

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°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).
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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 K_p , K_c and K_x . 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).
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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).
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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.
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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 $\text{Fe}(\text{OH})_3$
- (iv) Estimation of Al (III) by precipitating with oxine and weighing as $\text{Al}(\text{oxine})_3$ (aluminium oxinate)

(2) Inorganic Preparations: (Any Three)

- (i) Tetraamminecopper (II) sulphate, $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}$
- (ii) *Cis* and *trans*-Potassium dioxalatodiaquachromate (III), $\text{K}[\text{Cr}(\text{C}_2\text{O}_4)_2 \cdot (\text{H}_2\text{O})_2]$
- (iii) Tetraamminecarbonatocobalt (III) ion
- (iv) Potassium tris(oxalate)ferrate(III)
- (v) Cuprous Chloride, Cu_2Cl_2
- (vi) Preparation of Manganese(III) phosphate, $\text{MnPO}_4 \cdot \text{H}_2\text{O}$
- (vii) Preparation of Aluminium potassium sulphate $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$ (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.
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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 1stEd.*, 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).
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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).
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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).
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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).
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SEMESTER-6

CHEMISTRY-CC-13: INORGANIC CHEMISTRY-IV

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

UNIT I:

Theoretical Principles in Qualitative Analysis (H₂S 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 Chemistry 3rd 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.* New York, NY: John Wiley, 2000.
 - Spessard, G. O. & Miessler, G.L. *Organometallic Chemistry.* Upper Saddle River, NJ: Prentice-Hall, 1996.
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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-} , $\text{S}_2\text{O}_3^{2-}$, 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 acetylacetonato complexes of $\text{Cu}^{2+}/\text{Fe}^{3+}$. Find the λ_{max} of the complex.

(e) Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetonone, 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.
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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, λ_{max} , Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λ_{max} 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).
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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).
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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 CO₂ 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.
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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, Jasmine.

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 (M_n , M_w , 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.
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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.NaNO₂ solution
 - (b) (Poly vinyl propylidene (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).
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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 and nature of water pollutants, Techniques for measuring water pollution,

Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal.

Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

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).
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**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.
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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 C_p and C_v , 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 K_p , K_c and K_x 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 $\text{NaNH}_2/\text{NH}_3$). **(8 Lectures)**

3. Alcohols and Phenols and Ethers (Up to 5 Carbons): Alcohols: Preparation: Preparation of 1°, 2° and 3° 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): (Formaldehyde, 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-Ponndorf Verley reduction.

(6 Lectures)

Reference Books:

- Graham Solomon, T.W., Fryhle, C.B & Snyder, 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^- , $\text{S}_2\text{O}_3^{2-}$, NO_3^- , Cl^- , Br^- , I^- , NO_2^- , 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
-