTRY

DA

University of North Bengal
Raja Rammohunpur, Darjeeling - 734 013
West Bengal, India.

Distribution of marks of B.Sc. General Course

	Theoretical	Practical
Part - I	(2 X 45 =) 90	60
Part - II	(2 X 45 =) 90	60
Part - III	60	40
	240	160

Grand Total = 400

B.Sc. (General)
Part- I

Paper I (Organic) **(Group A : 30 marks)**

1. Elementary ideas of atomic and molecular, orbitals. Shape of s and p-atomic orbitals – hybridization of atomic orbitals of carbon-molecular geometry of CH_4, C_2H_4 and C_2H_2 Polarisation of a covalent bond – Inductive effect, electromeric effect, resonance effect and hyperconjugation effect, Cleavage of a covalent bond- hemolytic and heterolytic and cleavage – carbocation – stability of carbocation.

2. Emperical and molecular formula. Detection of nitrogen, sulphur and halogens in organic compound. Estimation of nitrogen by Kjeldahi's and Duma's method.

3. Preparation of alkenes from alcohols and alkylhalides, Elementary ideas of E_1 and E_2 reactions. Rearrangement during E_1 reaction should be dealt with Common addition reaction of alkenes (Stability of carbocations , Markovnikov's rule) and alkynes. Acidity of 1-alkynes.

4. Alcohol- Preparation (S_N^1 & S_N^2 mechanism should be dealt with), primary secondary and tertiary, difference in their properties. Method of distinguishing among three classes of alcohols, Glycerol-reaction and structures.

5 General methods of preparation of aldehydes and ketones – Addition and condensation reactions, base and acid catelysed condensation reactions- Aldol condensation, Haloform reaction including their mechanisms. Oxidation –reduction reaction – Cannizzaro reaction. Distinction between aldehydes and ketones.

(Physical) : (Group B: 15 marks)

1. Properties and Structure of gases :
The equation of state, Concept of an ideal gas, Real gases, Causes of deviations, Detail study of van der Walls equation, Critical constants. Continuity of state. Law of

corresponding states. Assumptions of kinetic theory, kinetic gas equation and its application, r.m.s. and average velocities, Maxwell distribution of molecular velocities (derivation omitted) – effect of temperature on distribution, molecular collision and mean free path. **15 Lect.**

2. Thermodynamics :
Basic definitions and mathematical background. First Law, enthalpy function, relation between C_p & C_v, Joule- Thomson experiment, Inversion temperature, Adiabatic changes in state. Enthalpies of chemical changes, Hess's Law; The second law, Carnot cycle and its efficiency, Refrigerator, Entropy Gibbs free energy. **15 Lect.**

Paper II (Inorganic) (Group A: 30 marks)

1. Natural Radioactivity: Radioactive disintegration, half-life, average life, group displacement law, radioactive equilibrium, Application – age of earth, carbon dating. Mass defect, Packing fraction, Binding energy, Nuclear stability – n/p ratio, Meson field theory, Artificial nuclear transmutation compound nucleus, few examples of a, D and proton induced reactions. Fission and fusion reaction.

2. Five series of atomic spectra of hydrogen atom by Bohr's theory , Explanation of five series of spectra by Bohr's formula, Elementary idea of four quantum numbers, Qualitative idea of Pauli's exclusion principle, Shape of s, p, d orbitals.

3. Modern periodic table- Understanding of the periodic table on the basis of electronic configuration, screening effect, Atomic radius, ionic radius, ionization potential, electron affinity, electro negativity – their periodicity.

4. Valency : Octet theory and limitation, simple idea of overlap of atomic orbitals (σ and π - bond), Hybridisation of atomic orbitals (qualitative idea), Molecular geometry of H_2O, H_2S, NH_3 and PH_3 on the basis of VSEPR theory and overlap of hybridized orbitals, Valency bond and molecular orbital theories (Elementary ideas).

(Physical): (Group B: 15 marks)

1. **Chemical equilibrium. :**
The laws of mass action and chemical equilibrium, Temperature dependence of equilibrium constant, Van't Hoff equation, Principle of Le Chattelier and Braun, effect of inert gas on equilibrium. Study of a few important homogeneous gaseous reactions. Clausius-Clapeyron equation, Phase rule and its applications to one component system; Nernst distributions law.

2. **Properties of liquids and solutions:**
Surface tension-formation of bubbles, viscosity, structure determination from dipole moment analysis. Relative lowering of vapour pressure, Elevation of boiling point, Depression of freezing point, Osmotic pressure (concept & final equation only)- their measurements, colligative properties of strong weak electrolytes.

Practical examination will be held at the end of first year in the following practical paper:

Paper III

The practical syllabus content for this part remains the same as the earlier one in use since 2003.

Organic Qualitative analysis	-	25
Organic Preparation and melting paint		20 + 5
Viva-Voce and Lab note book	-	10
Total Marks		60

Organic preparation: 1. m-dinitrobenzene from nitrobenzene; 2. p-nitroacetanilide from acetanilide. Melting paints of five different organic compounds.

B.Sc. (General)
Part- II

Paper – IV (Organic) (Group A: 30 marks)

1. Preparation and synthetic applications of Grignard reagent.Preparation and synthetic applications of carboxylic acid and its derivatives, ethyl aceto-acetate and diethyl malonate.

2. Amines – Primary, Secondary and Tertiary. Methods of separation and to distinguish them. Methods of preparation of primary amines – Hofmann hypobromite, Schmidt and Curtius reactions (mechanism omitted).

3. Optical isomerism-chiral centre. Optical isomerism of lactic and tartaric acids. Geometrical isomerism of double-bonded carbon compounds (abC=Cab).Geometrical isomerism of maleic and fumaric.

4 Carbohydrates- Definition, classification and reactions of monosaccharides, Glucose and Fructose and their structures (cyclic structures must be dealt with). Inversion of cane – sugar. **12 Lect**.

5. Structure of benzene. (4n + 2) - rule aromaticity. Substitution reactions of benzene (outline of mechanism through σ - complex) - halogenation, nitration, sulphonation, alkylation and acylation (Fridel-Crafts reaction). Directing influence of substituted benzene through stability of σ -complex.

6. Aromatic amines- diazonium salts and their reactions. Preparation and reactions of phenol-Reimer-Thiemann reaction- salicyldehyde and salicylic acid. Benzaldehyde – Benzoin condensation, Perkins reaction. Preparation and reaction of Picric acid. 15 Lect.

3

(Inorganic) (group B: 15 marks)

1. Characteristics of transition metal, reason for their differences from representative metals. Comparative study : Gr.VB : N,P. As, Sb, Bi. Electronic configuration, metallic-nonmetallic property, valence. Hydrides- preparation, stability, basic properties. Chlorides preparation, properties. Gr.-VI B : O, S-valence, Hydrides-boiling points, acidic character. Gr.-VII B : Special properties of Fluorine and Iodine.

2. Oxyacids : Name, structural formula, one method of preparation for each, nature of existence, basicity of (1) Chlorine (2) Iodine (3) Per acids of sulphur.

3. Extraction and chemistry of Ni, Sn, Hg, Li, Au.

4. Chemistry of : Hydrazine Sodium nitroprusside, Silicone, Borazene. Heavy water, Potassium dichromate, Potassium permanganate.

5. Carbonisation of coal : Superphosphate ; Detergent Soap, Terylene – manufacture and properties.

Paper – V (Inorganic) (group A: 15 marks)

1. Simple idea of Double salt and Complex salt. Perfect and imperfect complex, Nomenclature (IUPAC), Werner's coordination theory, ligand-monodentate, tri and tetradoutate, ambidentate, Chelate, Innermetallic complex (first order), Geometrical and optical isomerism in inorganic complexes.

2. Principles of Fe^{++} - $K_2 Cr_2 O_7$, titration, iodometric titration of standardization of $Na_2 S_2 O_3$, estimation of Cu^{++}. Calculation of errors – mean, median, mode. Standard deviation and standard error.

(Physical) (group B: 30 marks)

1. Dynamics (Chemical & Kinetics &Photochemistry):
Order and molecularity, Intergated rate laws for first & second order reactions, Determination of the order of a reaction. Opposing, consecutive, parallel and chain reactions (concept with example only). Effect of temperature on resction rate – activation energy (concept only). Laws of photochemistry, quantum yield, Lambert-Beer's law limitations and applications. Preliminary ideas of Fluorescence & Phosphorescence.

