Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur

Post Graduate Teaching Department of Chemistry (Autonomous)

SYLLABUS for M. Sc. CHEMISTRY

Choice Based Credit System (Semester Pattern)

Effective from 2022-23

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Scheme of teaching and examination under semester pattern Choice Based Credit System (CBCS) for M.Sc. Program in Chemistry

M. Sc. Chemistry Semester I												
Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Examination Scheme						
						Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks		
		Th	Pract	Total			External Marks	Internal Ass		Th	Pract	
MCH1T01	Paper - I: Inorganic Chemistry	4	-	4	4	3	60	40	100	50		
MCH1T02	Paper- II: Organic Chemistry	4	-	4	4	3	60	40	100	50		
MCH1T03	Paper -III: Physical Chemistry	4	-	4	4	3	60	40	100	50		
MCH1T04	Paper - IV: Analytical Chemistry	4	-	4	4	3	60	40	100	50		
MCH1L01	Practical - I: Inorganic Chemistry	-	8	8	4	3-8	100	-	100		50	
MCH1L02	Practical - II: Physical Chemistry	-	8	8	4	3-8	100	-	100		50	
MCH1S01	Seminar 1	2	-	2	1			25	25	12.5		
	TOTAL	**18**	**16**	**34**	**25**		**440**	**185**	**625**	**212.5**	**100**	

M. Sc. Chemistry Semester II												
Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Examination Scheme						
		Th	Pract	Total		Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks	
							External Marks	Internal Ass		Th	Pract
MCH2T01	Paper - V: Inorganic Chemistry	4	-	4	4	3	60	40	100	50	
MCH2T02	Paper - VI: Organic Chemistry	4	-	4	4	3	60	40	100	50	
MCH2T03	Paper - VII: Physical Chemistry	4	-	4	4	3	60	40	100	50	
MCH2T04	Paper - VII: Analytical Chemistry	4	-	4	4	3	60	40	100	50	
MCH2L01	Practical III: Organic Chemistry	-	8	8	4	3-8	100	-	100		50
MCH2L02	Practical IV: Analytical Chemistry	-	8	8	4	3-8	100	-	100		50
MCH2S01	Seminar 2	2	-	2	1			25	25	12.5	
	TOTAL	**18**	**16**	**34**	**25**		**440**	**185**	**625**	**212.5**	**100**

M. Sc. Chemistry Semester III												
Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Examination Scheme						
		Th	Pract	Total		Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks		
							External Marks	Internal Ass		Th	Pract	
MCH3T01	Paper - IX: Core – 1 Spectroscopy - 1	4	-	4	4	3	60	40	100	50		
MCH3T02	Paper - X: Core – 2	4	-	4	4	3	60	40	100	50		
MCH3T03	Paper -XI**: Specialization Paper (**Inorganic-1/ Organic-1 / Physical-1 / Analytical-1**)** Chemistry	4	-	4	4	3	60	40	100	50		
MCH3T04	**Paper - XII: Core Subject Centric** A**)** Nuclear Chemistry I / B**)** Environmental Chemistry I / C**)** Polymer Chemistry I / D**)** Natural Product Chemisrty I / E**)** Applied Analytical Chemisrty I **OR Foundation Course** Instrumental Methods - I OR MOOC/NPTEL	4	-	4	4	3	60	40	100	50		
MCH3L01	Practical - V**:** Inorganic/ Organic / Physical / Analytical Chemistry	-	8	8	4	3-8	100	-	100		50	
MCH3L02	Practical -VI**:** Inorganic/ Organic / Physical / Analytical Chemistry	-	8	8	4	3-8	100	-	100		50	
MCH3S01	Seminar 3	2	-	2	1			25	25	12.5		
	TOTAL	**18**	**16**	**34**	**25**		**440**	**185**	**625**	**212.5**	**100**	

M. Sc. Chemistry Semester IV											
Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Examination Scheme					
		Th	Pract	Total		Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks	
							External Marks	Internal Ass		Th	Pract
MCH4T01	Paper - XIII: Core – 1 Spectroscopy - 2	4	-	4	4	3	60	40	100	50	
MCH4T02	Paper - XIV: Core – 2	4	-	4	4	3	60	40	100	50	
MCH4T03	Paper - XV**:** **Specialization Paper (**Inorganic-2/ Organic-2 / Physical-2 / Analytical-2**)** Chemistry	4	-	4	4	3	60	40	100	50	
MCH4T04	**Paper - XVI: Core Subject Centric** A**)** Nuclear Chemistry 2 / B**)** Environmental Chemistry 2 / C**)** Polymer Chemistry 2 / D**)** Natural Product Chemisrty 2 / E**)** Applied Analytical Chemisrty 2 **OR Foundation Course** Instrumental methods- 2 OR MOOC/NPTEL	4	-	4	4	3	60	40	100	50	
MCH4L01	Practical VII**:** Inorganic/ Organic / Physical / Analytical Chemistry	-	8	8	4	3-8	100	-	100		50
MCH4P01	**Practical -VIII Project**	-	8	8	4	3-8	100	-	100		50
MCH4S01	Seminar 4	2	-	2	1			25	25	12.5	
	TOTAL	**18**	**16**	**34**	**25**		**440**	**185**	**625**	**212.5**	**100**

NOTE Sem III & IV:

Foundation Course: Candidate can opt for any one foundation course paper in the semester III and IV. However, Student shall opt for this paper from any other subject other than his / her main subject for postgraduation. If the candidate decides to opt for foundation course papers then he/she shall not be eligible to opt for Core (subject centric) papers in their subject.

Core (Subject Centric): Candidate can opt for this paper as shown in the semester – III and IV in his/her main subject of postgraduaion only. If the candidate decides to opt for core (subject centric) papers in his/her main subject of postgraduation then he/she shall not be eligible to opt for foundation course papers neither in own subject nor in any other subject.

- **General Scheme for Distribution of Marks in Practical Examination in Chemistry**
  Time:8-9h (One day Examination) Marks:100

Exercise-1	- 30 Marks	- Evaluated jointly by Internal and External Examiner
Exercise-2	- 30 Marks	- Evaluated jointly by Internal and External Examiner
Record	-20 Marks	- Evaluated by Internal
Viva-Voce	-20 Marks	- Evaluated by External
Total	**- 100 Marks**	

- **General Scheme for Distribution of Marks in Project Examination in Chemisrty**

The project work will carry total 100 marks and will be evaluated by both external and internal examiners in the Department.

The examiners will evaluate the project work considering the coverage of subject matter, presentation, literature etc.

For written Project work	- 40 Marks	-	Evaluated jointly by External and Internal
For Presentation	- 20 Marks	-	Evaluated jointly by External and Internal
ForViva-Voce	- 20 Marks	-	Evaluated by External Examiner
Internal Assessment	- 20 Marks	-	Evaluated by Internal Examiner
Total	**- 100 Marks**		

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Semester I - Inorganic Chemistry
Paper – I (Code: MCH1T01)

60 h (4 h per week): 15 h per unit 60 Marks

Course Outcomes: At the end of the course students would be able to

1. Predict the nature of bond and its properties through various electronic structural methods; bonding models
2. design new coordination compounds based on a fundamental understanding of their electronic properties
3. appreciate specialized and advanced topics in inorganic and coordination chemistry
4. Correlate structure and bonding with reactivity of boron clusters
5. analyze structures of various binary, ternary and quaternary compounds.

Unit-I

A) Stereochemistry and Bonding in Main Group Compound: 5h

VSEPR Theory: Various stereochemical rules and resultant geometry of the compounds of non-transitional elements, Shapes of simple inorganic molecules and ions containing lone pairs, shortcomings of VSEPR model. Bent's rule and energetics of hybridization.

B) Metal – Ligand Bonding: 10h

Crystal Field Theory: Splitting of d-orbital in tetragonal, square planar and trigonal bipyramidal complexes. Jahn-Teller effect, spectrochemical series, nephelauxetic effect. Limitations of crystal field theory. M.O. Theory for octahedral, tetrahedral & square planar complexes with and without π-bonding.

Unit-II

A) Metal – Ligand Equilibria in Solution: 5h

Stepwise and overall formation constants; trends in stepwise formation constants; factors affecting stability of metal complexes with reference to nature of metal ion, ligand, chelate effect and thermodynamic origin. Determination of formation constant by:
(1) spectrophotometric method (Job's and Mole ratio method)
(2) Potentiometric method (Irving-Rossotti Method)

B) Reaction Mechanism of Transition metal complexes-I: 10h

Energy Profile of a reaction, reactivity of metal complexes, Inert and Labile complexes, Kinetics of Octahedral substitution: Acid hydrolysis, factors affecting acid hydrolysis, Stereochemistry of intermediates in S_N1 & S_N2, Base hydrolysis, Conjugate base mechanism, Direct and indirect evidences in favour of conjugate mechanism, Annation reaction, reaction without metal-ligand bond breaking.

Unit-III: Cluster-1 15h

A) Boron hydrides: Classification, nomenclature, structure, bonding and topology of boranes, 4-digit coding (s, t, y, x) numbers for higher boranes and their utilities. Chemistry of diboranes: Study of Metalloboranes, Carboranes and Metallocarboranes with reference to preparations and structures.

B) Isopoly acids, Heteropoly acids and their anions.

Unit – IV: Solid state chemistry-I 15 h

i) Ionic Crystals &Their structures, radius ratio rule, effect of polarization on crystals.
ii) Covalent structure type- Sphalerite & Wurtzite.
iii) Geometry of simple crystal AB type: NaCl, CsCl & NiAs, reasons for preference for a particular structure in above AB type of compounds.
iv) AB2 type: Fluorite, antifluorites, Rutile structures. Li_2O, Na_2O, $CdCl_2$, CdI_2 structures.

v) Ternary Compounds ABO3 type: Perovskite, Barium titanate, lead titanate, CaTiO3, Tolerance factor, charge neutrality & deviation structures. FeTiO3.

List of Books

1) S. F. A. Kettle, J. N. Murral and S. T. Teddler: Valency Theory
2) C. A. Coulson: Valency
3) J. E. Huheey :Inorganic Chemistry
4) F .A. Cottonand G. Wilkinson: Advanced Inorganic Chemistry 3rd, 5thand 6th Editions.
5) A. F. Willims: Theoretical Approach in inorganic chemistry.
6) A. Mannas Chanda: Atomic Structure and chemical Bonding
7) L. E. Orgel: An Introduction To transition metal chemistry, Ligand field theory, 2nd Edition.
8) J. J. Logowski: Modern Inorganic Chemistry
9) B.Durrant and P.J.Durrant: Advanced Inorganic Chemistry
10) J. C. Bailar: Chemistry of coordination compounds.
11) W. L. Jolly: Modern Inorganic Chemistry
12) R. S. Drago: Physical methods in inorganic chemistry.
13) Waddington: Nonaqueous solvents.
14) Sisler: Chemistry of nonaqueous solvents.
15) A. K. Barnard: Therotical Inorganic Chemistry
16) Emeleus and Sharpe: Modern Aspect of Inorganic Chemistry.
17) F. A. Cotton: Chemical Applications of Group theory.
18) Jones: Elementary Coordination chemistry.
19) B. N. Figgis: Introduction to Ligand field.
20) S. F. A. Kettle: Coordination chemistry.
21) M.C.Day and J.Selbin: Theoretical Inorganic Chemistry.
22) J. Lewin and Wilkins: Modern Coordination Chemistry.
23) Gowarikar, Vishwanathan and Sheedar: Polymer science.
24) H. H. Jattey and M. Orchin: Symmetry in chemistry.
25) D. Schonaland: Molecular Symmetry in chemistry.
26) L. H. Hall: Group theory and Symmetry in chemistry
27) H. H. Jattey and M. Orchin: Symmetry in chemistry
28) R.L.Dutta and A.Symal: Elements of magneto chemistry
29) Inorganic Chemistry 4th Edition, P.Atkins, Oxford University Press.
30) Essential Trends in Inorganic Chemistry, D.M.P.Mingos, Oxford University Press.

Semester I - Organic Chemistry
Paper – II (Code: MCH1T02)

60 h (4 h per week): 15 h per unit 60 Marks

Course Outcomes: At the end of the course students will be able to

1. Implement rules of aromaticity to organic molecules
2. Sketch organic molecules in different projection formula and assign its configuration.
3. Apply their understanding about the organic reactions of industrial significance with respect to the chemo- selectivity, regioselectivity and enantioselectivity.
4. Analyze the product distribution and the stereochemistry of various organic products.
5. Evaluate the relationship between structure and reactivity

Unit-I: 15 h

A) Nature and Bonding in Organic Molecule: Delocalized chemical bonding, conjugation, cross conjugation, resonance, hyper-conjugation, Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons Huckel's rule, energy level of π-molecules orbitals, annulenes, antiaromaticity, homo-aromoaticity. Aromatic character and chemistry of

cyclopentadienyl anion, tropylium cation, tropone and tropolone, Frost Circles (The Polygon Method) for drawing energy levels in cyclic pi systems**.**

B) Carbenes: Types of carbenes, Structure and reactivity of carbenes, Generation, structure and reactions, insertion, addition, rearrangement reactions of carbenes, nucleophilic attack on carbenes, Simmons-Smith reaction, Reimer-Tiemann reaction, Carbylamine reaction, Shapiro reaction, Bamford-Stevens reaction and Wolff rearrangement

C) Nitrene: Generation, structure and reactions.

Unit-II: 15 h

Stereochemistry: Elements of symmetry, Concept of chirality and molecular dissymmetry, molecules with more than one chiral center, meso compounds, threo and erythro isomers, method of resolution, optical purity, topicity of ligands, enantiotopic and distereotopic ligands and faces, prochirality, Cahn**-**Ingold**-**Prelog System to describe configuration at chiral centers**.** Inter conversion of Newman, Sawhorse and Fischer projection.

Conformational analysis of cycloalkanes (5-8 membered rings), substituted cyclohexanes, mono substituted, disubstituted and trisubstituted cyclohexanes, decalin system, effect of conformation on reactivity, Conformational analysis of *n*-butane and its derivatives, 1,2-diols, 1,2-dihaloethane and related compounds

Asymmetrical synthesis, optical activity in absence of chiral carbon (biphenyl, spiranes and allenes), Chirality due to helical shape. Chirality of heteroatoms, stereospecific and stereoselective synthesis**.**

Unit-III: 15 h

A) Reaction mechanism: Types of reaction, Types of mechanism, kinetic and thermodynamic control, Hammond's postulate, Curtin**-**Hammett principle, Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, trapping of intermediates, checking for common intermediate, competition and cross-over experiments, isotope effects, Hard and soft acids and bases**.**

B) **Reaction Kinetics**: Reaction co-ordinate diagrams, rate laws and methods of determining concentration.

C) **Effect of Structure on reactivity:** Resonance and field effects, Steric effect, quantitative treatment. The Hammett equation and linear free energy relationship, substituent and reaction constants, Taft Equation.

D) **Aromatic electrophilic substitution**
The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The *o*/*p* ratio, ipso attack, orientation in benzene ring with more than one substituent, orientation in another ring system. Friedel-Crafts reaction, Vilsmeir-Hack reaction, Gatterman-Koch reaction, Pechman reaction, Diazonium coupling, Blanc chloromethylation, Kolbe–Schmitt reaction

Unit IV: 15h

A) Aliphatic nucleophilic substitution: The S_N1, S_N2, mixed S_N1, S_N2 and SET and S_Ni mechanisms**.** Nucleophilicty, effect of leaving group, ambient nucleophiles and ambient substrates regiospecificity, substitution at allylic and vinylic carbon atoms, Mitsunobu reaction

B) Concept of neighbouring group participation: Anchimeric assistance with mechanism, neighboring group participation by π and σ bonds, classical and non-classical carbocations, Intramolecular displacement by hydrogen, oxygen, nitrogen, sulphur and halogen**.** Alkyl, cycloalkyl, aryl participation, participation in bicyclic system, migratory aptitude.

C**) Aromatic Nucleophilic Substitution:** A general introduction to different mechanisms of aromatic nucleophilic substitution SNAr, S_N1, benzyne and SRN1 mechanisms, arynes as reaction

intermediate, Reactivity - effect of substrate structure leaving group and attacking nucleophile. The Von Richter and Smiles rearrangements, Chichibabin amination reaction. Benzyne: Structure, methods of generations and reactions

Combined List of Books for Semester I and II (Paper 2 and Paper 6: Organic Chemistry)

1) Advanced Organic Chemistry -Reaction mechanism and structure. Jerry March, John Wiley
2) Advanced Organic Chemistry- F.A. Carey and R. J. Sunberg, Plenum
3) A Guidebook to Mechanism in Organic Chemistry-Peter Skyes, Longman
4) Structure and Mechanism in Organic Chemistry-C.K. Gold, Cornell University Press
5) Organic Chemistry, R.T. Morrison Boyd. Prentice Hall
6) Modern Organic Chemistry-H.O. House, Benjamin
7) Principal of Organic Chemistry-R.O.C. Norman and J.M. Coxon, Blackie Academic and Professional
8) Reaction Mechanism in Organic Chemistry-S.M. Mukharji and S.P. Singh, Macmilan
9) Stereochemistry of Organic Compounds- D. Nasipuri, New Age International
10) Stereochemistry of Organic Compounds- P. S. Kalsi, New Age International
11) Frontier Orbitals and Organic Chemical Reactions-I. Fleming
12) Orbital Symmetry - R. E. Lehr and A. P. Marchand
13) Reactive Intermediate in Organic Chemistry-N. S. Isaacs
14) Stereochemistry of Carbon Compounds- E. L. Eliel
15) Physical Organic Chemistry-J. Hine
16) Name Reaction in Organic chemistry -Surrey
17) Advanced Organic Chemistry - L. F. Fieser and M. Fieser.
18) Organic Chemistry Vol. I and II - I. L. Finar
19) Modern Organic Chemistry- J.D. Roberts and M. C. Caserio
20) The Search for Organic Reaction Pathways (Longmann), Peter Skyes
21) Organic Chemistry 5th Edition (McGraw Hill), S. H. Pine
22) Organic Chemistry (Willard Grant Press Botcon), John Mcmurry
23) A Textbook of Organic Chemistry- R. K. Bansal New Age International
24) Organic Chemistry, J. Clayden, N. Greeves, S. Warren and P. Wothers, Oxford University Press
25) Organic Chemistry, 4th Edition, G Marc Loudon, Oxford University Press

Weblink to Equivalent MOOC on NPTEL/SWAYAM if relevant:

Introductory Organic Chemistry I- https://nptel.ac.in/courses/104106119
Mechanisms in Organic Chemistry- https://onlinecourses.nptel.ac.in/noc22_cy42
Mechanisms in Organic Chemistry: https://onlinecourses.nptel.ac.in/noc20_cy26/preview
Stereochemistry- https://nptel.ac.in/courses/104105086
Stereochemistry and Applications- https://nptel.ac.in/courses/104106127
Structure, Stereochemistry and Reactivity of Organic Compounds and Intermediates: A Problem-solving Approach- https://nptel.ac.in/courses/104105127

Semester I
Paper III)Code: MCH1T03(
Physical Chemistry

60 h)4 h per week(: 15 h per unit 60 Marks

Course Outcomes: At the end of the course students will be able to

6. Understand, analyze and exercise the principles of classical thermodynamics in various applications
7. Understand and execute the quantum mechanical problems and their applications
8. Understand the concept of adsorption and its application in surface chemistry
9. Analyze and understand the characterization techniques for polymer
10. Understand the principles of chemical kinetics and their applications in chemical dynamics

UNIT I: CLASSICAL THEMODYNAMICS 15h

A(Recapitulation of Laws of thermodynamics, Exact and inexact differentials, condition of exactness, Ptaff differential expression and equations, Applications of Ptaff differential equations to first and second law of thermodynamics, Carathéodory's principle and its equivalence to the Kelvin Plank and Clausius statement of the Second law of Thermodynamics, Homogeneous functions of degree 0 and 1, extensive and intensive properties, derivation of thermodynamic equations of state, Maxwell's relations. Third law of thermodynamics, Nernst Heat Theorem, unattainability of absolute zero, calculation of entropy based on third law of thermodynamics, residual entropy and its application, Numerical.

