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ನಗರ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ

BENGALURU
CITY UNIVERSITY

Office of the Registrar, Central College Campus, Dr. B.R. Ambedkar Veedhi, Bengaluru – 560 001.
PhNo.080-22131385, E-mail: registrarbcu@gmail.com

No.BCU/BoS/Syllabus-PG/Science/ 332 /2025-26 Date: 23.09.2025

NOTIFICATION

Sub: Syllabus for the Post Graduate Courses in the Faculty of Science– reg

Ref: 1. Recommendations of the Boards of Studies in the Faculty of Science
2. Academic Council resolution No.04 dated.22.09.2025
3. Orders of Vice-Chancellor dated. 23.09.2025

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The Academic Council in its meeting held on 22.09.2025 has approved the syllabus prepared by different Board of Studies for the Post Graduate Courses in the Faculty of Science. Accordingly, the following CBCS Syllabus for the Semester PG Courses of Science Faculty are hereby notified for implementation effective from the academic year 2025-26.

Sl. No.	Programmes
1.	M.Sc. Chemistry – I & II Semester
2.	M.Sc. Biochemistry – I to IV Semester
3.	M.Sc. Physics – I & II Semester
4.	M.Sc. Mathematics – I to IV Semester
5.	M.Sc. Psychology– I to IV Semester
6.	M.Sc. Counselling Psychology – I to IV Semester
7.	M.Sc. Fashion & Apparel Design – I to IV Semester
8.	M.Sc. Zoology – I & II Semester
9.	M.Sc. Botany – I to IV Semester
10.	M.Sc. Computer Science – I & II Semester
11.	M.Sc. Speech Language Pathology – I to IV Semester
12.	Master of Computer Applications – I & II Semester

The detailed Syllabi for above subjects are notified in the University Website: www.bcu.ac.in for information of the concerned.

REGISTRAR

Copy to;

1. The Registrar(Evaluation), Bengaluru City University
2. The Dean, Faculty of Science, BCU.
3. The Principals of the concerned affiliated Colleges of BCU- through email.
4. The P.S. to Vice-Chancellor/Registrar/Registrar (Evaluation), BCU.
5. Office copy / Guard file / University Website: www.bcu.ac.in

BENGALURU CITY UNIVERSITY

DEPARTMENT OF STUDIES AND RESEARCH IN CHEMISTRY

M. Sc., Chemistry (CBCS)

Syllabus

(w. e. f. 2025-2026)

Jnana Jyothi Central College Campus,
Dr. B. R. Ambedkar Veedhi
Bengaluru- 560 001

I Semester

Code No	Title	Theory/Practical (Hrs/Week)	Total no of Hrs/ Semester	Duration of Exam hours	Max. marks	Continuous Evaluation	Total marks	Credits
Ch 101	Inorganic Chemistry I	4	52	3	70	30	100	4
Ch 102	Organic Chemistry I	4	52	3	70	30	100	4
Ch 103	Physical Chemistry I	4	52	3	70	30	100	4
Ch 104	Analytical Chemistry	4	52	3	70	30	100	4
Ch 105	Mathematics for Chemists (Soft Core)	4	36	3	70	30	100	2
Ch 106	Practical I Inorg/Org/Phy	4	60	4	35	15	50	2
Ch 107	Practical II Inorg/Org/Phy	4	60	4	35	15	50	2
Ch 108	Practical III Inorg/Org/Phy	4	60	4	35	15	50	2
Ch 109	Practical IV Inorg/Org/Phy	4	60	4	35	15	50	2
							700	26

Scheme for continuous evaluation

A. Theory (each paper)

Tests* :30 Marks

* Two tests will be conducted and the average marks of the two tests will be taken for Internal assessment.

B. Practical: 30 marks for experiment + 5 marks for Viva-Voce

IA : 15 Marks (based on Test + Record)

QUESTION PAPER PATTERN

Semester I/II **Sub: Chemistry**

Time: 3 Hrs

Max. Marks: 70

Note: Answer question Number one and any FIVE in the remaining.

1. Answer any TEN subdivisions from the following **(10x2=20)**

a)

b)

c)

d)

e)

f)

g)

h)

i)

j)

k)

l)

2 to 8 **(5x10=50)**

(5+5) or (6+4) or (3+4+3)

2. Questions should be drawn from Unit-I
3. Questions should be drawn from Unit- II
4. Questions should be drawn from Unit- III
5. Questions should be drawn from Unit- IV

6,7,8 Questions should be drawn from Unit-I, II, III and IV.

Semester I

Ch: 101: Inorganic Chemistry -I **52 Hrs**

Unit I **13 Hrs**

Chemical Bonding

VSEPR theory- Shapes of molecules and ions containing lone pairs and bond pairs of electrons- ClF_3, ICl_4^-, I_3^-, $TeCl_6^{2-}$, XeF_6, $SbCl_6^{3-}$, IF_7, XeF_8^{2-}, TaF_8^{3-}, SbF_4^-, SF_5^- , SeF_3^+. Multiple bonding (sigma and pi bonds)- NSF_3, SO_2Cl_2, XeO_3, SO_4^{2-}, and SOF_4. Limitations of VSEPR theory. **Bents rule and energetics of hybridization. Electronegativity**-Pauling, Allred-Rochow and Mulliken scales, electronegativity and ionic character **Bonding-** Multicentre, synergic, agostic, delta and quadrupole bonding. **Lattice energy:** Born-Lande equation, Kapustinskii equation. **Fajan's rules**-Polarizability and partial covalent character. **Radius-ratio rules:** Limiting radius ratios of trigonal, tetrahedral, octahedral, and cubic. **Structures of simple solids:** NaCl, CsCl, ZnS (Zincblende and Wurtzite), Fluorite and antifluorite, Pervoskite ($CaTiO_3$), $YBa_2Cu_3O_{7-x}$ (x=1,2,3), Spinels, Inverse Spinels, and ReO_3. **Zintl ions**- Metal only clusters- Structures based on Wade's rule and polyhedral skeletal electron pair theory- Structures of Bi_9^{5+}, Te_6^{4+}, Se_8^{2+}, Bi_4^{2-}, Pb_5^{2-}, Bi_5^{3-}, and Sn_9^{4-}.**Molecular orbital theory-** Formation of sigma, pi, and delta bonds, LCAO and MO diagrams of heteronuclear diatomic (CO, NO, HF and ICl) and triatomic molecules (CO_2 and NO_2^-).

UNIT- II **13 Hrs**

Chemistry of main group elements:- Boranes- nomenclature, synthesis, structure and bonding in boranes, STYX code, carboranes- classification, structures of ortho, meta, para-$C_2B_{10}H_{12}$,Wades rules, Metallocarboranes- synthesis and structure of $[Fe(\eta^5\text{-}C_2B_9H_{11})_2]^{2-}$, $[Fe(\eta^5\text{-}C_2B_9H_{11})](\eta^5\text{-}C_5H_5)$, $[Mo(CO)_3(\eta^5\text{-}C_2B_9H_{11})]^{2-}$, synthesis, structure and bonding in borazine, **Phosphazenes**-Synthesis, structure and bonding in $(PNCl_2)_3$, S,N- compounds- S_2N_2, S_4N_4 and polythiazyl. **Silicates:-** Principles of silicates, structures, and classification with examples-ortho, pyro, cyclo, ino, phyllo and tecto silicates, isomorphous replacement; zeolites- sodalite and pentasil units, synthesis and structures of ZSM-5, Zeolite A, Faujasite, and their uses.

Unit III **13 Hrs**

HSAB Concept:

Classification of acids and bases as hard and soft. Electronegativity and hardness and softness. Acid–base strength, and hardness, and softness. The theoretical basis of the HSAB concept.

Symbiosis, Application of HSAB concept **Non-aqueous solvents:** Physical properties of a solvent, Types of solvents and their characteristics. The acid-base concept in non-aqueous media, Reactions in Liquid HF, NH_3, CH_3COOH, H_2SO_4, BrF_3, and FSO_3FSO_2, and N_2O_4, superacids. **Isopoly and Heteropoly acids of W and Mo:** Preparation, properties, structure and applications. **Stereoisomerism** Chirality, optical activity, circular dichroism, optical rotatory dispersion. Cotton effect. Use of CD and ORD in finding the absolute configuration of metal complexes. Magnetic circular dichroism and its uses.

Unit IV **13 Hrs**

Metal clusters –Factors favouring M-M bonds, Classification, synthesis, structure and bonding in $[Re_2Cl_8]^{2-}$, metal carbonyl clusters- low nuclear, and high nuclear carbonyl clusters. Electron counting in carbonyl clusters, Wade's- Mingos and Lauher's rules.