2. Electrochemistry :
Reversible and irreversible cells, Emf and its measurement, different types of half-cells reactions, Nernst equation, Reference electrodes. Solubility products. Common ion effect, Ionic product of water, pH. Hydrolysis of salts, Buffrs (only significance, no derivations). Theory of neutralization indicators. Arrhenius theory of electrolytic dissociation, Ostwald dilution law, Different types of conductance and their variation with concentration. Determination of Δ Conductometric titrations. Idea of activity of ions in solution.

3. Statistical thermodynamics :
Elementary idea of thermodynamic probability and entropy, Boltzmann distribution (no derivation), partition function.

4. Quantum chemistry & Spectroscopy :
Photoelectric effect, wave particle duality, uncertainty principle. Pure rotational & vibrational spectroscopy (only principle and condition).

5. Units and dimensions : SI units, Dimensional analysis of different equations. (This part may be taught separately or with different chapters where different equations are derived/used. However, question/s may also be set on this chapter). **2 Lect.**

6. **Surface chemistry and colloids:**
Types of adsorption, Freundlich and Langmuir Adsorption isotherm, change in enthalpy, entropy and free energy on adsorption. Theory of homogeneous catalysis, Elementary ideas of heterogeneous, acid- base and enzyme catalysis. Classification, preparation, purification and stability of colloids, Kinetic optical and electrical properties, coagulation, colloidal electrolytes.

Practical examination will be held at the end of second year the following practical paper:

Paper VI

Inorganic Qualitative Analysis	- 50
Viva-Voice and Lab note book	- 10
Total marks	- 60

The practical syllabus contents stated in the earlier syllabus in use since 2003 remain unchanged.

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Part – III

Paper VII (Industrial Chemistry) B. Sc. Part II (General) ***60 marks***

1. Fules : (i) Gaseous fuels : Manufacture & uses of Producer gas, Water-gas, Light petroleum gas and Bio-gas

   (ii) Liquid fuels : Crude of oil- refining, Gasolene Diesel oil,Octane number, Cetane number, Antiknock compounds.

2. Non-Conventional Sources of Energy ; Solar energy, Wind energy, Geothermal energy- Elementry ideas, applications.

3. Paints and Pigments : Methods of Preparation & uses of Ultramarine blue, Z_nO.

4. Ceramics : Manufacture of glazed porcelain (household items).

5. Insecticides : Different classes of insecticides – organophosphorous, carbamates, pyrethroids- applications in Tea, Tobacco & Mango and Pine apple industry.

6. Oils and fats : Distinction between oils & fats, Saponification value, Iodine value, Hydrogenation of fats & oils.

7. Polymers: Preliminary ideas of polythene, PVC, Polyurethane (composition & uses).

8. Cement : Cement-its composition, manufacture & uses, setting of cement.

9. Electroplating Theories of electroplanting, galvanization, application & uses.

Practical examination will be held at the end of third year in the following practical Paper:

Paper- VIII

Inorganic Quantitative Analysis – 20
Project work - 20
Total marks 40

The practical syllabus contents stated in the earlier syllabus in use 2003 remain unchanged.

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RECOMMENDED BOOKS

1. Advanced Organic Chemistry – Finar Vol. 1&2.
2. Basic Principles of Organic Chemistry – Roberts & Ceserio.
3. Organic Chemistry – Cram,Hammond, Hendriction, Pyne (4th edition)
4. Organic Chemistry – Morrion & Boyd.
5. Advanced Organic Chemistry – March.
6. Advanced Organic Chemistry – Carey & Sandberg.
7. Guide book to Mechanism in Organic Chemistry – Sykes.
8. Structure and Mechanism in organic Chemistry – Gould.
9. Highlights of Organic Chemistry – Nobel.
10. Modern Synthetic Organic Chemistry – House.
11. Organic Chemistry – Ghosh.
12. Principles of Organic Synthesis – Norman.
13. The Chemistry of Carbonyl Compounds – Gutsche.
14. Organic Synthesis- Irland.
15. The Modern Structural theory of Organic Chemistry – Ferguson.
16. Reaction Mechanism in Organic Chemistry – Mukherjee & Singh.
17. Experiments in Organic Chemistry – Fieser & Williamson, 5th Edn.
18. Unitized Experiments in organic Chemistry – Brewster & McEwen.
19. Elementary Practical Organic chemistry pt. I-II, Vogel.
20. Experimental Organic Chemistry- Singh, Gupta & Bajpai.
21. A Hand book of Organic Analysis – Clarke.
22. Advance Inorganic Chemistry- Cotton & Wilkinson.
23. Advanced Inorgaic Chemistry – Durrant & Durrant.
24. The Nature of Chemical Bonds – Pauling.
25. Electronic Structure and Chemical Bonding – Sebera.
26. Chemical Periodicity – Sanderson.
27. Inorganic Chemistry – Sanderson.
28. Valence-Coulson.
29. Valence and Molecular structure Cartmell & Fowles.
30. Inorganic Chemistry – Haslop & Robinson.
31. Theoretical Inorganic chemistry- Day & Selbin.
32. Source Book of Atomic Energy – Glastone.
33. Concise Inorganic chemistry – Lee.
34. Inorganic Chemistry – Moeller.
35. Modern Aspects of Inorganic chemistry – Emeleus & Anderson.
36. Inorganic Reactions and Structure- Gould.
37. Qualitative Inorganic Analysis- Vogel.
38. Semi Micro Analysis – Sarkar & Saha.
39. Quantitative Inorganic Analysis – Vogel.
40. Quantitative Inorganic Analysis – Charlot.
41. Physical chemistry – Alberty & Daniels.
42. Physical Chemistry – Barrow.
43. Physical Chemistry – Moore.
44. Elementry Physical Chemistry – Glasstone.
45. Theoretical Chemistry – Glasstone .
46. Text book of Physical chemistry – Glasstone.
47. Electrochemistry – Glasstone.

48. Physical Chemistry – Rakshit.
49. Thermodynamics – Rakshit
50. Understanding Physical Chemistry – Adamson.
51. Physical Chemistry – Moelwyn Hughes.
52. Practical Physical Chemistry – Findlay.
53. Practical Physical Chemistry – Gurtu & Kapoor.
54. Practical Physical Chemistry – De & Palit.
55. Spot tests in Inorganic Analysis – Feigl & Anger.
56. Industrial Chemistry – Riegel.
57. Industrial Chemistry – Shreve & Similar other books on Industrial Chemistry.
58. A Text Book of Physical chemistry – (Vol. 1-4) K.L. Kapoor.
59. Physical Chemistry Experiments – S. Dutta.
60. Fundamentals of Analytical chemistry- D.A. Skoog and D.M. West.
61. Organic spectroscopy (3rd ed.) – W. Kemp.
62. Specytroscopy – G. chatwal and S. Anand.
63. Biochemistry – Debajyoti Das.
64. Fundamentals of molecular spectroscopy – Banwell.
65. Physical chemistry – Atkins.
66. Physical Chemistry – S.R. Palit.
67. Industrial Chemistry – B.K. Sharma.
68. Industrial Chemistry –B.N. Chakraborty.
69. Biochemistry – C.B. Power and G. R. Chatwal
70. Applications of Absorption Spectroscopy of Organic compounds - R.Dyer
71. Spectrometric identification of Organic compounds (4th ed.) – R. M. ilverstein, G.C. Bossies & T.C. Morrill.
72. Stereochemistry of carbon compounds – E.L.Eliel.
73. Sterochemistry of organic compound – D Nasipuri.

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UNIVERSITY OF NORTH BENGAL

Accredited by NAAC with grade A

Raja Rammohunpur, Dist: Darjeeling, Pin: 734013.

