

B.Sc. (Hons.) CHEMISTRY
THREE-YEARS FULL-TIME
PROGRAMME
(Six-Semester Course)



(Effective from the Academic Year (2016-17))

CHOICE BASED CREDIT SYSTEM

B. SC. HONOURS WITH CHEMISTRY

B.Sc. (Hons) Chemistry First Semester (With Maths as General Elective)				
SN	Course Code	Course Name	L-T-P	Cr.
1	BCH-110	In organic Chemistry – I	3-1-0	4
2	BCH-113	Physical Chemistry – I	3-1-0	4
3	BMA-111	Calculus	5-1-0	6
4	BEN-101	Communication Skill (English)	2-0-0	2
5	BCH-160	Inorganic Chemistry – I Lab	0-0-4	2
6	BCH-163	Physical Chemistry – I Lab	0-0-4	2
7	PD-191A	Hobby Club	0-0-2	2
Total			26	22

B.Sc. (Hons) Chemistry First Semester (With Zoology as General Elective)				
SN	Course Code	Course Name	L-T-P	Cr.
1	BCH-110	In organic Chemistry – I	3-1-0	4
2	BCH-113	Physical Chemistry – I	3-1-0	4
3	BZH-110	Zoology-I	3-1-0	4
4	BEN-101	Communication Skill (English)	2-0-0	2
5	BCH-160	Inorganic Chemistry – I Lab	0-0-4	2
6	BCH-163	Physical Chemistry – I Lab	0-0-4	2
7	BZH-160	Zoology-I Lab	0-0-4	2
8	PD-191A	Hobby Club	0-0-2	2
Total			28	22

B.Sc. (Hons) Chemistry Second Semester (With Physics as General Elective)				
SN	Course Code	Course Name	L-T-P	Cr.
1	BCH-114	Organic Chemistry – I	3-1-0	4
2	BCH-115	Physical Chemistry – II	3-1-0	4
3	BPH-122	Electricity and Magnetism	3-1-0	4
4	CEA-101A	Environmental Science	2-0-0	2
5	BCH-164	Organic Chemistry – I Lab	0-0-4	2
6	BCH-165	Physical Chemistry – II Lab	0-0-4	2
7	BPH-172	Electricity and Magnetism Lab	0-0-4	2
8	PD-191A	Hobby Club	0-0-2	2
Total			28	22

B.Sc (Hons) Chemistry Second Semester (With Botany as General Elective)				
SN	Course Code	Course Name	L-T-P	Cr.
1	BCH-114	Organic Chemistry – I	3-1-0	4
2	BCH-115	Physical Chemistry – II	3-1-0	4
3	BBH-110	Botany-I	3-1-0	4
4	CEA-101A	Environmental Science	2-0-0	2
5	BCH-164	Organic Chemistry – I Lab	0-0-4	2
6	BCH-165	Physical Chemistry – II Lab	0-0-4	2
7	BBH-160	Botany-I Lab	0-0-4	2
8	PD-191A	Hobby Club	0-0-2	2
Total			28	22

B.Sc. (Hons) Chemistry Third Semester (With Maths as General Elective)

SN	Course Code	Course Name	L-T-P	Cr.
1	BCH-217	Inorganic Chemistry –II	3-1-0	4
2	BCH-218	Organic Chemistry –II	3-1-0	4
3	BCH-219	Physical Chemistry-III	3-1-0	4
4	BMA-230	Differential Equation-I	5-1-0	6
5		Skill Based Subject -I	3-1-0	4
6	BCH-267	Inorganic Chemistry –II Lab	0-0-4	2
7	BCH-268	Organic Chemistry –II Lab	0-0-4	2
8	BCH-269	Physical Chemistry-III Lab	0-0-4	2
Total			34	28

B.Sc (Hons) Chemistry Fourth Semester (With Physics as General Elective)				
SN	Course Code	Course Name	L-T-P	Cr.
1	BCH-221	Inorganic Chemistry –III	3-1-0	4
2	BCH-222	Organic Chemistry –III	3-1-0	4
3	BCH-223	Physical Chemistry-IV	3-1-0	4
4		General Elective – IV (Physics-II)	3-1-0	4
5		Skill Enhancement Subject -II	3-1-0	4
6		PDP/Interpersonal Skills	2-0-0	2
7	BCH-271	Inorganic Chemistry –III Lab	0-0-4	2
8	BCH-272	Organic Chemistry –III Lab	0-0-4	2
9	BCH-273	Physical Chemistry-IV Lab	0-0-4	2
10		General Elective Lab – IV (Physics-II)	0-0-4	2
Total			38	30

B.Sc. (Hons) Chemistry Fifth Semester				
SN	Course No.	Course Name	L-T-P	Cr.

1	BCH-320	Organic Chemistry –IV	3-1-0	4
2	BCH-321	Physical Chemistry-V	3-1-0	4
3	BCH-322	Discipline Specific Elective-I	3-1-0	4
4	BCH-323	Discipline Specific Elective-II	3-1-0	4
5		PDP/Interpersonal Skills	2-0-0	2
6	BCH-370	Organic Chemistry –IV Lab	0-0-4	2
7	BCH-371	Physical Chemistry-V Lab	0-0-4	2
8	BCH-372	Project	0-0-8	4
Total			34	26

B.Sc. (Hons) Chemistry Sixth Semester				
SN	Course No.	Course Name	L-T-P	Cr.
1	BCH-324	Inorganic Chemistry –IV	3-1-0	4
2	BCH-325	Organic Chemistry-V	3-1-0	4
3	BCH-326	Discipline Specific Elective-III	3-1-0	4
4	BCH-327	Discipline Specific Elective-IV	3-1-0	4
5	BCH-374	Inorganic Chemistry –IV Lab	0-0-4	2
6	BCH-375	Organic Chemistry -V Lab	0-0-4	2
7	BCH-376	Discipline Specific Elective Lab	0-0-4	2
8	BCH-377	Project/ Dissertation	0-0-6	6
Total				28

Sem 1	Sem 2	Sem 3	Sem 4	Sem 5	Sem 6	Total
22	22	28	30	26	28	156

Semester I

INORGANIC CHEMISTRY-I

UNIT-1: S & P BLOCK ELEMENT

Comparative study of the elements includes diagonal relationship, salient features of hydrides, solvation and complexation tendencies including their function.

Emphasis on comparative study of periodic properties of p-block elements (including diagonal relationship and excluding methods of preparation).

UNIT-2: CHEMISTRY OF NOBLE GASES

Chemical properties of noble gases with emphasis on their low chemical reactivity, chemistry of xenon, structure and bonding of fluorides, oxides and oxyfluorides of xenon.

UNIT-3: BORON FAMILY

Oxide of boron (B_2O_3), Oxyacid of boron (H_3BO_3)-preparation, properties and uses.

Preparation, properties and structure of diborane and borazine. Trihalides of boron- preparation, properties and relative strengths of trihalides of boron as Lewis acid.

UNIT-4: CARBON FAMILY

Catenation, carbides, fullerenes, fluorocarbons, silicates (structural aspects), silicones- general methods of preparations, properties and uses.

UNIT-5: NITROGEN & OXYGEN FAMILY

Oxides: structures of oxides of N, P. Oxyacids: structure and relative acid strengths of oxyacids of nitrogen and phosphorus. Structure of white, yellow and red phosphorus. Oxyacids of sulphur- structures and acidic strength of H_2O_2 - structure, properties and uses.

Reference Books:

- Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
- Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
- Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
- Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.

INORGANIC CHEMISTRY LAB-I:

(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 $\text{K}_2\text{Cr}_2\text{O}_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Reference text:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.

PHYSICAL CHEMISTRY- I

UNIT-1: CHEMICAL KINETICS

Rate of reaction, Rate equation, Factors influencing the rate of reaction- concentration, temperature, pressure, catalyst. Order of reaction, integrated rate expression for zero order, first order, second order reaction. Half life period of a reaction, methods for determination of order of reaction.