Nuclear Chemistry The atomic nucleus, elementary particles, quarks. Classification of nuclides based on *Z* and *N* values. Nuclear stability, nuclear potential, binding energy. **Nuclear Models: Shell model-** Salient features, forms of the nuclear potential, filling up of the orbitals, nuclear configuration, merits of the shell model. **Liquid drop model-** Basic postulates, merits, and demerits of the liquid drop model **Fermi gas model, collective model and optical model. Radioactivity-** Radioactive decay kinetics, parent-daughter decay -growth relationship, secular and transient equilibria. Theories of α, β^+, β^-, and γ-decay, internal conversion, Auger effect.

Suggested Books

1. Basic Inorganic Chemistry- F.A. Cotton, G. Wilkinson and P.L. Gaus; John Wiley and Sons, 3rd Edition, (2004).
2. Advanced Inorganic Chemistry, F.A. Cotton, G Wilkinson, C. A. Murillo, M. Bochmann; Wiley, 6th Edition (2007).
3. Inorganic Chemistry, J.E. Huheey, E.A. Keiter, and R.L. Keiter; 4th Edition, Pearson (1993).
4. Inorganic Chemistry, D.F. Shriver, P.W. Atkins, and C.H. Langford, 5th Edition, ELBS, Oxford University Press, (2010).
5. Chemistry of elements, N.N. Greenwood and A.E. Earnshaw, Butterworth, 2nd Edition, Heineman, (2012).
6. Concise Inorganic Chemistry, J.D. Lee; 5th Edition, Wiley (1996).
7. Essentials of Nuclear Chemistry, H.J. Arnikar; NAIL Publishers, 4th Edition, (2011). Chapters 1, 3 and 4.

8. Nuclear and Radiochemistry, G. Friedlander, J.W. Kennedy, E.S. Macias, and J.M. Miller; John Wiley and Sons (1981). Chapters 8 and 9.
9. Inorganic Chemistry, G.L. Miessler, and D.A. Tarr; Pearson, 5th Edition, (2014).
10. Inorganic Chemistry, C.E. Housecraft, and A.G. Sharpe; Pearson, 5th Edition, (2018).
11. Fundamental concepts of Inorganic Chemistry, A. K. Das, CBS Publishers, 2nd Edition, Vol 1, 2, and 3 (2010).

Ch-102: ORGANIC CHEMISTRY- I 52 Hrs

UNIT-I **13 Hrs**

Nature of Bonding in Organic Molecules

Delocalized chemical bonding: Conjugation, cross conjugation, resonance. Hyperconjugation. Tautomerism.

Aromaticity: Huckel's MO theory. HMO diagram for benzene. Huckel's rules of aromaticity. Aromatic systems with electron numbers other than six (including azulene, tropone, tropolone and annulenes).

Anti-aromaticity. Aromaticity in benzenoids. Homo-aromaticity. Alternant and non-alternant hydrocarbons. Energy levels in odd and even-alternant hydrocarbons, energy levels for the benzyl cation, benzyl free-radical and benzyl carbanion.

Mesoionic compounds. Heteroannulenes. Fullerenes: C-60.

Synthetic Molecular Receptors: Definition and significance. Structure and function of receptors with molecular clefts, molecular tweezers, receptors with multiple hydrogen bonding sites. Cyclodextrins, cyclophanes, catenanes and rotoxanes, calixarenes, ionophores and micelles.

UNIT-II **13 Hrs**

Reaction Mechanisms:

Reactive intermediates: Generation, structure, stability and reactivity of carbocations, carbanions, carbon free radicals, carbenes. Non-classical carbocations, nitrenes.

Reactions and mechanisms: Thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates.

Methods of determining mechanisms: Based on the structure of products, determination of the presence of intermediates, isotopic labeling, isotope effects, from stereochemical evidence.

Acids and bases: Hard and soft acids and bases. Effect of structure on the strengths of acids and bases.

Effect of structure on reactivity: Resonance and field effects; steric effects. The

Hammett equation and linear free energy relationship, substituent and reaction constants. Taft equation.

Aliphatic substitution reactions:

Nucleophilic substitution reaction at a saturated carbon: SN1, SN2, SN^i and SET mechanisms. Effect of substrate structure, attacking nucleophile and leaving group. Neighbouring group participation by sigma and pi bonds. Anchimeric effect. Ambident nucleophiles and substrates.

UNIT-III **13 Hrs**

Stereochemistry

Projection formulae: Fischer, Newman, Sawhorse and flying wedge projections - their interconversions for acyclic compounds.

Optical isomerism: Elements of symmetry and chirality. Chirality and optical rotation in compounds with a stereogenic centre. Center of chirality, axis of chirality, plane of chirality and helicity. Absolute and relative configurations: R/S system. (Cahn-Ingold Prelog sequence rules).

D/L, erythro and threo systems.

Stereochemistry of allenes, alkylidene cycloalkanes and spiranes (with a stereogenic axis), biphenyls, cyclophanes, ansa compounds, trans-cyclooctene, helicenes, benzphenanthrenes. Configurational nomenclature.

Diasteromeric (de) and enantiomeric excess (ee), Prochirality: Enantiotopic and diastereotopic atoms, groups and faces. [Si/Re]. Basics of Cram's and Prelog's rules of asymmetric induction, stereospecific and stereoselective reactions.

Conformational analysis: Conformational analysis of cycloalkanes: cyclobutane, cyclopentane, cyclohexanes (mono-substituted e.g., methyl, iso-propyl, tert-butyl and di-substituted cyclohexanes e.g., dialkyl-, dihalo-, diols), and cycloheptane. Conformations of decalin.

UNIT-IV **13 Hrs**

Carbohydrates:

Introduction. Determination of configuration of the mono saccharides, conformational analysis of monosaccharides. Synthesis of aldonic, uronic, aldaric acids and alditols Derivatives of

monosaccharides: acetals, ethers, aminosugars and deoxysugars. Structural elucidation of sucrose and maltose. Structures of lactose, cellobiose and trehalose. Photosynthesis of carbohydrates.

Heterocyclic compounds:

Introduction. Nomenclature of simple and fused heterocyclic compounds: Synthesis and reactions of pyrazole, imidazole, oxazole, isoxazole, thiazole, isothiazole. Synthesis of indole, benzimidazole, benzoxazole and benzisoxazole and coumarins.

SUGGESTED BOOKS

1. Organic Chemistry, R. T. Morrison, R. N .Boyd and S. K. Bhattacharjee, 7th edition, Pearson, (2018).
2. Organic Chemistry, J. Clayden, N. Greeves and S. Warren, 2nd edition, Oxford University Press, (2014)
3. Advanced Organic Chemistry – Reactions, Mechanism and Structure, J. March, John Wiley, (2008).
4. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg Plenum, (2000).
5. A Guide Book to Mechanism in Organic Chemistry, P. Sykes, 6th edition, Pearson, (2003).
6. Structure and mechanism of Organic Chemistry, C. K. Ingold, 2nd Edition, CBS, (2016).
7. Principles of Organic Synthesis, 3rd edition, R O C Norman and J M Coxon, Blackie Academic and Professional (Indian Reprint), (2012).
8. Stereochemistry, V.R. Dani, Asian Books, New Delhi, (2014).
9. Stereochemistry of Organic Compounds, D.Nasipuri, 3rd edition, New-Age International, (2018).
10. Organic Stereochemistry, M. J. T. Robinson, Oxford University Press, (2005).
11. Stereochemistry of Carbon Compounds, E. L. Eliel, S. H. Wilen and L. N. Mander, John Wiley, (1994).
12. Stereochemistry at a Glance, J. Eames, J.M. Peach, Blackwell, Oxford, (2003).
13. Heterocyclic Chemistry at a Glance, II edition, J. A. Joule and K. Mills, Wiley, New York, (2012).
14. Organic Chemistry, Volume I, I. L. Finar, 6th edition, Pearson, (2018).
15. Organic Chemistry, Volume II, I. L. Finar, 6th edition, Pearson, (2018).

Ch-103: PHYSICAL CHEMISTRY- I 52 Hrs

UNIT-I **13 Hrs**

Quantum Mechanics-I

Introduction to quantum mechanics. Schrödinger wave equation. Time-independent and time dependent Schrödinger wave equations and the relation between their solutions. Eigen functions and Eigenvalues. Physical Interpretation of wave function. Concepts of Operators: Laplacian, Hamiltonian, Linear and Hermitian operators. Angular Momentum operators and their properties. Commutation of operators. Normalization, orthogonality and orthonormality of wave functions. Average (expectation) values. Postulates of quantum mechanics. Solutions of Schrödinger wave equation for a free particle, particle in a ring, particle in a three-dimensional box. Quantum mechanical degeneracy, tunneling (no derivation). Application of Schrödinger equation to harmonic oscillator, rigid rotator. Eigen functions and eigenvalues of angular momentum. Ladder operator method for angular momentum. Schrödinger equation to hydrogen atom in spherical polar co-ordinates. Solution of equation and statements of solution of R equation. Total wave functions of hydrogen atom.