UNIT II: FORMULATION OF QUANTUM MECHANICS 15h

A**(** Introduction of Quantum Mechanics, Wave Function, Acceptability of Wave Functions, Normalized and Orthogonal Wave Functions, Operators, Operator Algebra, Eigen Functions and Eigen Values of Quantum Mechanical Properties **)**e**.**g**.** Linear, Angular momentum, etc**.(**, Hermitian Operators, Orbital and generalized Angular Momentum, Postulates of Quantum Mechanics, Problems on Operator algebra, Eigen Values and Average Values of quantities**.**

B**(** Application of Schrödinger Wave Equation to Simple Systems**:** Particle in a 3-Dimensional Box, Concept of degeneracy and breakdown in degeneracy, Rigid Rotor, Potential Well of Finite Depth **)**Tunneling Effect**(**, Simple Harmonic Oscillator, The Hydrogen Atom**.**

UNIT III: SURFACE CHEMISTRY AND MACROMOLECULES

A) Recapitulation of Surface tension, Adsorption**:** Freundlich adsorption isotherm, Langmuir theory, Gibbs adsorption isotherm, BET theory and estimation of surface area, enthalpy and entropy of adsorption**.** Surface film on liquids and catalytic activity, Electro-kinetic phenomena, Surface active agents, hydrophobic interactions, micellization, Critical Micelle Concentration **)**CMC**(**, mass action model and phase separation model of micelle formation, shape and structure of micelles, factors affecting CMC, micro-emulsion and reverse micelles**.**

B) Definition of macromolecule (Polymer), types of polymers, Number average & mass average molecular mass, molecular mass determination by Osmometery, Viscometry, Ultracentrifugation, light scattering & size-exclusion chromatography method, Numericals.

UNIT IV: CHEMICAL KINETICS 15h

A(Temperature dependence of chemical reaction rates, Arrhenius equation, Energy of activation, pre-exponential factor and its limitations, Collision theory and its limitations, steric factors, Transition State theory of gas and liquid phase bimolecular reactions, comparison of three theories of reaction rates.

B(Bodeinstein steady state approximation and its application in consecutive reactions, Dynamics of unimolecular reactions**:** Lindeman-Hinshelwood mechanism, RRKM theory, Thermodynamic formulation of transition state theory, Enthalpy, Gibbs free energy and enthalpy of activation**.**

List of books

1) R**.** P**.** Rastogi and R**.** R**.** Mishra, An Introduction to Chemical Thermodynamics, Vikas Publication, Gorakhpur, 2010**.**
2) P**.** W**.** Atkins and D**.** Paula, Physical Chemistry, 8th Edition, Oxford University Press, 2010**.**
3) E**.** N**.** Yenemin, Fundamentals of Chemical Thermodynamics, MIR, Publications**.**
4) G**.** K**.** Vemulapalli, Physical Chemistry, Prentice – Hall of India, 1997**.**

5) S. GlasstoneandDe Van No Strand, Thermodynamics for Chemists, 1965.
6) S. M. Blinder, Advanced Physical Chemistry,
7) D. Mcquarie and J. Simon, Physical Chemistry – A Molecular Approach, University Press, 2000
8) Ira N. Levine, Quantum Chemistry, 5th edition)2000(, Pearson educ., Inc.New Delhi
9) A.K.Chandra, Introductory Quantum Chemistry, 4th edition)1994(, Tata Mcgraw Hill, New Delhi.
10) M.W.Hanna, " Quantum Mechanics in Chemistry", Benjamin
11) L. Pualing and E. B. Wilson, Introduction to Quantum Mechanics with Applications to Chemistry, McGraw Hill, New York)1935(.
12) R. K. Prasad, Quantum Chemistry, New Age International, Delhi.
13) R. K. Prasad, Quantum Chemistry through problems and solutions, New Age International, New Delhi, 2009.
14) B. C. Reed, Quantum Mechanics, Jones and Bartlett, New Delhi, 2010.
15) G. M. Barrow, Physical Chemistry, Tata Mc-Graw Hill, V edition 2003.
16) H. K. Moudgil, Text Book of Physical Chemistry, Pretice Hall of India, New Delhi, 2010.
17) G. M. Panchenkov and V.P.Labadev, " Chemical Kinetics and catalysis", MIR Publishing
18) E.A. Moelwyn- Hughes, "Chemical Kinetics and Kinetics of Solutions", Academic
19) K. J .Laidler, Chemical Kinetics, Third Edition)1987(, Harper and Row, New York.
20) J. Raja Ram and J.C.Kuriacose, Kinetics and Mechanism of Chemical Transformations MacMilllan IndianLtd., New Delhi)1993(
21) C. H. Bamford and C. F. H. Tipper, Comprehensive Chemical Kinetics, **Vol 1**., Elsevier Publications, New York, 1969.
22) C. H. Bamford and C. F. H. Tipper, Comprehensive Chemical Kinetics, **Vol 2**., Elsevier Publications, New York, 1969.
23) S. Glasstone, K. J. Laidler and H. Eyring, The Theory of Rate Processes, Mc-Graw Hill, New York, 1941.
24) A. Findley, The Phase Rule and its Applications, Longmans Green and Co., Mumbai.
25) K. S. Birdi, Surface Chemistry Essentials, CRC Press, New York, 2014.
26) Eric KeightleyRideal, An Introduction to Surface Chemistry, Cambridge University Press, 1926.
27) D. M. Ruthven, Principles of Adsorption and Adsorption Processes, John Wiley & Sons, NewYork, 1984.
28) A. W. Adamson, A. P. Gasi, Physical Chemistry of Surfaces, Wiley, 2007.
29) P. C. Hiemenz and R. Rajagopalan, Principles of Colloid and Surface Chemistry, CRC Taylor and Fransis, 2007.
30) P. D. Hede and S. P. Beier, Inorganic and Applied Chemistry, e-Book, 2007.
31) Santosh Kumar Upadhyay, Chemical Kinetics and Reaction Dynamics, Springer 2006.
32) E.M. Mc Cash, Surface Chemistry, Oxford University Press, Oxford)2001(.
33) G. K. Agrawal, Basic Chemical Kinetics, Tata-Mc-Graw Hill, 1990.
34) N. B. Singh, N. S. Gajbhiye, S. S. Das, Comprehensive Physical Chemistry, New Age International, 2014.
35) K. L. Kapoor, Text Book of Physical Chemistry, Vol – I to Vol-VI, 2011.
36) Spectroscopic identification of organic compound-RM Silverstein,GCBassler and TC Morril, John Wally
37) Application of Spectroscopy to Organic Compound-J. R. Dyer, Printice Hall
38) Organic Spectroscopy-William Kemp, ELBS with McMillan
39) Spectroscopy of Organic Molecule-PS Kalsi, Wiley, Esterna, New Delhi
40) Organic Spectroscopy-RT Morrison and RN Boyd
41) Spectroscopic Methods in Organic Chemistry-DH Willson, I Fleming
42) Fundamentals of Molecular Spectroscopy-CN Banwell

Semester I
Paper IV (Code: MCH1T04)
Analytical Chemistry

60 h (4 h per week): 15 h per unit 60 Marks

Course Outcomes: At the end of the course students will be able to

1. Select a specific analytical technique based on sample and target analyte
2. Develop analytical ability and critical thinking in selection of statistics and their use in making interpretation meaningful and productive.
3. Understand the principles of chromatographic techniques.
4. Select proper chromatographic technique among the available techniques.
5. Explain the logic behind working of indicator used in each type of titration
6. Apply electroanalytical techniques based on conductance and emf measurements.

Unit I: Introduction and statistical analysis 15h

Introduction to analytical chemistry: Types of analysis-qualitative and quantitative. Classification of analytical methods- classical and instrumental, basis of their classification with examples. Stoichiometric and sub-stoichiometric reactions and calculations.

Statistical analysis and validation: Errors in chemical analysis. Classification of errors-systematic and random, additive and proportional, absolute and relative. Accuracy and precision. Mean, median, average deviation and standard deviation. Significant figures and rules to determine significant figures. Calculations involving significant figures. Confidence limit, correlation coefficient and regression analysis. Comparison of methods: F-test and T-test. Rejection of data based on Q-test. Least squares method for deriving calibration graph. Application of Microsoft Excel in statistical analysis (statistical functions and spreadsheets in MS-Excel). Validation of newly developed analytical method. Certified reference materials (CRMs). Numerical problems.

Unit II: Separation techniques 15h

Chromatography: Definition and Classification. Techniques used in Paper, Thin Layer and Column chromatography. Applications in qualitative and quantitative analysis.

Ion exchange: Principle and technique. Types of ion exchangers. Ion exchange equilibria. Ion exchange capacity. Effect of complexing ions. Zeolites as ion-exchangers. Applications.

Solvent extraction: Principle and techniques. Distribution ratio and distribution coefficient. Factors affecting extraction efficiency: Ion association complexes, chelation, synergistic extraction, pH. Numericals based on multiple extractions. Role of chelating ligands, crown ethers, calixarenes and cryptands in solvent extraction. Introduction to Solid phase extraction (SPE) and Microwave assisted extraction (MAE), Applications.

Unit III: Classical methods of analysis 15h

***Volumetric analysis*:** General principle. Criteria for reactions used in titrations. Primary standards and secondary standards. Theory of indicators. Types of titrations with examples-Acid-base, precipitation, redox and complexometric. Titration curves for monoprotic and polyprotic acids and bases. Indicators used in various types of titrations. Masking and demasking agents.

***Gravimetric analysis*:** General principles and conditions of precipitation. Concepts of solubility, solubility product and precipitation equilibria. Steps involved in gravimetric analysis. Purity of precipitate: Co-precipitation and post-precipitation. Fractional precipitation.

Precipitation from homogeneous solution. Particle size, crystal growth, colloidal state, aging and peptization phenomena. Ignition of precipitates.

Unit IV: Electrochemical methods of analysis-I **15h**

Conductometry: Concepts of electrical resistance, conductance, resistivity and conductivity. Specific, molar and equivalent conductance and effect of dilution on them. Measurement of conductance. Kohlrausch's law, Applications of conductometry in determination of dissociation constant, solubility product. Conductometric titrations. High frequency titrations. Numerical problems.

Potentiometry: Circuit diagram of simple potentiometer. Indicator electrodes: hydrogen electrode, quinhydrone electrode, antimony electrode and glass electrode. Reference electrodes: Calomel electrode and Ag/AgCl electrode. Theory of potentiometric titrations. Acid-base, redox, precipitation and complexometric titrations. Nernst equation, standard electrode potential, Determination of cell potential, n, K_f and K_{sp}. pH titrations. Buffers and buffer capacity. pH of buffer mixtures based on Henderson-Hasselbalch equation.

List of books:

1) Quantitative analysis: Day and Underwood (Prentice-Hall of India)
2) Vogel's Text Book of Quantitative Inorganic Analysis-Bassett, Denney, Jeffery and Mendham (ELBS)
3) Analytical Chemistry: Gary D. Christian (Wiley, India).
4) Instrumental Methods of Analysis: Willard, Merrit, Dean, Settle (CBS Publishers, Delhi, 1986)
5) Instrumental Methods of Chemical Analysis: Braun (Tata McGraw-Hill)
6) Advanced Analytical Chemistry: Meites and Thomas (McGraw-Hill)
7) Instrumental Methods of Analysis: G. Chatwal and S. Anand (Himalaya Publishing House)
8) Analytical Chemistry: Problems and Solution- S. M. Khopkar (New Age International Publication)
9) Basic Concepts in Analytical Chemistry: S. M. Khopkar (New Age International Publication)
10) Advance Analytical Chemistry: Meites and Thomas: (Mc Graw Hill)
11) An Introduction to Separation Science: L. R. Shyder and C. H. Harvath (Wiley Interscience)
12) Fundamentals of Analytical Chemistry: S. A. Skoog and D. W. West
13) Instrumental Methods of Chemical Analysis: G. W. Ewing

Semester I
Practical-I (Code: MCH1L01)
Inorganic Chemistry

8 h /week Marks:100

I. Preparation of Inorganic Complexes and their characterization by:

Elemental analysis and physico-chemical methods (Electronic and IR Spectra, magnetic susceptibility measurements, Thermal analysis and Molar conductance studies).

1. $K_3[Al(C_2O_4)_3](H_2O)_3$ 2. $[VO(acac)_2]$ 3. $Na[Cr(NH_3)_2(SCN)_4]$
4. $K_3[Cr(SCN)_6]$. 5. $[Mn(acac)_3]$ 6. $K_3[Fe(C_2O_4)_3]$
7. $Hg[Co(SCN)_4]$ 8. $[Co(Py)_2Cl_2]$ 9. $[Cu_2(CH_3COO)_4(H_2O)_2]$
10. $[Ni(DMG)_2]$ 11. $[Ni(NH_3)_6]Cl_2$ 12. $[Cu(NH_3)_4(H_2O)_2]SO_4$

II. Quantitative Analysis:

Separation and determination of two metal ions from the following alloys involving:
Volumetric, Gravimetric and Spectrophotometric methods
i) Copper (II) and Nickel (II)
ii) Copper (II) and Zinc (II)
iii) Nickel (II)—Zinc (II) and
iv) Copper(II)—Iron (III)

III. Qualitative analysis of radicals:
Semi-micro Analysis of inorganic mixture containing four cations out of which two will be rare metal ions such as W, Mo,Se,Ti,Zr,Ce,Th,V and U.(Spot Test for individual cations should be performed)

Semester I
Practical-II)Code: MCH1L02(
Physical Chemistry

8 h /week Marks: 100

Course Outcomes: At the end of the course, student will be able to

1. Understand various principles involved in small experiments and their interpretations.
2. To handle different apparatus and instruments with care and precision.
3. Interpret the results obtained and access the outcome.
4. Implement and relate the theoretical principle sin experiments

It is expected to perform minimum 14 experiments in a semester.

1) To study the variation of volume contraction with mole fraction of alcohol in alcohol -water system
2) To determine the activation parameters of viscous flow for a given liquid.
3) To Determine the critical micelle concentration)CMC(of a given surfactant / soap / shampoo by surface tension measurements.
4) Determination of molecular mass of a polymer by viscometry method.
5) To determine integral heat of KNO_3, at two different conc. and calculation of heat of dilution.
6) Effect of 1% NaCl, 1% succinic acid, 0.5% naphthalene on CST in phenol-water systems.
7) Distribution of succinic acid in H_2O- benzene, H_2O-ether and comparison of distribution coefficient.
8) To construct the phase diagrams of two components system)phenol- urea, diphenyl aminebenzophenone; a-naphtyl amine-phenol(forming compounds with congruent melting points.
9) To study the mutual solubility of glycerol-m-toluidine and to determine congruent points.
10) To study kinetics of hydrolysis of an ester by NaOH reaction.
11) To determine equilibrium constant of the equation $KI+I_2=KI_3$ by distribution method.
12) To study the kinetics of the reaction between potassium persulphate and potassium iodide.
13) Determination of order of reaction of oxidation of ethyl alcohol by acid dichromate.
14) To titrate conductometrically monobasic and dibasic acids with NaOH and determine the strength of given acid.
15) To determine equivalent conductance of weak electrolyte at infinite dilution by kaulrausch's method.
16) Determination of heat of reaction, entropy change and equilibrium constant of the reaction between metallic zinc and Cu^{+2} ions in solution.
17) Determination of thermodynamic constants ΔG, ΔH, ΔS for $Zn^{+2}+H_2SO_4 \rightarrow ZnSO_4+ 2H^+$ by emf measurement.
18) Titration of Ferrous Ammonium Sulphate against ceric sulphate and hence the formal redox potential of $Fe^{2+} \rightleftharpoons Fe^{3+}$ and $Ce^{3+} \rightleftharpoons Ce^{4+}$ systems.
19) To determine the pH of a buffer solutions using a quinhydrone electrode
20) Complexometric titrations)EDTA based(

Semester I
Seminar-I (Code: MCH1S01)

2 h /week Marks: 25

Seminar of 30 minutes duration will be a part of internal assessment for 25marks (1credit). Seminar should be delivered by the student under the guidance of concerned teacher on the topic allotted by the teacher. The topic will be related to the syllabus. Marks will be allotted by a group of teachers.

M.Sc. Chemistry
Semester II - Inorganic Chemistry
Paper V (Code: MCH2T01)

60 h (4 h per week): 15 h per unit 60 Marks

Course Outcomes: At the end of the course, student would be able to

1. recollect the principles of electronic structure, bonding and reactivity of coordination complexes
2. understand the concept of synthesis and stability of transition metal organometallic complexes
3. develop the possible catalytic pathways leading to desired products
4. apply the principles of transition metal coordination complexes to derive reaction mechanisms.
5. identify the structural aspects of metal carbonyls and metal nitrosyls.
6. unravel and interpret the structural aspects of spinels and related compounds.

Unit - I

A) Electronic spectra of Transition Metal complexes 10h

Determining the Energy terms, Spin-orbit (L-S) coupling scheme, Hund's rule, Hole Formulation, Derivation of the term symbol for a d^2 configuration, Electronic spectra of transition metal complexes – Laporte 'orbital' selection rule, spin selection rule. Orgel diagrams for octahedral metal complexes. Charge transfer spectra, Racah parameters, calculations of 10Dq, B, β parameters. Tanabe- Sugano Diagrams of octahedral complexes with d^2 & d^8 configuration.

B) Magnetic Properties of Transition Metal complexes 5h

Abnormal magnetic properties, orbital contributions and quenching of orbital angular momentum, spin-orbit coupling. Magnetic moment, electronic spectra and structure of tetrahalocobalt (II) complexes, tetrahedral and octahedral Ni(II) complexes. High spin-low spins crossover.

Unit – II 15h

Reaction mechanism of Transition Metal Complexes-II: Substitution reaction in square planar complexes: the trans effect, cis effect, steric effect, solvent effect, effect of leaving group, effect of charge, effect of nucleophile, effect of temperature. Trans effect theories, uses of trans-effect, mechanism of substitution reactions in Pt(II) complexes. Electron transfer reactions. Types of electron transfer reactions, conditions of electron transfer, and mechanism of one-electron transfer reactions, outer sphere and inner sphere mechanisms, two electron transfer reactions complimentary and non-complimentary reactions. Tunneling effect, cross-reaction, Marcus-Hush theory, bridged activated mechanism.

Unit-III: Metal pi-Complexes 15h

Metal carbonyls: Structure and bonding, vibrational spectra of metal carbonyls for bonding and structure elucidation, important reaction of metal carbonyls. Metal carbonyl clusters with reference to classification, EAN rule, synthesis and structures.

Metal nitrosyls: Nitrosylating agents for synthesis of metal nitrosyls, vibrational spectra and X-ray diffraction studies of transition metal nitrosyls for bonding and structure elucidation, important reactions of transition metal nitrosyls, structure and bonding. Dinitrogen and dioxygen complexes.

Unit-IV

A) **Metal-Metal bonds (Cluster-2)**: **7h**

Occurrence of metal-metal bond, Classification of metal clusters, Binuclear, trinuclear, tetranuclear, pentanuclear and hexanuclear with reference to halide, oxide, alkoxide and acetate clusters.

B) Solid state chemistry-II 8h

AB_2O_4 type- compounds: Normal & inverse,2-3 and 4-2 spinel, packing of oxygen in tetrahedral & octahedral sites, sites occupancy number of sites surrounding each oxygen, application of charge

neutrality principles, site preferences in spinel, distorted spinel. Hausmannite (Jahn-Teller distortions), Factors causing distortion in spinel.