CHOICE BASED CREDIT SYSTEM

B.Sc. Honours & Program Course with CHEMISTRY

Revised Syllabus

(First, Third & Fifth Semester)

CBCS

ODD SEMESTERS – 1, 3, 5

SEMESTER-I [H] & [Prog]	COURSE NAME
CC-I	Inorganic Chemistry
CC- II	Physical Chemistry
GE- 1	Sec-A: Inorganic Chemistry Sec-B: Organic Chemistry
DSC-1	Sec-A: Inorganic Chemistry Sec-B: Organic Chemistry
SEMESTER -3 [H] & [Prog]	**COURSE NAME**
CC-V	Inorganic Chemistry
CC-VI	Organic Chemistry
CC-VII	Physical Chemistry
SEC- 1 [H]	Pharmaceutical Chemistry
GE-3	Sec A: Physical Chemistry Sec B : Organic Chemistry
DSC-3	Sec A: Physical Chemistry Sec B : Organic Chemistry
SEC- 1(DSC)	Pharmaceutical Chemistry
SEMESTER-5 [H] & [Prog]	**COURSE NAME**
CC-XI	Organic Chemistry
CC-XII	Physical Chemistry
DSE-1	Analytical Methods in Chemistry
DSE-2	Inorganic Materials of Industrial Importance
SEC- 3 (DSC)	Pesticide Chemistry
DSE- 1 (DSC)	Inorganic Materials of Industrial Importance

CHEMISTRY

SYLLABUS (CBCS)

(B.Sc. HONOURS)

1st, 3rd, 5th SEMESTER

SCHEME for B.Sc. (HONOURS) 1st SEMESTER

YEAR	SEMESTER	CORE COURSE [CC]
1st	1st	CC-I : INORGANIC CHEMISTRY
		CC-II : PHYSICAL CHEMISTRY

SCHEME for B.Sc. (HONOURS) 3rd SEMESTER

YEAR	SEMESTER	CORE COURSE [CC]	SKILL ENHANCEMENT COURSE [SEC]
2nd	3rd	CC-V : INORGANIC CHEMISTRY	SEC-1 : Pharmaceutical Chemistry
		CC-VI: ORGANIC CHEMISTRY	
		CC-VII: PHYSICAL CHEMISTRY	

SCHEME for B.Sc. (HONOURS) 5th SEMESTER

YEAR	SEMESTER	CORE COURSE [CC]	DISCIPLINE SPECIFIC ELECTIVE [DSE]
3rd	5th	CC- XI : ORGANIC CHEMISTRY	DSE -I : Analytical Methods in Chemistry
		CC -XII : PHYSICAL CHEMISTRY	DSE -2 : Inorganic Materials of Industrial Importance

SCHEME for B.Sc. Students of Honours with other Disciplines (GENERIC ELECTIVE)

YEAR	SEMESTER	GENERIC ELECTIVE	
1st	1st	GE-I	Section -A : Inorganic Chemistry Section – B : Organic chemistry
2nd	3rd	GE-3	Section -A : Physical Chemistry Section -B : Organic Chemistry

B.Sc. Program Course in CHEMISTRY

SCHEME for B.Sc. Program Course 1st SEMESTER

Year	Semester	DISCIPLINE SPECIFIC COURSE	
1st	1st	DSC-I	Section -A: Inorganic Chemistry
			Section- B: Organic Chemistry

SCHEME for B.Sc. Program Course 3rd SEMESTER

Year	Semester	DISCIPLINE SPECIFIC CORE	SKILL ENHANCEMENT COURSE
2nd	3rd	DSC-3 Section-A: Physical Chemistry Section -B :Organic Chemistry	SEC-1 (DSC) : Pharmaceutical Chemistry

SCHEME for B.Sc. Program Course 5th SEMESTER

Year	Semester	DISCIPLINE SPECIFIC ELECTIVE	SKILL ENHANCEMENT COURSE
3rd	5th	DSE-I(DSC) : Inorganic Materials of Industrial Importance	SEC-3 (DSC) Pesticide Chemistry

UNIVERSITY OF NORTH BENGAL

CHEMISTRY

Semester 1

HONOURS IN CHEMISTRY

CC-I: INORGANIC CHEMISTRY

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

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.

Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number. **(14 Lectures)**

UNIT II: Periodicity of Elements:

s, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

(b) Atomic radii (van der Waals)

(c) Ionic and crystal radii.

(d) Covalent radii (octahedral and tetrahedral)

(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.

(f) Electron gain enthalpy, trends of electron gain enthalpy.

(g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. **(16 Lectures)**

UNIT III: Chemical Bonding:

(i) *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

(ii) *Covalent bond:* Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions (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.

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

(iv) *Weak Chemical Forces:* van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points. **(26 Lectures)**

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. **(4 Lectures)**

Reference Books:

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

CHEMISTRY PRACTICAL: CC-I: LAB

60 Lectures

(A) Titrimetric Analysis

(i) Calibration and use of apparatus

(ii) Preparation of solutions of different Molarity/Normality of titrants

(B) Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.

(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.

(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Reference text:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.

CHEMISTRY CC- II: PHYSICAL CHEMISTRY

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

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, Dietirici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states. **(18 Lectures)**

UNIT II: Liquid state:

Qualitative treatment of the structure of the liquid state; 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. **(6 Lectures)**

UNIT III: Solid state:

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, and KCl. **(16 Lectures)**

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, and buffer action.

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. **(20 Lectures)**

Reference Books:

- Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 10th Ed., Oxford UniversityPress (2014).
- Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
- Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
- Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009).
- Engel, T. & Reid, P. *Physical Chemistry* 3rd Ed. Pearson (2013).

CHEMISTRY PRACTICAL: CC- II LAB

60 Lectures

(Any three)

1. Surface tension measurements.

(a) Determine the surface tension by drop number method.

(b) Study the variation of surface tension of detergent solutions with concentration.

2. Viscosity measurement using Ostwald's viscometer.

(a) Determination of viscosity of aqueous solutions of polymer / ethanol / sugar at room temperature.

(b) Study the variation of viscosity of sucrose solution with the concentration of solute.

3. Indexing of a given powder diffraction pattern of a cubic crystalline system.

4. pH metry

(a) Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.

(b) Preparation of buffer solutions of different pH

(i) Sodium acetate-acetic acid

(ii) Ammonium chloride-ammonium hydroxide

(c) pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.

(d) Determination of dissociation constant of a weak acid.

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York (2003).
- Halpern, A. M. & Mc Bane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

Semester 3

CHEMISTRY: CC -V: INORGANIC CHEMISTRY

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

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 Arkle-de Boer process and Mond's process, Zone refining. **(6 Lectures)**

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)**

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)**

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)**

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)**

Reference Books:

- Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
- Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. 1994.
- Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann. 1997.
- Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
- Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
- Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* 4th Ed., Pearson, 2010.
- Atkin, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

CHEMISTRY PRACTICAL: CC- V LAB

60 Lectures

(A) Iodo / Iodimetry 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.

(B) Quantitative Estimation of

(i) Fe^{3+} and Cu^{2+}

(ii) Fe^{3+} and Cr^{3+}

(iii) Fe^{3+} and Ca^{2+}

Reference Books:

- Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6thEd.,* Pearson, 2009.

CHEMISTRY CC-VI: ORGANIC CHEMISTRY

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

UNIT I: Chemistry of Halogenated Hydrocarbons:

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – SN1, SN2 and SNimechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromaticsubstitution; SNAr, 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)**

UNIT II: Alcohols, Phenols, Ethers and Epoxides:

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-BlancReduction; 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 substitutionreactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism;

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides withalcohols, ammonia derivatives and LiAlH4 **(16 Lectures)**

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 (Clemensen, Wolff-Kishner, LiAlH4, NaBH4, 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)**

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 substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann-bromamide degradation and Curtius rearrangement. **(10 Lectures)**

UNIT V: Sulphur containing compounds:

Preparation and reactions of thiols, thioethers and sulphonic acids. **(4 Lectures)**

Reference Books:

- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Graham Solomons, T.W. *Organic Chemistry,* John Wiley & Sons, Inc.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.

CHEMISTRY PRACTICAL: CC-VI LAB

60 Lectures

1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
2. Organic preparations: (Any Five)

(i) Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidine and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method:

   a. Using conventional method.
   b. Using green approach

(ii) Benzoylation of one of the following amines (aniline, *o*-, *m*-, *p*- toluidine's and *o*-, *m*-, *p*-anisidine) and one of the following phenols (β-naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction.

(iii) Oxidation of ethanol/ isopropanol (Iodoform reaction).