UNIT-II **13 Hrs**

Quantum Mechanics-II

Quantum numbers and their characteristics. List of wave functions for few initial states of hydrogen like atoms. Diagrams of radial and angular wave functions. Radial and angular distribution function and their significance. Electron spin (Stern-Gerlach experiment), spin-orbital, anti-symmetry and Pauli-exclusion principle, Slater determinant Coupling of Angular momenta. Russell-Saunders and JJ-coupling, Atomic Term symbols. Spin-orbital interaction and explanation of term multiplicities (Na-D doublet). Zeeman effect. Approximate methods: Need for approximate methods. Perturbation method. Rayleigh Schrödinger perturbation theory for time-independent non-degenerate system. Application to electron in a box under the influence of an electric field. Application to He atom. Variation theory-statement and proof. Application of variation method to particle in a one-dimensional box and He atom. Unifying principles**.** Interaction of electromagnetic radiation with matter- time-dependent perturbation theory, transition moment integral, selection rules- symmetry and spin forbidden transitions.

UNIT-III **13Hrs**

ChemicalDynamics-I

Macroscopic and microscopic kinetics, Review of theories of reaction rate-Collision theory and Transition state theory, Comparison of collision theory with transition state theory, Arrhenius equation- characteristics, Significance of energy of activation, Temperature coefficient and its evaluation. Thermodynamical formulation of reaction rates (Wyne-Jones and Eyring treatment), Reaction between ions in solutions – Influence of ionic strength on reaction rates (primary and secondary salt effects). Concept of Steady State Kinetics, Chain reactions – chain length and chain inhibition, comparison of photochemical and thermal reactions, Mechanisms of thermal and photochemical reactions between hydrogen-bromine and hydrogen-chlorine. Comparative study of thermal and photochemical hydrogen-halogen reactions. Pyrolysis of acetaldehyde, Decomposition of ethane.

Kinetics of fast reactions- Introduction, Study of reactions by relaxation method (Temperature and pressure jump), flow method (Plug-flow method and Stopped-flow method), Flash photolysis and Shock tube method.

UNIT-IV **13 Hrs**

Chemical Dynamics-II

Kinetics of homogeneous catalysis: kinetics of auto catalytic reactions, kinetics of acid-base catalysed reactions. Comparison of enzyme catalysed and chemical catalysed reactions, Mechanism (Lock and Key theory), Kinetics of enzyme catalyzed reactions – Henri-Michaelis Menten mechanism, Significance of Michaelis-Menten constant, Lineweaver-Burk plot. Effects of enzyme concentration, pH, Temperature, Activators and Inhibitors on enzyme activity.

Unimolecular reactions: Perrin theory, Lindemann theory, and Hinshelwood theory.Surface chemistry: Types of adsorption isotherms, Effect of temperature on adsorption, Mechanical adsorption, Estimation of surface area using BET equation, Gibbs adsorption isotherm and its significance, Surface tension and surface energy, Pressure difference across curved surface (Laplace equation), Vapour pressure of droplets (Kelvin equation), Surface film on liquids (electro-kinetic phenomena), Catalytic activity of surfaces.

SUGGESTED BOOKS

1. Physical Chemistry- P. Atkins and J. D. Paula, 9th Edn., Oxford University Press (2010).
2. Physical Chemistry: A Molecular Approach, D. A. McQuarie and Simon, Viva, New Delhi, (2003).
3. Introduction to Quantum Chemistry, A. K. Chandra, 3rd Edn. Tata McGraw Hill, (1991).
4. Quantum Chemistry, Ira. N. Levine, Prentice Hall, New Jersey, (1991).
5. Quantum Chemistry, R. K. Prasad, New Age International, 4th Edn., (2010).
6. Quantum Mechanics by G. R. Chatwal and S. K. Anand, Himalaya Publications, 8thEdn, (2012).
7. Chemical Kinetics- K. J. Laidler, McGraw Hill. Inc. New York (1988).
8. Chemical kinetics methods, C. Kalidas, New Age International Publisher, New Delhi (1995).
9. Principles of Chemical Kinetics – House J. E. Wm C Brown Publisher, Boston, (1997).
10. Kinetics and Mechanism of Chemical Transformations- J. Rajaraman and J. Kuriakose, Mc Millan India Ltd., (2011).
11. Biochemistry, - Geoffrey Zubay, 2nd Edn., Macmillan Publishing Co. New York (1988).
12. Physical Chemistry of Surfaces- A. W. Adamson, Wiley-Interscience Publisher Inc., New York, (1997).
13. Introduction to surface chemistry and Catalysis by Gabor A. Somorjai and Yimin Li, John 2nd Edn. Wiley and Sons Ltd, Hoboken, United States, (2010).
14. Fundamentals of Chemical Kinetics M.R. Wright, Harwood publishing, Chichester, (1999).

Ch-104: ANALYTICAL CHEMISTRY 52 Hrs

UNIT – I **13 Hrs**

Basic concepts

Safety measures in chemical laboratories, Fire hazards, toxic chemicals: Acids/bases/solvents handling, storage, dilution, disposal of chemicals, acid/ solvent bottles etc. toxic chemicals sampling and handling hazards, safety data sheets, miniaturization of analytical instruments, their significance in modem chemical analysis. Preparation of dilute acids from concentrated/fuming acids like H_2SO_4, handling liquid bromine, elemental mercury, solvent ether, liquor ammonia, liquid nitrogen.

Errors in chemical analysis: absolute, relative error, random error distribution, Gaussian curve, Limitations of analyical methods, determinate and indeterminate errors, minimization of errors. Accuracy and precision, distribution of random errors, the normal error curve. Statistical treatment of finite samples - measures of central tendency and variability: mean, median, range, standard deviation, variance, confidence limits, Comparison of an experimental mean and a true mean. F-test, rejection of result - Q-test, Student's t-test, numerical problems.

UNIT-II **13 Hrs**

Quantitative Analysis-Classical methods

Classification of analytical methods, types of instrumental analysis, factors influencing choice of analytical method, qualitative and quantitative analysis, Units used in chemical analysis, their conversion, ppm, ppb, ppt etc.

Titrimetry:

Acid-Base: Theory of indicators, Ex: Phenophthalien, Methyl red. Titration curves for mono functional acid and base, pH calculations, fractions of phosphoric acid species as a function of pH. Titration curves for H_3PO_4.

Complexometry: Theory of metal ion indicators, EDTA titrations, suitability of polydentate ligands as titrants, expressions for the different forms of EDTA in solution as a function of pH, conditional stability constants, effect of pH and nature of titration curve. Masking and demasking, type of EDTA titrations, titrations involving monodentate, bidentate and polydentate ligands.

Redox: Mechanism of indicator action, criteria for the selection of indicators. Feasibility of redox titration. Titration of multicomponet system. Nernst equation. Applications: Oxidants

such as Ce(IV), bromate, Iodates.

Precipitation: Solubility product. Theoretical principles of precipitation: Titration curve, end point detection, Mohr, Volhard and adsorption indicators. Applications: Estimation of F^-, K^+, CO_3^{2-}, $C_2O_4^{2-}$, acetylenes and mixture of halides.

Gravimetry

Quantitative precipitation, *Precipitation from Homogeneous Solution (PFHS)*, Formation and treatment of precipitates, co-precipitation, post precipitation. Conditions for precipitation, washing, drying and igniting the precipitates, Important precipitating agents such as DMG, oxine, thiocyanate and their significance in inorganic analysis. errors in gravimetric analysis.

Unit-III **13 Hrs**

Quantitative Analysis - Instrumental methods

Electromagnetic radiation, interaction with matter, absorption, Beer-Lambert's law, derivation, molar absorptivity, Sandell sensitivity, Ringbom plot, deviations, limitations, Calibration with standards, standard addition, internal standard addition, limit of detection, limit of quantification, Instrumentation, radiation sources, wavelength selection devices, optical slits, single beam and double beam instruments, photo electric colorimeter, scanning devices, merits and limitations, numerical problems on application of Beer's law.

Unit IV **13 Hrs**

Separation Methods

Solvent Extraction - Types, batch, continuous, efficiency, selectivity. Distribution coefficient,Nernst distribution law, derivation, factors affecting the partition, applications. Chromatography- Types, Terminology, Principles of paper, thin layer, column, gas chromatography, column efficiency, plate theory, factors affecting the column efficiency, band broadening, R_f factor, Van-Deemter equation, medium performance liquid chromatography, high performance liquid chromatography, reserved phase liquid chromatography, super critical fluid chromatography, characteristics of super critical fluids, 2D-thin layer chromatography, electrophoresis, principles, applications etc. numerical problems on solvent extraction, R_f factor and van Demeter equation.