Effect of temperature on the rate of reaction, Arrhenius equation, Theories of reaction rate- simple collision theory for unimolecular and bimolecular collision.

Unit-2 ELECTROCHEMISTRY-I

Electrolytic conduction, factors affecting electrolytic conduction, specific conductance, molar conductance, equivalent conductance and relation among them, Arrhenius theory of ionization, Ostwald's dilution law, Debye-Huckel equation, Transport number, definition and determination of Hittorf's methods.

UNIT-3 SOLID STATE

Classification of solids, laws of crystallography- (i) Law of constancy of interfacial angles (ii) Laws of rationality of indices (iii) Law of symmetry

Definition of unit cell and space lattice, Bravais lattices, crystal system. X-ray diffraction by crystals, derivation of Bragg equation,

UNIT-4 LIQUID STATE

Structure of liquids, properties of liquids- surface tension, viscosity, vapor pressure, Refractive Index and Types of Crystals.

UNIT-5 GASEOUS STATE

Maxwell's distribution of velocities and energies(derivation excluded), average velocity and most probable velocity, collision diameter, collision number, collision frequency, deviation of real gases from ideal behavior, derivation of vander Waal's equation of state.

Reference Books:

- Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press

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).

PHYSICAL CHEMISTRY LAB-I

1. Surface tension measurements.

- a. Determine the surface tension by (i) drop number (ii) drop weight 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 (i) polymer (ii) ethanol and (iii) 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. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.*; W.H. Freeman & Co.: New York (2003).

BMA-111 Calculus (With Elective)

Code	Name	Credit(6)
BMA-111	Calculus	5-1-0

Unit-1: Limit & Continuity : The real line and its geometrical representation; ϵ - δ treatment of limit and continuity; Properties of limit and classification of discontinuities; Properties of continuous functions.

Unit-2: Differentiability: Successive differentiation; Leibnitz Theorem; Statement of Rolle's Theorem; Mean Value Theorem; Taylor and Maclaurin's Theorems; Indeterminate forms.

Unit 3: Applications of Differentiation : Asymptotes; Concavity, convexity and points of inflection; Curvature; Extrema; elementary curves, tangent and normal in parametric form; Polar Coordinates.

Unit-4: Partial Differentiation: Limits and continuity of functions of two variables; Partial derivatives; Taylor's theorem and Maclaurin's Theorem for function of two variables; Maxima and minima for function of two variables.

Unit-5: Double and triple integrals; Change of order in double integrals. Application of Integration : length of a curve; Arc length as a parameter; Evolute & Envelope; Volumes and surface areas of solids of revolution.

Reference Books:

1. Gorakh Prasad, Differential Calculus, Pothishala Pvt. Ltd. Allahabad, 2000.
 2. Gorakh Prasad, Integral Calculus, Pothishala Pvt. Ltd. Allahabad, 2000.
 3. Gabriel Klambauer, Mathematical Analysis, Marcel Dekker Inc. New York 1975.
 4. Shanti Narayan, Elements of Real Analysis, S. Chand & Company, New Delhi.
 5. Shanti Narayan, A Text Book of Vector Calculus, S. Chand & Company, New Delhi.
 6. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
 7. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus*, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
 8. H. Anton, I. Bivens and S. Davis, *Calculus*, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
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Zoology (Elective)

BIODIVERSITY-I: NON-CHORDATA

UNIT 1

Protozoa General characters and Reproduction in Protozoa., Porifera General characters and Structural organization of Sycon.

UNIT II

Platyhelminthes General characters: Structure and larval forms, Cnidaria General characters and Polymorphism in Cnidarians

UNIT III

Aschelminthes General characters and Life history of Ascaris and its parasitic adaptations. Annelida General characters and Adaptive radiations in Polychaeta.

UNIT IV

Arthropoda General characters and Larval forms of crustacea; metamorphosis in Insecta

UNIT V

Mollusca General characters and Torsion and detorsion Echinodermata General characters and Water-vascular system and larval forms

SUGGESTED BOOKS

1. Barnes, R.D. Invertebrate Zoology (1982) VI Edition. Holt Saunders International Edition.
2. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. & J.I., Spicer (2002) The Invertebrates: A New Synthesis. III Edition. Blackwell Science.
3. Barrington, E.J.W. (1979) Invertebrate Structure and Functions. II Edition. E.L.B.S. and Nelson. 50
4. Boradale, L.A. and Potts, E.A. (1961) Invertebrates: A Manual for the use of Students. Asia Publishing Home.
5. Bushbaum, R. (1964) Animals without Backbones. University of Chicago Press. 51

Semester II

ORGANIC CHEMISTRY – I

Unit-I

Basics of Organic Chemistry-I

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

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

Unit-II

Basics of Organic Chemistry-II

Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

Unit-III

Stereochemistry:

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

Unit-IV

Chemistry of Aliphatic Hydrocarbons

(i) A. Carbon-Carbon sigma bonds

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

(ii) Carbon-Carbon pi bonds:

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

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti

Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.

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

Unit-V

Cycloalkanes and Conformational Analysis

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

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.

ORGANIC CHEMISTRY LAB- II

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)
5. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds, Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)
6. Chromatography
- 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)

PHYSICAL CHEMISTRY II

Unit-I

Thermochemistry-I:

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

First law: Concept of heat, q , work, w , internal energy, U , and statement of first law; enthalpy, H , relation between heat capacities, calculations of q , w , U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

Unit-II

Thermochemistry-II :

Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature.

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the

second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

Unit-III

Systems of Variable Composition:

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

Unit-IV

Chemical Equilibrium:

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p , K_c and K_x . Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

Unit-V

Solutions and Colligative Properties:

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

Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Reference Books

- Peter, A. & Paula, J. de. *Physical Chemistry 9th Ed.*, Oxford University Press (2011).
- 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)

PHYSICAL CHEMISTRY LAB- II

Thermochemistry

- (a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
- (b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
- (c) Calculation of the enthalpy of ionization of ethanoic acid.
- (d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
- (e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
- (f) Determination of enthalpy of hydration of copper sulphate.
- (g) Study of the solubility Δ of benzoic acid in water and determination of H.

Any other experiment carried out in the class.

PHYSICS-C III (BPH-122)	ELECTRICITY AND MAGNETISM	L-T-P	Credits
		4-0-0	4

Unit-I

Electric Field and Electric Potential

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry.

Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole.

Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

Unit-II

Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics.

Unit-III

Magnetic Field: Magnetic force between current elements and definition of Magnetic Field **B**. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of **B**: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.

Unit-IV

Electromagnetic Induction & Ballistic Galvanometer: Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current.

Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping.

Unit-V

Electrical Circuits & Network theorems: AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2)

Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit.

Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem,, Maximum Power Transfer theorem.

Reference Books:

- Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
 - Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
 - Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
 - Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
 - Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
 - Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.
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PHYSICS-C III LAB (BPH-172)	ELECTRICITY MAGNETISM LAB	AND	L-T-P	Credits
			0-0-4	2

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De'Sauty's bridge.
6. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
7. To verify the Thevenin and Norton theorems.
8. To verify the Superposition, and Maximum power transfer theorems.
9. To determine self inductance of a coil by Anderson's bridge.
10. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
13. Determine a high resistance by leakage method using Ballistic Galvanometer.
14. To determine self-inductance of a coil by Rayleigh's method.
15. To determine the mutual inductance of two coils by Absolute method.

NOTE: Each student is required to perform at least seven experiments.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House

- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
 - Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
 - A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.
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Botany (Elective Subject)

Unit 1

Plant Diversity

Algae, Fungi and Lichen: Salient features, habitat, range of thallus structure, reproduction and broad classification of algae; General account, classification and reproduction in fungi; Economic importance of algae, fungi and Mycorrhiza

Unit 2

Brief account of Lichen and Economic importance of lichens.

Bryophytes: General characteristics, broad classification and reproduction in Bryophytes, Economic importance of Bryophytes.

Unit 3

Pteridophytes

General characteristics, broad classification and reproduction in Pteridophytes, Evolution of stellar system.