(iv) Bromination of any one of the following:
   (a) Acetanilide by conventional methods
   (b) Acetanilide using green approach (Bromate-bromide method)

(v) Nitration of any one of the following:
   (a) Acetanilide/nitrobenzene by conventional method
   (b) Salicylic acid by green approach (using ceric ammonium nitrate).

(vi) Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline.

(vii) Reduction of *p*-nitrobenzaldehyde by sodium borohydride.

(viii) Hydrolysis of amides and esters.

(ix) Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.

(x) *S*-Benzylisothiouronium salt of one each of water soluble and water insoluble acids(benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).

(xi) Aldol condensation using either conventional or green method.

(xii) 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

- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
- Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.* Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000).

CHEMISTRY: CC-VII: PHYSICAL CHEMISTRY

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

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.

Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes.

Nernst distribution law: its derivation and applications. **(28 Lectures)**

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)**

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)**

UNIT IV: Surface chemistry:

Physical adsorption, chemisorption, adsorption isotherms (Freundlich and Langmuir), nature of adsorbed state. **(6 Lectures)**

Reference Books:

- Peter Atkins & Julio De Paula, *Physical Chemistry* 10th Ed., Oxford University Press (2014).
- Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa (2004).
- Mc Quarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books Pvt. Ltd.: New Delhi (2004).
- Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics.* CRC Press: NY (2011).
- Zundhal, S.S. *Chemistry concepts and applications* Cengage India (2011).
- Ball, D. W. *Physical Chemistry* Cengage India (2012).
- Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP (2009).
- Levine, I. N. *Physical Chemistry 6th Ed.,* Tata McGraw-Hill (2011).
- Metz, C. R. *Physical Chemistry 2nd Ed.,* Tata McGraw-Hill (2009).

CHEMISTRY PRACTICAL: CC-VII LAB

60 Lectures

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

II. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method:

(a) simple eutectic and

(b) congruently melting systems.

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

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

(i) $I_2(aq) + I^- \rightarrow I_3^-(aq)^{2+}$

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

V. Study the kinetics of the following reactions. (Any One)

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method (Any ONE)
    a. Acid hydrolysis of methyl acetate with hydrochloric acid.
    b. Saponification of ethyl acetate.
3. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

VI. Adsorption:

Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

SKILL ENHANCEMENT COURSE for Honours and Program Course

SEC-1 [Honours] and SEC-1 (DSC)

PHARMACEUTICAL CHEMISTRY

(Credits: 02)

Theory: 30 Lectures

Drugs & Pharmaceuticals

Classification, Structure and drug discovery, design and development and therapeutic uses; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, ibuprofen); Antimalarials: Chloroquine (with synthesis). antibiotics (detailed study of 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).Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

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 B2, Vitamin B12 and Vitamin C.

Practicals (any two)

1. Preparation of Aspirin and its analysis.
2. Preparation of magnesium disilicates (Antacid).
3. Preparation of methyl salicylate (oil of wintergreen).
4. Any other Practical as desired.

Reference Books:

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

Semester 5

CHEMISTRY: CC-XI: ORGANIC CHEMISTRY

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

UNIT I: Pericyclic Reactions:

Introduction to Pericyclic Reactions and their classification; Molecular orbitals of conjugated π-systems (Ethane, 1,3-Butadiene, 1,3,5-Hexatriene and Benzene) and their symmetry properties; HOMO and LUMO. Electrocyclic reactions– Introduction, Classification, Disrotation and Conrotation, Woodward Hoffmann rules, Stereochemical aspects. Cycloaddition reactions– Introduction, Classification, Examples of thermal and photochemical cycloaddition reactions, Activated Dienes and Dienophiles, Regioselectivity, Atomic orbital coefficient, Stereospecificity, Endo-addition rules. Secondary orbital interactions. Sigmatropic rearrangements – Introduction, Classification, Claisen and Cope rearrangements. **(20 Lectures)**

UNIT II: Nucleic Acids

Components of nucleic acids, Nucleosides and nucleotides;

Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides. **(5 Lectures)**

UNIT III: Amino Acids, Peptides and Proteins

Amino acids, Peptides and their classification.

α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, p*K*a 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)**

UNIT IV: 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. **(8 Lectures)**

UNIT V: Lipids

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity. **(5 Lectures)**

UNIT VI: 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. **(8 Lectures)**

Reference Books:

- Berg, J.M., Tymoczko, J.L. & Stryer, L. (2006) *Biochemistr*y. 6th Ed. W.H. Freeman and Co.
- Nelson, D.L., Cox, M.M. & Lehninger, A.L. (2009) *Principles of Biochemistry. IVEdition.* W.H. Freeman and Co.
- Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2009) *Harper'sIllustrated Biochemistry.* XXVIII edition. Lange Medical Books/ McGraw-Hill.

CHEMISTRY PRACTICAL: CC- XI LAB

60 Lectures (Any Five)

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:

- Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
- Arthur, I. V. *Quantitative Organic Analysis,* Pearson.

CHEMISTRY: CC-XII: PHYSICAL CHEMISTRY

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

UNIT I: Quantum Chemistry

Black body radiation, Photoelectric effect, Compton effect, Planck's quantum theory, Wave particle duality, Heisenberg Uncertainty principle, 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 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.

(16 Lectures)

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,

(16 Lectures)

UNIT III: 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, photosensitised reactions, quenching. fluorescence and phosphorescence, chemiluminescence. **(12 Lectures)**

UNIT IV: Colloids

Classification, Preparation, Purification, Stability of colloids, Properties of colloids (optical, kinetic and electrical properties), Schulze Hardy rule, Gold number, Determination of Avogadro's number, Colloidal electrolytes and their properties, Isoelectric point, Electrical double layer and Zeta potential, Micelles. **(8 Lectures)**

UNIT V: Statistical Thermodynamics:

Concepts of permutation, combination, factorials and probability, Thermodynamic probability and entropy, Boltzmann distribution, Partition function (translational, rotational, vibrational and electronic), Thermodynamic functions and equilibrium constant in terms of partition function.

(8 Lectures)

Reference Books:

- Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi (2006).
- Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
- House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA (2004).
- Kakkar, R. *Atomic & Molecular Spectroscopy*: *Concepts & Applications*, Cambridge University Press (2015).
- Lowe, J. P. & Peterson, K. *Quantum Chemistry*, Academic Press (2005).

CHEMISTRY PRACTICAL: CC-XII LAB

60 Lectures

1. Verify Lambert – Beer's Law and determine the concentration of $KMnO_4$ / $K_2Cr_2O_7$ in a solution of unknown concentration.
2. 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).
3. Analysis of the given Vibration – Rotation Spectrum of HCl [g].
4. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.

DISCIPLINE SPECIFIC ELECTIVE

CHEMISTRY-DSE-1: ANALYTICAL METHODS IN CHEMISTRY [Honours]

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Qualitative and quantitative aspects of analysis:

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals. **(5 Lectures)**

Optical methods of analysis:

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument;

Basic principles of quantitative analysis: estimation of metal ions from aqueous solution. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques.

Structural illustration through interpretation of data, Effect and importance of isotope substitution.

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector), choice of flame and Burner designs. Techniques of atomization and sample introduction. **(20 Lectures)**

Thermal methods of analysis:

Theory of thermogravimetry (TG), basic principle of instrumentation.

Techniques for quantitative estimation of Ca and Mg from their mixture. **(5 Lectures)**

Electroanalytical methods:

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values. **(10 Lectures)**

Separation techniques:

Solvent extraction: Classification, principle, Distribution coefficient and distribution ratio, efficiency of the technique, percentage extraction, separation factor, Selection of solvent.

Mechanism of extraction: extraction by solvation and chelation.

Technique of extraction: batch and continuous extractions.

Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

Chromatography: Classification, principle and efficiency of the technique.

Mechanism of separation: adsorption, partition & ion exchange.

Development of chromatograms: frontal, elution and displacement methods.

Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.

Ion-exchange: Principle, Types of ion-exchangers, Quality of resins, Swelling of resins, Action of ion-exchange resin, Ion-exchange equilibrium, Ion-exchange capacity, Deionization of water.

Role of computers in instrumental methods of analysis **(20 Lectures)**

Reference Books:

- Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
- Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
- Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.
- Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
- Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
- Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand, 1974.