List of Books

1) J.E.Huheey: Inorganic Chemistry
2) F.A.Cottonand G. Wilkinson: Advanced Inorganic Chemistry 3rd, 5th and 6th Editions.
3) A.F. Willims: Theoretical Approach in inorganic chemistry.
4) Mannas Chanda: Atomic Structure and chemical Bonding
5) L. E. Orgel: An Introduction To transition metal chemistry, Ligand field theory, 2nd Edition.
6) J. J. Logowski: Modern Inorganic Chemistry
7) B.Durrant and P.J.Durrant: Advanced Inorganic Chemistry
8) J C. Bailar: Chemistry of coordination compounds.
9) W. L. Jolly: Modern Inorganic ChemistryJones: Elementry Coordination chemistry.
10) B. N. Figgis: Introduction to Ligand field.
11) M.C.Day and J.Selbin: Therotical Inorganic Chemistry.
12) J. Lewin and Wilkins: Modern Co-ordination chemistry.
13) Purcell and Kotz: Inorganic Chemistry.
14) D. Banerjea: Co-ordination chemistry, Tata Mc. Graw. Pub.
15) A.F. Wells: Structural inorganic chemistry, 5th Edition, Oxford.
16) S. G. Davies: Organotransition metal chemistry applications to organic synthesis.
17) R. C. Mehrotra: Organometallic chemistry Tata McGraw Hill. Pub.
18) G. S. Manku: Thereotical priciples of inorganic chemistry
19) A. B. P. Lever: Inorganic electronic spectroscopy.
20) R.C.Maurya:Synthesis and charecterisation of novel nitrosyls compounds, Pioneer Pub. Jabalpur2000.
21) R.H.Crabtree:The Organometalic chemistry of Transition metals, John Wiley.
22) D.N.Styanaryan:Electronic Absorption Spectroscopy and related techniques, University Press.
23) R. S. Drago: Physical methods in inorganic chemistry
24) F.Basolo andG.Pearson: Inorganic Reaction Mechanism
25) Organometallics II and I complexes with transition metal- carbon bonds: Manfred Bochmann-
26) Oxford Press.
27) Advanced Inorganic Chemistry Vol I and II – Satyaprakash, Tuli, Bassu and Madan- S Chand.
28) M.Tsusui,M.Nlevy,M.Ichikwa and K.Mori:Introduction to metal pi-complexe chemistry,Plenum press,NY
29) A.E.Martel; Coordination Chemistry-VolIandII,VNR.

M.Sc. Chemistry
Semester II - Organic Chemistry
Paper VI (Code: MCH2T02)

60 h (4 h per week): 15 h per unit 60 Marks

Course Outcomes: At the end of the course students will be able to

1. Predict the orientation and stereochemistry of the product of addition and elimination reaction
2. Apply enolate chemistry to achieve molecular complexity
3. Design organic reactions in order to achieve the required product(s)
4. Formulate green chemistry synthesis to increase atom economy
5. Application of free radicals in functional group transformation

Unit-I **15 h**

A) Addition to carbon-carbon multiple bond: Mechanistic and stereochemical aspects of addition reaction involving electrophiles, nucleophiles and free radicals, regio and

chemoselectivity, Orientation and stereochemistry, Addition to cyclopropanes, Hydrogenation of double bond and triple bonds. Hydrogenation of aromatic rings, hydroboration-oxidation, epoxidation, Michael addition

B) Elimination reactions: The E1, E2 and E1CB mechanisms, Stereochemistry of E2 elimination, Orientation of the double bond, Saytzeff and Hoffman's rule, Effect of substrate structure, attacking base, leaving group and medium, Mechanism and orientation in pyrolytic elimination involving selenium oxide, Cope and Chugaev elimination

Unit II: **15 h**

Addition to carbon-hetero atom multiple bond: Ionization of carbon hydrogen bond and prototopy, Base and acid catalysed halogenation of ketones, keto-enol equilibria, structure and rate in enolisation, concerted and carbanion mechanism for tautomerism, geometry of carbanions, kinetic and thermodynamic control in the generation of enolates, Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters, and nitriles, Wittig reaction, Mechanisms and synthetic applications of condensation reactions involving enolates-Aldol, Knoevengel, Claisen, Mannich, Benzoin, Perkin, Stobbe reaction, Robinson annulation, Hydrolysis of esters and amide, Baylis-Hillman reactions, Ugi and Passerini reaction.

Unit III: **15 h**

Free radical reactions: Generation of free radicals, Type of free radical reactions, free radical substitution, mechanism at an aromatic and aliphatic substrate, reactivity at a bridgehead position. The reactivity and selectivity principle of halogenation at an alkyl carbon, allylic carbon (NBS), hydroxylation at an aromatic carbon by means of Fenton's reagent. Auto-oxidation, chlorosulphonation (Reed Reaction) Coupling of alkynes and arylation of aromatic compounds by diazonium salts, Sandmeyer reaction, Hunsdiecker reaction, Barton reaction, Hoffmann-Loefler-Freytag reaction, McMurry coupling, Samarium(II) iodide reagents for functional group transformations and C-C bond formation.

Applications of tributytin hydride: Reduction of halides, alcohols and acids, addition to carbon-carbon double bond, cyclization of free radical intermediates, tandem radical cyclization reactions, fragmentation reactions

Unit IV **15h**

A) Molecular rearrangements and fragmentation reactions:

Molecular rearrangements: Definition and classification. Molecular rearrangements involving:

1) electron deficient carbon: Pinacol-Pinacolone, Wagner- Meerwein, Tiffenev –Demjnov ring expansion, and Arndt-Eistert synthesis, Dienone-phenol rearrangement

2) electron deficient nitrogen: Hofmann, Lossen, Curtius, Schmidt and Beckmann rearrangements

3) electron deficient oxygen: Baeyer-Villiger oxidation

4) Base catalysed rearrangements: Benzilic acid, Favourski, Sommlett-Hauser and Smiles rearrangement

Fragmentation reactions: Electron push and pull requirement, Beckmann fragmentation, Eschenmoser fragmentation, Alicyclic-Grobb rearrangement

B) Green Chemistry: Designing a green synthesis: Choice of starting material, choice of solvents. Basic principle of green chemistry, Concept of atom economy with suitable examples, Green Synthesis of styrene, urethane, caprolactum, paracetamol, Synthesis of Ibuprofen. Microwave

induced green synthesis, Ionic liquids as Green Solvents, Chemical reactions involved in Bhopal gas tragedy, Minamata disease, Seveso (Italy) disaster

Weblink to Equivalent MOOC on SWAYAM if relevant:

Essentials of Oxidation, Reduction and C_C Bond Formation. Application in Organic Synthesis- https://nptel.ac.in/courses/104101127

Environmental Chemistry- https://nptel.ac.in/courses/105107176

Principles of Organic Synthesis- https://nptel.ac.in/courses/104103110

Introductory Organic Chemistry II- https://onlinecourses.nptel.ac.in/noc21_cy46/preview

Semester II
Paper VII)Code: MCH2T03(
Physical Chemistry

60 h)4 h per week(: 15 h per unit 60 Marks

Course Outcomes: At the end of the course students will be able to

1. Understand, the concept of partial molar quantities and thereby the basics of solution thermodynamics
2. Understand the quantum mechanical applications in actual practice and in spectroscopy
3. Understand the concept of ideal and non-ideal solutions
4. Understand the theories of electrolytes
5. Understand the thermodynamics of real processes
6. Understand the distribution laws and their applications
7. Understand the fundamentals of Nuclear sciences

UNIT I: THERMODYNAMICS AND PHASE EQUILIBRIA 15h

A) Partial molar quantities**:** Determination of partial molar quantities, chemical potential, partial molar volume, Gibbs Duhem equation, Gibbs Duhem Mergules equation.

B) Recapitulation of Gibbs Phase rule (Without Derivation), degrees of freedom, reduced phase rule, construction of phase diagram, one component systems **)**Helium, carbon**(**, 1st and 2nd order phase transition, lambda line, two component systems forming solid solutions having congruent and incongruent melting point, partially miscible solid phase, three component systems, graphical presentation, related Numerical.

UNIT II: QUANTUM MECHANICS - II 15h

A**)** Approximate methods, variation principle, its application in Linear and non-linear functions, MO theory applied to H_2^+ molecule and H_2 molecule **(**calculation of energy**)**, Introduction to perturbation theory (First order correction to wave function and energy), Application to He atom.

B**)** Electronic structure of atoms**:** Russel Sanders terms and coupling schemes, term separation energies of the p^n configuration, term separation energies for d^n configuration, magnetic effects**:** spin orbit coupling and Zeeman splitting**.**

C**)** Hybridization, hybrid orbitals in terms of wave functions of s and p orbitals, sp and sp^2 hybridizations, Simple Hückel theory applied to**:** ethylene, butadiene and cyclobutadiene**.**

UNIT III: THERMODYNAMICS AND NON-EQUILIBRIUM THERMODYNAMICS 15h

A) Concept of fugacity, determination of fugacity, The Le-Chatelier's Principle and its quantitative treatment. Ideal and non-ideal solutions, excess functions for non-ideal solutions, Entropy of mixing, Enthalpy of mixing, Fractional Distillation, Distillation of Azeotropic Mixtures.

B) Activity and activity coefficients. Concept of ion atmosphere and electrophoretic effect, Debye Hückel theory for activity coefficients of electrolytic solutions, determination of activity and activity coefficients, ionic strength and dependence of activity coefficients on ionic strength, numerical**.**

B**(** Nonequilibrium Thermodynamics**:** Conservation of mass and energy in time dependent closed and open systems, Thermodynamic criteria of irreversibility, rate of entropy production and entropy exchange in irreversible processes**.** The generation of the concept of Chemical Affinity and the extent

of advancement of chemical reactions, Thermodynamic constraints on the signs of chemical affinity and the velocity of chemical reaction, application to any one coupled reaction.

UNIT IV: STATISTICAL THERMODYNAMICS AND NUCLEAR CHEMISTRY 15h

A(Statistical thermodynamics: Lagrange's Method of Undetermined Multipliers)Conditional Maximization(, Stirling Approximation, Concept of Distribution, Thermodynamic Probability and most probable distribution, Maxwell Boltzmann, Bose Einestein, Fermi Dirac statistics, comparison between three statistics.

B(Nuclear C hemistry: Introduction, radioactive decay and equilibrium, thermonuclear reactions, photonuclear reactions, Radiometric titration, isotopic dilution analysis, NAA. Counters: Proportional counter, GM counter, Scintillation counter, Ionization chamber counter.

List of books

1) Ira N. Levine, Quantum Chemistry, 5th edition)2000(, Pearson educ., Inc.New Delhi
2) A. K. Chandra, Introductory Quantum Chemistry, 4th edition)1994(, Tata Mc-graw Hill, New Delhi.
3) M.W. Hanna, "Quantum Mechanics in Chemistry", Benjamin
4) L. Pualing and E. B. Wilson, Introduction to Quantum Mechanics with Applications to Chemistry, McGraw Hill, New York)1935(.
5) R. K. Prasad, Quantum Chemistry, New Age International, Delhi.
6) R. K. Prasad, Quantum Chemistry through problems and solutions, New Age International, New Delhi, 2009.
7) B. C. Reed, Quantum Mechanics, Jones and Bartlett, New Delhi, 2010.
8) R. P. Rastogi and R. R. Mishra, An Introduction to Chemical Thermodynamics, Vikas Publication, Gorakhpur, 2010.
9) P. W. Atkins'and D. Paula, Physical Chemistry, 8th Edition, Oxford University Press, 2010.
10) G. K. Vemulapalli, Physical Chemistry, Prentice – Hall of India, 1997.
11) S. Glasstone, An Introduction to Electrochemistry, East-West Press Pvt. Ltd., New Delhi, 2004.
12) H. K. Moudgil, Text Book of Physical Chemistry, Pretice Hall of India, New Delhi, 2010.
13) S. O. Pillai, Solid State Physics, New Age International, New Delhi, 2102.
14) N. B. Hanny, Treaties in Solid State Chemistry,
15) M. C. Day and J Selbin, Theoretical Inorganic Chemistry, Reinhold Pub. Corp., New York,
16) I Prigogine and R. Defay, Chemical Thermodynamics, Longmans, London, 1954.
17) S. R. DeGroot and P. Mazoor, Non-Equilibrium Thermodynamics, North-Holland Co., Amsterdam, 1969.
18) G. Lebon, D. Jou and Casa Vazquez, Understanding Non-equilibrium Thermodynamics, Springer, 2008.
19) I.Prigoggine, "An Introduction to Thermodynamics of Irreversible Processes," Wiley-Interscience.
20) R. P. Rastogi, Introduction to Non-equilibrium Physical Chemistry, Elsevier, Amsterdam, 2008.
21) G. A. Somorjai, Introduction to Surface Chemistry and Catalysis, Wiley, 2010.
22) M. C. Gupta, Statistical Thermodynamics, New Age International.
23) K. Huang, Statistical Mechanics, Wiley, New Delhi, 2003.
24) Andrew Maczek, Statistical Thermodynamics, Oxford University Press Inc., New York)1998(.
25) C.N.Rao. Nuclear Chemistry
26) B. G. Harvey, Introduction to Nuclear Physics and Chemistry, Prentice Hall, Inc.)1969(.
27) H.J. Arnikar, Essentials of Nuclear Chemistry, 4th Edition)1995(, Wiely-Eastern Ltd., New Delhi.
28) L. E. Smart and E. A. Moore, Solid State Chemistry-An Introduction, CRC Tylor and Fransis, 2005.
29) D. D. Sood, A. V. R. Reddy, Fundamentals of Radiochemistry, Indian Association of Nuclear Chemists and Allied Scientists, 2007.
30) C. N. R. Rao and Gopalakrishnan, "New Directions in Solid State Chemistry " Second Edition, Cambridge University Press.
31) Anthony R. West, "Solid State Chemistry and its Applications" Wiley India Edition.
32) C. Kalidas and M. V. Sangaranarayana, Non-Equilibrium Thermodynamics.

Semester II
Paper IV (Code: MCH2T04)
Analytical Chemistry

60 h (4 h per week): 15 h per unit 60 Marks

Course Outcomes: At the end of the course, student will be able to

1. Suggest most suitable modern chromatographic technique for separation of analyte from matrix.
2. Explain various types of columns and detectors used in chromatography.
3. Discuss molecular absorption and molecular emission spectroscopy principle and applications.
4. Design experiments based on spectrophotometry and polarographic analysis.
5. Formulate experiments based on optical and electroanalytical techniques.

Unit-I: Modern separation techniques **15h**

A] ***Gas Chromatography***: Principle including concept of theoretical plates and van-Deemter equation. Instrumental set up- carrier gas, sampling system, column and detector. Types of columns, their advantages and limitations. Detectors in GC analysis. Temperature programmed GC. Factors affecting retention, peak resolution and peak broadening.

B] ***Liquid chromatography***: Principle, Instrumentation, Advantages and applications of HPLC. Types of columns and detectors. Principle and applications of size exclusion, gel permeation, ion retardation, normal phase and reverse phase chromatography.

C] ***Supercritical fluid chromatography***: Introduction and applications.

Unit II: Optical methods of analysis-I **15h**

A] **Spectrophotometry and Colorimetry**: Principle of colorimetry. Beer's law, its verification and deviations. Instrumentation in colorimetry and spectrophotometry (single and double beam). Sensitivity and analytical significance of molar extinction coefficient and λ_{max}. Comparison method, calibration curve method and standard addition method for quantitative estimation. Role of organic ligands in spectrophotometric analysis of metal ions. Ringbom plot and Sandell's sensitivity. Photometric titrations. Determination of pK value of indicator. Simultaneous determination. Composition and stability constant of complex by Job's and mole ratio methods. Derivative spectrophotometry. Numerical problems.

B] **Flame photometry**: Principle. Instrumentation and types of burners. Factors affecting flame photometric determination. Limitations of flame photometry. Interferences in flame photometry. Applications.

Unit-III: Optical methods of analysis-II **15h**

Atomic absorption spectroscopy: Principle. Atomic energy levels. Grotrian diagrams. Population of energy levels. Instrumentation. Sources: Hollow cathode lamp and electrodeless discharge lamp, factors affecting spectral width. Atomizers: Flame atomizers, graphite rod and graphite furnace. Cold vapour and hydride generation techniques. Factors affecting atomization efficiency, flame profile. Monochromators and detectors. Beam modulation. Detection limit and sensitivity. Interferences and their removal. Comparison of AAS and flame emission spectrometry. Applications of AAS.

Unit-IV: Electrochemical methods of analysis-II **15h**

A] ***Polarography***: Principle of DC polarography. Instrumentation in polarography. Advantages and limitations of DME. Types of currents- residual current, migration current, diffusion current, limiting current, adsorption current, kinetic current and catalytic current. Ilkovic equation-diffusion current constant and capillary characteristics. Derivation of equation of

polarographic wave and half wave potential. Experimental determination of half wave potential. Reversible, quasi reversible and irreversible electrode reactions. Polarographic maxima and maximum suppressor. Oxygen interference and deaeration. Introduction to pulse, a.c. and oscillographic techniques and their advantages. Applications of polarography in determination of dissolved oxygen, metal ion quantification and speciation, simultaneous determination of metal ions, analysis of organic compounds. Limitations of polarography.

B] **Amperometric titrations:** Principle, types and applications in analytical chemistry.

List of books:

1) Quantitative analysis: Day and Underwood (Prentice-Hall of India)
2) Vogel's Text Book of Quantitative Inorganic Analysis-Bassett, Denney, Jeffery and Mendham (ELBS)
3) Analytical Chemistry: Gary D. Christian (Wiley India).
4) Instrumental Methods of Analysis: Willard, Merrit, Dean, Settle (CBS Publishers, Delhi, 1986)
5) Sample Pre-treatment and Separation: R. Anderson (John Wiley and Sons)
6) Stoichiometry: B.I.Bhatt and S.M. Vora, 2nd Edition (Tata Mc-Graw Hill publication)
7) Instrumental Methods of Chemical Analysis: Braun (Tata McGraw-Hill)
8) Advanced Analytical Chemistry: Meites and Thomas (McGraw-Hill)
9) Instrumental Methods of Analysis: G. Chatwal and S. Anand (Himalaya Publishing House)
10) Analytical Chemistry: Problems and Solution- S. M. Khopkar (New Age International Publication)
11) Basic Concepts in Analytical Chemistry: S. M. Khopkar (New Age International Publication)
12) Advance Analytical Chemistry: Meites and Thomas: (Mc Graw Hill)
13) An Introduction to Separation Science: L. R. Shyder and C. H. Harvath (Wiley Interscience)
14) Fundamental of Analytical Chemistry: S. A. Skoog and D. W. West
15) Instrumental Methods of Chemical Analysis: G. W. Ewing
16) Polarography: Koltoff and Ligane
17) Electroanalytical Chemistry: Sane and Joshi (Quest Publications)

Semester II
Practical-III (Code: MCH2L01)
Organic Chemistry

8 h /week Marks: 100

Course Outcomes: At the end of the course students would be able to

1. Design the methodologies to develop eco-friendly and green technology for industry and research.
2. Develop methods and remedies for reactions with environmental pollution.
3. Improve scientific practical information orally and in writing.
4. Get awareness about laboratory safety and handling of chemicals.
5. Apply different purification techniques recrystallization, thin layer chromatography, distillation and solvent extraction

A) Introduction to lab safety, purification techniques- Crystallization, Distillation, Column chromatography, TLC

B) Use of Computers- Chem Draw, Chem Sketch for drawing simple organic molecules, aliphatic and aromatic compounds

C) Qualitative Analysis: Separation, purification and identification of the mixture of two organic compounds (binary mixture with two solid, one solid one liquid and two liquids) using chemical methods or physical techniques.

Minimum 8-10 mixtures to be analyzed

D) Organic preparations: Student is expected to carry out minimum of 3-4 two stage organic preparation and 6-7 single stage preparation from the following lists (Total 10 preparations).