Unit 4

Gymnosperms

Salient features and diagnostic characters of; Distribution in India, Heterospory, Economic Importance with reference to Wood, Resins, Essential oils and Drugs

Unit 5

Angiosperms

Salient feature, Role of Herbaria and Botanical Gardens, Broad outline of Bentham & Hooker system of classification with merits and demerits

References

1. Lee, R.E. 2008. Phycology, Fourth Edition, Cambridge University Press, USA.
2. Bilgrami, K.S. and Saha, L.C., 2001, A Text Book of Algae, CBS Publishers, New Delhi.
Kumar, H.D. 1999. Introductory Phycology. East-west Press Pvt ltd., Delhi.
3. Alexopolous, C.J., Mims, C.W. and Blackwell, M. (1996), Introductory Mycology, John Wiley and Sons, New York.
4. Bold, H.C. & Wayne, M.J. 1996 (2nd Ed.) Introduction to Algae.

Semester III

GREEN CHEMISTRY & BIOCHEMISTRY

UNIT-1: INTRODUCTION TO GREEN CHEMISTRY

Green chemistry -Principle of atom economy. Examples of reactions following the principles of green chemistry and atom economy. Green Preparation of propene, Green synthesis of Ibuprofen

UNIT-II MICROWAVE MEDIATED ORGANIC SYNTHESIS

Microwave activation – advantage of microwave exposure – specific effects of microwave – Neat reactions– solid supported reactions (with two specific examples) -functional group transformation – oxidation - reduction reactions.Solvent free one pot synthesis of phthalocyanine complex of copper (II).

UNIT-III IONIC LIQUIDS

Introduction –classification of ionic liquids- synthesis of ionic liquids – physical properties – recyclability- applications of ionic liquids for the following reactions –alkylation, hydroformylation, Friedel-Craft reaction and Diels-Alder reaction.

UNIT-4 ENZYMES:

Nomenclature, Characteristics (mention of Ribozymes), Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes, Coenzymes and cofactors, Enzyme inhibitors, Introduction to Biocatalysis: Importance in “Green Chemistry” and Chemical Industry.

UNIT-5: CARBOHYDRATES & PROTEIN:

Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle.

Proteins: classification, biological importance; Primary, secondary and tertiary structures of proteins: α -helix and β -pleated sheets, Denaturation of proteins

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.

GREEN CHEMISTRY PRACTICALS (THIRD SEMESTER)

1. To determine the turbidity of given water sample by turbidity meter.
2. To determine the BOD of water sample by titration method
3. To determine the COD of water sample.
4. To determine the pollution level in water sample by coagulation method with inorganic coagulant.
5. To observe the decrease in pollution level in water sample by coagulation-flocculation method with inorganic coagulant and organic polymers.
6. To optimize the pH of sugar industrial waste water with the help of lime.
7. Effect of pH on action of salivary amylase.
8. Effect of temperature on the action of salivary amylase.
9. Study the activity of trypsin using fresh tissue extracts.

Reference Books:

- Vogel, A.I. *A Textbook of Quantitative Inorganic Analysis*, ELBS. 1978
-

ORGANIC CHEMISTRY-II

UNIT-1: ALKENES & DIENES

Nomenclature of alkenes, mechanism of dehydration of alcohols and dehydrohalogenation of alkyl halides. Saytzeff rule, Hofmann elimination, physical properties and relative stabilities of alkenes. Chemical reactions of alkenes – mechanisms involved in hydrogenation, electrophilic and free radical additions, Markownikoff's rule, hydroboration-oxidation, reduction, ozonolysis, hydration, hydroxylation and oxidation with KMnO_4 , polymerization of alkenes, substitution at allylic and vinylic positions of alkenes. Industrial application of ethylene and propene.

Nomenclature and classification of dienes: isolated, conjugated and cumulated dienes. Structure of butadiene, Chemical reactions – 1, 2 and 1, 4 additions (electrophilic & free radical mechanisms), Diels –Alder reaction.

UNIT-2: ALKYNES

Nomenclature, structure and bonding in alkynes. Methods of formation. Chemical reactions of alkynes, acidity of alkynes. Mechanism of electrophilic and nucleophilic addition reactions, hydroboration – oxidation of alkynes, metal –ammonia reductions, oxidation and polymerization.

UNIT-3: ALKYL & ARYL HALIDES

Nomenclature and classes of alkyl halides, methods of formation, chemical reactions. Mechanisms and stereochemistry of nucleophilic substitution reactions of alkyl halides, $\text{S}_{\text{N}}2$ and $\text{S}_{\text{N}}1$ reactions with energy profile diagrams.

Methods of formation and reactions of aryl halides, the addition-elimination and the elimination – addition mechanisms of nucleophilic aromatic substitution reactions.

Relative reactivities of alkyl halides vs allyl, vinyl and aryl halides.

UNIT-4: ARENES AND AROMATICITY

Nomenclature of benzene derivatives: Aromatic nucleus and side chain, Structure of benzene: Molecular formula and Kekule structure Aromaticity: Huckel rule, aromatic ions, anti-aromatic, non-aromatic compounds. Aromatic electrophilic substitution – general pattern of the mechanism, mechanism of nitration, halogenations, sulphonation, and Friedel – Crafts reaction. Energy profile diagrams. Activating/deactivating substituent, orientation and ortho/para ratio. Side chain reactions of benzene derivatives, Birch reduction. Methods of formation and chemical reactions of alkyl benzenes, aryl benzenes and biaryl.

UNIT-5: POLY NUCLEAR HYDROCARBONS

Haworth synthesis of naphthalene and phenanthrene, Pschorr synthesis of phenanthrene, synthesis of anthracene involving Friedel-Crafts acylation of benzene with phthalic anhydride and Diels-Alder reaction between 1,3-butadiene and 1,4-naphthoquinone, reaction of naphthalene, anthracene and phenanthrene, relative reactivities at different positions and

mechanism of electrophilic substitution reactions in naphthalene, anthracene and phenanthracene.

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).

ORGANIC CHEMISTRY PRACTICALS (THIRD SEMESTER)

1. Preparation and purification through crystallization or distillation and ascertaining their purity

through melting or boiling point:

- (i) Phenyl benzoate from phenol and benzoyl chloride
- (ii) M-dinitrobenzene from nitrobenzene (use 1:2 conc. HNO_3 - H_2SO_4 mixture if fuming HNO_3 is not available).
- (iii) Picric acid
- (iv) Aspirin from salicylic acid

2. To study the differential extraction of compounds.

3. Crystallization and decolourization of impure naphthalene from ethanol.

4. Mixed M.P determination of urea & Cinnamic acid mixture of various composition (1:4, 1:1 & 4:1)

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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PHYSICAL CHEMISTRY- III

UNIT-1: THERMODYNAMICS

Definition of thermodynamics terms: system, surrounding, types of systems, intensive and extensive properties. State and path functions, Thermodynamic processes. Concept of heat and work. Zeroth Law of thermodynamics, first law of thermodynamics: statement, definition of internal energy and enthalpy. Heat capacity, heat capacities at constant volume and pressure and their relationship. Joule's law – joule – Thomson coefficient for ideal gas and real gas: and inversion temperature. Calculation of work done, heat, internal energy, enthalpy for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process.

UNIT-2: PHASE EQUILIBRIUM

Statement and meaning of the terms: phase component and degree of freedom thermodynamic derivation of Gibbs phase rule, phase rule, phase equilibria of one component system- example water and sulphur systems. Phase equilibrium of two components system solid liquid equilibria: simple eutectic example Pb -Ag system, desilverization of lead, congruent system (Zn-Mg system), incongruent system (Na-K system).

UNIT-3: SURFACE CHEMISTRY

Adsorption by solids, Application of adsorption, Adsorption of gases by solids, Factors influencing the adsorption, Langmuir theory of adsorption, Adsorption from solution, Gibbs adsorption isotherm.