SUGGESTED BOOKS:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 2nd edition, Saunders College Publishing, New York, (2005).
2. Analytical Chemistry, G.D. Christian, 6th edition, John Wiley & Sons, Inc, India, (2004).
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6tl'edition, prentice Hall, Inc. New Delhi, (1993).
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J. D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt Ltd., New Delhi, (2003).
5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, (1990).
6. Principles and Practice of Analytical Chemistry, F.W. Fifield and Kealey, 3rd edition, Blackwell Sci., Ltd. Malden, USA, (2000).
7. Modern Analytical Chemistry, David Harvey, McGraw Hill, New Delhi, (2000).
8. Practical Volumetric Analysis, Peter A C McPherson, RSC, Cambridge, UK, (2015).
9. Analytical Chemistry for Technicians, John Kenkel, 4th edn. CRC press, London, (2014).
10. Undergraduate Instrumental Analysis, J.W. Robinson, E.M. Skelly Frame, G. M. Frame II, 6th Edition, Marcel Dekker, New York, (2009).

Ch-105: MATHEMATICS FOR CHEMISTS 36 Hrs

UNIT-I **12 Hrs**

Vectors: vectors, dot and cross products; scalar and vector triple products and their applications. Tensors and their applications in chemistry

Matrix Algebra and Determinants: Review of different types of matrices (including Hermetian and skew Hermetian); matrix addition and multiplication; determinant of a square matrix, transpose, adjoint and inverse of a square matrix. Solution to system of linear equation (a) by matrix method and (b) by Cramer's Rule. Characteristic equation of a square matrix, eigenvalues and eigenvectors. Slater and Secular determinant. Numerical Problems from Chemistry.

UNIT-II **12 Hrs**

Calculus: Rule for differentiation: Chain rule (for $f(x)=U^n$, sinu, loguetc). Implicit differentiation and parametric differentiation and successive differentiation of order 2 (for explicit functions only).

Elementary differential equation: Variable separable, exact first order equations, linear and homogeneous equation. Second order homogeneous differential equation with constant coefficients (f(D), y=0). Solution of differential equation by power series method.

Applications of differentiation in chemistry. Derivative as a slope of the tangent, as a rate measure-{velocity and acceleration}. Increasing and decreasing functions- Maxima and minima-second derivative test-point of inflections-problems restricted to polynomial. Numerical Problems from Chemistry.

UNIT-III **12 Hrs**

Integrations: Basic rules-simple substitution-Method of partial fractions-Integration by parts. Definate integral and application to areas of plane curves. Functions of several variables: partial derivatives; co-ordinate transformation from cartesian co-ordinates to spherical and cylindrical coordinates and vice-versa.

Fourier series: Introduction, Fourier coefficients and application of fourier series

Errors: Precision, Accuracy and averages.

Probability: Review of permutations and combinations. Probability and addition theorem for mutually exclusive events and multiplication theorem for independent events. Curve fitting-Method of least squares. Numerical Problems from Chemistry.

SUGGESTED BOOKS

1. Mathematical Preparation for physical chemistry, F. Daniells, M.Graw Hill Inc., US, (1959).
2. Mathematics for chemists, D. M. Hirst, Chemical Publishing Company Incorporated, New York, (1979).
3. Mathematics for chemists, P. G. Francis, Springer, (2011).
4. Basic Mathematics for chemists, P. Tebutt, Wiley-Blackwell, (1994).
5. Calculus and analytic geometry, 9^{th} edition, G. B. Thomas, R.L. Finney, Addison-Wesley Publishing Company, Inc. (1996).
6. Short Course in differential equations, Rainvilles and Bedient, IBH publishers, (1968).
7. Mathematics for chemistry, G. Doggett and B. T. Sutcliffe Longmann Publishers, (1995).

INORGANIC CHEMISTRY PRACTICALS

(4 days a week, 4 hours a day)

I/II/III SEMESTER PRACTICALS

C-l06 : Inorganic Practical-I (Semi-micro qualitative analysis)

Semi-micro qualitative analysis of mixtures containing two anions, two common cations and one less familiar elements: W, Mo, Ce, Zr, V, and Li.

C-107: Inorganic Practical -II (Complex Preparation)

Preparation of Inorganic Complexes

1. Ferrous oxalate
2. Potassium *tris*(oxalate)ferrate trihydrate
3. Mercury tetrathiocyanatocobaltate
4. Potassium *tris*(oxalato)aluminate trihydrate
5. Potassium trioxalato manganate(III)
6. *Tris*(thiourea)copper(II) sulfate
7. Hexamminenickel(II) chloride
8. *Bis*(8-quinolinato)copper(II)

C-108 : Inorganic Practical -III (Gravimetry)

1. Determination of Calcium as Calcium oxalate CaC_2O_4. H_2O.
2. Determination of Aluminuim as Aluminium oxinate.
3. Determination of zinc as $ZnNH_4PO_4$.
4. Determination of Fe as Fe_2O_3 in Fe and Cr Solution.
5. Determination of nickel as nickel(dimethylglyoximate) in Cu and Ni Solutions.
6. Determination of copper as CuSCN in Cu and Fe Solution.

C-109 : Inorganic Practical IV (Volumetry)

1. Determination of percentage of Fe and oxalate in $K_3[Fe(C_2O_4)_3].3H_2O$.
2. Determination of Ca and Mg in Dolomite.
3. Determination of Fe and Al in a mixture using EDTA.
4. Determination of Cu in Cu and Ni solution iodometrically.
5. Determination of Fe in Cu and Fe Solution using $K_2Cr_2O_7$.
6. Determination of Cr in Fe and Cr solution using ceric ammonium sulfate.

SUGGESTED BOOKS

1. Vogel's Text book of Qualitative Chemical Analysis, J. Bassett, G. H. Jeffery and J. Mendham, 7th edition, ELBS (2013).
2. Vogel's text book of Quantitative Chemical Analysis, 6th Edition, J. Bassett, G. H. Jeffery and J. Mendham, and R. C. Denny, J. D. Bames, M. Thomas, Prentice Hall (2000).
3. Inorganic Semimicro Qualitative Analysis, V. V. Ramanujam; The National Pub. Co. (1990).
4. Practical Inorganic Chemistry, G. Marr and B. W. Rockett, Von Nostrand Reinhold Co., London (1972).
5. An Advance Course in Practical Chemistry, A. Ghoshal, B. Mahapatra and A. K. Nad, New Central Book Agency Pvt. Ltd., 3rd Edition, (2007).
6. Advanced Inorganic analysis, S. K. Agarwal, and Keemtilal; Pragati Prakashan, 12th Edition (2014).
7. Comprehensive Co-ordination Chemistry, S.P. Banerjee, Books and Allied (P) Ltd., (2019).

ORGANIC CHEMISTRY PRACTICALS

(4 days a week, 4 hours a day)

I/II/III SEMESTER PRACTICALS

Ch-106 Organic Chemistry Practical-I

(Preparation (one-stage)

1. Oxidation of cyclohexanol.
2. Preparation of S-benzylisothiuroniumchloride.
3. Synthesis of picric acid.
4. Synthesis of glucose pentaacetate.
5. Synthesis of 2,4,6-tribromoaniline.
6. Cannizarro reaction: benzaldehyde to benzyl alcohol and benzoic acid.
7. Dehydration of cyclohexanol to cyclohexene.
8. Claisen-Schmidt reaction: benzaldehyde and acetone to dibenzalacetone.
9. Sandmeyer reaction: 4-chlorotoluene from 4-toluidine.
10. Pechmann reaction: resorcinol and ethylacetoacetate to 7-hydroxy-4-methylcoumarin.
11. Synthesis of 2,4-dichlorophenoxyacetic acid.
12. Synthesis of resacetophenone .

Ch-107 Organic Chemistry Practical-II

(Qualitative analysis)

Systematic analysis and identification of bifunctional organic compounds.