1) Oxidation: Adipic acid by chromic acid oxidation of cyclohexanol.
2) Benzophenone → benzhydrol
3) Aldol condensation: Dibenzal acetone from benzaldehyde.
4) Sandmeyer reaction: p- chlorotoluene from p-toluidine
5) Cannizzaro reaction
6) Friedel Crafts Reaction: β-Benzoyl propionic acid from succinic anhydride and benzene.
7) Benzoin → 2,4,5-triphenyl imidizole
8) Sucrose → Oxalic acid
9) Methyl acetoacetate → 5-methyl-isoxazol-3-ol
10) Ethyl acetoacetate → 4-aryl-6-methyl-3,4-dihydro-2(1*H*)-pyrimidinone ester
11) Ethyl acetoacetate → Diethyl 1,4-dihydro-2,6-dimethyl-4-phenylpyridine-3,-5dicarboxylate
12) Dye prepartion: Sulphanilic acid → Methyl orange
13) Dye prepartion: p-nitroaniline → p-red
14) Acetanilide → p-nitroacetanilide →p-nitroaniline
15) Aniline → 2,4,6-tribromo aniline → 2,4,6-tribromoacetanilide
16) Nitrobenzene →m-dinitrobenzene →m-nitroaniline
17) toluene →p-nitrotoluene →p-nitrobenzoic acid
18) Glycine → Benzoyl glycine → 4-benzilidene-2-phenyl oxazole
19) Benzaldehyde → chalcone → chalcone dibromide

Semester II
Practical-IV (Code: MCH2L02)
Analytical Chemistry

8 h /week Marks: 100

Course Outcomes: At the end of the course, student will be able to

1. Carry out calibration of glassware available in the laboratory.
2. Analyze the data obtained through experiments using statistical analysis parameters.
3. Estimate quantitatively analyte present in different samples using classical and instrumental methods of analysis.
4. Design experiments based on classical and instrumental techniques.
5. Understand the principles involved in visual and instrumental volumetric techniques.
6. Formulate experiments based on optical and electroanalytical techniques.

Section (A): Classical methods and separation techniques:

Calibration, validation and computers

1. Calibration of pipette and burette.
2. Statistical analysis of data.
3. Use of MS-Excel in statistical analysis of data and curve fitting.

Volumetry

1. Determination of Na_2CO_3 in washing soda.
2. Determination of NaOH and Na_2CO_3 in a mixture.
3. Estimation of nickel in given solution by direct complexometric titration with EDTA using bromopyrogallol red.
4. Estimation of nickel in given solution by complexometric back-titration with EDTA.
5. Estimation of chloride in given solution by Mohr's titration.
6. Estimation of chloride in given solution by Volhard's titration.
7. Determination of volume strength of commercial hydrogen peroxide by redox titration with $KMnO_4$.
8. Estimation of phenol/ aniline by bromination method.
9. Estimation of glucose.
10. Estimation of acetone.
11. Estimation of formaldehyde.
12. Estimation of Mn in the presence of Fe using masking phenomenon (ferromanganese alloy).

Gravimetry

1. Estimation of barium as barium sulphate.
2. Estimation of calcium as calcium oxalate/ calcium carbonate/ calcium oxide.

Separation techniques

1. Qualitative separation of metal ions by paper chromatography for 2/3 components.
2. Determination of ion-exchange capacity of resin.
3. Separation of ions by ion exchange.

Section (B): Instrumental techniques: Electroanalytical techniques

1. Analysis of commercial vinegar by conductometric titration.
2. Estimation of phenol by conductometric titration with NaOH.
3. Determination of strength of HCl and CH_3COOH in a mixture conductometrically.
4. Determination of strength of HCl and oxalic acid in a mixture conductometrically.
5. Determination of strength of oxalic acid and CH_3COOH in a mixture conductometrically.
6. Determination of degree of dissociation and dissociation constant of acetic acid conductometrically.
7. Estimation of phenol in dilute solution by conductometric titration with NaOH.
8. Determination of strength of HCl and CH_3COOH individually and in a mixture potentiometrically.
9. Determination of Fe(II) by potentiometric titration with $K_2Cr_2O_7$.
10. Determination of three dissociation constants of H_3PO_4 by pH-metric/ potentiometric titration.

Optical methods

1. Determination of pK of indicator by colorimetry.
2. To estimate the amount of NH_4Cl colorimetrically using Nesseler's Reagent.
3. To study the complex formation between Fe(III) and salicylic acid and find the formula and stability constant of the complex colorimetrically (Job's method).

4. To determine the dissociation constant of phenolphthalein colorimetrically.
5. Estimation of iron in wastewater sample using 1,10-phenanthroline.

Semester II
Seminar-II (Code: MCH2S01)

2 h /week Marks: 25

Seminar of 30 minutes duration will be a part of internal assessment for 25 marks (1 Credit). Seminar should be delivered by the student under the guidance of concerned teacher on the topic allotted by the teacher. The topic will be related to the syllabus. Marks will be allotted by a group of teachers.

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M.Sc. Chemistry

Semester III

Core – I Spectroscopy - I

Paper IX (Code: MCH3T01)

60 h (4 h per week): 15 h per unit 60 Marks

Course Outcomes: At the end of the course, student will be able to

1. Understand the symmetry properties of molecules
2. Interprete the structure of simple organic molecles using mass spectrometry
3. Corelate the presence of functional groups with IR frequincies
4. Apply the IR and Raman spectroscopy to simple molecules

Unit - I: Symmetry properties of molecules and group theory: **15h**

Symmetry elements and symmetry operations. Properties of group. Point groups and Schoenflies symbols. Symmetry operations as a group. Matrix representations of groups. Multiplication table for C_{2v}, C_{3v} and C_{2h}. Reducible and irreducible representations. Similarity transformation. Classes of symmetry operations. Great Orthogonality Theorem. Derivation of character tables for H_2O and NH_3 using Great Orthogonality Theorem. Application of character tables in selection rules of IR, Raman and Electronic spectroscopy.

Unit - II: **15h**

A] Mass spectrometry: Theory, ion production(EI, CI, FD, FAB), ion analysis, ion abundance, isotopic contribution, N-rule, types of fission processes, high resolution mass spectrometry, metastable peak, molecular ion peak, Mclaffferty rearrangement, mass spectral fragmentation of organic compounds alkanes, alkenes, alkynes, alcohols, amines, amides, acids, aldehydes, ketones, halides, Structure determination of organic molecules by mass spectrometry, problem based on mass spectral data

B] Mössbauer spectroscopy: Basic principle, experimental techniques, recoil emission and absorption, source, absorber, isomer shift, quadrupole interaction, magnetic hyperfine interaction, applications in determining electronic structure, molecular structure, crystal symmetry, magnetic structure, surface studies, biological applications.

Unit - III: **15h**

A] Microwave spectroscopy: Classification of molecules on the basis of M.I., rigid and non rigid rotor, effect of isotopic substitution on transition frequencies, stark effect, microwave spectrometer, application in deriving: molecular structure, dipole moment, atomic mass and nuclear quadrupole moment.

B] ESR spectroscopy: Introduction, principle of ESR, ESR spectrometer, hyperfine coupling, zero field splitting, factors affecting g values, Kramer's degeneracy, application of ESR spectra to study free radicals like hydrogen, methyl radical, 1,4-semibenzoquinone, naphthalene, transition metal complexes, biological systems.

Unit IV: **15h**

A] Infrared spectroscopy: Diatomic molecules: 1) Molecules as harmonic oscillator, Morse potential energy function, vibrational spectrum, fundamental vibrational frequencies. Force constant, zero point energy, isotope effect. The Anharmonic oscillator, the interactions of rotations and vibrations. P,Q,R branches, vibration of polyatomic molecules, selection rules, normal modes of vibration, group frequencies, overtone and combination frequencies. Structure determination of organic molecules by IR spectroscopy, problem based on IR spectral data

B] Raman Spectroscopy: Rayleigh scattering. Raman Scattering, classical and quantum theories of Raman effect. Rotational Raman Spectra for linear and symmetric top molecules. Vibrational Raman Spectra, rotational fine structure. Selection rules, coherent antiStokes Raman spectroscopy, Structure determination from Raman and Infra-red spectroscopy.

List of books

1] Spectroscopic identification of organic compound-RM Silverstein,GC Bassler and TC Morril, John Wally
2] Introduction to NMR spectroscopy-R. J. Abraham, J. Fisher and P Loftus Wiely
3] Application of Spectroscopy to Organic Compound-J. R. Dyer, Printice Hall
4] Organic Spectroscopy-William Kemp, ELBS with McMillan
5] Spectroscopy of Organic Molecule-PS Kalsi, Wiley, Esterna, New Delhi
6] Organic Spectroscopy-RT Morrison and RN Boyd
7] Practical NMR Spectroscopy-ML Martin, JJ Delpench, and DJ Martyin
8] Spectroscopic Methods in Organic Chemistry-DH Willson, I Fleming
9] Fundamentals of Molecular Spectroscopy-CN Banwell
10] Spectroscopy in Organic Chemistry-CNR Rao and JR Ferraro
11] Photoelectron Spectroscopy-Baber and Betteridge
12] Electron Spin Resonance Spectroscopy-J Wertz and JR Bolten
13] NMR –Basic Principle and Application-H Guntur
14] Interpretation of NMR spectra-Roy H Bible
15] Interpretation of IR spectra-NB Coulthop
16] Electron Spin Resonance Theory and Applications-W gordy
17] Mass Spectrometry Organic Chemical Applications, JH Banyon

Semester III
Core – II General Chemistry - I
Paper X (Code: MCH3T02)

60 h (4 h per week): 15 h per unit 60 Marks

Course Outcomes: At the end of the course students would be able to

1. Identify a pericyclic reaction and categorise it as a cycloaddition, a group transfer reaction, a sigmatropic rearrangement, or an electrocyclic reaction,
2. Apply frontier molecular orbital (FMO) theory to rationalise selectivity and reactivity aspects of pericyclic reactions.
3. Understand the reaction mechanism of various common reagents employed in organic synthesis
4. Understand the reactivity of sulphur, silicon and phosphorous elements.
5. Evolution of cross-coupling reactions in modern organic synthesis

Unit I: Pericyclic Reactions 15 h

Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1, 3, 5-hexatriene, allyl system, classification of pericyclic reaction. FMO approach, Woodward-Hoffman correlation diagram method and Perturbation of Molecular Orbital (PMO) approach of pericyclic reaction under thermal and photochemical conditions Electrocyclic reactions, conrotatary and disrotatary motion 4n and (4n+2) systems, Cycloaddition reaction with more emphasis on [2+2] and [4+2], Cycloaddition of ketenes, Secondary effects in [4+2] cycloaddition. Stereochemical effects and effect of substituents on rate of cycloaddition reaction, Diels-Alder reaction, 1,3-dipolar cycloaddition and chelotropic reaction. Sigmotropic rearrangement, suprafacial, and antarafacial shift involving carbon moieties, retention and inversion of configuration, [3,3] and [5,5] sigmotropic rearrangements, Claisen, Cope, Sommelet-Hauser rearrangements, Ene reaction, Nazarov cyclization, DeMayo reaction, Total synthesis of Endiandric Acid A, B, C and D

Unit II 15 h

A) Oxidation: (1) Oxidation of alkanes, aromatic hydrocarbons and alkenes, Dehydrogenation with S, Se, Fremy's salt, DDQ, chloranil and $PhI(OAc)_2$, Oxidation with SeO_2, Epoxidation of olefins, application of epoxides, Sharpless asymmetric epoxidation, Dihydroxylation of olefins using $KMnO_4$, OsO_4, Woodward and Prevost dihydroxylation, Oxidative cleavage of olefins, Ozonolysis

(2) Oxidation of alcohols: Chromium reagents, pyridiniumchlorochromate (PCC), pyridiniumdichromate (PDC), Collin and Jones reagent, Combination of DMSO with DCC, $(COCl)_2$, NCS and $(CH_3CO)_2O$ for oxidation of alcohols, Oxidation with MnO_2, Oppenauer oxidation

(3) Oxidation of aldehydes and ketones, Conversion of ketones to α, β-unsaturated ketones and α-hydroxy ketones, Baeyer-Villiger oxidation, Chemistry and synthetic applications of $Pb(OAc)_4$, Dess-Martin periiodinane, IBX

B) Reduction: (1) Catalytic heterogeneous and homogeneous hydrogenation, Hydrogenation of alkenes, alkynes and arenes, Selectivity of reduction, Mechanism and stereochemistry of reduction, Raney Ni-catalyst, Adam catalyst, Lindlar catalyst, Wilkinson catalyst.

(2) Reduction by dissolving metals, Reduction of carbonyl compounds, conjugated systems, aromatic compounds and alkynes. Birch reduction, Hydrogenolysis

(3) Reduction by hydride transfer reagents, Meerwein-Pondorff-Verley reduction, Reduction with$LiAlH_4$ and $NaBH_4$, stereochemical aspects of hydride addition, Derivatives of $LiAlH_4$ and $NaBH_4$, Selectivity issues, Diisobutylaluminium hydride (DIBAL-H), Sodium cyanoborohydride,Reduction with boranes and derivatives Reduction of carbonyl group tomethylene, Reduction with diimide and trialkylsilanes

Unit III: Chemistry of P, S, Si, and Boron compounds 15 h

1) Phosphours and sulphur ylide: Preparation and their synthetic application along with stereochemistry

2) Umpolung concept: Dipole inversion, generation of acyl anion, use of 1,3-dithiane, ethylmethylthiomethylsulphoxide, *bis*-phenylthiomethane, metallated enol ethers, alkylidene dithiane, ketone thioacetals, 2-propenethiobismethyl thioallyl anion, thiaminehydrochloride based generation of acyl anion

3) Organoboranes- preparation and properties of organoborane reagents e.g. RBH_2, R_2BH, R_3B, 9-BBN, catechol borane. Thexylborane, cyclohexylborane, $ICPBH_2$, IPC_2BH, Hydrboration mechanism, stereo and regeoselectivity, uses in synthesis of primary, secondary tertiary alcohols, aldehydes, ketones, alkenes, Synthesis of *EE, EZ, ZZ* dienes and alkyenes. Mechanism of addition of IPC_2BH. Allylboranes- synthesis, mechanism and uses

4) Organosilicon compounds in organic synthesis, Me_3SiCl, Me_3SiH and Peterson reaction, Synthesis and reactions of alkenyl, alkynyl and aryl silanes

Unit IV: Organometallic Chemistry

Transition metal complexes in organic synthesis-Introduction-oxidation states of transition metals, 16-18 rule, dissociation, association, insertion, oxidative addition, reductive elimination of transition metal

Organopalladium in organic synthesis-Heck reaction, carbonylation, Wacker oxidation, coupling reactions: Kumada Reaction, Stille coupling, Sonogashira, Negishi and Suzuki coupling reactions and their importance

Applications of $Co_2(CO)_8$, $Ni(CO)_4$, $Fe(CO)_5$ in organic synthesis. Wilkinson catalyst of Ruthenium and Rhodium – synthesis and uses its use in hydrogenation reactions Olefin metathesis by Ist and IInd generation catalyst, reaction mechanism and application in the synthesis of homo and heterocyclic compounds, Ziegler-Natta polymerization, Tebbe reagent

List of books

1) Organic Chemistry, J. Clayden, N. Greeves, S. Warren and P. Wothers, Oxford University Press
2) Some Modern Methods of Organic Synthesis-W. Carruthers
3) Advance Organic Chemistry Part-B-F. A. Caray and R. J. Sundberg Plenum Press
4) Protective Group in Organic Synthesis-T. W. Greene and PGM
5) The Chemistry of Organo Phosphorous-A. J. Kirbi and S.G. Warren
6) Organo Silicon Compound-C. Eabon
7) Organic Synthesis via Boranes-H. C. Brown
8) Organo Borane Chemistry-T. P. Onak
9) Organic Chemistry of Boron-W. Gerrard
10) Organometallics: A concise Introduction, Ch. Elshebroicn and A. Salzer, VCH, chapters, 12-16 4.
11) Organotransition Metal Chemistry: Applications to Organic Synthesis, S.G. Davies, Permagaon 1982.
12) Organometallics in Organic Synthesis – Swan & Black

Organometallic Chemistry - E.J. Elias and Gupta

Semester III
Inorganic Chemistry Specialization Paper – I
Paper XI (Code: MCH3T03)

60 h (4 h per week): 15 h per unit 60 Marks

Course Outcomes: At the end of the course, student would be able to

1. apply the principles of transition metal coordination complexes in understanding functions of biological systems
2. identify the medicinal applications of inorganic compounds
3. understand mechanism of energy transfer processes in biological systems
4. develop the possible enzymatic pathways in biosystems
5. explain oxygen transport mechanisms in biosystems

Unit -I **15h**

A) Essential and trace metals in biological systems: Biological functions of inorganic elements, biological ligands for metal ions. Coordination by proteins, Tetrapyrrole ligands and other macrocycle. Influence of excess and deficiency of V, Cr, Mn, Fe, Co, Cu,& Zn. Genetic defects in the absorption of trace elements. Regulation and storage of trace elements. Role of minerals. Toxic effects of metals.

B) Metal storage, transport and biomineralization with respect to Ferritin, Transferrin and Siderophores, Na+ /K+ pump. Role of Ca in transport and regulation in living cells.

C) Medicinal use of metal complexes as antibacterial, anticancer, use of cis-platin as antitumor drug, antibiotics & related compounds. Metal used for diagnosis and chemotherapy with particular reference to anti-cancer drugs.

Unit-II **15h**

A) Bio-energetics and ATP cycle: DNA polymerization, metal complexes in transmission of energy, chlorophylls, photosystem I and photosystem II in cleavage of water, Model systems.

B) Electron transfer in Biology: Structure and functions of metalloproteins in electron transfer proteins, cytochromes & Fe-S proteins, Non-heme iron proteins; Rubredoxins, Synthetic models. Biological Nitrogen fixation (in vitro and in vivo)

Unit-III **15h**

Transport & Storage of Dioxygen: Heme proteins & oxygen uptake, structure and functions of haemoglobin, myoglobin, hemocyanins & hemerythrin. Perutz mechanism showing structural changes in porphyrin ring system. Oxygenation and deoxygenation. Model compounds. Cyanide poisoning and treatment. Vanadium storage and transport.

Unit-IV **15h**

Metallo-enzymes: Apoenzymes, Haloenzyme & Coenzyme. The principle involved and role of various metals in i) Zn-enzyme: Carboxyl peptidase & Carbonic anhydrase. ii) Fe-enzyme: Catalase Peroxidase & Cytochrome P-450 iii) Cu-enzyme: Super Oxide dismutase iv) Molybdenum:- Oxatransferase enzymes, Xanthine oxidase, Co-enzyme Vit.B_{12}, Structure of vitamin B_{12} Co-C bond cleavage, Mutase activity of co- Enzyme B-12, Alkylation reactions of Methyl Cobalamin. Synthetic model of enzyme action, stability and ageing of enzyme.

List of Books:

1) Akhmetov, N.: General and Inorganic Chemistry.
2) Aylett, B. and Smith, B.: Problems in Inorganic Chemistry, (English University Press)
3) Bertini, et al: Bioinorganic Chemistry (Viva)
4) Charlot, G and Bezier, D.: Quantitative Inorganic Analysis (johnWiley).
5) Douglas, B. E. McDanirl, D. H. et al: Concept and Models of Inorganic Chemistry (4th edt.) J. Wiley
6) Dutt P. K.: General and Inorganic Chemistry.(Sarat Books House)
7) Fenton, David E.: Biocoordination chemistry, Oxford
8) Jolly, W. L. :Inorganic Chemistry (4th edn.) Addison-Wesley.
9) Katakis, D. and Gordon, G.: Mechanism of Inorganic Reactions.(J.Wiley).

Semester III
Practical - V (Code: MCH3L01)
Inorganic Chemistry Specialization

8 h /week Marks: 100

Course Outcomes: At the end of the course, student will be able to

1. Understand the principles involved in instrumental methods of analysis.
2. Estimate various species in different samples.
3. Interpret the results obtained by subjecting them to statistical analysis.
4. Carry out real sample analysis using classical and modern techniques.
5. Extract and analyze chlorophyll from plant samples.
6. Determine the rate constant and kinetics of reaction.