UNIT-4: DISTRIBUTION LAW

Nernst distribution law, conditions for the validity of Nernst distribution law, Derivation of molecular complexity from distribution law. Application of distribution law i.e. calculation of solubility of solute in solvent, determination of equilibrium constant from distribution law, distribution indicator, process of extraction and determination of degree of hydrolysis and study of complex ion formation, limitation of distribution law.

UNIT-5: ELECTROCHEMISTRY – II

Kohlrausch's Law, calculation of molar ionic conductance and effect of viscosity, temperature & pressure on it. Application of Kohlrausch's law in calculation of conductance of weak electrolytes at infinite dilution.

Application of conductivity measurements: determination of degree of dissociation, determination of K_a of acids, determination of solubility product of sparingly soluble salts, conductance titrations. Definition of pH and pKa, Buffer action, Buffer mechanism of buffer action.

Reference Books:

Peter Atkins & Julio De Paula, *Physical Chemistry 9th Ed.*, Oxford University Press

(2010).

- Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa (2004).
- McQuarrie, 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.

PHYSICAL CHEMISTRY PRACTICALS -III

1. To determine the melting point and eutectic point of given mixture
2. To determine the partition coefficient of benzoic acid between water and benzene at room temperature.
3. Buffer Solution:
Preparation of buffer solution.

NH₄Cl - NH₄OH and determination of pH of buffer solution
CH₃COOH and CH₃COONa and determination of pH of buffer solution.
4. Surface Tension measurement (Use of organic solvent excluded)
 - (a) Determination of surface tension by drop number method & drop weight method
 - (b) Variation of surface tension of detergent solution with concentration.
5. Phase equilibria: Construction of phase diagram of
 - (a) Simple eutectic system
 - (b) Congruent melting point using cooling curve.

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).

Code	Name	Credit (6)
BMA-230	Differential Equations-I(Elective)	5-1-0

Unit 1: Geometrical meaning of a differential equation. Exact differential equations, integrating factors. First order higher degree equations solvable for x,y,p Lagrange's equations, Clairaut's equations. Equation reducible to Clairaut's form.

Unit-2: Linear differential equations with constant coefficients. Homogeneous linear ordinary differential equations. Equations reducible to homogeneous equation.

Unit -3: Method of variations of parameters. Method of undetermined coefficients. Reduction of order of a differential equation. Linear differential equations of second order: Reduction to normal form.

Unit-4: Transformation of the equation by changing the dependent variable/ the independent variable. Solution by operators of non-homogeneous linear differential equations.

Unit-5: Ordinary simultaneous differential equations. Solution of simultaneous differential equations involving operators $x (d/dx)$ or $t (d/dt)$ etc. Simultaneous equation of the form $dx/P = dy/Q = dz/R$. Total differential equations. Condition for $Pdx + Qdy + Rdz = 0$ to be exact. General method of solving $Pdx + Qdy + Rdz = 0$ by taking one variable constant.

Reference Books:

1. B.Rai & D.P. Chaudhary : Ordinary Differential Equations; Narosa, Publishing House Pvt. Ltd.
2. D.A. Murray : Introductory Course in Differential Equations. Orient Longman (India)

Semester IV

INORGANIC CHEMISTRY-III

UNIT-1: CHEMISTRY OF ELEMENTS OF 1ST TRANSITION SERIES:

Definition of transition elements, position in the periodic table, General characteristics & properties of 1st transition elements, Structures & properties of some compounds of transition elements– TiO_2 , VOCl_2 , FeCl_3 , CuCl_2 and $\text{Ni}(\text{CO})_4$

UNIT-2: CHEMISTRY OF ELEMENTS OF IIND & IIIRD TRANSITION SERIES:

General characteristics and properties of the IInd and IIIRD transition elements Comparison of properties of 3d elements with 4d & 5d elements with reference only to ionic radii, oxidation state, magnetic and Spectral properties and stereochemistry.

UNIT-3: LANTHANIDES:

Comparative study of lanthanide elements with respect to electronic configuration atomic and ionic radii, oxidation state and complex formation, lanthanide contraction. Separation of lanthanides. Application of lanthanide complexes.

UNIT-4: COORDINATION COMPOUNDS

Werner's coordination theory, effective atomic number concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complexes,

UNIT-5: HALOGEN FAMILY

Basic properties of halogen, interhalogens types properties, hydro and oxyacids of chlorine – structure and comparison of acid strength.

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.

INORGANIC CHEMISTRY PRACTICALS (FOURTH SEMESTER)

1. Semi micro qualitative analysis of mixture containing not more than four radicals (including interfering and excluding insoluble):
Pb²⁺, Hg²⁺, Ag⁺, Bi³⁺, Cu²⁺, Cd²⁺, As³⁺, Sb³⁺, Sn²⁺, Fe³⁺, Cr³⁺, Al³⁺, Co²⁺, Ni²⁺, Mn²⁺, Zn²⁺, Ba²⁺, Sr²⁺, Ca²⁺, Mg²⁺, NH⁴⁺, CO₃²⁻, S²⁻, SO₃²⁻, S₂O₃²⁻, NO₂⁻, CH₃COO⁻, Cl⁻, Br⁻, I⁻, NO₃⁻, SO₄²⁻, C₂O₄²⁻, PO₄³⁻.
2. Inorganic preparations:
 - (a) Cuprous chloride
 - (b) Manganese (II) phosphate

Reference Book:

- 1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.
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ORGANIC CHEMISTRY-III

UNIT-1: ALCOHOLS

Monohydric alcohols—nomenclature, methods of formation by reduction of aldehydes, ketones,

Carboxylic acids and esters. Hydrogen bonding. Acidic nature, Reactions of alcohols. Dihydric alcohols- nomenclature, methods of formation, chemical reactions of vicinal glycols, oxidative cleavage [$\text{Pb}(\text{OAc})_4$ and HIO_4] and pinacol-pinacolone rearrangement.

UNIT-2:EPOXIDES

Synthesis of epoxides, acid and base-catalyzed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organolithium reagents with epoxides

UNIT-3: PHENOLS

Nomenclature, structure and bonding, preparation of phenols, physical properties and acidic character. Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols — electrophilic aromatic substitution, Mechanisms of Fries rearrangement, Claisen rearrangement, Reimer-Tiemann reaction, Kolbe's reaction and Schotten and Baumann reactions.

UNIT-4: CARBOXYLIC ACIDS

Nomenclature, structure and bonding, physical properties, acidity of carboxylic acids, effects of substituents on acid strength, Preparation of carboxylic acids. Reactions of carboxylic acids. Hell-Volhard-Zelinsky reaction. Synthesis of acid chlorides, esters and amides, reduction of carboxylic acids. Mechanism of decarboxylation. Methods of formation and chemical reactions of halo acids. Hydroxy acids: malic, tartaric and citric acids. Methods of formation and chemical reactions of unsaturated monocarboxylic acids. Industrial manufacture of acetic acid and benzoic acid (flow sheet diagram). Dicarboxylic acids: methods of formation and effect of heat and dehydrating agents.

UNIT-5: CARBOXYLIC ACID DERIVATIVES

Structure and nomenclature of acid chlorides, esters, amides (urea) and acid anhydrides, relative stability of acyl derivatives. Physical properties, interconversion of acid derivatives by nucleophilic acyl substitution, Preparation of carboxylic acid derivatives, chemical reactions. Mechanisms of esterification and hydrolysis (acidic and basic).

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.
- Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P)

ORGANIC CHEMISTRY LAB-III

1. Systematic identification (detection of extra elements, functional groups, determination of melting point or boiling point and preparation of at least one pure solid derivative) of the following simple Compound: Naphthalene, anthracene, acenaphthene, benzyl chloride, p-dichlorobenzene, m-dinitrobenzene, p-nitrotoluene, resorcinol, hydroquinone, α -naphthol, β -naphthol, benzophenone, ethyl-methyl ketone, benzaldehyde, vanillin.
2. To find out equivalent weight of acid (neutralization and silver salt method).