Ch-108 Organic Chemistry Practical – III

Preparation (Two- and three -stages)

1. 4-Bromoaniline from acetanilide.
2. 3-Nitrobenzoic acid from benzoic acid/methyl benzoate.
3. 2,4-Dinitrophenylhydrazine from chlorobenzene.
4. *N*-Methylanthranilic acid from phthalic acid.
5. Benzanilide from benzophenone.
6. Benzilic acid from benzoin.
7. Synthesis of acridone.
8. Synthesis of hydantoin.
9. Anthracene to anthrone

10. Succinic acid to N-bromosuccinimide.

11. Maleic acid to dimethyl acetylene dicarboxylate.

Ch-109: Organic Chemistry Practical-IV

(Quantitative analysis)

1. Titrimetric estimation of mono-, dicarboxylic-, amino- and aryloxyacetic acids.

2. Saponification value of oil.

3. Estimation of glucose by Fehling's method/Bertrand's method.

4. Estimation of keto-group.

5. Estimation of phenols.

6. Iodine value of oil (Chloramine-T method)

7. Acid and ester, acid and amide in the mixture of two.

SUGGESTED BOOKS

1. Vogel's Text Book of Practical Organic Chemistry – 5th edition, B. S. Furniss, A. J. Hannaford, P. W. G. Smith and A. R. Tatchell - Pearson, (2003).
2. Laboratory manual of Organic Chemistry- B. B. Dey, M. V. Sitaraman and T.R. Govindachari, Allied Publishers, New Delhi, (1996).
3. Practical Organic Chemistry, IV edition, – F. G. Mann and B. C. Saunders, - Pearson, 2009).
4. Text Book of Practical Organic Chemistry including qualitative analysis – IV Edition, A. I. Vogel and A. R. Tatchell, Longman, London, (1996).
5. Test Book of Quantitative Organic Analysis- A. I. Vogel, (1996).
6. A Handbook of Organic Analysis – Qualitative and Quantitative – IV Edition, H. T. Clarke, Hodder and Staughton, New Delhi (2017).
7. Comprehensive practical organic chemistry: Preparation and quantitative Analysis, V. K. Ahluwalia, R. Aggarwal, Universities Press (India), (2000).
9. Comprehensive practical organic chemistry: Qualitative analysis, V. K. Ahluwalia, S. Dhingra, Universities Press (India), (2000).
10. An advanced course in practical chemistry, A. Ghoshal, B. Mahapatra and A.Kr. Nad, New Central Book Agency, Calcutta, (2000).
11. Advanced practical organic chemistry, J. Mohan, Vol. I and II, Himalaya Publishing House, (1992).
12. Practical organic chemistry (Quantitative analysis), B. B. Dey, M. V. Sitaraman and T. R. Govindachari, Allied Publishers, New Delhi,(1992).
13. Advanced Practical Organic Chemistry, III Edition, J. Leonard, B. Lygo and G. Procter, CRC Press, Routledge, (2013).
14. Qualitative Organic Analysis – Spectrochemical Techniques W. Kemp, II edition, Mc-Graw Hill, London, (1986).

PHYSICAL CHEMISTRY PRACTICALS

(4 days a week, 4 hours a day)

I/II/III SEMESTER PRACTICALS

C-106 : Physical Chemistry Practical -I

1. Study of Acid catalysed hydrolysis of methyl acetate at lab temperature and reporting the calculated and graphical rate constants
2. Determination of Velocity constant for the saponification of Ethyl acetate at lab temperature and comparing it with graphical value.
3. Verification of Beer's Law: Colorimetric estimation of Cu^{2+} ions and reporting the Molar extinction coefficient.
4. Colorimetric estimation of Fe^{2+} ions in a given solution by titrating FAS versus $KMnO_4$ solution.
5. Colorimetric estimation of Fe^{2+} ions in a given solution by using EDTA.
6. Study of kinetics of the reaction between KI ad $K_2S_2O_8$solution by colorimetry.
7. Construction of phase diagram of two component systems (Napthalene-n-dinitrobenzene) and determination of E_c , ET and the composition of given unknown.
8. Determination of partial molar volume of solute – water system (NaCl-H_2O/KCl-H_2O/KNO_3-H_2O by apparent molar volume method.
9. Determination of partial molar volume of ethanol – water system by intercept method
10. Verification of Freundlich and Langmuir isotherm for adsorption of oxalic/acetic acid on activated charcoal.

C-107: Physical Practical -II

(Conductometric Experiments)

1. Precipitation titration of lithium sulphate/sodium sulphate versus $BaCl_2$ and reporting the unknown concentration.
2. Determination of concentration of a weak acid (acetic acid/oxalic acid) by titrating against a weak base.
3. Determination of a dissociation constant of weak acid (CH_3COOH/HCOOH/$ClCH_2COOH$) and mean ionic activity coefficient of weak acids by conductivity method.
4. Determination of Equivalent conductance of a weak electrolyte (CH_3COOH) at infinite dilution using Kohlrausch's law.
5. Determination of the concentration of a strong acid and a salt in a given a mixture of by titrating

against a strong base.

(Potentiometric Experiments)

6. Determination of single electrode potential of Cu^{2+}/Cu and Zn^{2+}/Zn and estimate the given unknown concentration.
7. Potentiometric titration of KI vs KMnO4.
8. Titration of $AgNO_3$ versus KCl and estimation of the concentration of $AgNO_3$.
9. Determination of pKa and Ka values of the weak acid (CH_3COOH/HCOOH/$ClCH_2COOH$) by titrating against a strong base using quinhydrone electrode.
10. Determination and comparison of pH values of buffer solutions by using quinhydrone electrode and glass electrode.

C-108: Physical Chemistry Practical -III

1. Study of acid hydrolysis of methyl acetate for two different concentrations of HCl/H_2SO_4 and reporting the relative strength.
2. Study the hydrolysis of methyl acetate in the presence of HCl at two different temperatures and reporting the energy of activation.
3. Determination of dissociation constant of a given indicator by colorimetric method.
4. Study of kinetics of autocatalytic reaction between $KMnO_4$ versus oxalic acid.
5. Evaluation of Arrhenius parameter for the reaction between $K_2S_2O_8$ versus KI (first order)
6. Determination of degree of hydrolysis of aniline hydrochloride at room temperature and calculation of dissociation constant of the base by pH metry.
7. Verification of Beers law: Estimation of MnO_4^{2-} ions colorimetrically and determination of concentration of the given unknown solution and calculation of molar extinction coefficient.
8. Analysis of a binary mixture (glycerol and water) by measuring viscosity using viscometer
9. Determination of heat of solution of organic acid (benzoic acid/salicylic acid) by variable temperature method (graphical method).
10. Construction of phase diagram of Urea - KCl -H_2O system, athree component system.

C-109: Physical Chemistry Practical -IV

Conductometry

1. Determination of concentration of mixture of strong acid and weak acid versus strong base.
2. Determination of concentration of a Weak acid with salt versus strong base.
3. Determination of strength of a strong acid, weak acid and a salt versus strong base

4. Determination of the solubility of sparingly soluble salt ($BaSO_4$) by conductometric method.

pHmetry

5. Determination of the acidic and basic dissociation constant and isoelectric point of an amino acid by pH metry.
6. Determination of pK_a value or Dissociation constant of phosphoric acid by pHmetry.
7. pH titration of (a) HCl against NaOH (b) Copper sulphate against NaOH and (c) CH_3COOH/HCOOH against NaOH- Determination of K_a.

Potentiometry

8. Determination of concentration and amount of $K_2Cr_2O_7$ by titrating against FAS and calculation of redox potential.
9. Determination of concentration of mixture of acids by titrating against NaOH solution.
10. Determination of concentration of $KMnO_4$ by titrating against FAS and calculation of redox potential.

SUGGESTED BOOKS

1. Advanced Practical Physical Chemistry by J. B. Yadav, GoelPublications, Meerut (2012).
2. Senior Practical Physical Chemistry by B. C. Kosla, Simla Printers, New Delhi (1987).
3. Experimental Physical Chemistry by Daniel et al., McGraw Hill, New York (1962).
4. Practical Physical Chemistry by A.M James and P. E. Pritchard, Longman's Group Ltd (1968).
5. Experimental Physical Chemistry by Wilson, Newcombe& others, Pergamon Press, New York (1962).
6. Experimental Physical Chemistry by R. C. Behra and B Behra, Tata McGraw, New Delhi (1983).
7. Experimental Physical Chemistry by V. D. Atavale and Parul Mathur, New Age International, New York, (2001).
8. Practical's in physical chemistry A. Modern Approach by P.S Sindhu, Mac. Millan Publishers, Delhi, (2006).
9. Advanced Physical Chemistry Experiments by J.N. Gurtu and Gurtu, Pragati Prakashan, (2011)
10. Practical Physical Chemistry by A.J. Findlay.
11. Experiments in Chemistry-D.V. Jahagirdar, Himalaya Publishing House, Bombay, (1994).

II Semester

Code No	Title	Theory/Practical (Hrs/Week)	Total no of Hrs/ Semester	Duration of Exam hours	Max. marks	Continuous Evaluation	Total marks	Credits
Ch 201	Inorganic Chemistry II	4	52	3	70	30	100	4
Ch 202	Organic Chemistry II	4	52	3	70	30	100	4
Ch 203	Physical Chemistry II	4	52	3	70	30	100	4
Ch 204	Molecular Spectroscopy	4	52	3	70	30	100	4
Ch 205	Green Synthesis (Soft Core)	4	36	3	70	30	100	2
Ch 205	Chemistry of Selected Elements	4	36	3	70	30	100	2
Ch 206	Practical I Inorg/Org/Phy	4	60	4	35	15	50	2
Ch 207	Practical II Inorg/Org/Phy	4	60	4	35	15	50	2
Ch 208	Practical III Inorg/Org/Phy	4	60	4	35	15	50	2
Ch 209	Practical IV Inorg/Org/Phy	4	60	4	35	15	50	2
							700	26

Scheme for continuous evaluation

A. Theory (each paper)

Tests* :30 Marks

* Two tests will be conducted and the average marks of the two tests will be taken for Internal assessment.