PRACTICAL: DSE -1 LAB: ANALYTICAL METHODS IN CHEMISTRY [Honours]

60 Lectures

I. Separation Techniques (Any Two)

1. Chromatography:

(a) Separation of mixtures

(i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.

(ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.

(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.

(c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC.

II. Solvent Extractions: (Any One)

(i) To separate a mixture of Ni^{2+}& Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry.

(ii) Solvent extraction of zisconium with amberliti LA-1, separation from a mixture of irons and gallium.

3. Determine the pH of the given aerated drinks /fruit juices/ shampoos and soaps.

4. Analysis of soil:

(i) Determination of pH of soil.

(ii) Total soluble salt

(iii) Estimation of calcium, magnesium, phosphate, nitrate

5. Ion exchange: (Any One)

(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.

(ii) Separation of metal ions from their binary mixture.

(iii) Separation of amino acids from organic acids by ion exchange chromatography

III. Spectrophotometry: (Any Three)

(i) Determination of pKa values of indicator using spectrophotometry.

(ii) Structural characterization of compounds by infrared spectroscopy.

(iii) Determination of dissolved oxygen in water.

(iv) Determination of chemical oxygen demand (COD).

(v) Determination of Biological oxygen demand (BOD).

(vi) Determination of the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Reference Books:

- Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
- Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, D.C. *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
- Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.
- Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Edition.
- Mikes, O. & Chalmes, R.A. *Laboratory Handbook of Chromatographic & Allied Methods*, Elles Harwood Ltd. London.
- Ditts, R.V. *Analytical Chemistry: Methods of separation.*

DISCIPLINE SPECIFIC ELECTIVE for Honours and Program Course

DSE - 2 [Honours]

DSE - 1 (DSC) [Program]

INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

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. **(18 Lectures)**

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)**

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 an anodizing. **(12 Lectures)**

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)**

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)**

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)**

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.
- D. Kingery, H. K. Bowen, D. R. Uhlmann: *Introduction to Ceramics,* Wiley Publishers, New Delhi.
- 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.

PRACTICALS: DSE-II [Honours]

DSE-I (DSC) [Program] LAB:

INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE

60 Lectures (Any Five)

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.
- D. Kingery, H. K. Bowen, D. R. Uhlmann: *Introduction to Ceramics,* Wiley Publishers, New Delhi.
- 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).

SKILL ENHANCEMENT COURSE [for Program Course]

SEC - 3 [DSC]

PESTICIDE CHEMISTRY

CREDIT – 2

Number of Lectures – 30

THEORY

1. General introduction to pesticides (natural and synthetic)
2. Benefits and adverse effects of pesticides
3. Changing concepts of pesticides
4. Structure activity relationship
5. Synthesis and technical manufacture and uses of representative pesticides in the following classes:

(a) Organochlorines (DDT, Gammaxene)

(b) Organophosphates (Malathion, Parathion)

(c) Carbamates (Carbofuran and carbaryl)

(d) Quinones (Chloranil)

(e) Anilides (Alachlor and Butachlor)

PRACTICAL (Any ONE)

1. To calculate acidity/alkalinity in given sample of pesticide formulations as per BIS specifications.
2. Preparation of simple organophosphates, phosphonates and thiophosphates
3. Any other practical deemed relevant.

Reference Book:

- Cremlyn, R. Pesticides. Preparation and Modes of Action, John Wiley & Sons, New York, 1978.

GE: GENERIC ELECTIVE and DSC: DISCIPLINE SPECIFIC ELECTIVE

SEMESTER-1

GE -1 and DSC -1 :

ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Section A: Inorganic Chemistry (30 Periods)

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.

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, Shapes of s, p and d atomic orbitals.

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)**

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. Fagan'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)**

Section B: Organic Chemistry (30 Periods)

Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pKa values. Aromaticity: Benzenoids and Hückel's rule. **(8 Lectures)**

Stereochemistry

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (up to 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)**

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)**

Reference Books:

- Lee, J.D. Concise Inorganic Chemistry ELBS, 1991
- Cotton, F.A., Wilkinson, G & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
- Douglas, B.E., McDaniel, D.H & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
- Huheey, J.E., Keiter, E.A., Keiter, R.L & Medhi, O.K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 2006.
- Graham Solomon, T.W., Fryhle, C.B & Dnyder, S.A. Organic Chemistry, John Wiley & Sons (2014). McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
- Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
- Eliel, E.L. Stereochemistry of Carbon Compounds, Tata McGraw Hill education, 2000
- Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
- Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
- Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.

PRACTICAL: GE-I and DSC-I

ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

60 Lectures

Section A: Inorganic Chemistry - Volumetric Analysis (ANY THREE)

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 (ANY THREE)

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
2. Separation of mixtures by Chromatography: Measure the Rf 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:

- Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012
- Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009
- 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.

SEMESTER -3

GE-3 and DSC-3

SOLUTIONS, PHASE EQUILIBRIA, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC CHEMISTRY-II

(Credits: Theory-04, Practicals-02)

Theory:

60 Lectures

Section A: Physical Chemistry (30 Lectures)

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. Nernst distribution law and its applications. **(8 Lectures)**

Phase Equilibria

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule. Derivation of Clausius-Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component system (water). **(6 Lectures)**

Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. 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). **(8 Lectures)**

Electrochemistry

Reversible and irreversible cells. Concept of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Calculation of thermodynamic properties (of a reversible cell): ΔG, ΔH and ΔS and equilibrium constant from EMF data. Potentiometric titrations-qualitative treatment (acid-base and oxidation-reduction only). **(8 Lectures)**

Section B: Organic Chemistry (30 Lectures)

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

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 inter conversion. Reactions: Reformatsky Reaction, Perkin condensation. **(6 Lectures)**

Amines and Diazonium Salts

Amines (Aliphatic and Aromatic): (Upto 5 carbons) Preparation: Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2

Diazonium salts: Preparation: from aromatic amines. Reactions: conversion to benzene, phenol.

(6 Lectures)

Amino Acids, Peptides and Proteins

Preparation of Amino Acids: Strecker synthesis, Gabriel's phthalimide synthesis. Reactions of Amino acids: ester of –COOH group, acetylation of $–NH_2$ 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). **(10 Lectures)**

Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of absolute configuration of Glucose. Structure of disacharrides (sucrose) and polysaccharides' (starch and cellulose) excluding their structure elucidation.

(8 Lectures)

PRACTICAL: GE -3 and DSC-3 LAB

SOLUTIONS, PHASE EQUILIBRIA, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL ORGANIC CHEMISTRY

Section A: Physical Chemistry

Conductance

Perform the following conductometric titrations (Including theoretical background):

(a) Strong acid vs. strong base

(b) Weak acid vs. strong base

Potentiometry (ANY ONE)

1. Perform the following potentiometric titrations (Including theoretical background):

(i) Strong acid vs. strong base

(ii) Weak acid vs. strong base

(iii) Potassium dichromate vs. Mohr's salt

Section B: Organic Chemistry

Systematic Qualitative Organic Analysis of Organic Compounds possessing mono functional Groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines)
and preparation of one derivative.
(Including the study of chemical reactions involved in the detection of functional groups and preparation of their derivatives).

UNIVERSITY OF NORTH BENGAL

Raja Rammohunpur, Dist: Darjeeling, Pin: 734013.

CHOICE BASED CREDIT SYSTEM (CBCS)

B.Sc. Honours & Program Course with CHEMISTRY

Revised Syllabus

(Second, Fourth & Sixth Semester)

WITH EFFECT FROM 2022-2023 ACADEMIC SESSION

NORTH BENGAL UNIVERSITY

CHEMISTRY

CBCS - 2nd, 4th & 6th SEMESTER HONOURS & PROGRAM COURSE

SYLLABUS LAYOUT FOR CHEMISTRY HONOURS & PROGRAM COURSE

SEMESTER	PAPER	TOPIC
SEMESTER 2 Hons. & Prog.	CC-3	Organic Chemistry
	CC-4	Physical Chemistry
	GE-2 & DSC-2	Section A: Physical Chemistry Section B: Organic Chemistry
SEMESTER 4 Hons. & Prog.	CC-8	Inorganic Chemistry
	CC-9	Organic Chemistry
	CC-10	Physical Chemistry
	SEC-2 (H) & SEC-2 (DSC)	Green Methods in Chemistry
	GE-4 & DSC-4	Section A: Inorganic Chemistry Section B: Physical Chemistry
SEMESTER 6 Hons. & Prog.	CC-13	Inorganic Chemistry
	CC-14	Organic Chemistry
	DSE-3	Polymer Chemistry
	DSE-4 & DSE-2 (DSC)	Industrial Chemicals and Environment
	SEC-4 (DSC)	Chemistry of Cosmetics and Perfumes

CHEMISTRY HONOURS SYLLABUS

SEMESTER-2

CHEMISTRY-CC-3: ORGANIC CHEMISTRY- I

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

UNIT I:

Basics of Organic Chemistry

Organic Compounds: Classification and Nomenclature, Hybridization.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation; Organic acids and bases: their relative strength.