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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PHYSICAL CHEMISTRY-IV

UNIT-1 THERMOCHEMISTRY AND CHEMICAL ENERGIES:

Definition of important terms used in thermochemistry. Energy changes during chemical Reactions, derivation of 1st law of thermodynamic. Heat of reaction, enthalpy and enthalpy change, bond energy and its calculation. Hess's law of heat summation and its application for the calculation of various enthalpies of reaction. Spontaneous processes. Criteria of spontaneity.

UNIT-2 THERMODYNAMICS - II

Second law of thermodynamics. Need of the law, different definitions of the law, Thermodynamic scale of temperature. Concept of entropy, entropy as a state function of V and T, entropy as a function of P and T. Entropy change in physical processes. Entropy as criteria of Spontaneity and equilibrium. Entropy change in ideal gases and mixing of gases, work function, Gibb's free energy function. Gibbs function (G) and Helmholtz function (A) as thermodynamic function. Criteria of spontaneity of reversible processes in terms of enthalpy change, entropy change, work function and free energy function. Variation of G and A with P, V and T. Gibb Helmholtz equation and its application , Third law of thermodynamics and its applications. Partial molar quantities. Chemical potential. Gibb's Duhem equation. Gibb's adsorption equation and its application.

UNIT-3 COLLOIDAL STATES

Colloids, classification of colloids, solids in liquids (sols) properties: Kinetic, optical and Electrical, stability of colloids, protective colloids, Hardy-schulze Rule, gold number, Emulsion types of emulsion and their preparation, Emulsifier. Gels (liquid in solids): Classification and properties, General application of colloids.

UNIT-4 CRITICAL PHENOMENON

Critical temperature, critical pressure, critical volume and their determination. PV isotherms of real gases, continuity of states, the isotherms of Vander Waal's equation, relationship between critical constants and Vander Waal's constants. Critical compressibility factor, the law of corresponding states. Liquefaction of gases.

UNIT-5 NUCLEAR CHEMISTRY:

Radioactivity, Properties of radiation, detection & measurement of radioactivity, types of radioactive decay, Group displacement law, rate of radioactive decay, half life, calculation of half life, radioactive dating, nuclear reactions: nuclear fission and nuclear fusion reaction. Nuclear binding energy.

Reference Books:

- Atkins, P.W & Paula, J.D. *Physical Chemistry*, 9th Ed., Oxford University

Press (2011).

- 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).

PHYSICAL CHEMISTRY LAB- IV

1. To determine the enthalpy of neutralization of strong acid/ strong base.
2. To determine the enthalpy of ionization of ethanoic acid.
3. To determine the solubility of benzoic acid in water at room temperature.
4. Determination of enthalpy of hydration of CuSO₄.
5. Determination of basicity of polyprotic acid by thermochemical methods in terms of change of temperature observed in the graph.
6. Determination of heat capacity of calorimeter and integral enthalpy (Endothermic & Exothermic).
7. To determine parachor value of –CH₂ group.
8. To determine the viscosity index of given oil by Redwood viscometer-I

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 V

INORGANIC CHEMISTRY-IV

UNIT-1: METAL - LIGAND BONDING IN TRANSITION METAL COMPLEXES:

Limitation of valence bond theory, an elementary idea of crystal-field theory, crystal field splitting in octahedral, tetrahedral and square planar complexes, factors affecting the crystal-field parameters.

UNIT-2: MAGNETIC PROPERTIES OF TRANSITION METAL COMPLEXES:

Types of magnetic behavior, methods of determining magnetic susceptibility, spin-only formula. L-S coupling, correlation of μ_s and μ_{eff} values, orbital contribution to magnetic moments, application of magnetic moment data for 3d-metal complexes.

UNIT-3: ELECTRON SPECTRA OF TRANSITION METAL COMPLEXES:

Types of electronic transitions, selection rules of d-d transitions, spectroscopic ground states, spectrochemical series, Orgel - energy level diagram for d^1 and d^9 states, discussion of the electronic spectrum of $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ complex ion.

UNIT 4 ACIDS AND BASES:

Bronsted-Lowry, Lux-Flood, Solvent System and Lewis concepts of acids and bases. Factors affecting strengths of Lewis acids and bases. HSAB theory and applications

UNIT-5: NON-AQUEOUS SOLVENTS

Physical properties of a solvent, types of solvents and their general characteristics, reactions in non-aqueous solvents with reference to liquid NH_3 and liquid SO_2

INORGANIC CHEMISTRY (FIFTH SEMESTER):

UNIT-I: ORGANOMETALLIC CHEMISTRY

Definition, Nature of Metal Carbon bond, classification of organometallic compounds by bond types viz. i) covalent ii) Ionic iii) Electron deficient, cluster compounds bond compounds including sandwich derivatives. Structure and bonding in Metal carbonyls, cyclopentadienyl derivative, metal-ethylenic, metal-acetylenic complexes, Applications of organometallic compounds as homogeneous catalysts in hydrogenation, hydroformylation, polymerization, oligomerization and metathesis reactions of alkenes and alkynes (Ziegler - Natta polymerization of ethylene and propylene).

UNIT-II INORGANIC POLYMER-I

Borazine, Phosphazene & Sulphazene: Synthesis, properties nature of bonding, structures and applications.

UNIT-II INORGANIC POLYMER-I

Silicates, Phosphates & Borates: Synthesis, properties nature of bonding, structures and applications.

UNIT-IV BIO-INORGANIC CHEMISTRY

Essential and trace elements in biological processes, bioinorganic chemistry of haemoglobin and myoglobin, vitamin B12, carboxypeptidase A and chlorophyll, biological role of alkali and alkaline earth metal ions with nitrogen fixation (special reference to Ca^{2+}). Medicinal aspects of some metal complexes - platinum metal complexes as anticancer agents and their probable mechanism, anticancer activity of Cu, Co and Au complexes. Antibacterial and antiviral activity of metal complexes.

UNIT-V CORROSION & ITS CONTROL

Types of Corrosion: Wet corrosion, dry corrosion, galvanic corrosion, water-line corrosion, differential aeration corrosion & stress corrosion, Factors effecting corrosion, Protection from corrosion: Barrier, sacrificial, cathodic and anodic protection.

INORGANIC CHEM PRACTICALS (FIFTH SEMESTER):

1. Determination of acetic acid in commercial vinegar using NaOH
2. Determination of alkali content - antacid tablet using HCl
3. Estimation of calcium content in chalk as calcium oxalate by permanganometry.
4. Gravimetric Analysis
 - (i) Aluminium as oxinate
 - (ii) Mg as $\text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}$
 - (iii) Ba as BaSO_4
4. Synthesis of
 - (a) Sodium hexa nitritocobaltate (III)
 - (b) Sodium ammonium hydrogen phosphate

ORGANIC CHEMISTRY-IV

UNIT-1: ORGANOMETALLIC COMPOUNDS

Reagents-formation, structure and chemical reactions. Organozinc compounds: formation and chemical reactions. Organolithium compounds: formation and chemical reactions. Organo lead compounds: formation and chemical reactions. Organo cadmium compounds: formation and chemical reactions. Organo copper compounds: formation and chemical reactions

UNIT-2: ORGANOSULPHUR COMPOUNDS

Nomenclature, structural features, Methods of formation and chemical reactions of thiols, thioethers, sulphonic acids, sulphonamides and sulphaguanidine. Synthetic detergents alkyl and aryl sulphonates.

UNIT-3: ORGANO PHOSPHORUS COMPOUNDS

Nomenclature, Trivalent phosphorus compounds - trialkyl and triaryl phosphine (method of formation and reactions), Pentavalent phosphorus compounds, organic phosphoranes, phosphorus ylides, Wittig reaction. Biological role of phosphorus.