B. Practical: 30 marks for experiment + 5 marks for Viva-Voce

IA : 15 Marks (based on Test + Record)

Semester II

Ch-201: Inorganic Chemistry-II 52 Hrs

Unit I **13 Hrs**

Metal-ligand equilibria in solution: Stepwise and overall formation constant and their relationship, trends in stepwise formation constant, kinetic and thermodynamic stability of metal complexes, factors affecting the stability of metal complexes with reference to the nature of the metal ion and ligand -chelate effect, macrocyclic effect, and their thermodynamic origin. Determination of binary formation constant, by spectrophotometry, pH metry, polarography and ion-exchange methods.

Structure and bonding: Structure and bonding in hydride, dihydrogen, dioxygen, isocyanide, dinitrogen and tertiary phophine complexes of transition metals. Metal carbonyls-terminal and bridge carbonyls, detection. Metal nitrosyls- terminal (linear and bent) and bridge.

Unit II **13 Hrs**

Metal-Ligand Bonding: Coordination numbers 3 to 8, factors favouring low and high co-ordination numbers. **Crystal field theory:** Salient features, splitting of d-orbitals in tetrahedral, square planar, square pyramidal, trigonal bipyramidal and octahedral. Limitations of CFT. CFSE-factors affecting CFSE, calculation of CFSE., spectrochemical series, and Jahn Teller effects. **Applications of CFT**- colours of transition metal ions, magnetic properties of octahedral and tetrahedral complexes, variation in lattice energy and enthalpy of hydration of 3d metal complexes and site preference in spinels and inverse spinels. Experimental evidence for metal-ligand covalent bonding in metal complexes. Nephelauxetic effect.

Molecular Orbital Theory: Construction of MO diagrams of tetrahedral and octahedral metal complexes with (i) σ-bonding only and (ii) σ- and π- bonding. **Angular overlap model**. Stereochemical non-rigidity and its detection.

Unit III **13 Hrs**

Electronic Spectra of Co-ordination complexes

Spectrosocpic ground states, microstates, selection rules, term symbols for d^n ions, Racah parameters.Orgel diagrams- Spectra of 3d metal hexaaqua complexes of V^{3+}, Cr^{3+}, Mn^{2+}, Co^{2+} and Ni^{2+}, $CoCl_4^{2-}$. Calculation of Dq, B, and β- parameters. Drawbacks of Orgel diagrams, Correlation

diagrams, Tanaube-Sugano diagrams, Advantages of T-S diagrams over Orgel diagrams. Charge transfer spectra- classification. Spectral properties of lanthanide and actinide metal complexes.

Unit IV **13 Hrs**

Magnetic properties of coordination complexes-types of magnetism, temperature effect, Curie and Curie-Weiss law. Gram and Molar Susceptibility- magnetic moment, Magnetic susceptibility determination by Guoy, Faraday and VSM method. Orbital contribution and quenching of orbital moment, super-exchange, spin-orbital coupling, ferro- and antiferromagnetic coupling, spin-crossover. Magnetic properties of lanthanide and actinide complexes.

Photochemical reactions of transition metal complexes

Basic chemical processes, Kasha's rule, quantum yield, Jablonski diagrams, Photochemical versus thermal reactions.Photochemical reactions- Modes of photochemical excitation in the transition metal complexes, Prompt and delayed reactions, Photochemical reactions of metal carbonyls, Photochemical reactions in the Co(III) and Cr(III) complexes. Photochemical splitting of water by $[Ru(bipy)_3]^{2+}$.

Suggested Books

1. Advanced Inorganic Chemistry, F.A. Cotton, G. Wilkinson, C.A. Murillo, M.Bochmann, Wiley , 6th Edition, (2007).
2. Inorganic Chemistry, J.E. Huheey, E.A. Keiter and R.L. Keiter, 4th Edition, Pearson, (1993).
3. Inorganic Chemistry, D.F. Shriver, P.W. Atkins and C.H. Langford, 5th Edition, ELBS, Oxford University Press, (2010).
4. Inorganic Chemistry, G.L. Miessler and D.A. Tarr, Pearson, 5th Edition, (2014).
5. Inorganic Electronic Spectroscopy, A.B.P. Lever, 2nd Edition, Elsvier, (1984).
6. Electronic absorption spectroscopy and related techniques, D.N. Sathyanarayana, University Press, (2001).
7. Inorganic Chemistry, A Unified Approach by W.W. Porterfield, Elsvier 2nd Edition, (2005).
8. Fundamental concepts of Inorganic Chemistry, A.K. Das and Mahua Das, Volume 5, CBS Publishers, (2014).
9. Selected topics in Inorganic Chemistry, Wahid U. Malik, G.D.Tuli, and R.D. Madan , S.Chand and Company Pvt. Ltd., 8th Revised Edition, (2014).

Ch-202: Organic Chemistry – II 52 Hrs

Unit-I **13 Hrs**

Aromatic Substitution Reactions

Electrophilic Substitution Reactions: The arenium ion mechanism. Orientation and reactivity. Energy profile diagrams. The *ortho*/*para* ratio, *ipso* attack, orientation in benzene and high order rings with one or more substituents. Quantitative treatment of reactivity in substrates and electrophiles. Effect of leaving group. Amination, sulfonylation reactions; Diazonium coupling reaction, Vilsmeier-Haack reaction, Friedel-Craft reaction, Gatterman reaction, Gatterman-Koch reaction and Hoesch reaction.

Nucleophilic substitution reactions: The SNAr, SN1, benzyne and SRN1 mechanisms. Reactivity: effect of substrate structure, leaving group and attacking nucleophile. Chichibabin reaction, Goldberg reaction, Bucherer reaction, Schiemann reaction, von Richter reaction, Sommelet-Hauser and Smiles rearrangements.

Unit II **13 Hrs**

Addition Reactions

Addition to carbon-carbon multiple bonds: mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals. Regio-, stereo- and chemo- selectivities. Orientation and reactivity. Addition to cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Addition of alkenes and/or alkynes to alkenes and/or alkynes. Ene synthesis. Michael reaction and Knoevanagel condensation.

Addition to carbon-heteroatom multiple bonds: Mechanism of metal hydride reduction (NaH, LiH, $LiAlH_4$, $NaBH_4$) of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents and organolithium reagents to carbonyl compounds and unsaturated carbonyl compounds. Conversion of aldehydes to nitriles. Hydrolysis of nitriles and addition of amines to isocyanates. Formation of xanthates. Wittig, Mannich and Stobbe reactions.

Unit-III **13 Hrs**

EliminationReactions

The E2, E1 and E1cB mechanisms and their spectrum. E2C and E2H mechanisms. Orientation of the double bond. Reactivity-effects of substrate structure, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination reactions. Chugaev reaction.

Rearrangement Reactions:

Carbon-carbon: Wagner-Meerwein, Pinacol-Pinacolone, Fries, Benzil-benzilic acid rearrangements, Wolff rearrangement and Arndt-Eistert reaction, Demjanov reaction, Fritsch-Buttenberg-Wiechell rearrangement. Favorskii rearrangement, Dienone-phenol rearrangement, Baker-Venkataraman rearrangement.

Carbon-nitrogen: Beckmann-, Hofmann-, Curtius-, Lossen- and Schmidt- rearrangements. Stevens-, Neber and Benzidine rearrangement,

Carbon-oxygen: Wittig rearrangement, Baeyer-Villiger oxidation.

Unit IV **13 Hrs**

Chemistry of biological molecules - II

Amino acids and Peptides:

Essential and non-essential amino acids. Classification and nomenclature of peptides. Sanger and Edman methods of sequencing. Cleavage of peptide bond by chemical methods. Peptide synthesis: Protection of amino group (Boc-, Z- and Fmoc-) and carboxyl group as alkyl and aryl esters. Use of DCC, EEDQ, HOBt and active esters, in peptide bond formation reactions. Deprotection and racemization in peptide synthesis. Solid phase peptide synthesis of oxytocin and enkephalins.

Vitamins:

Synthesis of Vitamin A, Vitamin B_1 (thiamine), Vitamin B_6 (pyridoxine), folic acid, pantothenic acid, riboflavin, Vitamin C, Vitamin E (α-tocopherol), Vitamin H (biotin), Vitamin K_1 and K_2 .