Homolytic and Heterolytic fission; Electrophiles and Nucleophiles; Types, shape and their relative stability of Carbocations, Carbanions, and Free radicals.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions. **[6 Lectures]**

UNIT II:

Stereochemistry

Fischer, 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, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, Meso structures, Racemic mixture and resolution. D/L and R/S designations. **[18 Lectures]**

UNIT III:

Chemistry of Aliphatic Hydrocarbons

A. Carbon-Carbon sigma bonds

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

B. Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/Anti Markownikoff addition), hydroboration-oxidation, ozonolysis, catalytic reduction, 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: Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

C. Cycloalkanes and Conformational Analysis

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms. **[24 Lectures]**

UNIT IV:

Aromatic Hydrocarbons Aromaticity

Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups. **[12 Lectures]**

Reference Books:

- Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*, Wiley: London, 1994.
- Kalsi, P. S. *Stereochemistry Conformation and Mechanism*, New Age International, 2005.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.

CHEMISTRY LAB: CC-3 PRACTICAL

ORGANIC CHEMISTRY PRACTICAL

(Any THREE)

1. Checking the calibration of the thermometer
2. Purification of organic compounds by crystallization using the following solvents:

(a) Water; (b) Alcohol; (c) Alcohol-Water

3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)

4. Effect of impurities on the melting point-mixed melting point of two unknown organic compound.

5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100^{o}C by distillation and capillary method)

6. Chromatography (Any ONE)

(a) Separation of a mixture of two amino acids by ascending and horizontal paper chromatography

(b) Separation of a mixture of two sugars by ascending paper chromatography

(c) Separation of a mixture of o- and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

Reference Books:

- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed. Pearson (2012).

CHEMISTRY- CC-4: PHYSICAL CHEMISTRY- II

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

UNIT I:

Chemical Thermodynamics

Basic Definition and Mathematical background of Thermodynamics.

Intensive and extensive variables; state and path functions; isolated, closed and open systems; Zeroth Law

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 under isothermal and adiabatic conditions.

Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion; Hess's Law and Application.

Calculation of bond energy, bond dissociation energy and resonance energy from thermodynamics data, Variation of Heats of reaction with temperature (Kirchhoff's equation) on enthalpy of reactions.

Second law: Statement of the Second law of thermodynamics; Carnot's Cycle and its efficiency. Thermodynamic Scale of Temperature. Concept of Entropy, 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. Joule-Thomson coefficient; Inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state. **[34 Lectures]**

UNIT II:

Systems of Variable Composition

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures. **[6 Lectures]**

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. 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. **[10 Lectures]**

UNIT IV:

Solutions and Colligative Properties

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws.

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. Van't Hoff Factor. Application in calculating molar masses of normal, dissociated and associated solutes in solution. **[10 Lectures]**

Reference Books

- Peter, A. & Paula, J. de. *Physical Chemistry* 10th Ed.*,* Oxford University Press (2014).
- Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa (2004).
- Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
- McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* Viva Books Pvt. Ltd.: New Delhi (2004).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics.* CRC Press: NY (2011).
- Levine, I .N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill (2010).
- Metz, C.R. *2000 solved problems in chemistry,* Schaum Series (2006).

CHEMISTRY LAB: CC-4 PRACTICAL

PHYSICAL CHEMISTRY PRACTICAL

(Any Three)

1. Determination of Surface Tension of solutions of different compositions and composition of the unknown solution.
2. Determination of Coefficient of Viscosity of solutions of different compositions and composition of an unknown solution.
3. Determination of pH of a solution by Colour Matching.
4. Determination of heat capacity of the calorimeter
5. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
6. Calculation of the enthalpy of ionization of ethanoic acid.
7. Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
8. Study of the solubility of benzoic acid in water and determination of ΔH.

Reference Books

- Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
- Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry* New Age International: New Delhi (2001).

SEMESTER-4

CHEMISTRY- CC-8: INORGANIC CHEMISTRY- III

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

UNIT I:

Coordination Chemistry

Werner's theory, valence bond theory (inner and outer orbital complexes).

Crystal field theory, measurement of 10 Dq (Δ_o), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (Δ_o, Δ_t). 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, Labile and inert complexes. **(26 Lectures)**

UNIT II:

Transition Elements

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation 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)**

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)**

UNIT IV:

Bioinorganic Chemistry

Metal ions present in biological systems, classification of elements according to their action in biological system. 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 in medicine.

Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.

(10 Lectures)

Reference Books:

- Purcell, K.F. & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co, 1977.
- Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.
- Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
- Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999.
- Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
- Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.

CHEMISTRY LAB: CC-8 PRACTICAL

INORGANIC CHEMISTRY PRACTICAL (ANY TWO)

(1) Gravimetric Analysis: (Any One)

(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 $Al(oxine)_3$ (aluminium oxinate)

(2) Inorganic Preparations: (Any Three)

(i) Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$

(ii) *Cis* and *trans*-Potassium dioxalatodiaquachromate (III), $K[Cr(C_2O_4)_2.(H_2O)_2]$

(iii) Tetraamminecarbonatocobalt (III) ion

(iv) Potassium tris(oxalate)ferrate(III)

(v) Cuprous Chloride, Cu_2Cl_2

(vi) Preparation of Manganese(III) phosphate, $MnPO_4.H_2O$

(vii) Preparation of Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum)

(3) Chromatography of metal ions: (Any One)

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 Book:

- Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.

CHEMISTRY-CC-9: ORGANIC CHEMISTRY-III

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

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.

Diazonium Salts: Preparation and their synthetic applications. **(18 Lectures)**

UNIT II:

Polynuclear Hydrocarbons

Reactions of naphthalene, phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons. **(8 Lectures)**

UNIT III:

Heterocyclic Compounds

Classification and nomenclature, Structure, aromaticity in 5-membered 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), Pyrimidine, Structure elucidation of 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, Pomeranz-Fritsch reaction.

Derivatives of furan: Furfural and furoic acid. **(22 Lectures)**

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. **(6 Lectures)**

UNIT V:

Terpenes

Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral and Neral and α-terpineol. **(6 Lectures)**

Reference Books:

- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry of Natural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds,* John Welly & Sons (1976).
- Graham Solomons, T.W. *Organic Chemistry,* John Wiley & Sons, Inc.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P) Ltd. Pub.
- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry,* Oxford University Press.
- Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan (2010).

CHEMISTRY LAB: CC-9 PRACTICAL

ORGANIC CHEMISTRY PRACTICAL

(1) Detection of extra elements.

(2) Functional group test for nitro, amine and amide groups.

(3) Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)

Reference Books

- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000).

CHEMISTRY-CC-10: PHYSICAL CHEMISTRY-IV

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

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, and (iv) conductometric titrations. **(22 Lectures)**

UNIT II:

Electrochemistry

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials.

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 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). **(28 Lectures)**

UNIT III:

Electrical & Magnetic Properties of Atoms and Molecules

Dipole moment and molecular polarizabilities and their measurement. Clausius-Mosotti equation (derivation not required). Concept of Diamagnetism, Paramagnetism, Magnetic susceptibility and its measurement. **(10 Lectures)**

Reference Books:

- Atkins, P.W & Paula, J.D. *Physical Chemistry*, 10th Ed., Oxford University Press (2014).
- Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa (2004).
- Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP (2009).
- Barrow, G. M., *Physical Chemistry 5th Ed.,* Tata McGraw Hill: New Delhi (2006).
- Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
- Rogers, D. W. *Concise Physical Chemistry* Wiley (2010).
- Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. *Physical Chemistry 4th Ed.,* John Wiley & Sons, Inc. (2005).