UNIT-4: HETEROCYCLIC COMPOUNDS

Introduction: Molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine. Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution. Mechanism of nucleophilic substitution reactions in pyridine derivatives. Comparison of basicity of pyridine, piperidine and pyrrole. Introduction to condensed five and six-membered heterocycles. Preparation and reactions of indole, quinoline and isoquinoline with special reference to Fischer indole synthesis, Skraup synthesis and Bischler-Napieralski synthesis. Mechanism of electrophilic substitution reactions of indole, quinoline and isoquinoline.

UNIT-5: ORGANIC SYNTHESIS VIA ENOLATES

Acidity of hydrogens, alkylation of diethyl malonate and ethyl acetoacetate. Synthesis of ethyl acetoacetate: the Claisen condensation. Keto-enol tautomerism of ethyl acetoacetate. Alkylation of 1,3-dithianes. Alkylation and acylation of enamines

ORGANIC CHEMISTRY (FIFTH SEMESTER)

UNIT-I: NMR SPECTROSCOPY

Principle of nuclear magnetic resonance, the PMR spectrum, number of signals, peak areas, equivalent and nonequivalent protons positions of signals and chemical shift, shielding and deshielding of protons, proton counting, splitting of signals and coupling constants, magnetic equivalence of protons. Discussion of PMR spectra of the molecules: ethyl bromide, n-propyl bromide, isopropyl bromide, 1, 1-dibromoethane, 1, 1, 2-tribromoethane, ethanol, acetaldehyde, ethyl acetate, toluene, benzaldehyde, acetophenone, *p*-anisidine and *p*-nitrotoluene. Simple problems on PMR spectroscopy for structure determination of organic compounds.

UNIT-II: MASS SPECTROSCOPY

Introduction, instrumentation, mass spectrum, determination of molecular formula, parent peak and base peak, recognition of molecular ion peak, fragmentation pattern of alkanes, alkenes and benzene.

UNIT-III: CARBOHYDRATES: CLASSIFICATION AND NOMENCLATURE

Monosaccharides, mechanism of osazone formation, interconversion of glucose and fructose, chain lengthening and chain shortening of aldoses. Configuration of monosaccharides. Erythro and threo diastereomers. Conversion of glucose into mannose. Formation of glycosides, ethers and esters. Determination of ring size of glucose and fructose. Open chain and cyclic structure of D (+)-glucose & D (-) fructose. Mechanism of mutarotation.

UNIT-IV: CARBOHYDRATES : STRUCTURES OF RIBOSE AND DEOXYRIBOSE.

An introduction to disaccharides (maltose, sucrose and lactose) and polysaccharides (starch and cellulose) involving structure determination.

UNIT-5: SYNTHETIC DYES

Color and constitution (electronic concept). Classification of dyes. Chemistry and synthesis of Methyl orange, Congo red, and Malachite green, Crystal violet, Phenolphthalein, Fluorescein, Alizarin and Indigo.

Reference Books:

- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. Vith Edition. W.H. Freeman and Co.

Nelson, D.L., Cox, M.M. and Lehninger, A.L. (2009) Principles of Biochemistry. IV Edition. W.H. Freeman and Co.

ORGANIC CHEM LAB-IV

1. Systematic identification (detection of extra elements, functional groups, determination of melting point or boiling point and preparation of at least one pure solid derivative) of the following simple mono and bifunctional organic compounds. oxalic acid, succinic acid, benzoic acid, salicylic acid, aspirin, phthalic acid, cinnamic acid, benzamide, urea, acetanilide, benzamide, aniline hydrochloride, p-toluidine, phenyl salicylate(salol), glucose, fructose, sucrose, o-,m-, p-nitroanilines, thiourea.
2. Estimation of phenol (bromide- bromate method) and aniline (bromide-bromate and acetylation method).

Reference Books:

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

PHYSICAL CHEMISTRY-IV (FIFTH SEMESTER)

UNIT-I:CHEMICAL EQUILIBRIUM

Types of Reactions (reversible and irreversible) Equilibrium state. Le-chatelier Principle. Law of mass action and its application to derive the law of chemical equilibrium. Thermodynamical derivation of law of chemical equilibrium. Equilibrium constant and free energy function, isotherms and reaction isochor, Clausius -Clapeyron equation and its application.

UNIT-2 PHOTO CHEMISTRY:

Interaction of radiation with matter. Photo chemical reactions and their difference with thermal reaction law of photo chemistry. Grothus- Drapper law, Stark- Einstein law, Lambert law, Beer's law. Jablonski diagram depicting various processes occurring in the excited state qualitative description of Fluorescence, phosphorescence, non-radiation processes (internal conversion, inter system crossing) quantum yield, photosensitized reactions, energy transfer processes (some simple examples), chemiluminescence.

UNIT-3 SOLUTION

Ideal and non-ideal solution, Normality, Molarity, Methods of expressing concentrations of solution, activity and activity coefficient. Dilute solution, concentrated solution, Raoult's law. Abnormal molar mass. Degree of dissociation and association of solutes

UNIT-4:COLLIGATIVE PROPERTIES

Colligative properties, Relative lowering of vapor pressure. Molecular weight determination, osmotic law of osmotic pressure and its measurements. Determination of molecular weight by osmotic pressure method. Elevation of boiling point and depression in freezing point. Thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point. experimental methods for determining various colligative properties.

UNIT-5:STATISTICAL THERMODYNAMICS

Statistical thermodynamics of Maxwell Boltzmann distribution law. Maxwell-Boltzmann law and the concept of negative temperature, Maxwell-Boltzmann law of distribution of energy and velocity (evaluation of energy). Derivation of equation of states for a monatomic ideal gas.

PHYSICAL CHEMISTRY- V

Unit-I

Quantum Chemistry

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and “particle-in-a-box” (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy. Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy. Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution. Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

Unit-II

Chemical bonding:

Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+ . Bonding and antibonding orbitals. Qualitative extension to H_2 . Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and

heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH_2 , H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules.

Unit-III

Molecular Spectroscopy:

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation. Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution. Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.

Unit-IV

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. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

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).

- Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
- Kakkar, R. Atomic & Molecular Spectroscopy, Cambridge University Press (2015).

PHYSICAL CHEMISTRY PRACTICALS (FIFTH SEMESTER):

1. To determine the refractive index of given liquid and calculation of specific and molar refractivity.
2. Determination of concentration of binary mixture by measurement of refractive index.
3. Setting of a Galvanic Cell and determination of cell voltage.
4. To verify Lambert-beer Law for KMnO_4 solution & determine the conc. of given unknown solution
5. To verify Lambert-beer Law for CuSO_4 solution & determine the conc. Of given unknown solution of CuSO_4 .
6. To prepare the following colloidal sol: Arsenious sulphide, Ferric hydroxide sol, Aluminum hydroxide sol

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 VI

INORGANIC CHEMISTRY-VI (SIXTH SEMESTER):

Unit-I

Organometallic Compounds

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 trialkylaluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium. Wacker Process, Synthetic gasoline (Fischer Tropsch reaction) Synthesis gas by metal carbonyl complexes.

UNIT-2: ORGANIC REAGENTS IN INORGANIC ANALYSIS:

Criteria for choice of organic reagents, use of following reagents in inorganic analysis: DMG, cupferron, 8-hydroxyquinoline, Nitroso α - naphthol, EDTA, Acetylacetonone, dithiozone, dithiocarbamate. Advantages and disadvantages of organic reagents in inorganic analysis.

UNIT-3:OXIDATION AND REDUCTION

Use of redox potential data - analysis of redox cycle, redox stability in water - Frost, Latimer and Pourbaix diagrams, Principles involved in the extraction of elements.

UNIT-4:INORGANIC ENGINEERING MATERIALS:

Definition, Refractories, properties of , refractories , cement, Inorganic cementing material, Gypsum plaster, cement, manufacturing of Portland cement, chemical constitution of Portland cement, chemical composition of cement, glasses & ceramics, manufacturing of glasses, types of glasses.

UNIT-5: CRYSTAL STRUCTURE:

Structures of binary compounds such as zinc blende, wurtzite, NiAs, CsCl, CaF₂, rutile, Cristobalite, CdI₂, BiI₃, ReO₃, corundum and Mn₂O₃, factors affecting crystal structures.