SUGGESTED BOOKS

1. Advanced Organic Chemistry - Reactions, Mechanism and Structure, Jerry March, John Wiley (2008).
2. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg Plenum, (2000).
3. A Guide Book to Mechanism in Organic Chemistry, P. Sykes, VI edition, Pearson, (2003).
4. Structure and Mechanism of Organic Chemistry, C. K. Ingold, II Edition, CBS, (2016).
5. Organic Chemistry, R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, VII edition, Pearson, (2018).
6. Principles of Organic Synthesis, III edition), R.O. C. Norman and J. M. Coxon, Blackie Academic and Professional (Indian Reprint), (2012).
7. Natural Products: their chemistry and biological significance, J. Mann, Longman, (2000)
8. Organic Chemistry, Volume I, I. L. Finar, VI edition, Pearson, (2018).
9. Organic Chemistry, Volume II, I. L. Finar, VI edition, Pearson, (2018).
10. Organic Chemistry, J Clayden, N Greeves and S Warren, II edition, Oxford University Press, (2014)
11. Name Reactions - A collection of detailed reaction mechanisms, J. J. Li Springer, (2012).
12. Modern Methods of Organic Synthesis W. Carruthers and I. Coldham, IV edition, Cambridge University Press, (2015).
13. Peptides Chemistry: A practical text book, M. Bodansky, Springer-Verlag NY, (1988).
14. Solid-phase peptide synthesis: A practical Approach-E. Artherton and R. C. Sheppard, Oxford Univ. Press, (1989).
15. Peptides: Chemistry and Biology, N. Selwad and H.-D. Jakubke, Wiley-VCH, (2002).

Ch-203: Physical Chemistry- II 52 Hrs

Unit-I **13 Hrs**

Thermodynamics-I

Thermodynamics: Concepts of partial molar properties – partial molar free energy, chemical potential, partial molar volume and its significance. Gibbs-Duhem equation, Gibbs-Duhem Margulus equation. Determination of partial molar volume: Graphical method, intercept method and Apparent molar volume method. Concept of fugacity; Determination of fugacity by graphical method and compressibility factor method. Activity and activity coefficient: Determination of activity coefficient by EMF and solubility method. Thermodynamics of nonideal system-Excess thermodynamic function, GE, SE , HE etc. Phase Rule: Derivation of phase rule from the concept of chemical potential. Application of Phase Rule to three components system: Principle of triangular diagram: Plots for a mixture of three liquids consisting of one, two and three pairs of partially miscible liquids.

Statistical Thermodynamics: Objectives of statistical thermodynamics, Concept of distributions, Types of ensembles. Thermodynamic probability, Most probable distribution Law – Partition Function, (Definition and significance): Molar and molecular partitions-translational, rotational, vibrational and electronic partition functions- Relation between thermodynamic functions (E, H,S,G and C_v) and the partition functions.

Unit-II **13 Hrs**

Thermodynamics-II

Sackur-Tetrode equation for entropy of translation function. Relation between equilibrium constant and partition function. Different Distribution Laws: Types of Statistics: Maxwell – Boltzmann , Bose-Einstein and Fermi-Dirac statistics. Derivation of the equations for above three distribution Laws. Comparison of Bose-Einstein and Fermi-Dirac statistics with Maxwell – Boltzmann statistics. Problems and their Solutions.

Non-equillbrium Thermodynamics: Thermodynamic criteria for non-equillibrium states-Phenomenological Laws and Onsager's reciprocity relations, Coupled and Non-coupled reactions, Entropy production and entropy flow. Electro kinetic Phenomenon. Postulates and methodologies: Uncompensated heat and thermodynamics fuction production. deDonder's inequality. Rate of entropy production. Transformations of the generalized fluxes and forces :eg., Chemical reaction, heat flow, Diffusion or material flow, flow of electric current.

Unit-III **13 Hrs**

Electrochemistry

Electrochemistry of solutions: Ionic atmosphere, Debye-Huckel theory for the problem of activity coefficient, Debye-Huckel limiting Law, Debye-Huckel equation for appreciable concentration, Debye-Huckel Onsagar conductance equation and its extension to ion solvent interations, Debye-Huckel Bjerrum mode, Ion association, triple ions, triple ions and conductance minima. Thermodynamics of electrified interface, derivation of electro capillary Lipmann's equation, surface excess, thermodynamic aspects of surface excess. The method of determination and measurement of interfacial tension as a function of applied potential difference across the interface.

Unit-IV **13 Hrs**

Electrochemistry-II

Structure of electrified interface: Helmholtz theory, Guoy- Chapman theory, Stern model. Overpotential: Concentration, activation and ohmic overpotential; Derivation of Butler- Volmer equation.

Semiconductor- solution interface: Theory of double layers at semiconductor- electrolyte interface.

Electrocatalysis: Definition and Influence of various parameters. Quantum aspects of charge transfer at electrode solution interface, quantization of charge transfer, tunnelling of electrons for hydrogen evolution with reference to electrocatalysis.

Polarography technique -Principle, DME- Merits and limitations, experimental, polarogram, half wave potential, diffusion controlled current, Ilkovic equation (no derivation), qualitative and quantitative estimation of metal ions.

Advanced Electrodes: Rotating disc electrodes, Membrane electrodes (Definition, examples with diagrams and applications to each), carbon electrodes.

SUGGESTED BOOKS

1. Molecular thermodynamics, Donald A. Mc Quarrie, John D. Simon University Science Books California, (1999).
2. Thermodynamics for Chemists by S. Glasstone, East-West Press, New Delhi, (1960).
3. Thermodynamics, by Rajaraman and Kuriacose, East-West Press, (1986).
4. Statistical Thermodynamics, M. C. Gupta (Wiley Eastern Ltd.) 1993.
5. Elements of Classical and Statistical Thermodynamics, L. K. Nash, Addison-Wiley (1979).
6. Thermodynamics, Statistical Thermodynamics and Kinetics by Thomas Engel & Philip Reid, Pearson Education inc. (2007).
7. Modern Electrochemistry Vol-1 and 2, J. O. M. Bockrisand A. K. N. Raddy, Plenum, New York (1978).
8. An introduction to electrochemistry: Samuel Glasstone, East-West, Edition New Delhi, (1942).
9. Text book of physical chemistry Samuel Glasstone, 2nd edition, Mac Millan India Ltd., (1991).
10. Principles and applications of Electrochemistry- D. R. Crow 3rd edition, Chapmanhall London (1988).
11. Physical chemistry thorugh problems by S K Dogra and S Dogra, Wiley Eastern Ltd., 4thEdn. (1993).
12. Electrochemical methods by A. J. Bard and I. R. Faulkner,2nd Edn., Wiley New York, (2000).
13. Chemical and Electrochemical Energy Systems, R, Narayan and B. Viswanathan (University Press), (1998).

Ch-204: Molecular Spectroscopy 52 Hrs

Unit-I **13 Hrs**

Symmetry and Group Theory in Chemistry

Definition of groups, subgroups, cyclic groups, conjugate relationships, classes, simple theorems in group theory. Symmetry elements and symmetry operations, point groups, Schöenflies notations, representations of groups by matrices, reducible and irreducible representations, characters of representations, Great Orthogonality Theorem (without proof) and its applications, character tables and their uses (representations for the C_n, C_{nv}, C_{nh}, D_{nh} etc groups to be worked out explicitly) Mulliken symbols for irreducible representations. Direct products, Applications of group theory to quantum mechanics identifying non-zero matrix elements, derivation of the orthonormalization conditions. Applications of group theory and hybrid orbitals

Unit-II **13 Hrs**

Infrared Spectroscopy-I

Vibrations of molecules, harmonic and anharmonic oscillators- vibrational energy expression, energy level diagram, vibrational wave functions and their symmetry, selection rules, expression for the energies of spectral lines, computation of intensities, hot bands, effect of isotopic substitution Diatomic vibrating rotor, Born-Oppenheimer approximation, vibrational-rotational spectra of diatomic molecules, P, Q and R branches, breakdown of the Born-Oppenheimer approximation.

Infrared Spectroscopy-II

Vibrations of polyatomic molecules: Normal coordinates, translations, vibrations and rotations, vibrational energy levels and wave functions, fundamentals, overtones and combinations Vibration-rotation spectra of polyatomic molecules- parallel and perpendicular vibrations of linear and symmetric top molecules Techniques and instrumentation, FTIR.

Unit-III **13 Hrs**

Microwave Spectroscopy

Rotations of molecules, rigid diatomic molecule- rotational energy expression, energy level diagram, rotational wave functions and their symmetry, selection rules, expression for the energies of spectral lines, computation of intensities, effect of isotopic substitution, centrifugal distortion and the spectrum of a non-rigid rotor. Rotational spectra of polyatomic molecules- linear, symmetric top and asymmetric top molecules, Stark effect, techniques and instrumentation.