CHEMISTRY LAB: CC-10 PRACTICAL

PHYSICAL CHEMISTRY PRACTICAL

(Any Four)

1. Determination of cell constant

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

3. Perform the following conductometric titrations: Strong acid vs. strong base

4. Perform the following conductometric titrations: Weak acid vs. strong base

5. Perform the following conductometric titrations: Mixture of strong acid and weak acid vs. strong base

6. Perform the following conductometric titrations: Strong acid vs. weak base

7. Perform the following potentiometric titrations: Strong acid vs. strong base

8. Perform the following potentiometric titrations: Weak acid vs. strong base

9. Perform the following potentiometric titrations: Dibasic acid vs. strong base

10. Perform the following potentiometric titrations: Potassium dichromate vs. Mohr's salt

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.;* McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

SEMESTER-6

CHEMISTRY-CC-13: INORGANIC CHEMISTRY-IV

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

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, and phosphate) and need to remove them after Group II. **(10 Lectures)**

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, and polynuclear 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).

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene. **(22 Lectures)**

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. **(18 Lectures)**

UNIT IV:

Catalysis by Organometallic Compounds

Study of the following industrial processes and their mechanism:

1. Alkene hydrogenation (Wilkinsons Catalyst)
2. Hydroformylation (Co salts)
3. Wacker Process
4. Synthetic gasoline (Fischer Tropsch reaction)
5. Synthesis gas by metal carbonyl complexes **(10 Lectures)**

Reference Books:

- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall, 1996.
- Cotton, F.A.G.; Wilkinson & Gaus, P.L. *Basic Inorganic Chemistry 3rd Ed.;* Wiley India,
- Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed.,* Harper Collins 1993, Pearson,2006.
- Sharpe, A.G. *Inorganic Chemistry*, 4th Indian Reprint (Pearson Education) 2005
- Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry3rd Ed.,* John Wiley and Sons, NY, 1994.
- Greenwood, N.N. & Earnshaw, A. *Chemistry of the Elements*, *Elsevier 2nd Ed*, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
- Lee, J.D. *Concise Inorganic Chemistry 5th Ed.,* John Wiley and sons 2008.
- Powell, P. *Principles of Organometallic Chemistry*, Chapman and Hall, 1988.
- Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.,* Oxford University Press, 1994.
- Basolo, F. & Pearson, R. *Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution 2nd Ed.,* John Wiley & Sons Inc; NY.
- Purcell, K.F. & Kotz, J.C., *Inorganic Chemistry*, W.B. Saunders Co. 1977
- Miessler, G. L. & Tarr, D.A. *Inorganic Chemistry 4th Ed.,* Pearson, 2010.

- Collman, J. P. *et al. Principles and Applications of Organotransition Metal Chemistry*. Mill Valley, CA: University Science Books, 1987.
- Crabtree, R. H. *The Organometallic Chemistry of the Transition Metals*. *j* New York, NY: John Wiley, 2000.
- Spessard, G. O. & Miessler, G.L. *Organometallic Chemistry*. Upper Saddle River, NJ: Prentice-Hall, 1996.

CHEMISTRY LAB: CC-13 PRACTICAL

INORGANIC CHEMISTRY PRACTICAL

1. **Qualitative semimicro analysis of mixtures containing four radicals**. 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-}, $S_2O_3^{2-}$, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, 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. 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.

2. (Any One)

(a) Measurement of 10 Dq by spectrophotometric method

(b) Verification of spectrochemical series.

(c) Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.

(d) Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}. Find the λmax of the complex.

(e) 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

- Vogel's *Qualitative Inorganic Analysis,* Revised by G. Svehla. Pearson Education, 2002.
- Marr & Rockett *Practical Inorganic Chemistry.* John Wiley & Sons 1972.

CHEMISTRY-CC-14 ORGANIC CHEMISTRY-V

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

UNIT I:

Organic Spectroscopy

Introduction to absorption and emission spectroscopy.

UV Spectroscopy: Types of electronic transitions, $\lambda_{max.}$, Chromophores and Autochromes, 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.

Applications of IR, UV and NMR for identification of simple organic molecules. **(30 Lectures)**

UNIT II:

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. 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. **(19 Lectures)**

UNIT III:

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. **(11 Lectures)**

Reference Books:

- Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P) Ltd. Pub.
- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. *Polymer Science*, New Age International (P) Ltd. Pub.
- Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry of Natural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Graham Solomons, T.W. *Organic Chemistry,* John Wiley & Sons, Inc.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry,* Oxford University Press.
- Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Prakashan (2010).
- Kemp, W. *Organic Spectroscopy*, Palgrave.
- Pavia, D. L. *et al. Introduction to Spectroscopy* 5th Ed. Cengage Learning India Ed. (2015).

CHEMISTRY LAB: CC-14 PRACTICAL

ORGANIC CHEMISTRY PRACTICAL

(Any Three)

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:

- Vogel, A.I. *Quantitative Organic Analysis,* Part 3, Pearson (2012).
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000).

SKILL ENHANCEMENT COURSE

SEC-2 (H) & SEC-2 (DSC): SEMESTER 4

GREEN METHODS IN CHEMISTRY:

(Credits: 02)

Theory and Hand-on Experiments

Definitions of Green Chemistry. Brief introduction of twelve principles of Green Chemistry, with examples, Special emphasis on atom economy, reducing toxicity, and green solvents. Green Chemistry and catalysis and alternative sources of energy, Green energy and sustainability

The following Real world Cases in Green Chemistry should be discussed:

1. Surfactants for carbon dioxide – Replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments.
2. Right fit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments.
3. Designing of environmentally safe marine antifoulant.
4. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

GREEN METHODS IN CHEMISTRY PRACTICAL or PROJECT WORK or INDUSTRY/LABORATORY VISIT

(A) PRACTICAL (Any Two)

(1) Preparation and characterization of biodiesel from vegetable oil.

(2) Bromination of Anilide Using Green Approach.

(3) Preparation of Benzilic acid by using Green Approach.

(4) Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper(II).

OR

(B) PROJECT WORK on relevant topics of GREEN CHEMISTRY

(Note: Preparation and Submission of Project File)

OR

(C) INDUSTRY/LABORATORY VISIT

(Note: Submission of Detailed Report after the Visit. Certificate of Participation to be provided to the Students.

Reference Books:

- 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).
- Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. Green Chemistry Experiments:A monograph I.K. International Publishing House Pvt Ltd. New Delhi, Bangalore.
- Lancaster, M. Green Chemistry: An introductory text RSC publishing, 2nd Edition.
- Sidhwani, I.T., Saini, G., Chowdhury, S., Garg, D., Malovika, Garg, N. Wealth from waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated "A Social Awareness Project", Delhi University Journal of Undergraduate Research and Innovation,**1(1)**: 2015.

SEC- 4 (DSC): SEMESTER-6

CHEMISTRY OF COSMETICS & PERFUMES

(Credits: 2)

Theory and Hand-on Experiments

THEORY

A general study including preparation and uses of the following:

Hair dye, hair spray, shampoo, face powder, 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 sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone.

COSMETICS and PERFUMES PRACTICAL or PROJECT WORK or INDUSTRY/LABORATORY VISIT

(A) PRACTICAL (ANY TWO)

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

OR

(B) PROJECT WORK on relevant topics of COSMETICS & PERFUMES

(Note: Preparation and Submission of Project File)

OR

(C) INDUSTRY/LABORATORY VISIT

(Note: Submission of Detailed Report after the Visit. Certificate of Participation to be provided to the Students.

Reference Books:

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

DISCIPLINE SPECIFIC ELECTIVE

DSE-3 [H]: SEMESTER-6

POLYMER CHEMISTRY

(Credits: Theory-04, Practicals-02)

1. Introduction and history of polymeric materials:

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers. Classifications including di-,tri-, and amphiphilic polymers.

2. Functionality and its importance:

Addition and Condensation - Mechanism of Cationic, anionic and free radical addition polymerization.