A) INSTRUMENTAL METHODS

I pH METRY:

1. Stepwise proton ligand and metal ligand constant of complexes by Irving Rossetti method

II COLORIMETRY AND SPECTROPHOTOMETRY

1. simultaneous determination of manganese (KMnO4) and chromium (K2Cr2O7)
2. simultaneous determination of cobalt (II) and nickel(II)
3. Determination of composition and stability constant of complexes by Job's method of continuous

variation , mole ratio method and slope ratio method

III POTENTIOMETRY

1. Estimation of halide in a mixture by potentiometry
2. Determination of stepwise stability constant of silver thiosulphate complex by potentiometrically

IV CONDUCTOMETRY

1. Estimation of amount of acid in a mixture by conductometric titration

B) INORGANIC REACTION MECHANISM

Kinetics and mechanism of following reactions:

1. Substitution reactions in octahedral complexes (acid/base hydrolysis)
2. Redox reactions in octahedral complexes
3. Isomerization reaction of octahedral complexes

C) BIOINORGANIC CHEMISTRY (CHLOROPHYLL

1. Extraction and absorption spectral study of chlorophyll from green leaves of student choice
2. separation of chlorophyll and their electronic spectral studies
3. Complexation study of metal ions with biologically important amino acids

List of Books

1. Day And Underwood :Quantitative Analysis
2. Vogel A : A Textbook Of Quantitative Inorganic Analysis, Longman
3. Flaschka : Edta Titration
4. Merits And Thomas:Advanced Analytical Chemistry
5. Ewing, G. W. : Instrumental Methods Of Chemical Analysis, Mcgraw-Hill
6. Drago, R.S:Physical Methoods In Inorganic Chemistry
7. Christain G.D:Analytical Chemistry
8. Khopkar S.M.:Basic Concept Of Analytical Chemistry
9. Koltath And Ligane:Polorography

10. Braun:Instrumental Methods Of Chemical Analysis
11. Willard, Merritt And Dean: Instrumental Methods Of Chemical Analysis ,Van Nostrand
12. Strouts,Crifi;Llan And Wisin: Analytiacl Chemistry
13. Skoog S.A. And West D. W.:Fundamental Of Analytical Chemistry
14. Dilts R.V.: Analytiacl Chemistry
15. Jahgirdar D.V :Experiments In Chemistry
16. Chondhekar T.K: Systematic Experiments In Physical Chemistry, Rajbog S.W., Aniali Pubn.
17. Wlehov G. J: Standard Methods Of Chemicalanalysis 6th Ed
18. Ramesh Rand Anbu M , Chemical Methods For Envirnmental Analysis : Watewr And Sedient , Macmillion India
19. Akjmetov, N :General And Inorganic Chemistry
20. Aylett, B. And Smith , B. :Problems In Inorganic Chemistry
21. Charlot, G. And Bezier, D.: Quantitative Inorganic Analysis (John Wilry)
22. Douglas, B. E. Mcdanirl, D. H. Et Al : Concept Amd Models Of Inorganic Chemistry (4th Ed) J Wiley
23. Dutt P. K.:General And Inorganic Chemistry (Sarat Book House)
24. Fenton, David E.:Biocoordination Chemistry, Oxford
25. Jolly, W. L. :Inorganic Chemistryu (4 Th Ed) Addison-Wesley
26. Bertini, Et Al:Bioinorganic Chemistry (Viva)
27. Katakis, D. And Gordon, G :Mechanism Of Inorganic Reactions (J. Wiley)

Semester III
Practical - VI (Code: MCH3L02)
Inorganic Chemistry Specialization

8 h /week Marks: 100

Course Outcomes: At the end of the course, student will be able to

1. Determine various parameters and their significance in water quality.
2. Understand the principles involved in water, air and soil analysis.
3. Carry out analysis of various water, air and samples.
4. Interpret the results obtained and access the quality of water, air or soil sample.
5. Explain alternate methods of analysis for the same samples.
6. Develop own method of water, air and soil analysis.

WATER ANALYSIS

1 Sampling of water**-**tap water, overhead storage tank water, pond water and lake water
2 Physico **–**chemical and organoleptic characteristics of the above water sample
3 Statistical evolution of the data obtained for optimization of result
4 Determination of total solids, total dissolved solids and total suspended solids and its significance
5 Determination and comparison of chlorine content in tap water, storage tank and swimming pool
6 Determination of acidity and alkalinity in water samples
7 Determination of total, permanent and temporary hardness of water sample
8 Determination of DO, COD, and BOD of water sample
9 Analysis of chemicals used in water and waste water treatment**-**alum, bleaching powder, activated carbon
10 Analysis iron and manganese in water sample by visual titrimetry
11 Analysis of copper and nickel in water sample by Spectrophotometry
12 Analysis of phenol in water sample by Spectrophotometry
13 Analysis of nitrite in water sample by Spectrophotometry
14 Analysis of chromium in water sample
15 Analysis of chloride in water sample
16 Analysis of sulphate in water sample
17 Determination of turbidity of a given water sample
18 Estimation of Na, K, by flame photometry in given water

AIR ANALYSIS

Determination of SOx and NOx and TSPM **(**total suspended particulate matter**)** and RSPM in ambient air

SOIL ANALYSIS

1 Analysis of different types of soil like pH, conductivity, alkalinity etc**.**
2 Determination of N,K, P of soil by flame photometry
3 Analysis of nutrients**-**nitrogen **(**total, ammonia, nitrite & nitrate **)**, phosphate total
4 Determination of macro &micro nutrients in soil

List of books

1. Water analysis : J. Rodier
2. A Text book of Inorganic Analysis : A.I.Vogel
3. Colorimetric Determination of metals : E.B.Sandell
4. Environmental Chemistry : Moore J W and Moore E A. Academic Press, New York, 1976.
5. Environment and Man Vol VII: The Chemical Environment Edited by J Lenihar and W Fleecher Vlackie Publication, 1977.

6. The Chemistry of Environment: R A Horne, Wiley Interscience Publication 1978.
7. Fundamentals of Air Pollution: A C Stern
8. Instrumental Methods of Analysis: Willard,Merrit and Dean
9. Analytical Chemistry: Meites and Thomas
10. Standard Methods for Examination of water and waste water: A E Greenberg, A D Eaton, APHA, AWWA,WEF
11. Chemistry for Environmental Engineering and Science: C N Sawyer, P L McCarty and G F Parkin
12. Laboratory Manual for the Examination of Water, waste water and soil: H H Rupa and H Krist, V C H Publication
13. Manual on Water and Waste water analysis: D S Ramteke and C A Moghe, NEERI
14. Environmental Chemistry: B K Sharma and H Kaur
15. Environmental Chemistry: A K De
16. Environmental Pollution- Management and control for sustainable Development: R K Khatoliya
17. Environmental Chemistry: A K Bhagi and G R Chatwal

Semester III
Organic Chemistry Specialization Paper – I
Paper XI (Code: MCH3T03)

60 h (4 h per week): 15 h per unit 60 Marks

Course Outcomes: At the end of the course students would be able to

1. Understand the applications of enolates in C-C bond formation
2. Demonstrate stereochemical description of common organic reactions
3. Understand the use of resolution for separation of racemic mixtures.
4. Recognize the chemical reactions of carbonyl compounds and alkenes under photochemical conditions.

Unit I: 15 h

Alkylation of enolates and other carbon nucleophiles:

Generation and properties of enolates and other stabilized carbaions, regioselectivity and stereoselectivity in enolate formation from ketones and esters, alkylation of enolates of ketones, aldehydes, esters, carboxylic acids, amides, and nitriles, Generation and alkylation of dianions, intramolecular alkylation of enolates, control of enantioselectivity in alkylation reactions, The nitrogen analogs of enols and enolates: Enamine and imine anions

Unit II: Reactions of carbon nucleophiles with carbonyl compounds 15 h

Aldol addition and condensation reaction, mechanism, Control of regioselectivity and stereoselectivity of aldol reacions of aldehydes and ketones, Aldol addition reactions of enolates of esters and other carbonyl derivatives, Reaction of (*E*) or (*Z*)-enolates with chiral aldehydes, The Mukaiyama aldol reaction, Control of facial selectivity in aldol and Mukaiyama aldol reaction, Intramolecular aldol reaction and the Robinson annulation, Evans aldol reaction, Mannich reaction, Conjugate addition of enolates, organomettalic reagents and cyanide ion, Conjugate addition with tandem alkylations, Control of facial selectivity in conjugate addition reaction

Unit III: Advanced Stereochemistry 15 h

A) Recapitulation of Stereochemical concepts- enantiomers, diastereomers, homo topic and heterotopic ligands, racemization and resolution methods, Chemo-, regio-, diastereo- and enantio-controlled approaches; Chirality transfer, Stereoselective addition of nucleophiles to carbonyl

group: Re-Si face concepts, Cram's rule, Felkin Anh rule, Houk model, Cram's chelate model. Asymmetric synthesis, use of chiral auxiliaries, asymmetric hydrogenation, asymmetric epoxidation and asymmetric dihydroxylation

B) Stereochemistry of fused and bridged ring systems: Nomenclature, synthesis; stereochemical aspects of Perhydrophenanthrene, Perhydroanthracene, hydrindane, Steroids; Bridged system (bi, tri and polycyclo system) including heteroatoms, Bredt's Rule. Conformations of following compounds with justification of each: cis and trans-1,3- and l,4-di-t-butyl-cyclohexanes; Cis-4-di-t-butylcis-2,5-dihydroxycyclohexane; Twistane; bicyclo- [2.2.2]octane; Trans-anti-transPerhydro-anthracene and the lactone; cyclohexane-l,4-dione; 1,2,2,6,6-penta-methyl-4- hydroxy-4-phenylpiperidine; ψ-tropine; 2-hydroxy-2-phenyl quinolizidine; 4-t-butyl-4- methyl-l,3-dioxane; cis- and trans-2,5-di-t-butyl-l,3-dithianes;cis-2,5-di-t-butyl-l,3,2- dioxaphosphorinan-2-one

Unit IV: Photochemistry **15 h**

Interaction of radiation with matter, types of excitation, rate of excited molecules, quenching, Quantum efficiency, quantum yield, transfer of excitation energy, singlet and triplet states, experimental methods in photochemistry of carbonyl compounds, and transition, Norrish type I and Norrish type II reactions Paterno–Buchi reaction, Photoreduction, Photochemistry of enones, Hydrogen abstraction rearrangement of unsaturated ketones and cyclohexadienones

Photochemistry of *p*-benzoquinones, photochemistry of aromatic compounds with reference to isomerization, addition and substitution Photochemical isomerization of *cis* and *trans* alkenes, Photochemical cyclization of reaction, Photo-Fries rearrangement, di-pi methane rearrangement, Photo theory reaction of anilides, photochemistry of vision

List of books

1) Advance Organic Chemistry Part-B-F. A. Caray and R. J. Sundberg Plenum Press (for Unit I and II)
2) Organic Chemistry, J. Clayden, N. Greeves, S. Warren and P. Wothers, Oxford University Press
3) Principle of Organic Synthesis R. O. C. Norman and J. M. Coxon
4) Modern Synthetic Reaction. H. O. House and W. A. Benjamin
5) Organic Synthesis: The Disconnection Approach-S. Warren
6) Designing Organic Synthesis-S. Warren
7) Some Modern Methods of Organic Synthesis-W. Carruthers
8) Advance Organic Reaction. Mechanism and Structure-Jerry March
9) Organic Reaction and their Mechanism-P. S. Kalsi
10) Protective Groups in Organic Synthesis-T. W. Greene
11) The Chemistry of Organo Phosphorous-A. J. Kirbi and S. G. Warren
12) Organo Silicon Compound-C. Eabon
13) Organic Synthesis via Boranes-H. C. Brown
14) Organo Borane Chemistry-T. P. Onak
15) Organic Chemistry of Boron-W. Gerrard

Semester III
Practical - V (Code: MCH3L01)
Organic Chemistry Specialization

8 h /week Marks: 100

Course Outcomes: At the end of the course students would be able to

1. Understand and employ concept of type determination and separation
2. Perform micro scale chemical elemental analysis
3. Recrystallize /distill the separated compounds
4. Extend these skills to organic synthesis

A) QUALITATIVE ANALYSIS

Separation of the components of a mixture of three organic compounds (three solids, two solids and one liquid, two liquids and one solid, all three liquids and identification of any two components using chemical methods or physical techniques. Minimum 8-10 mixtures to be analyzed.

B) Isolation of Organic Compounds from Natural Source (Any five)

1) Isolation of caffeine from tea leaves.
2) Isolation of casein from milk (the students are required to try some typical colour reactions of proteins)
3) Isolation of lactose from milk (purity of sugar should be checked by TLC and PC and Rf value reported.)
4) Isolation of nicotine dipicrate from tobacco
5) Isolation of cinchonine from cinchona bark
6) Isolation of piperine from black pepper
7) Isolation of lycopene from tomatoes
8) Isolation of β-carotene from carrots
9) Isolation of cysteine from hair
10) Isolation of oleic acid from olive oil (involving the preparation of complex with urea and separation of linoleic acid
11) Isolation of eugenol from cloves
12) Isolation of (+) limonene from citrus rinds

Semester III
Practical - VI (Code: MCH3L02)
Organic Chemistry Specialization

8 h /week Marks: 100

Course Outcomes: At the end of the course students would be able to

1. Meticulously record physical constants
2. Perform qualitative estimation of functional groups
3. Monitor the progress of reaction
4. Recrystallize /distill the separated compounds
5. Extend these skills to organic synthesis

A) Quantitative Analysis

Student is expected to carry out following estimations (minimum 5 estimations.)

1) Estimation of Vitamin "C" Iodometry.
2) Estimation of Phenol by $KBrO_3$-KBr.
3) Estimation of Amine by Bromate/ Bromide solution.
4) Estimation of Formaldyde by Iodometry.
5) Estimation of Glucose by Benedict's solution.
6) Estimation of given carbonyl compound by hydrazone formation.
7) Estimation of Aldehyde by Oxidation method.
8) Determination of percentage of number of hydroxyl group in an organic compound by acetylation method.

B) Organic multi-step preparations (Two/Three steps): Minimum 7-8 preparations

1) Aniline → Diaminoazobenzene → p-aminoazobenzene
2) Benzoin → Benzyl → Dibenzyl
3) Aniline → acetanilide →p-bromoacetanilide →p-bromoaniline
4) Aniline → Acetanilide →p-nitroacetanilide →p-nitroaniline
5) Benzaldehyde (thiamine hydrochloride) → benzoin → benzil → benzilic acid
6) p-Nitrotoluene →p-nitrobenzoic acid→ PABA →p-iodobenzoic acid
7) p-Cresol → p-cresylacetate → 2-hydroxy-5-methyl acetophenone → 2-hydroxy chalcone
8) Benzaldehyde → benzilidene acetophenone → 4,5-dihydro-1,3,5-triphenyl-1H-pyrazole
9) Aniline → phenylthiocarbamide → 2-aminobenzthiazole (Microwave in step I)
10) Chlorobenzene → 2,4- Dinitrochlorobenzene → 2,4- Dinitrophenylhydrazine.
11) Acetophenone → acetophenone phenyl hydrazone → 2-phenylindole
12) Benzion → benzoin benzoate → 2,4,5-triphenyl oxazole
13) Benzophenone → benzpinacol → benzopinacolone (Photochemical preparation)
14) Benzophenone → Benzophenone oxime → Benzanilide → Benzoic acid + aniline
15) Aniline → aniline hydrogen sulphate → sulphanilic acid → Orange II
16) Aniline → N-arylglycine → indoxyl → indigo
17) Phthalimide → Anthranilic acid → Phenyl glycine-o-carboxylic acid → Indigo
18) Phalic anhydride → Phthalimide → Anthranilic acid → o-chlorobenzoic acid
19) Phalic anhydride → Phthalimide → Anthranilic acid →Diphenic acid
20) Ethyl acetoacetate → 3-methyl-pyrazol-5-one → 4,4-dibromo-3-methyl-pyrazol-5-one Butanoic acid
21) Biosynthesis of ethanol from sucrose
22) Enzyme catalyzed reactions

List of books:

1) Text book of organic medicinal chemistry-Wilson,Geswold
2) Medicinal chemistry Vil I and II-Burger
3) A textbook of pharmaceitical chemistry-Jayshree Ghosh
4) Introduction to medicinal chemistry-A Gringuadge
5) Wilson andGisvold text book of organic medicinal and pharmaceutical chemistry-Ed.Robert F Dorge
6) An introduction to drug design-S S Pandey,and JR Demmock

7) Goodman and Gilmans pharmacological basis of therapeutics- Stragies for organic drug sythesis and design-D Lednicer
8) Textbook of Medicinal Chemistry- A. Kar
9) Medicinal Chemistry - D Sriram and P. Yogeeswari

Semester III

Physical Chemistry Specialization Paper – I

Paper XI (Code: MCH3T03)

60h *(*4h*/*week*)* 15h*/*unit 60 Marks

Course Outcomes: At the end of the course students will be able to

1. Understand, the concept of partition function, its generation and applications
2. Understand the applications of electrochemistry in various fields
3. Understand the concept of ideal and non-ideal solutions
4. Understand the theories of advanced chemical dynamics
5. Understand the various photophysical processes and phenomena

UNIT I: STATISTICAL THERMODYNAMICS 15h

A**)** **Statistical thermodynamics:** Atomic and Molecular quantum levels, Significance of Boltzmann Distribution law, partition Functions and ensembles, ensemble averaging, postulates of ensemble averaging, canonical, grand canonical and micro canonical ensembles, corresponding distribution laws using Lagranges method of undetermined multipliers**.** Ortho and para hydrogen, principle of equipartition of energy, calculation of average energy.

B**)** Partition function, Translational partition function, Rotational partition function, Vibrational partition function, Electronic partition function, Applications of partition functions, Numerical**.**

UNIT II: ELECTROCHEMISTRY OF SOLUTION 15h

A**)** OHP and IHP, potential profile across double layer region, potential difference across electrified interface; Structure of the double layer: Helmholtz-Perrin, Gouy Chapman model, Stern region, Graham Devanathan- Mottwatts, Tobin, Bockris, Devnathan Models**.**

B**)** Over potentials, exchange current density, derivation of Butler Volmer equation under near equilibrium and non-equilibrium conditions, Tafel plot

C**)** Electrical double lever, theories of double layer, electro-capillary phenomena, electro-capillary curve**.** Electro-osmosis, electrophoreses**.** Streaming and Sedimentation potentials**.** Zeta potentials and its determination by electrophoresis, influence of ions on Zeta potential**.**

UNIT III: CHEMICAL DYNAMICS - I 15h

A**)** Dynamics of complex reactions**:** reversible, parallel, consecutive, concurrent and branching reactions, free radical and chain reactions, reaction between Hydrogen – Bromine and Hydrogen – Chlorine **(**thermal and photochemical**)**, decomposition of ethane, acetaldehyde, N_2O_5, Rice Herzfeld mechanism, Oscillatory autocatalytic and Belousov-Zhabotinsky reactions, Lotka-Volterra mechanism, the brusselator and the oregonator**.**

B**)** **Fast Reactions:** relaxation methods, flow methods, flash photolysis, magnetic resonance method, relaxation time and numerical**.**

UNIT IV: PHOTOCHEMISTRY 15h

A**)** **Photophysical phenomenon:** Introduction, photo and photochemical excitation and de-excitation, fluorescence, delayed fluorescence, and phosphorescence, fluorescence quenching**:** concentration quenching, quenching by excimer and exciplex emission, fluorescence resonance energy transfer between photoexcited donor and acceptor systems**.** Stern-Volmer relation, critical energy transfer distances, energy transfer efficiency, examples and analytical significance, bimolecular collisions, quenching and Stern-Volmer equation**.**

B**)** **Photochemical reactions:** photocatalysis (photoreduction and photooxidation), photodimerization, photochemical substitution, photoisomerization, photosensitization, chemiluminescence, photochemistry of environment**:** Greenhouse effect**.**

List of books:

1) G. M. Panchenkov and V. P. Labadev, " Chemical Kinetics and catalysis", MIR Publishing
2) E.A. Moelwyn- Hughes, "Chemical Kinetics and Kinetics of Solutions", Academic
3) K. J. Laidler, Chemical Kinetics, Third Edition (1987), Harper and Row, New York
4) J. Raja Ram and J. C. Kuriacose, Kinetics and Mechanism of Chemical Transformations MacMilllan Indian Ltd., New Delhi (1993)
5) J.G. Calvert and J.N. Pitts, Jr., Photochemistry, John Wiley and Sons, New York (1966).
6) K. K. Rohtagi-Mukherjee, Fundamentals of Photochemistry, New Age International, New Delhi(1986).
7) R. P. Wayne, Principles and Applications of Photochemistry, Oxford University Press, Oxford(1988).
8) N. J. Turro, Modern Molecular Photochemistry, Univ. Science Books, Sansalito (1991).
9) J. F. L. Lakowicz, Principles of Fluorescence Spectroscopy, 2nd Edition (1999), PlenumPublishers, NewYork.
10) F.W.Sears, " Introdction to Thermodynamics, Kinetic Theory of Gases and statistical mechanics".AddisonWesley
11) H. K. Moudgil, Text Book of Physical Chemistry, Pretice Hall of India, New Delhi, 2010.
12) M. C. Day and J Selbin, Theoretical Inorganic Chemistry, Reinhold Pub. Corp., New York,
13) N. J. Turro, V. Ramamurthy and J. C. Scaiano, Principles of Photochemistry – An Introduction, Viva Books, New Delhi, 2015.
14) G. A. Somorjai, Introduction to Surface Chemistry and Catalysis, Wiley, 2010.
15) M. C. Gupta, Statistical Thermodynamics, New Age International.
16) K. Huang, Statistical Mechanics, Wiley, New Delhi, 2003.
17) Andrew Maczek, Statistical Thermodynamics, Oxford University Press Inc., New York (1998).
18) B. K. Agarwal and M. Eisner, Statistical Mechanics, Wiley Eastern, New Delhi (1988).
19) D. A. McQuarrie, Statistical mechanics, Harper and Row Publishers, New York (1976).
20) J.O.M.Bokris and A.K.N.Reddy, "Modern Elcrtrochemistry". Wiley
21) S. Glasstone, "Introduction to Electrochemistry" Affilisated East West Press, New Delhi.
22) S. O. Pillai, Solid State Physics, New Age International, New Delhi, 2102.
23) D. R. Crow, " The Principle of electrochemistry", Chapman Hall
24) G. K. Agrawal, Basic Chemical Kinetics, Tata-Mc-Graw Hill Pvt., Ltd. 1990
25) K. L. Kapoor, Text Book of Physical Chemistry, Vol – I to Vol-VI, 2011.
26) Santosh Kumar Upadhyay, Chemical Kinetics and Reaction Dynamics, Springer 2006.