Raman Spectroscopy

Classical theory of the Raman effect, polarizability as a tensor, polarizability ellipsoids, quantum theory of the Raman effect, Pure rotational Raman spectra of linear and aymmetric top molecules, vibrational Raman spectra, Raman activity of vibrations, rule of mutual exclusion, rotational fine structure- O and S branches, Polarization of Raman scattered photons Structure determination from Raman and IR spectroscopy-AB_2 and AB_3 molecules, Techniques and instrumentation.

Unit-IV **13Hrs**

Electronic Spectroscopy

Born-Oppenheimer approximation, vibrational coarse structure, intensities by Franck-Condon principle, Dissociation energy, rotational fine structure, Fortrat diagram, pre-dissociation.

Electronic structure of diatomic molecules- basic results of MO theory, classification of states by electronic angular momentum-□,□,□, and □ molecular orbitals, selection rules, spectrum of singlet and triplet molecular hydrogen

Electronic spectra of polyatomic molecules- localized MOs, spectrum of HCHO, change of shape on excitation

Decay of excited states- radiative (fluorescence and phosphorescence) and non-radiative decay, internal conversion

SUGGESTED BOOKS

1. Chemical Applications of Group Theory, F. A. Cotton, Wiley Eastern (1976).
2. Molecular Symmetry, D. S. Schonland, Van Nostrand (1965).
3. Introduction to Molecular Spectroscopy, C. N. Banwell, TMH Edition (1994).
4. Introduction to Molecular Spectroscopy, G. M. Barrow, McGraw Hill (Int. Students Edition), (1988).
5. Molecular Spectroscopy, J. D. Graybeal, McGraw Hill (Int. Students Edition) (1990).
6. Spectroscopy, Vols. 1-3, B. P. Straughan and W. Walker, Chapman Hall, (1976).
7. Molecular Symmetry and Group theory by Robert L. Carter, John Wiley and sons (2005).
8. Vibrational Spectroscopy theory and Applications, D.N. Satynarayana, New Age International, New Delhi, (2004).
9. Molecular Symmetry by David J. Willock, John Wiley and Sons Ltd., (2009).
10. Spectroscopy, B.P. Starughan and S. Walker, John Wiley & Sons Inc., New York Vol 1and 2, (1976).

Ch-205 Green synthesis and named reactions (soft core) 36 Hrs

Unit-I

Use of ultrasound and Microwaves in organic Synthesis 12 Hrs

Twelve principles of green chemistry with their explanations and examples, green solvents and atom efficiency (% atom utilization), tandem, cascade and domino reactions in organic synthesis

*Use of ultrasound***:** Introduction, instrumentation, the phenomenon of cavitation. Sonochemical esterification, substitution, addition, alkylation, oxidation, reduction and coupling reactions.

Use of microwaves: Introduction, concept, reaction vessel/medium, specific effects, advantages and limitations. N-alkylation and alkylation of active methylene compounds, condensation of active methylene compounds with aldehydes and amines. Deprotection of esters and silyl ethers. Oxidation of alcohols and sulfides.

Ionic-liquids: Introduction, structure, synthesis and applications in nucleophilic displacement reactions, hydroformylation, epoxidation, Diels-Alder reaction. Some important ionic liquids in organic synthesis.

Unit-II 12 Hrs

Polymer supported reagents in organic synthesis

Introduction- properties of polymer support, advantages of polymer supported reagents and choice of polymers. Applications.

Substrate covalently bound to the support: Dieckmann cyclisation. Preparation of polymer bound aldehyde and application in aldol and Wittig reactions. Synthesis of polystyrylboronic acid and use in diol protection reaction.

Reagent linked to a polymeric material: Preparation of sulfonazide polymer and application in diazotransfer reaction. Synthesis of polymer bound per acid and its applications.

Polymer supported catalytic reactions: Preparation of polymer supported $AlCl_3$ and application in etherification and acetal formation reactions.

Phase transfer catalysis and Crown ethers

Phase transfer catalysis: Introduction, definition, mechanism of phase transfer catalysis. Types of phase transfer catalysts and reactions and their Advantages.

Preparation of catalysts and their application in substitution, elimination, addition, alkylation, oxidation and reduction reactions.

Crown ethers: Introduction, nature of donor site. General synthesis of Crown ethers.

Synthetic applications: Alkylation, generation of carbenes and aromatic substitution. Generation and application of superoxide anions. Cation deactivation reactions.

Unit-III

Multi-component Reactions **12 Hrs**

Studies on the mechanistic aspects and use of the following reactions in organic synthesis: Passerini-Ugi; Hantsch; Biginelli; Doebner-Miller; Ritter; Jacobson; Betti; Robinson-Schopf; Barbier; Baylis-Hilmann; Petasis; Ivanov and Suzuki coupling reaction.

SUGGESTED BOOKS

1. Some modern methods of Organic Synthesis, W. Caruthers, Cambridge Univ. Press London, 2nd Edition, (1998).
2. Organic synthesis: Special techniques, V. K. Ahluwalia and R. Aggarwal, Narosa, New Delhi, (2003).
3. Green Chemistry, environment friendly alternatives, R. Sanghi and M. M. Srivastava, Narosa, New Delhi, (2003).
4. Green Chemistry-an introductory text, M. Lancaster, Royal Society of Chemistry, UK, (2003).
5. Organic chemistry, Vol. 2, 6th Edition, I. L. Finar, Longman, (1992).
6. Crown ethers & cryptands, G. W. Gokel, Royal Society of Chemistry, UK, (1991).
7. Macrocyclic Polyether Chemistry, G. W. Gokel, S. M. Korzeniowski, Vol 1 to3, Wiley, NY, (1978, 1981,1987).
8. Phase Transfer Catalysis in Organic Synthesis, W. B. Weber, G. W.Gokel, Springer, Berlin, (1977).
9. Phase Transfer Catalysis, E. V. Dehmlov, S. S. Dehmlov, 2nd Edn., Verlag chemie, Wienheim, (1983).
10. Polymers as aids in Organic synthesis, N. K. Mathur, C. K. Narang and R.E. Williams, Academic Press, NY,(1980).
11. Anastas, P.T., Warner, J. Green Chemistry: Theory and Practice; Oxford University Press; London. (1988)
12. Mukesh Doble, Anil Kumar Kruthiventi, Green Chemistry and Engineering, (2007)
13. V.K. Ahluwalia and M.R. Kidwai; New Trends In Green Chemistry, Anamalaya Publishers (2005).
14. P.T. Anastas and J.K. Warmer; Oxford Green Chemistry. Theory and Practical University Press (1998).

Ch 205 :Chemistry of Selected Elements 36 hrs

Unit I **12 Hrs**

Compounds of hydrogen atom and hydride ions, dihydrogen and hydrogen bonding. Classes of binary hydrides, molecular hydrides, saline hydrides and metallic hydrides. Interhalogen compounds: Synthesis and structures of XY, XY_3, XY_5 and XF_7. Physical properties, structure, and chemical properties of cationic interhalogens.

Unit II **12 Hrs**

Oxides and oxoacids of nitrogen, phosphorous and chlorine. Peroxoacids of sulphur.

Silicones – Synthesis, types of silicones. Preparation of linear, cyclic, and cross-linked silicones. Silicone oils, silicone rubbers, and silicone resins. Application of silicones.

Chemistry of the group 18 elements

Occurrence, recovery, and uses of elements. Clathrate compounds.

Chemistry of Xenon- Synthesis, structure, and properties of xenon fluorides. Bonding in XeF_2, XeF_6 and XeF_4. Synthesis and structures of XeO_3, $XeOF_4$, $XeOF_2$, and $XeOF_4$.

Unit III **12 Hrs**

Chemistry of Lanthanides

Occurrence, electronic configuration. Extraction of lanthanides from monazite sand. Separation of lanthanides from lanthanide mixture. **Properties of Lanthanides** Oxidation states, atomic and ionic radii. Lanthanide contraction. Electronic and magnetic properties of lanthanides.

Chemistry of Actinides

Position of actinides in the periodic table. Electronic configuration and ionic radii. Separation of neptunium, plutonium, and americium from uranium present in spent reactor fuel- Fluoride precipitation and Solvent Extraction methods. Synthesis of transuranium elements.

Electronic and magnetic properties of actinides. Comparison between lanthanides and actinides.

Suggested Books

1. Concise Inorganic Chemistry, J.D. Lee, 5th Edition, Wiley India, (1996).
2. Chemistry of Elements, N.N. Greenwood and A. E. Earnshaw, 2nd Edition, Butterworth-Heinemann, (1996).
3. Selected topics in Inorganic Chemistry, W.U. Malik, G.D. Tuli and R.D. Madan, 8th Revised Edition, S. Chand and Company, (2014).
4. Basic Inorganic Chemistry, F. A. Cotton, G. Wilkinson and P.L. Guas, 3rd Edition, John Wiley and Sons, (2002).

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