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.

3. Kinetics of Polymerization:

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. Metallocene-based Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics - thermosetting (phenol-formaldehyde, Polyurethanes) and thermosetting (PVC, polythene).

4. Determination of molecular weight of polymers (*Mn*, *Mw*, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance.

5. Properties of Polymers (Physical, thermal, Flow & Mechanical Properties)

6. Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride), poly(vinyl acetate), polymers, acrylic polymers, fluoro polymers, polyamides and related polymers.

Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes

7. Rubbers - natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization.

Biodegradable and conducting polymers with examples.

Reference Books:

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

DSE LAB: DSE-3 PRACTICAL or PROJECT WORK

(A) POLYMER CHEMISTRY PRACTICAL (Any THREE)

1. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein
(a) Preparation of IPC
(b) Purification of IPC
(c) Interfacial polymerization
2. Redox polymerization of acrylamide
3. Precipitation polymerization of acrylonitrile
4. Preparation of urea-formaldehyde resin
5. Preparations of novalac resin/ resold resin.
6. Microscale Emulsion Polymerization of Poly(methylacrylate).
7. Determination of molecular weight by viscometry:
(a) Polyacrylamide-aq.$NaNO_2$ solution
(b) (Poly vinyl proplylidine (PVP) in water
8. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
9. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).

OR

(B) PROJECT WORK on relevant topics of POLYMER CHEMISTRY

(Note: Preparation and Submission of Project File)

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).

CHEMISTRY-DSE- 4 (H) & DSE-2 (DSC): SEMESTER-6

INDUSTRIAL CHEMICALS AND ENVIRONMENT

(Credits: Theory-04, Practicals-02)

1. 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, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

2. 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.

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 andnature of water pollutants, Techniques for measuring water pollution,

Water purification methods. Effluent treatment plants (primary, secondary and tertiarytreatment). 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.

3. 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.

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.
- J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
- S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
- K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
- S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.
- S.E. Manahan, *Environmental Chemistry*, CRC Press (2005).
- G.T. Miller, *Environmental Science* 11th edition. Brooks/ Cole (2006).
- Mishra, *Environmental Studies*. Selective and Scientific Books, New Delhi (2005).

DSE-4 INDUSTRIAL CHEMICALS & ENVIRONMENT PRACTICAL or INDUSTRY/LABORATORY VISIT

(A) PRACTICAL (Any Three)

1. Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
2. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.
3. Measurement of dissolved CO_2.
4. Study of some of the common bio-indicators of pollution.
5. Estimation of SPM in air samples.
6. Preparation of borax/ boric acid.

OR

(B) INDUSTRY/LABORATORY VISIT

(Note: Submission of Detailed Report after the Visit. Certificate of Participation to be provided to the Students.

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.
- J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
- S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
- K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
- S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.

GENERIC ELECTIVE& DISCIPLINE SPECIFIC CORE COURSES

GE-2 & DSC-2: SEMESTER: 2

CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL GROUP ORGANIC CHEMISTRY-I

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

SECTION-A: PHYSICAL CHEMISTRY (30 Lectures)

Chemical Energetics:

1. **Review of thermodynamics and the Laws of Thermodynamics**: Basic Definitions and mathematical background. First Law, Enthalpy Functions, Relation between Cp and Cv, Joule-Thomson Experiment, Inversion of Temperature, Adiabatic Changes in State, Enthalpies of Chemical Changes, Important principles and definitions of thermochemistry. Hess's Law. The Second Law, Carnot Cycle and its efficiency. Variation of enthalpy of a reaction with temperature - Kirchhoff's equation. Statement of Third Law of thermodynamics. Entropy. **(10 Lectures)**

2. Chemical Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases. **(8 Lectures)**

3. Ionic Equilibria: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts.

Buffer solutions. Solubility and solubility product of sparingly soluble salts - applications of solubility product principle. **(12 Lectures)**

SECTION-B: ORGANIC CHEMISTRY (30 Lectures)

1. Functional group approach for the following reactions: Aromatic hydrocarbons (benzene): Preparation from phenol, by decarboxylation, from acetylene. Reactions: (benzene): Electrophilic substitution: Nitration, halogenation and sulphonation. 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). **(6 Lectures)**

2. Alkyl and Aryl Halides: Alkyl Halides (Up to 5 Carbons). Types of Nucleophilic Substitution (SN1 and SN2) reactions. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation. Williamson's ether synthesis: Elimination vs Substitution. Aryl Halides Preparation: (Chloro, bromo and iodo-benzene): from phenol, Sandmeyer & Gattermann reactions. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). **(8 Lectures)**

3. Alcohols and Phenols and Ethers (Up to 5 Carbons): Alcohols: Preparation: Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Reduction of aldehydes, ketones, carboxylic acid and esters. Reactions: HX (Lucas test), esterification, oxidation (with alk. $KMnO_4$, acidic dichromate). Oppeneaur oxidation. Diols: (Up to 6 Carbons) oxidation of diols. Pinacol Pinacolone rearrangement.

Phenols: (Phenol) Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction.

Ethers (aliphatic and aromatic): Cleavage of ethers with HI. **(10 Lectures)**

4. Aldehydes and ketones: (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde) Preparation: from acid chlorides and nitriles. Reactions - Reaction with HCN, ROH. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Benzoin condensation, Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.

(6 Lectures)

Reference Books:

- Graham Solomon, T.W., Fryhle, C.B & Dnyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
- McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
- Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
- Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
- Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
- Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
- Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
- Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
- Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
- Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).

GE-2 & DSC-2 [PRACTICAL]

SECTION A: PHYSICAL CHEMISTRY

(ANY TWO)

1. Determination of heat capacity of calorimeter for different volumes.

2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

3. Measurement of pH of different solutions like aerated drinks/ fruit juices/shampoos/ soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.

4. (a) Preparation of buffer solutions: (ANY ONE)

(i) Sodium acetate-acetic acid

(ii) Ammonium chloride-ammonium hydroxide

Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section B: ORGANIC CHEMISTRY

(ANY TWO)

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

2. Criteria of Purity: Determination of melting and boiling points.

3. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(ANY ONE)

(a) Bromination of Phenol/Aniline

(b) Benzoylation of amines/phenols

(c) Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone

Reference Books:

- 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.
- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

GE-4 & DSC-4 [SEMESTER-4]

TRANSITION METAL & COORDINATION CHEMISTRY, STATES OF MATTER & CHEMICAL KINETICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

SECTION-A: INORGANIC CHEMISTRY (30 Lectures)

1. Transition Elements (3d series)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic properties, and ability to form complexes. stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu. **(8 Lectures)**

2. Lanthanoids and actinoids:

Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only). **(4 Lectures)**

3. Coordination Chemistry

Valence Bond Theory (VBT): Inner and outer orbital complexes of 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)

4. 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 Δ_o. Spectrochemical series. Comparison of CFSE for O_h and T_d complexes, Tetragonal distortion of octahedral geometry, Jahn-Teller distortion, Square planar coordination. **(10 Lectures)**

SECTION - B: PHYSICAL CHEMISTRY (30 Lectures)

1. 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). 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)**

2. 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)

3. 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 (qualitative treatment only). **(8 Lectures)**

3. 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 . 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. **(8 Lectures)**

Reference Books:

- Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007)
- Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
- Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998)
- Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
- Cotton, F.A. & Wilkinson, G. Basic Inorganic Chemistry, Wiley
- Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press.
- Wulfsberg, G. Inorganic Chemistry, Viva Books Pvt. Ltd
- Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd., 2008

GE-4 & DSC-4: PRACTICAL

Section A: Inorganic Chemistry

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

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

Anions : CO_3^{2-}, S^{2-}, SO_2^-, $S_2O_3^{2-}$, NO_3^-, Cl^-, Br^-, I^- , NO_3^- , SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, F^- (Spot tests should be carried out wherever feasible)

Section B: Physical Chemistry

(ANY TWO)

1. Determination of Density of a liquid.

2. (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 solution with concentration

3. (a) Determination of the coefficient of 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.

4. Chemical Kinetics

Study the kinetics of the following reactions. (ANY ONE)

(a) Acid hydrolysis of methyl acetate with hydrochloric acid

(b) Saponification of ethyl acetate.

Reference Books:

- Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
- Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand

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