Semester III
Practical - V (Code: MCH3L01)
Physical Chemistry Specialization

8 h /week Marks: 100

Course Outcomes: At the end of the course students will be able to

1. Inculcate the potential of establishing any new laboratory at UG or PG level.
2. Execute the theoretical principles in practical
3. Analyze and interpret the results of their performances
4. Inculcate the skills of preparing, maintaining and developing the chemicals and reagents
5. Understand the role of laboratory safety and preparedness

Thermodynamics:

1) Determination of partial molar volume of solute and solvent (ethanol-water, methanol-water, KCl-water mixture)

Solutions:

2) Study the variation of solubility of potassium hydrogen tartarate with ionic strength using a salt having a common ion and hence determine the mean ionic activity coefficients.

3) Determination of temp. dependence of the solubility of a compound in two solvents having similar intermolecular interactions(benzoic acid in water and DMSO – water mixture) and calculation of the partial molar heat of solution.

Phase equilibrium:

4) To study the effect of addition of an electrolyte such as NaCl, KCl,Na_2SO_4,K_2SO_4 etc. on the solubility of an organic acid(benzoic acid or salicylic acid).
5) To determine the heat of crystallization of $CuSO_4$,$5H_2O$
6) To determine the heat of reaction involving precipitation of a salt $BaSO_4$
7) To determine transition temperature of $CaCl_2$ by thermometric method and to determine transition temperature of $CaCl_2$, sodium bromide by solubility method

Kinetics:

8) To determine the activation energy of hydrolysis of an ester by acid.
9) Kinetics of reaction between sodium thiosulphate and KI. Determination of rate constant; study of influence of ionic strength
10) Kinetics of decomposition of H_2O_2 catalysed by iodide ion. Also determination of activation energy of reaction.

Conductometry:

11) Estimate the concentration of H_2SO_4, CH_3COOH, $CuSO_4.5H_2O$ in a given solution by carrying out conductometric titration against NaOH solution.
12) Determine the eq. conductance of strong electrolyte (KCl, NaCl, HCl, KNO_3) at several concentration and hence verify Onsager's equation.
13) Carry out the following precipitation titration conductometrically. a. 50 ml.0.02N $AgNO_3$ with 1N HCl; b.50 ml.0.02N $AgNO_3$ with 1N KCl; c. 50 ml 0.004 N $MgSO_4$ with 0.1 N $Ba(OH)_2$; d. 50 ml 0.002 N $BaCl_2$ with 1 N Li_2SO_4; e. 50 ml.0.02 N $BaCl_2$ with 1N K_2SO_4

Potentiometry:

14) To prepare calomel electrode and to determine the potential of calomel electrode by potentiometry.
15) To determine stability constant of Fe^{3+} with potassium dichromate in presence of dilute sulphuric acid by redox titration.
16) To determine solubility product of Silver chloride by potentiometric method.
17) Determination of redox potential of the couples(Fe^{2+}/Fe^{3+},Co^{3+}/Co^{2+},Cr^{3+}/Cr^{2+},MnO_4^-/Mn2+(any two) and equilibrium constant.
18) Study of complex formation by potentiometry e.g.Ag^+-$S_2O_3^{-2}$, Fe^{3+}-SCN^-,Ag^+-NH_3(any two) and calculation of stability constant.

Spectrophotometry:

19) To verify Beers law for solution of potassium permanganate and to find molar extinction coefficient.
20) To determine the indicator constant (pK_{In}) of methyl orange/red spectrophotometrically.

Polarography:

1) Determination of the half-wave potential of the cadmium ion in 1M potassium chloride solution.
2) Investigation of the influence of dissolved oxygen.
3) Determination of cadmium in solution.
4) Determination of lead and copper in steel.

List of Books

1) Vogel A : A Textbook Of Quantitative Inorganic Analysis, Longman
2) Das and Behra, Practical Physical Chemistry
3) Carl W. Garland, Joseph W. Nibler and David P. Shoemaker, Experiments in Physical Chemistry, Mc-Graw Hill, 8th Edition, 2009.
4) Farrington Daniels, Joseph Howard Mathews, John Warren Williams, Paul Bender, Robert A. Alberty, Experimental Physical Chemistry, Mc-Graw Hill, Fifth Edition, 1956.
5) John W. Shriver and Michael George, Experimental Physical Chemistry, Lab Manual and Data Analysis, The University of Alabama in Huntsville, Fall 2006
6) Day And Underwood :Quantitative Analysis

7) Merits And Thomas:Advanced Analytical Chemistry
8) Ewing, G. W. : Instrumental Methods of Chemical Analysis, Mcgraw-Hill
9) Drago, R.S:Physical Methoods In Inorganic Chemistry
10) Christain G.D:Analytical Chemistry
11) Khopkar S.M.:Basic Concept Of Analytical Chemistry
12) Koltath And Ligane:Polorography
13) Braun:Instrumental Methods Of Chemical Analysis
14) Willard, Merritt And Dean: Instrumental Methods Of Chemical Analysis ,Van Nostrand
15) Strouts,Crifi;Llan And Wisin: Analytiacl Chemistry
16) Skoog S.A. And West D. W.:Fundamental of Analytical Chemistry
17) Dilts R.V.: Analytiacl Chemistry
18) Jahgirdar D.V :Experiments In Chemistry
19) Chondhekar T.K: Systematic Experiments In Physical Chemistry, Rajbog S.W., Aniali Pubn.
20) Wlehov G. J: Standard Methods Of Chemicalanalysis 6th Ed

Semester III
Practical - VI (Code: MCH3L02)
Physical Chemistry Specialization

8 h /week Marks: 100

Course Outcomes: At the end of the course, student will be able to

1. Determine various parameters and their significance in water quality.
2. Understand the principles involved in water and air analysis.
3. Carry out analysis of various water, air and samples.
4. Carry out synthesis and analysis of various polymers.
5. Interpret the results obtained and access the quality of polymer sample.
6. Explain alternate methods of analysis for the same samples.

A. Ambient air analysis: SPM, RSPM, SO_x and NO_x in ambient air.
B. Water Analysis
    1. Determination of acidity and alkalinity in water samples
    2. Determination of total, calcium and magnesium hardness in water samples
    3. Analysis of chloride in water sample
    4. Analysis of sulphate in water sample
    5. Analysis of Fluoride in water sample by spectrophotometry.
    6. Analysis of Nitrate in water sample by spectrophotometry.
    7. Estimation of Na, K, by flame photometry in given water sample
    8. Determination of DO and COD of water sample
C. Synthesis of polymers:
    1. Synthesis of Thiokol rubber (condensation)
    2. Urea-formaldehyde (condensation)
    3. Glyptal resin: glycerine phthalic acid (crosslinked Polymer Chemistry)
    4. Polyacryonitril (bulk polymerization)
    5. Polyacryonitril (emulsion polymerization)
    6. Polymethylomethacrylate (emulsion of suspension Polymer Chemistry)
    7. Nylon-66 (interfacial polycondensation)
    8. Coordination polymers
    9. Conducting polymer (electro- or peroxodisulphate oxidation)
D. Characterization of Polymer
    1. Viscosity and molecular mass of polymer.
    2. Density of polymer by flotation methods.
    3. IR spectra.

4. Magnetic and electrical properties of polymers, magnetic susceptibility and electrical conductivity of coordination and conducting polymers.
5. Thermal analysis and degradation of polymers:
   TGA: Isothermal and non-isothermal;
   DTA: Glass transition temperature and melting point
6. Kinetics of polymerization:
   i. Polycondensation
   ii. Peroxide initiation polymerization.

List of books:

1. Textbook of polymer science: F.W. Billmayer Jr. Wiley.
2. Polymer science: V.R. Gowarikar, N. V. Viswanathan and J. Sreedhar, Wiley-Eastern.
3. Fractional monomers and polymers: K Takemoto, Y. Inaki, and R.M. Ottam Brite.
4. Contemporaty polymer chemistry: H.R. Alcock and F. W. Lambe, Prentice Hall.
5. Principles of polymer Chemistry: Flory, Cornell Univ. press.
6. Introduction to polymer chemistry: R. B. Seymour, McGraw Hill.
7. Principles of polymerization: Odian.
8. A first course in polymer chemistry: A. Strepikheyew, V. Derevistkay and G. Slonimasky, Mir Publishers, Moscow.
9. Laboratory preparation of macro chemistry: EMM effery, McGraw Hill Co.
10. A practical course in polymer chemistry: S. J. Punea , Pergamon Press.

Semester III
Analytical Chemistry Specialization Paper – I
Paper XI (Code: MCH3T03)

60h *(*4h*/*week*)* 15h/unit 60 Marks

Course Outcomes: At the end of the course, student will be able to

1. Explain the principles involved in radiation chemistry.
2. Compare various detectors used in radiochemistry and select among them for desired analysis.
3. Compare various voltammetric techniques for given type of anlaysis.
4. Understand the electrodes used in different voltammetric techniques and their comparison.
5. Design experiments for water quality assessment based on parameter under study.

Unit-I: **Radioanalytical Chemistry** **15h**

Radioactivity, Law of radioactive decay, Half life and mean life, Elementary principles of GM and proportional counters, Gamma Ray Spectrometer, Ionization chamber, HPGe detector, NaI(Tl) detector**.** Preparation of some commonly used radioisotopes (^{22}Na, ^{60}Co, ^{131}I, ^{65}Zn, ^{32}P)**,** Use of radioactive isotopes in analytical and physico-chemical problems, Neutron Activation Analysis, Isotope Dilution Analysis, Radiometric titrations (Principle, Instrumentation, applications, merits and demerits), Radiochromatography, Carbon dating, Numericals based on above.

Unit-II: **Electrochemical methods of analysis-III** **15h**

Stripping Voltammetry: Principle and technique in anodic and cathodic stripping voltammetry, applications to metal ion analysis, limitations.

Adsorptive stripping voltammetry: Principle, technique, applications to metal ions and organic analysis. Advantages over anodic stripping voltammetry. Catalytic effects in voltammetry.

Working electrodes: Mercury electrodes, carbon electrodes, film electrodes.

Cyclic voltammetry: Principle and technique. Randles-Sevcik equation. Interpretation of voltammogram- reversible, irreversible and quasi-reversible systems. Applications of cyclic voltammetry in study of reaction mechanism and adsorption processes.

Electrochemical sensors *(Chemically modified electrodes):* Biosensors, catalytic sensors and gas sensors. Comparison of voltammetry with AAS and ICP-AES.

Unit-III: **Miscellaneous techniques** **15h**

Fluorometry and phosphorimetry: Principles of fluorescence and phosphorescence. Jablonski diagram. Concentration dependence of fluorescence intensity. Fluorescence quenching. Instrumentation. Applications.

Nephelometry and turbidimetry: Principle, instrumentation and applications.

Photoacoustic spectroscopy: Theory. Instrumentation. Advantages over absorption spectroscopy. Chemical and surface applications of PAS.

Electrogravimery: Theory of electrolysis. Electrode reactions. Decomposition potential. Overvoltage. Characteristics of deposits and completion of deposition. Instrumentation. Application in separation of metals.

Unit IV: **Water pollution and analysis** **15h**

Sources of water pollution, composition of potable water, importance of water analysis, sampling and sample preservation, physico-chemical analysis of water. Mineral analysis (temperature, pH, conductivity, turbidity, solids, alkalinity, chloride, fluoride, sulphates, hardness), Demand analysis (DO, BOD, COD, TOC), nutrients (nitrogen-total, nitrate, nitrite, phosphate) and heavy metals (As, Cd, Cr, Hg and Pb). A brief idea of coagulation and flocculation. Water treatment plants: Sand filters and other types of filters.

List of books:

1. Essentials of Nuclear Chemistry: H. J. Arnikar (Willey Eastern Ltd)
2. Substoichiometry in Radioanalytical Chemistry: J. Ruzicka and J Stary (Pergamon Press)
3. Introduction to Radiation Chemistry: J. W. T. Spinks and R. J. Woods
4. Radiochemistry: A. N. Nesmeyanov (Mir Publications)
5. Instrumental Methods of Analysis: Willard, Meriit and Dean(Van Nostrand)
6. Instrumental Methods of Analysis: G. Chatwal and S. Anand (Himalaya Publishing House)
7. Vogel's Text Book of Quantitative Inorganic Analysis: Bassett, Denney, Jeffery and Mendham (ELBS)
8. Advanced Analytical Chemistry: Meites and Thomas (McGraw-Hill)
9. Atomic Absorption Spectroscopy: Robinson (Marcol Dekker)
10. Instrumental Methods of Chemical Analysis: Braun (Tata McGraw-Hill)
11. Analysis of Water: Rodier
12. Laboratory manual of water analysis: Moghe and Ramteke (NEERI)
13. Electroanalytical chemistry: Joseph Wang
14. Electroanalytical stripping methods: Brainina and Neyman (Wiley-Interscience)
15. Trace analysis: S. Lahiri (Narosa Publishing House)
16. Electroanalytical Chemistry: Bard (Marcel-Dekker)
17. Chemistry in Engineering and Technology- Vol I and II: J.C. Kuriacose and J. Rajaram (Tata-McGraw Hill)

Semester III
Practical - V (Code: MCH3L01)
Analytical Chemistry Specialization

8 h /week Marks: 100

Course Outcomes: At the end of the course, student will be able to

1. Understand the fundamental principles forming basis for the instrumental methods of analysis.
2. Select most suitable technique for the desired analysis.
3. Identify experimental conditions necessary to carry out the analysis of different samples.
4. Compare results obtained through different techniques.
5. Formulate experiments based on optical and electroanalytical techniques.
6. Demonstrate working of each instrument used in analysis.

pH-metry

1. Determination of percent Na_2CO_3 in soda ash by pH-metric titration.
2. Determination of isoelectric point of amino acid.
3. Determination of three dissociation constants of phosphoric acid.

Conductometry

1. Estimation of acids in mixtures.
2. Displacement titration of CH_3COONa with HCl.
3. Precipitation titration of $MgSO_4$ and $BaCl_2$.
4. Titration of mixture of CH_3COOH, H_2SO_4 and $CuSO_4$ with NaOH.
5. Determination of dissociation constants of weak acids.

Potentiometry

1. Estimation of Cl^-, Br^- and I^- in a mixture.
2. Determination of percent purity of phenol by potentiometric titration with NaOH.
3. Estimation of acids in mixtures.
4. Potentiometric titration of phosphoric acid with NaOH.

Electrogravimetry

1) Estimation of nickel and copper individually as well as in mixture.

Spectrophotometry

1. Simultaneous determination of chromium and manganese in given mixture.
2. Simultaneous determination of two dyes in a mixture.
3. Estimation of Mn in steel.
4. Estimation of Cu/Ni in alloys.
5. Estimation of iron in water sample using 1,10-phenanthroline.
6. Estimation of Fe(III) in given solution by photometric titration with EDTA (salicylic acid method).

Flame photometry

1) Estimation of Li, Na, K, Ca in vegetable/ soil / water samples.

Polarography

1. Determination of $E_{1/2}$ of Cd^{2+} and Zn^{2+} at DME.
2. Estimation of Cd^{2+} and Zn^{2+} in respective solutions by calibration curve and standard addition methods.

Semester III
Practical - VI (Code: MCH3L02)
Analytical Chemistry Specialization

8 h /week Marks: 100

Course Outcomes: At the end of the course, student will be able to

1. Know the principles forming basis for different detectors used in radiation measurements.
2. Identify stable and radioisotopes of given elements based on their stability.
3. Design radioanalytical method for the determination of radioisotope concentration in sample..
4. Operate radiation source equipments and detector equipments without getting exposed to radiation.
5. Determine half wave potentials of various metal ions and quantitate them using polarography.
6. Intreprete cyclic voltammograms of reversible and irreversible redox systems.

Radioanalytical techniques

1. GM-counter: Plateau, nuclear statistics, half thickness of aluminium absorbers, dead time.
2. Gamma ray spectrometer: Calibration using standard sources, determination of half life (Mn-56, I-128, In-116)
3. Experiments based on radiation chemistry: G-value-G(NO_2^-).
4. Working of GM counter, plateau, statistics, geometry effects, dead time, energy of beta particle, back scattering
5. Working of gas flow proportional counter, plateau, statistics, geometry effects, dead time, energy of beta particle
6. Working with scintillation counter, gamma ray spectra, energy calibration and resolution, half life determination of single and composite nuclei.

Cyclic voltammetry

1) Study of cyclic voltammograms of $K_3[Fe(CN)_6]$.

Turbidimetry and nephelometry

1. Estimation of sulphate in water sample by turbidimetry.
2. Estimation of phosphate by nephelometry.
3. Determination of molecular weight of polymer.

Polarimetry

1. Determination of specific and molar rotation of optically active compound.
2. Kinetics of inversion of cane sugar in the presence of HCl.
3. Determination of percentage of two optically active substances (d-glucose and d-tartaric acid) in mixture.

Water analysis

1. *Mineral analysis*: Temperature, pH, conductivity, turbidity, solids, alkalinity, chloride, fluoride, sulphate, hardness
2. *Demand analysis*: DO, COD, BOD
3. *Metals*: Na, K, Ca, Fe, Cd and Pb

Soil analysis

pH, Electrical conductivity, sodium, potassium, calcium and phosphates.