INORGANIC CHEMISTRY PRACTICALS - (SIXTH SEMESTER):

Inorganic Synthesis:

(a) Preparation of sodium trioxalate ferrate (III), [Na₃[Fe(C₂O₄)₃] and determination of its composition by permanganometry.

(b) Preparation of copper tetraammine complex $[\text{Cu}(\text{NH}_3)_4] \text{SO}_4$

(c) Preparation of cis and trans- bisoxalatodiaqua chromate (III) ion.

(d) Mercuric tetrathiocyanatocobaltate (II), $\text{Hg} [\text{Co}(\text{SCN})_4]$

2 (a) **Colorimetry:** To verify Beer-Lambert law for $\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ and determine the concentration of the given $\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ solution.

(b) **Solvent extraction**

Separation and estimation of Fe (II) (estimation by calorimetrically)

1. **Paper chromatography of:**

Ni(II) & Co(II) ; CU(II) & Cd(II)

Reference Books:

Recommended Texts:

- Vogel, A.I. *Qualitative Inorganic Analysis*, Longman, 1972
- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall, 1996-03-07.
- 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. & Person, 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. & Donald, A. Tarr, *Inorganic Chemistry 4th Ed.*, Pearson, 2010.
- Collman, James P. et al. *Principles and Applications of Organotransition Metal Chemistry*. Mill Valley, CA: University Science Books, 1987.
- Crabtree, Robert H. *The Organometallic Chemistry of the Transition Metals. j* New York, NY: John Wiley, 2000.
- Spessard, Gary O., & Gary L. Miessler. *Organometallic Chemistry*. Upper Saddle River, NJ: Prentice-Hall, 1996.

ORGANIC CHEMISTRY-VI (SIXTH SEMESTER)

UNIT-1:FATS, OIL AND DETERGENTS:

Occurrence, chemical composition and importance, hydrogenated oils, Rancidity, acid value, saponification and iodine numbers, difference between toilet and washing soaps, comparison of soap and detergents, classification and principle of cleansing action of detergents.

UNIT-2:POLYMERS:

Polymers, Classification on the basis of source, repeating units, sequences, method of polymerization, intermolecular interactions, atoms present. Mechanism of polymerisation. Synthesis of polymers: Nylon-6,6.; Perlon, Dacron, PAN, PVC. Natural rubber, synthetic rubber, vulcanization; Plastics; resins

UNIT-3:Alkaloids

Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure, Medicinal importance elucidation and synthesis of Nicotine, cocaine, atropine.

UNIT-4: DRUGS

Introduction, structure and use of methylene blue, Prontosil, use of pronyosil in synthesis of other sulpha drugs. Synthesis, structure and uses of sulphadiazine, mode of action of p-aminobenzenesulphonamide on bacteria.

UNIT-5: GENERAL ASPECTS, PREPARATION AND USES OF THE FOLLOWING DRUGS:

- (i) Analgesics and antipyretics: paracetamol, Aspirin, phenacetin
- (ii) Antimalarials: Chloroquinine, pamaquine, primaquine
- (iii) Antiseptics and disinfectants: Chloro cresol, povidone – Iodine
- (iv) Antibiotics: penicillin, Chloroamphenicol

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).
- Billmeyer, F. W. *Textbook of Polymer Science*, John Wiley & Sons, Inc.
- 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.
- 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).

ORGANIC CHEMISTRY PRACTICALS SIXTH SEMESTER:

Determination of :

- (a) Acid value: Resin, Plasticizers
- (b) Iodine number : Linseed oil, Castrol oil
- (c) Saponification value: coconut oil, polyester.

Synthesis of the following organic compounds:

- (a) p-Nitroacetanilide from acetanilide and its hydrolysis to p-nitroaniline.
- (b) Phthalimide from phthalic anhydride and its rearrangement to anthranilic acid.
- (c) Benzanilide from benzophenone.

Synthesis of urea-formaldehyde and phenol-formaldehyde resin.

Paper Chromatography

Determination of R_f values and identification of organic compounds

- (a) Separation of a mixture of phenylalanine and glycine. Alanine and aspartic acid. Leucine and glutamic acid . Spray reagent-ninhydrin.
- (b) Separation of mixture of D,L-alanine, glycine and L-leucine using n-butanol : acetic acid water (4:1:5). Spray reagent-ninhydrin.

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).

PHYSICAL CHEMISTRY-V (SIXTH SEMESTER)

UNIT-1: ROTATIONAL SPECTROSCOPY

Introduction of electromagnetic radiations, regions of the spectrum, basic features of different spectrometers. Statement of the Born-Openheimer approximation, degree of freedom of diatomic molecule. Energy level of a rigid rotor (semiclassical principle) selection rule, spectral intensity. Distribution using population distribution (Maxwell-Boltzmann distribution) determination of bond length, qualitative description of nonrigid rotator. Isotopic effect.

UNIT-2: VIBRATIONAL SPECTROSCOPY

Infrared spectrum: energy levels of simple harmonic oscillator. Selection rule. Pure vibration spectrum. Intensity determination of force constant and qualitative relation of force constant and bond energies, effect of anharmonic motions and isotope on the spectrum. Rotational – vibration spectrum. Calculation of energy of levels and selection rule

UNIT-3: RAMAN SPECTROSCOPY

Quantum theory of Raman effect. Classical theory of Raman effect. Pure rotational Raman spectra. Raman activity of vibration. Vibration Raman spectra. Rotation - vibration Raman spectrum. Polarisation of light and Raman effect. Experimental technique. Application of Raman effect.

UNIT-4: ELECTRONIC SPECTRA

Concepts of potential energy curves for bonding and antibonding molecular orbitals. Qualitative description of selection rule. Franck-Condon principle. Qualitative description of π and δ orbitals and their energy level and their respective transition.

UNIT-5: ELECTRON SPIN RESONANCE SPECTROSCOPY:

Electron Spin Resonance (ESR) spectroscopy: elementary idea, Its principle, hyperfine structure, ESR of simple radicals. Application ESR spectroscopy.

PHYSICAL CHEMISTRY-VI (SIXTH SEMESTER)

UNIT-1: BLACK BODY RADIATION

Black body radiation and Planck's quantum hypothesis, Photoelectric effect and Einstein's quantum hypothesis, Compton Effect, Bohr's model of hydrogen atom and its defects. Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment)

UNIT-2 QUANTUM MECHANICS and SIMPLE HARMONIC OSCILLATION:

Introduction, quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, 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 wave functions. Vibrational energy of Diatomic molecules and zero-point energy.

UNIT-3 HYDROGEN LIKE ATOM :

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression), radial distribution functions of 1s, 2s, 2p, 3s, 3p and 3d orbitals. Average and most Probable distances of electron from nucleus. Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, hydrogen atom).

UNIT-4 CHEMICAL BONDING:

Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+ . Bonding and antibonding orbitals. Qualitative extension to H_2 . Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB).

UNIT-5 POLYMERS CHEMISTRY

Polymerisation, classification of polymers, natural and synthetic polymers. General methods of preparation. Addition and Condensation of polymers. Number average molecular weight, Weight average molecular weight. Determination of molecular weight by osmotic, pressure method, viscosity method, light scattering method, kinetics of condensation polymerisation, kinetics of chain polymerisation, kinetics of cationic, anionic and condensation polymerisation. Copolymerisation.

PHYSICAL CHEMISTRY PRACTICAL -VI (SIXTH SEMESTER)

1. To determine the CST of phenol-water system.
2. To determine the CST of aniline-water system.
3. To determine molecular weight of volatile substance by Victor Meyer method.

4. To determine molecular weight of non-volatile solute by Beckmann's freezing methods.
5. To determine molecular weight of non-volatile solute by Rast's camphor method.
6. To study adsorption of aqueous acetic acid by activated charcoal & to study adsorption isotherms.
7. To determine the strength of ferrous ammonium sulphate solution potentiometrically by titrating it against a standard solution of potassium permanganate.
8. To determine the strength of ferrous ammonium sulphate solution potentiometrically by titrating it against a standard solution of potassium dichromate.
9. To determine the strength potassium halides solution potentiometrically by titrating it against a standard solution of silver nitrate.