Semester III
Core Subject Centric - I
Applied Analytical Chemistry
Paper XII (Code: MCH3T04)

60h (4h/week) 15h/unit 60 Marks

Course Outcomes: At the end of the course, student will be able to

1. Understand the principles involved in analysis of ores, cement, petroleum, soil, coal and pharmaceutical samples.
2. Estimate various analytical parameters of different samples.
3. Interpret the results obtained by subjecting them to statistical analysis.
4. Carry out real sample analysis using classical and modern techniques.
5. Develop own method of analysis.
6. Carry out validation of self-developed analytical method for pharmaceutical analysis.

Unit-I: Analysis of ores and cement **15h**

Ores: Composition and analysis of the followings ores- Bauxite, Pyrolusite, Dolomite, Chromite.

Portland cement: Composition, raw material, manufacturing processes, characteristics, analysis.

Unit-II: Analysis of petroleum and petroleum products **15h**

Introduction, determination of flash and fire point, Pensky Marten's apparatus, cloud and pour point, aniline point, drop point, viscosity and viscosity index, Redwood and Saybolt viscometer, API specific gravity, water and sulphur in petroleum products, carbon residue, corrosion stability, decomposition stability, emulsification, neutralization and saponification number.

Unit-III: Soil and coal analysis **15h**

Soil analysis- Classification and composition, pH and conductivity, analysis of constitutents such as nitrogen, phosphorous, potassium and microconstitutents (Zn and Cu).

Coal analysis- Proximate analysis (moisture content, ash content, volatile matter, fixed carbon). Ultimate analysis (carbon, hydrogen, sulphur, nitrogen, oxygen content). Combustion of carbonaceous fuel- Flue gas. Calorific value and its units, Bomb calorimeter.

Unit-IV: Pharmaceutical analysis **15h**

Requirements of a quality control laboratory for pharmaceutical units.

Structures, category, identification (qualitative) and assay (quantitative) of following drugs

1. Antibiotics: Amoxycillin, Azithromycin, Cefixime, Levofloxacin
2. Antihistamine: Cetirizine, Cinnarizine
3. Vitamins: Thymine hydrochloride (Vitamin-B_1) Riboflavin (Vitamin-B_2), Ascorbic acid (Vitamin-C)
4. Analgesics: Diclofenac, paracetamol, Aspirin.

List of books

1. ISI Handbook of Food Analysis: Vol.I to X (Bureau of India Standards Publication, New Delhi)
2. Practical Pharmacognosy: T. N. Vassudevan
3. Aids of analysis of food and drugs: Wicholls
4. Indian Pharmacopoeia-1985
5. British Pharmacopoeia-1990
6. Handbook of Drugs and cosmetics aids: Mehrotra
7. Experiments and calculations in engineering chemistry: S. S. Dara, (S. Chand)

8. A Laboratory Manual on Soil Mechanics(Testing and Interpretation): Ravi Kumar Sharma (Wiley)
9. Kellogg Soil Survey Laboratory Methods Manual. Soil Survey Investigations: US Department of Agriculture.
10. Handbook of Coal analysis: James G. Speight (wiley)
11. Standard Methods of Chemical Analysis: F. J. Welcher (D. Van Nostrand Co.)

Semester III
Core Subject Centric - I
Environmental Chemistry
Paper XII (Code: MCH3T04)

60h *(*4h*/*week*)* 15h*/*unit 60 Marks

Course Outcomes: At the end of the course, student will be able to

1. Understand the principles involved environmental ecology development.
2. Get an idea about various pollutants in environment and their ill-effects.
3. Explain the causes of pollution in various components of atmosphere.
4. Summarize the consequences of pollution and their impact on surrounding living and non-living things.
5. Identify the causes and consequences of radiation pollution and remedies for it.

Unit -I: Basic Concept of Environment **15 h**

A)

1) Basic zone of earth atmosphere,
2) Classifications and atmospheric variations with respect to temperature.
3) Components of the environment (atmosphere, hydrosphere, lihospere and biospere)
4) Importance and significance with respect to resource utilizations and conservations

B)

1) Basic concept of ecology and its relationship with the environment.
2) Ecosystem (terrestrial and aquatic), functions of ecosystem, ecological pyramids (categories), their functions and importance with respect to number of producers and consumers.

C) Bio-Geochemical cycle, nutrient cycling (number of nutrient cycle), their role in supporting physical, bio-environment and succession

D)

1) Environmental pollution, definition of pollution and pollutants.
2) Classification of pollutants with respect to types of pollution (air, water, soil, thermal and radioactive), impact on health and control measures.

Unit -II: Water **15 h**

A) Origin, hydrological cycle, mineral composition of water (anions and cations), importance and availability

B) Sources of water (surface and groundwater), physico-chemical characteristics, water quality criteria (health, aesthetics and organoliptic), water quality consideration with respect to water quality index.

C) Water quality management, water shed management, distribution system with respect to storages (drinking, irrigation and industrial), rain water harvesting (need and implementation).\

D) Water pollution, sources of water pollution (point and non-point), water quality consideration for human health, control of water pollution and measures to improve water quality

Unit -III: Air **15 h**

A) Major regions of atmosphere, composition of air, thermal structure as per atmospheric boundary layer, atmospheric stability, special and temporal processes of atmospheric process, major transport processes (advection, diffusion, turbulence, convections), lapse rate and temperature inversion.

B) Photochemical reaction (chemical reaction with atmospheric gaseous matrix), depletion of ozone, environmental effects of ozone depletion, global warming, effects on climate, green house effects (main sources), remedial measures for reversion of green house gases, chemistry of acid rain and photochemical smog.

Unit -IV: Soil **15 h**

A) Chemical and mineralogical composition of soil, classification of soil (as per chemical and mineralogical compositions), types of soils, salinity and sodicity of soil, impacts/effects on fertility and productivity, measures to combact salinity and sodicity.

B) Physico-chemical properties of soil (role and significance with respect to plant/crop growth), role of macro and micro nutrients and interaction with soil bacterial population, soil indicator plants, importance of soil quality in agriculture productivity.

C) RADIOACTIVE POLLUTION:

1) Introduction to radiation chemistry, types of radiations, types of radiation particles, availability of nuclear reactors in India for electricity generation, comparison of energy generation with respect to renewable and non-renewable fuel sources.
2) .Radioactive pollution, sources, effects and control measures, effect of radiation on human health with respect to **mSv** (milli-sievert) and effective dose limits.

D) Noise pollution

1) Sources of noise pollution, effect of noise pollution on human health, measures to reduce noise levels, regulations of ambient noise levels with respect to areas/zones.

Semester III
Core Subject Centric - I
Natural Product Chemistry
Paper XII (Code: MCH3T04)

60h *(*4h*/*week*)* 15h*/*unit 60 Marks

Course Outcomes: At the end of the course students would be able to

1. Learn the important aspects of steroids and terpenoids.
2. Understand the biosynthesis of natural products.
3. Analyze the enzyme reactions involved in various life processes
4. Illustrate the structure elucidation of unknown naturally occurring organic compound
5. Apply the knowledge of organic reactions for the total synthesis of useful natural products

Unit I **15 h**

A) Terpenoids: Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, stereochemistry, and synthesis of the following representative molecules: Citral, Geraniol, α-terpeneol, Menthol, Farnesol, Zingiberene, Santonin, Phytol, Abietic acid and β-carotene, Vitamin A

B) Genesis of biological isoprene unit, Biosynthesis (**ONLY**) of the following tepenoids: myrecene, linalool, geraniol, α-terpeneol, limonene, camphor, α-pinene, β-pinene, farnesol, β-bisabolene and squelene

C) Total synthesis of isocomene, hirsutene, capnellene, modephane

Unit- II **15 h**

Alkaloids: Definition, nomenclature and physiological action, occurrence, isolation, generalmethods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring,role of alkaloids in plants Structure, stereochemistry, and total synthesis of the following: Ephedrine, (+)-coniine, Nicotine, Atropine, Quinine, Reserpine and Morphine

Biosynthesis (**ONLY**) of the followings: hygrine, tropinone, nicotine, pelletierine, conine

Unit-III **15 h**

A) Steroids: Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry.Isolation, structure determination and synthesis of Cholesterol, Bile acids, Androsterone, Testosterone, Estrone, Progesterone and Aldosterone.

Biosynthesis of steroids (lanosterol)

B) Plant Pigments: Occurrence, nomenclature and general methods of structure determination, isolation and synthesis of Apigenin, Luteolin, Quercetin, Myrcetin, Quercetin-3-glucoside, Vitexin, Diadzein, Butein, Cyanidin-7-arabinoside, Cyanidin, Hirsutidin. Biosynthesis of flavonoids: Acetate pathway and The Shikimate pathway: Biosynthesis of Cinnamic acids, lignans and lignin, coumarins, flavonoids and stilbens, isoflavanoids

Unit IV: Enzyme chemistry **15h**

A) Enzymes: Introduction, chemical and biological catalysis, remarkable properties of enzymes likecatalytic power, specificity and regulation. Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Nomenclature and classification, Fischer's lock and key and Koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labeling and enzyme modification by site-directed mutagenesis. Baker's yeast catalysed reactions

B) Mechanism of Enzyme Action: Transition-state theory, orientation and steric effect, acid-basecatalysis, covalent catalysis, strain or distortion. Enzyme mechanisms for chymotrypsin, ribonuclease, lysozyme and carboxypeptidase A

C) Co-Enzyme Chemistry: Structure and biological functions of coenzyme A, thiamine pyrophosphate,pyridoxal phosphate, NAD^+, $NADP^+$, FMN, FAD, lipoic acid, biotin as CO_2 carrier. Mechanisms ofreactions catalyzed by the above cofactors

List of books

1) Organic Chemistry Vol. II - I. L. Finar
2) Classical Methods in Structure Elucidation of Natural Products: *R. W. Hoffmann*, Wiley-VCH
3) Chemistry of Alkloids-S. W. Pelletier
4) Chemistry of Steroids-L. F. Fisher and M. Fisher
5) The Molecules of Nature-J. B. Hendricsion
6) Biogenesis of Natural Compound - Benfield
7) Natural Product Chemistry and Biological Significance- J. Mann, R. S Devison, J. B. Hobbs, D. V. Banthripde and J. B. Horborne
8) Introduction to Flavonoids-B. A. Bohm, Harwood
9) Chemistry of Naturally Occurring Quinines-R. H. Thomson
10) The Systematic Identification of Flavonoids- Marby, Markham, and Thomos

Semester III
Core Subject Centric - I
Nuclear Chemistry
Paper XII (Code: MCH3T04)

60h (4h/week) 15h/unit 60 Marks

Course Outcomes: At the end of the course, student will be able to

1. Understand the reasons of radioactive disintegration and terminology involved to explain it.
2. Compare various nuclear models for explaining the nuclear structural.
3. Elaborate the energetic involved in nuclear reactions and their difference with chemical reactions.
4. Understand the interaction of various ionizing and non-ionizing radiation with matter.
5. Explain the conditions and consequences of nuclear fission and fusion reactions.
6. Apply nuclear waste management system in nuclear chemistry laboratory.

Unit-I: Radioactive decay **15h**

Various modes of decay, natural radioactivity, successive radioactive decay and growth kinetics, radioactive equilibrium, half life, half life of mixed radioisotopes, decay schemes, its determination by experimental methods, statistical nature of nuclear radiation, treatment of nuclear data and calculation of standard deviation, probability

Unit-II: Nuclear structure **15h**

mass-energy relationship, nuclear binding energy, semi-empirical mass formula, nuclear stability rules, nuclear properties, mass size, spin and parity, nature of nuclear forces, liquid drop model, shell model, its evidence and advantages, comparison of the two models, calculations based on above. Energetics of nuclear reaction, cross reaction, comparison with chemical reactions, various types of nuclear reactions, photonuclear, spallation and thermonuclear reaction

Unit-III: Interaction of radiations with matter, detectors **15h**

Interaction with matter and detection of gamma rays with matter by photoelectric, Compton and pai production, interaction of beta particles, neutrons and heavy charged particles, various methods of detecting nuclear radiations, gas filled counters, ionization chamber, proportional and GM counters, scintillation detector and solid state detectors- Ge(Li), Si(Li) and HPGe.

Unit-IV: Nuclear fission and Fusion **15h**

Probability, mass and charge distribution, release of energy and neutrons, spontaneous fission, nuclear reactors and their uses for power production, brief idea about thermal and fast breeder reactors, reprocessing of nuclear fuel, PUREX process, heavy water- manufacturing and use in reactors. accelerators, nuclear fusion. Production of isotopes by nuclear reactions, production of new elements, radioactive waste management and disposal.

List of books:

1. H. J. Arnikar - Essentials of Nuclear Chemistry (Willey Eastern Ltd)
2. G. Friendlander, J. W. Kennedy,E. S. Macias and J. M. Miller-Nuclear and Radiochemistry (Wiley Intersciences, New York)
3. G. R. Choppin and J. Rydberg- Nuclear Chemistry-Principles and Applications(Pergamon press, London)
4. B. G. Harvey-Introduction to Nuclear Physics and Chemistry(Prentice Hall of India)
5. A. N. Nesmeyanov - Radiochemistry- (Mir Publications)

6. M. N. Sastry-Introduction to Nuclear Science, Affiliated East-West Press, New Delhi
7. G. Hughes- Radiation Chemistry- Oxford University Press, London
8. V. Verschinskii and A. K. Pikeav-Introduction to Radiation Chemistry, Israel Publication, Jerusalem- Robinson (Marcol Dekker)
9. Farhat Aziz and M. A. J. Radgers-Radiation Chemistry-Principles and Applications, VCH Publishers FRC.
10. M. Hassinsky-Nuclear Chemistry and its application, Addison Wesley

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Semester III
Core Subject Centric - I
Polymer Chemistry
Paper XII (Code: MCH3T04)

60h *(*4h/week*)* 15h/unit 60 Marks

Course Outcomes: At the end of the course, student will be able to

1. Understand the principles involved Polymer design and develoment.
2. Get an idea about various polymers and their uses.
3. Explain the various methods of polymer preparation.
4. To provide an idea about various utilities and preparation of industrially suitable polymers.

Unit-I: Introduction to polymers **15h**

Nomenclature and classification of polymers, Polymerization: condensation, addition, radical chain-ionic and co-ordination and co-polymerization and their mechanisms, Types of polymers- linear, branched, crosslinked, ladder, thermoplastic, thermosetting, fibres, elastomers, natural polymers, addition and condensation polymers. Stereoregular polymers- atactic, syndiotactic and isotactic.

Unit-II: Molar mass and its determination **15h**

Molecular mass and molar distribution. Number average, mass average, viscosity, average molecular mass and relation between them. Molecular mass distribution. Determination of molecular mass-Osmometry (membrane and vapour phase), light scattering, gel permeation chromatography, sedimentation and ultracentrifuge, viscosity method and end-group analysis.

Unit III: Physical characteristics of polymers **15 h**

Morphology and order in crystalline polymers**.** Configuration of polymer chains, crystal structure of polymers**.** Morphology of crystalline polymers, strain**-**induced morphology, crystallization and melting**.** The glass transition temperature **(**Tg**)**, relationship between T_g and T_T, Effect of molecular weight, dilments, chemical structure, chain topology, branching and cross linking**.** Methods of determination of glass transition and crystallinity of polymers**.**

Unit IV: Commercial polymers **15 h**

A**)** Organic polymers**:** Commercial polymers, synthesis and and application of polyethylene, Cellulose Acetate, PMMA, polyaimdes, polyesters, Urea resins and eposy resins**.**

B**)** Functional polymers**:** Fire retarding polymers and conducting polymers, biomedical polymers, Liquid Crystal Polymers.

List of books:

1) Textbook of polymer science: F.W. Billmayer Jr. Wiley.
2) Polymer science: V.R. Gowarikar, N. V. Viswanathan and J. Sreedhar, Wiley-Eastern.
3) Fractional monomers and polymers: K Takemoto, Y. Inaki, and R.M. Ottam Brite.
4) Contemporaty polymer chemistry: H.R. Alcock and F. W. Lambe, Prentice Hall.
5) Principles of polymer Chemistry: Flory, Cornell Univ. press.
6) Introduction to polymer chemistry: R. B. Seymour, McGraw Hill.
7) Principles of polymerization: Odian.
8) A first course in polymer chemistry: A. Strepikheyew, V. Derevistkay and G. Slonimasky, Mir Publishers, Moscow.
9) Laboratory preparation of macro chemistry: EMM effery, McGraw Hill Co.
10) A practical course in polymer chemistry: S.J. Punea , Pergamon Press.

Semester III
Paper XII Foundation Course - I (Code: MCH3T04)
Instrumental methods - I

60 h (4 h per week): 15 h per unit **60 Marks**

Course Outcomes: At the end of the course, student will be able to

1. Understand interaction between electromagnetic radiation with matter.
2. Calculate the energy of radiation in various units and interconvert them.
3. Discuss various types of sources and detectors used in different spectroscopies.
4. Summarize the principles involved in UV-visible and IR spectroscopy.
5. Apply proper spectral techniques depending on type of sample and required information.
6. Discuss various chromatographic techniques for multicomponent analysis.

Unit – I **15 h**

Basic concepts of spectral methods of analysis: Electromagnetic spectrum, Quantization of energy levels, types of transitions, absorption and emission spectroscopy, atomic and molecular spectroscopy.

Unit – II **15 h**

UV-Visible spectroscopy: Principle, instrumentation and applications.

Unit – III **15 h**

IR spectroscopy: Principle, instrumentation and applications.

Unit – IV **15 h**

Chromatography: Principle, instrumentation and applications of paper, thin layer and column chromatography.

Semester III
Seminar-III (Code: MCH3S01)

2 h /week Marks: 25

Seminar of 30 minutes duration will be a part of internal assessment for 25 marks (1 Credit). Seminar should be delivered by the student under the guidance of concerned teacher on the topic allotted by the teacher. The topic will be related to the syllabus. Marks will be allotted by a group of teachers.

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M.Sc. Chemistry

Semester IV

Core – I Spectroscopy - II

Paper XIII (Code: MCH4T01)

60 h (4 h per week): 15 h per unit 60 Marks

Course Outcomes: At the end of the course, student will be able to

1. Interprete the structures of simple molecules using physical methods of analysis
2. Understand and interprete the NMR data
3. Analyse X ray diffraction data
4. Develop the skills of analytical ability
5. Execute out the combined application of spectral method

Unit I: **15 h**

A] Ultraviolet and visible spectroscopy: Natural line width, line broadening, transition probability, Born-Oppenheimer approximation, rotational, vibrational and electronic energy levels. General nature of band spectra. Beer- Lambert Law, limitations, Frank-Condon principle, various electronic transitions, effect of solvent and conjugation on electronic transitions, Fiesher Wooodward rules for dienes, aldehydes and ketones. Structure differentiation of organic molecules by UV Spectroscopy

B] Photoelectron spectroscopy: Basic principles, photoelectric effect, ionization process, Koopman theorem, PES and XPES, PES of simple molecules, ESCA, chemical information from ESCA, Auger electron spectroscopy.

Unit II: Nuclear magnetic Resonance Spectroscopy **15 h**

Magnetic properties of nuclei, resonance condition, NMR instrumentation, chemical shift, spin spin interaction, shielding mechanism, factors affecting chemical shift, PMR spectra for different types of organic molecules, effect of deuteration, complex spin spin interaction (1^{st} order spectra), stereochemistry, variations of coupling constant with dihedral angle, electronegativity, Karplus equation etc., classification of molecules as AX, AX_2, AMX, A_2B_2, Shift reagents. NMR studies of ^{13}C, chemical shift in aliphatic, olefinic, alkyne, aromatic, heteroatomic and carbonyl compounds, ^{19}F, ^{31}P. Structure determination of organic molecules by NMR spectroscopy

Unit III: **15 h**

A] Application of NMR spectroscopy: FT-NMR, advantages of FT-NMR, two dimensional NMR spectroscopy-COSY, HETCOR, NOSEY, DEPT, INEPT, APT, INADEQUATE techniques, Nuclear overhauser effect, use of NMR in medical diagnosis

B] Problems based on structure determination of organic molecules by using NMR (^1H and ^{13}C nuclei) data, Structure elucidation using combined techniques including UV, IR, NMR and mass spectrometry (based on data and copies of the spectra)

Unit IV: Diffraction techniques **15 h**

X ray diffraction: Braggs condition, Miller indices, Laue method, Bragg method, Debye Scherrer method, identification of unit cells from systematic absences in diffraction pattern, structure of simple lattices and x-ray intensity, structure factor and its relation to intensity and electron density, absolute configuration of molecules.