DEPARTMENTAL ELECTIVE
ANALYTICAL METHODS IN CHEMISTRY

Unit-I

Qualitative and quantitative aspects of analysis:

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

Unit-II

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, geometrical isomers, keto-enol tautomers. 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; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

Unit-II

Thermal methods of analysis:

Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

Unit-III

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 pK_a values.

Unit-IV

Separation techniques:

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation.

Technique of extraction: batch, continuous and counter current 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. Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral

Chromatographic techniques using chiral columns (GC and HPLC). Role of computers in instrumental methods of analysis.

Reference Books:

- Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman .
- Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
- 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, Thomson Asia Pvt. Ltd. Singapore.
- Mikes, O. & Chalmes, R.A. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
- Ditts, R.V. Analytical Chemistry – Methods of separation.

ANALYTICAL METHODS IN CHEMISTRY

I. Separation Techniques

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 R_f values.

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

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

II. Solvent Extractions:

(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 zirconium with Amberlite LA-1, separation from a mixture of iron and gallium.

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

4. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.

5. Analysis of soil:

(i) Determination of pH of soil.

(ii) Total soluble salt

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

6. Ion exchange:

(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

1. Determination of pK_a values of indicator using spectrophotometry.

2. Structural characterization of compounds by infrared spectroscopy.

3. Determination of dissolved oxygen in water.

4. Determination of chemical oxygen demand (COD).

5. Determination of Biological oxygen demand (BOD).

6. Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by

Job's method.

Reference Books:

- Vogel, Arthur I: A Text book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman .
- Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.

- 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, Thomson Asia Pvt. Ltd. Singapore.
- Mikes, O. & Chalmes, R.A. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Ltd. London.

DEPARTMENTAL ELECTIVE

MOLECULAR MODELLING & DRUG DESIGN

Unit-I

Introduction to Molecular Modelling:

Introduction. Useful Concepts in Molecular Modelling: Coordinate Systems. Potential Energy Surfaces. Molecular Graphics. Surfaces. Computer Hardware and Software. The Molecular Modelling Literature.

Unit-II

Force Fields:

Fields. Bond Stretching. Angle Bending. Introduction to nonbonded interactions. Electrostatic interactions. van der Waals Interactions. Hydrogen bonding in Molecular Mechanics. Force Field Models for the Simulation of Liquid Water.

Unit-III

Energy Minimization and Computer Simulation:

Minimization and related methods for exploring the energy surface. Non-derivative method, First and second order minimization methods. Computer simulation methods. Simple thermodynamic properties and Phase Space. Boundaries. Analyzing the results of a simulation and estimating Errors.

Unit-IV

Molecular Dynamics & Monte Carlo Simulation:

Molecular Dynamics Simulation Methods. Molecular Dynamics using simple models. Molecular Dynamics with continuous potentials. Molecular Dynamics at constant temperature and pressure. Metropolis method. Monte Carlo simulation of molecules. Models used in Monte Carlo simulations of polymers.

Unit-V

Structure Prediction and Drug Design:

Structure prediction - Introduction to comparative Modeling. Sequence alignment. Constructing and evaluating a comparative model. Predicting protein structures by 'Threading', Molecular docking. Structure based de novo ligand design, Drug Discovery – Chemoinformatics – QSAR.

Reference Books:

- A.R. Leach, Molecular Modelling Principles and Application, Longman, 2001.
- J.M. Haile, Molecular Dynamics Simulation Elementary Methods, John Wiley and Sons, 1997.
- Satya Prakash Gupta, QSAR and Molecular Modeling, Springer - Anamaya

MOLECULAR MODELLING & DRUG DESIGN PRACTICAL

- i. Compare the optimized C-C bond lengths in ethane, ethene, ethyne and benzene. Visualize the molecular σ bond orbitals and ethene, of ethyne, etha benzene and π bond sp² orbital.
- ii. (a) Perform a conformational analysis of butane. (b) Determine the enthalpy of isomerization of *cis* and *trans* 2-butene.
- iii. Visualize the electron density and electrostatic potential maps for LiH, HF, N₂, NO and CO and comment. Relate to the dipole moments. Animate the vibrations of these molecules.
- iv. (a) Relate the charge on the hydrogen atom in hydrogen halides with their acid character. (b) Compare the basicities of the nitrogen atoms in ammonia, methylamine, dimethylamine and trimethylamine.
- v. (a) Compare the shapes of the molecules: 1-butanol, 2-butanol, 2-methyl-1-propanol, and 2-methyl-2-propanol. Note the dipole moment of each molecule. (b) Show how the shapes affect the trend in boiling points: (118 °C, 100 °C, 108 °C, 82 °C, respectively).
- vi. Build and minimize organic compounds of your choice containing the following functional groups. Note the dipole moment of each compound: (a) alkyl halide (b) aldehyde (c) ketone (d) amine (e) ether (f) nitrile (g) thiol (h) carboxylic acid (i) ester (j) amide.
- vii. (a) Determine the heat of hydration of ethylene. (b) Compute the resonance energy of benzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.
- viii. Arrange 1-hexene, 2-methyl-2-pentene, (*E*)-3-methyl-2-pentene, (*Z*)-3-methyl-2-pentene, and 2,3-dimethyl-2-butene in order of increasing stability.
- ix. (a) Compare the optimized bond angles H₂O, H₂S, H₂Se. (b) Compare the HAH bond angles for the second row dihydrides and compare with the results from qualitative MO theory.

Note: Software: ChemSketch, ArgusLab (www.planaria-software.com), TINKER 6.2 (dasher.wustl.edu/ffe), WebLab Viewer, Hyperchem, or any similar software.

Reference Books:

- A.R. Leach, Molecular Modelling Principles and Application, Longman, 2001.
 - J.M. Haile, Molecular Dynamics Simulation Elementary Methods, John Wiley and Sons, 1997.
 - Satya Prakash Gupta, QSAR and Molecular Modeling, Springer - Anamaya Publishers, 2008.
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DEPARTMENTAL ELECTIVE

CHEMISTRY-DSE: NOVEL INORGANIC SOLIDS

Unit-I

Synthesis and modification of inorganic solids:

Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydrothermal method, Ion-exchange and Intercalation methods.

Unit-II

Inorganic solids of technological importance:

Solid electrolytes – Cationic, anionic, mixed Inorganic pigments – coloured solids, white and black pigments. Molecular material and fullerenes, molecular materials & chemistry – one-dimensional metals, molecular magnets, inorganic liquid crystals.

Unit-III

Nanomaterials:

Overview of nanostructures and nanomaterials: classification. Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires. Bio-inorganic nanomaterials, DNA and nanomaterials, natural and artificial nanomaterials, bionano composites.

Unit-IV

Introduction to engineering materials for mechanical construction:

Composition, mechanical and fabricating characteristics and applications of various types of cast irons, plain carbon and alloy steels, copper, aluminum and their alloys like duralumin, brasses and bronzes cutting tool materials, super alloys thermoplastics, thermosets and composite materials.

Unit-V

Composite materials:

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites.

Reference Books:

- Shriver & Atkins. Inorganic Chemistry, Peter Atkins, Tina Overton, Jonathan Rourke, Mark Weller and Fraser Armstrong, 5th Edition, Oxford University Press (2011-2012)

- Adam, D.M. Inorganic Solids: An introduction to concepts in solid-state structural chemistry.

CHEMISTRY PRACTICAL LAB: NOVEL INORGANIC SOLIDS

1. Determination of cation exchange method
2. Determination of total difference of solids.
3. Synthesis of hydrogel by co-precipitation method.
4. Synthesis of silver and gold metal nanoparticles.

Reference Book:

- Fahan, *Materials Chemistry*, Springer (2004).