Electron diffraction: scattering intensity vs scattering angle, Wierl equation, measurement techniques, elucidation of structure of simple gas phase molecules, low energy electron diffraction and structure of surfaces.

Neutron diffraction: Scattering of neutrons by solids and liquids, magnetic scattering, measurement techniques, elucidation of structure of magnetically ordered unit cell.

List of books

18] Spectroscopic identification of organic compound-RM Silverstein,GC Bassler and TC Morril, John Wally

19] Introduction to NMR spectroscopy-R. J. Abraham, J. Fisher and P Loftus Wiely
20] Application of Spectroscopy to Organic Compound-J. R. Dyer, Printice Hall
21] Organic Spectroscopy-William Kemp, ELBS with McMillan
22] Spectroscopy of Organic Molecule-PS Kalsi, Wiley, Esterna, New Delhi
23] Practical NMR Spectroscopy-ML Martin, JJ Delpench, and DJ Martyin
24] Spectroscopic Methods in Organic Chemistry-DH Willson, I Fleming
25] Fundamentals of Molecular Spectroscopy-CN Banwell
26] Spectroscopy in Organic Chemistry-CNR Rao and JR Ferraro
27] Photoelectron Spectroscopy-Baber and Betteridge
28] Electron Spin Resonance Spectroscopy-J Wertz and JR Bolten
29] NMR –Basic Principle and Application-H Guntur
30] Interpretation of NMR spectra-Roy H Bible
31] Interpretation of IR spectra-NB Coulthop
32] Electron Spin Resonance Theory and Applications-W gordy
33] Mass Spectrometry Organic Chemical Applications, JH Banyon
34] Spectroscopy- H. Kaur

Semester IV
Core – II General Chemistry - II
Paper XIV (Code: MCH4T02)

60 h (4 h per week): 15 h per unit 60 Marks

Course Outcomes: At the end of the course, student will be able to

1. Understand the states of solids and their magnetic properties.
2. Understand the category and type sof magnetic substances.
3. Understand the electrical properties of molecules and their uses in spectroscopic tools.
4. Summarize the principles involved Nano-synthesis.
5. Discuss various crystal structures and understand the pattern of defects in them.

UNIT I: SOLID STATE AND THEIR MAGNETIC PROPERTIES 15h

A**)** Solid State Chemistry**:** Metals, Insulators and Semiconductors, Electronic structure of solids-band theory**.** Band structure of metals, Insulators and Semiconductors, Intrinsic and Extrinsic Semiconductors, p-n junction, energy band formation, forward bias and reversed bias p-n junction, their applications, Superconductors— types, Meissner effect, BCS theory, Low Temperature Superconductor **(**LTSC**)** and High Temperature Superconductor **(**HTSC**)**, Conventional and organic Superconductors, their applications**.**

B**)** Magnetic Properties**:** Behaviour of substances in magnetic field, effect of temperature, Curie and Curie-weiss law, calculation of magnetic moments, magnetic materials, their structure and properties, Applications, structure/ property relations, numerical**.**

UNIT II: ELECTRICAL PROPERTIES OF MOLECULES 15h

Dipole moments of molecules, basic ideas of electrostatic interactions, polarizability, orientation polarization, Debye equations, limitation of the Debye theory, Clausius-Mossotti equation**.** electrostatic of dielectric medium, molecular basis of dielectric behavior, structural information from dipole moment measurements, use of individual bond dipole moments, application to disubstituted benzene derivatives, dipole moment and ionic character of a molecule, determination of dipole moment from dielectric measurements in pure liquids and in solutions**.** The energies due to dipole-dipole, dipole induced dipole and induced dipole-induced dipole interaction**.** Dispersion, dielectric loss and refractive index**.** Lennard-Jones potential**.**

UNIT III: SOLID STATE REACTIONS AND NANOPARTICLES 15h

A**)** **Solid State Reactions:** General principle, types of reactions**:** Additive, decomposition and phase transition reactions, tarnish reactions, kinetics of solid state reactions, factors affecting the solid state reactions**.** photographic process**.**

B**)** **Nanoparticles and Nanostructural materials:** Introduction, methods of preparation, physical properties, and chemical properties, sol-gel chemistry of metal alkoxide, application of

Nanoparticles, Charecterization of Nanoparticles by SEM and TEM**.** Nanoporous Materials**:** Introduction, Zeolites and molecular sieves, determination of surface acidity, porous lamellar solids, composition**-**structure, preparation and applications**.**

UNIT-IV: CRYSTAL STRUCTURES

A) Introduction to crystals, Unit Cell and lattice parameters, Symmetry elements in crystals, Absence of fivefold axis, Space groups, The Bravais Lattices, Miller Indices, Bragg's Equation, seven crystal system, Packing in crystals, Hexagonal Closest Packing (HCP) Cubic Closest Packing (CCP), Voids, packing fraction, Numerical.

B) Lattice Defects: Perfect & Imperfect crystals, point defects**,** Interstitial, Schottky defect, Frenkel defect, line defect & other entities, thermodynamics of Schottky & Frankel defects. Dissociation, theory of dislocation, plane defects- Lineage boundary, grain boundary, stacking fault, 3D defects, Defects & their concentrations, ionic conductivity in solids, Non stoichiometric compounds. Electronicproperties of Non-stoichiometric oxides.

Semester IV
Inorganic Chemistry Specialization Paper – II
Paper XV (Code: MCH4T03)

60 h (4 h per week): 15 h per unit 60 Marks

Course Outcomes: At the end of the course, student would be able to

2) Understand the importance of nanostructural materials.
3) Derive reaction rates of solid state reactions
4) Classify and characterize the coordination polymers
5) understand mechanism of photophysical and photochemical processes
6) Explain various redox processes in complexes.
7) Apply the structural aspects of metal pi complexes in organic synthesis.

Unit-I **15h**

A) Supramolecular chemistry:

Definition, intermolecular bonds, concepts and perspectives, cationic recognition, anionic recognition, neural molecular recognition: self-assembly concept and its application in molecular and supramolecular chemistry, supra molecular chemistry, supramolecular devices and machines.

B) Inorganic pharmaceuticals:

Lithium drgus, gold antiarithritic drugs, Bismuth drugs in the treatment of gastric ulcers, Cyclams as anti HIV agents, Radio-dignostic agents, contrast agenst for MRI and X-ray imaging.

C) Nanostructural materials:

Nanofibres, MXenes (two-dimensional inorganic compounds), Molecular Precursor routes to Nanoporous Materials: Zeolites & molecular sieves, porous lamellar solids, composition-structure, preparation & applications.

Unit-II **15h**

A) **Coordination Polymers**: Coordination polymers and their classification. Synthesis and applications of coordination polymers. Use of polymeric ligands in synthesis of coordination polymers. Organosilicon polymers. Synthesis and their uses.

B) **Characterization of coordination polymers on the basis of**:

i) Spectra (UV, Visible, IR and NMR)

ii) Magnetic and thermal (TGA, DTA and DSC) studies

Unit-III **15h**

A] Photophysical and photochemical properties of Gold(I) complexes: Introduction, Binuclear and trinuclear complexes, Mixed metal Systems, Photochemical reactivity, Solid state studies, Mononuclear Gold(I) complexes, Mononuclear three coordinate Gold(I) complexes

B) Redox reactions by Excited Metal Complexes: Energy transfer under conditions of weak interaction & strong interaction – exciplex formation, conditions of excited states to be useful as redox reactants, excited electron transfer, metal complexes as attractive candidates (2,2-bipyridine & 1,10-Phenanthroline complexes.), illustration of reducing and oxidizing character of ruthenium(II); role of spin-orbit coupling, lie time of these processes. Application of redox processes of electronically excited states for catalytic purposes, transformation of low energy reactants in to high energy products, chemical energy in to light.

C) Excited States of Metal Complexes: Electronically excited states of metal complexes, charge transfer spectra, charge transfer excitations, methods for obtaining charge transfer spectra.

Unit-IV **15h**

Transition Metal Pi Complexes-Carbon multiple bonds. Nature of bonding, structural characteristics & synthesis, properties of transition metal pi- Complexes with unsaturated organic molecules, alkenes alkynes, allyl, diene, dienyl, arene & trienyl complexes. Application of transition metal, organometallic intermediates in organic synthesis relating to nucleophilic & electrophilic attack on ligands, role in organic synthesis.

List of books:

1. Barsoum ,M.W.,Fundamentals of Ceramics,McGraw Hill ,New Delhi
2. Ashcroft ,N.W. and Mermin,N.D.,SolidStaePhysics,Saunders College
3. CallisterW.D.,Material Science and Engineering, An Introduction,Wiley
4. Keer,H.H,Principals of Solid State,Wiley Eastern
5. Anderson J.C.,LeverK.D.,Alexander J.M and Rawlings,R.D.,ELBS
6. GrayG.W.Ed.Thermotropic Liquid Crystals,John Wiley
7. Kelkar and Hatz Handbook of Liquid Crystals,ChemieVerlag.
8. Kalbunde K.I.,Nanoscale Materials in Chemistry,JohnWiley,NY.
9. Shull R.D.,McMichael R.D. and SwartzendrubL.J.,Studies of Magnetic Properties of Fine particles and their relevance to Mataerials Science, Elsevier Pub. Amsterdam
10. Optoelectronic Properties of Inorganic Compounds, D. Max Roundhill and John P. Fakler, Jr. Plenum Press, New York

Semester IV
Practical - VII (Code: MCH4L01)
Inorganic Chemistry Specialization

8 h /week Marks: 100

Course Outcomes: At the end of the course, student will be able to

1. Prepare various complexes by wet chemical methods.
2. Carry out characterization of prepared complexes.
3. Interpret the electronic and magnetic properties of complexes.
4. Elucidate the spin states of various complexes using susceptibility studies.
5. Deduce the structures of crystalline solids.
6. Carry out photochemical reactions in complexes

A) Preparation and characterization of following complexes/organometallic compound including their structural elucidation by the available physical methods**. (**element analysis molecular weight determination, conductance and magnetic measurement and special studies**)**

1 Preparation of mercury tetrathiocyanotocobaltate**(**II**)**

2 Preparation of Iron **(**II**)** oxalate & potassium trioxalatoferrate **(**III**)** trihydrate

3 Preparation of cis & trans potassium dioxalatodiaquochromate **(**III**)**

4 Preparation of hexa-aminecobalt(III) chloride
5 Preparation of hexa-aminenickel(II) chloride
6 Preparation of tris (acetylacetonato) manganese (III)
7 Preparation of N-N bis (salicyldehyde) ethylene diaminonato nickel (II)
8 Preparation of trinitrotriaminocobalt(III)
9 Preparation of chloropentammine cobalt (III) chloride
10 Preparation of potassium trioxalatochromate (III)
11 To prepare copper (II) acetylacetonate complex
12 To prepare cis and trans bis (glycinato) Cu II monohydrate complex
13 To prepare dipyridineiodine (I) nitrate
14 Preparation of ammonium nickel(II) sulphate

B) SOLID STATE

1 Preparation of oxides and mixed oxides (MnO2 , NiO, Cu2O, Fe3O4, ZnFe2O4, ZnMn2O4, CuMnO4and NiFe2O)
2 Preparation of silica and alumina by sol –gel technique
3 To study the electrical conductivity of ferrites, magnetite's, doped oxides and pure samples and determine band gap

C) SEPARTION AND QUANTITATIVE ESTIMATION OF BINARY AND TERNARY MIXTURE BY THE USE OF FOLLOWING TECHNIQUES:

1 Paper and thin layer chromatography
2 Ion exchange
3 Solvent extraction

D) INORGANIC PHOTOCHEMISTRY

1. Synthesis of potassium ferrioxalate and determination of intensity of radiation
2. Photo oxidation of oxalic acid by UO_2^+ sensitization
3. Photo decomposition of HI and determination of its quantum yield

List of books:

1. Practical Inorganic Chemistry - Pass
2. Practical Inorganic Chemistry - Marr & Rocket
3. Basic Concept Of Analytical Chemistry - Khopkar S. M.
4. Synthesis And Characterisation Of Inorganic Compounds – W. L. Jolly, Prentice Hall
5. Inorganic Experiments – J. Derck Woollins, Vch.
6. Practical Inorganic Chemistry – G. Marrand, B.W. Rockett, Van Nostrand
7. A Text Book Of Quantitative Inorganic Analysis – A.I. Vogel, Longoman.
8. Edta Titration – F. Laschka
9. Instrumental Methods Of Analysis – Willard, Merit And Dean (Cbs, Delhi)
10. Inorganic Synthesis – Jolly
11. Instrumental Methods Of Chemical Analysis – Yelri Lalikov
12. Fundamental Of Analytical Chemistry- Skoog D .A. And West D. M. Holt Rinehart And Winston Inc.
13. Experimental Inorganic Chemistry7 – W.G. Palmer, Cambridge
14. Solid Stst Chemistry – N.B. Hanney
15. Introduction To Thermal Analysis , Techniques And Applications – M. E. Brown, Springer
16. Preparation And Properties Of Solid State Materials – Wilcox, Vol I&Ii, Dekker
17. The Structure And Properties Of Materials – Vol Iv, John Wulff,Wiley Eastern

Semester IV
Organic Chemistry Specialization Paper – II
Paper XV (Code: MCH4T03)

60 h (4 h per week): 15 h per unit 60 Marks

Course Outcomes: At the end of the course students would be able to

1. Understands the reactivity of heterocyclic compounds in various reaction conditions

2. Understand the electrophilic, nucleophilic reactions and synthesis of various heterocycles.
3. Design the synthesis of drugs and natural products
4. Demonstrate the applications of organometallic reagents in C-C bond formation

Unit I: Heterocycles **15h**

A) **Azoles:** Structural and chemical properties; Synthesis of pyrazole, isothiazole and isoxazole; Synthesis of imidazoles, thiazoles and oxazoles; Nucleophilic and electrophilic substitutions; Ringcleavages, Carbonyldiimidazole as coupling agent

B) Benzofused heterocycles: Synthesis of indole, benzofuran and benzo-thiophene, quinoline and isoquinoline Nucleophilic, electrophilic and radical substitutions; Addition reactions; Indole rings in biology.

C) Diazines: Structural and chemical properties; Synthesis of pyridazines, pyrimidines, pyrazines; Nucleophilic and electrophilic substitutions.

D) Synthesis of following bioactive compounds: Vitamin B6, Ondansetron, Serotonin, Indometacin, Cyanamid, fentiazac, trimethoprim, papaverine

Unit II: Designing the synthesis based on retrosynthetic analysis **15 h**

A) Disconnection Approach: An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter-conversions, the importance of the order of events in organicsynthesis, one group C-X and two group C-X disconnections, chemoselectivity, reversal of polarity, cyclisation reactions, amine synthesis

B) One Group C-C Disconnections: Alcohols andcarbonyl compounds, regioselectivity, alkenesynthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis

C) Two Group C-C Disconnections: Diels-Alder reaction, 1,3-difunctionalised compounds, α,β-unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalisedcompounds, Michael addition and Robinson annelation, Methods of ring synthesis, Linear and convergent synthesis

Unit III: **15 h**

A) Protection and Deprotection of functional groups: Protection and deprotection of functional groups like, hydroxyl, amino, carbonyl and carboxylic acids groups, Solid phase peptide synthesis.

B) Total synthesis of FR-900848, cubane, biotin, longifolene and taxol

C) Prostaglandins: Occurrence, nomenclature, classification, biogenesis and physiological effects. Synthesis of PGE2 and PGF2 (E. J. Corey and Gilbert Stork synthesis only) and iodolactonization reaction

Unit IV: **15 h**

Organometallic compounds of Group I and II Metals: Synthesis and applications of organolithium and organomagnesium reagents, nucleophilic addition to aldehyde, ketones, ester, epoxide, CO_2, CS_2, isocyanates, ketenes, imines, amides, lactones, Stereochemistry of Grignard addition to carbonyl compounds, *o*-metallation of arenes using organolithium compounds, Organocopper reagents: Preparation and applications in C-C bond forming reaction, mixed oragnocuprates, Gilman's reagent. Organo Hg and Cd reagents in organic synthesis, Reformatsky reaction, Barbier reaction

Books:

1) Organic Chemistry, J. Clayden, N. Greeves, S. Warren and P. Wothers, Oxford University Press
2) Principal of Modern Heterocyclic Chemistry-L. A. Paquelte
3) Heterocyclic Chemistry-J. Joule and G. Smith
4) Heterocyclic Chemistry-Morton
5) An Introduction to Chemistry of Heterocyclic Compound-J. B. Acheson
6) Organic Synthesis, The disconnection approach-S. Warren
Designing Organic Synthesis-S. Warren

Semester IV
Practical - VII (Code: MCH4L01)
Organic Chemistry Specialization

8 h /week Marks: 100

Course Outcomes: At the end of the course students would be able to

1. Meticulously record physical constants
2. Perform qualitative estimation of functional groups
3. Monitor the progress of reaction
4. Recrystallize /distill the separated compounds
5. Extend these skills to organic synthesis

Note: Any 3 sets should be conducted from the following convergent and divergent synthesis sets. Students should acquire pre-experiment (Reading MSDS, purification of reactants and reagents, mechanism, stoichiometry etc) and post-experiment skills (work-up, isolation and purification of products, physical constants characterization using any spectroscopic methods etc.)

SET-I

A) Convergent Synthesis 1 (Three Stage Synthesis)
1. Stage I: Anisole to 4-nitro anisole to 4-amino anisole (2 steps)
2. Stage II: Toluene to 4-nitro toluene to 3-acyl nitro toluene (2 steps)
3. Stage III: Synthesis of N-(1-(2-methyl-5-nitrophenyl) ethyl) aniline from 4-amino anisole, 3-acyl nitro toluene and SBH (One pot synthesis: MCR)

B) Divergent Synthesis 1 (5 Single Stage Synthesis from Acetyl acetone):
1. Acetyl acetone to Pyrimidine
2. Acetyl acetone to 2,4-dimethyl-1H-benzo[*b*][1,4]diazepine
3. Acetyl acetone to pyrazole
4. Acetyl acetone with 1mmol benzaldehyde to 3-benzylidenepentane-2,4-dione
5. Acetyl acetone with 3 mmol benzaldehyde into 3-benzylidene-6-phenylhex-5-ene-2,4- dione

SET-II

A). Convergent Synthesis 2(Three Stage Synthesis)
1. Stage I: 4-Nitro toluene to 4-amino toluene (Reduction by using Sn/HCl)
2. Stage II: Phenol into 2-hydroxy benzaldehyde (Reimer-Tiemann reaction)
3. Stage III: Synthesis of amidoalkyl-2-naphthols from β-Naphthol,4-amino toluene and of 2-hydroxy benzaldehyde (One pot synthesis: MCR)

B). Divergent Synthesis (5 Single Stage Synthesis from β-Naphthol)
1. β-Naphthol to Synthetic dye (By diazonium coupling)
2. β-Naphthol to 6-Bromo-2-naphthol (Bromination reaction)
3. β-Naphthol to β-Naphthyl methyl ether (Methylation reaction)
4. β-Naphthol to temperature dependent sulfonation (Sulfonation reaction)
5. β-Naphthol to (±) Binol then Resolution of Binol (Resolution technique)

SET-III

A). Convergent Synthesis-3 (Three Stage Synthesis)
1. Stage I: Salicylic acid to 5-Chloro-2-hydroxybenzoic acid
2. Stage II: o- Anisidine to 2-methoxy-4-nitroaniline
3. Stage III: Synthesis of 5-chloro-2-hydroxy-N-(2-methoxy-4-nitrophenyl) benzamide from 5-Chloro-2-hydroxybenzoic acid, -methoxy-4-nitroaniline (One pot synthesis: MCR)

B). Divergent Synthesis-3 (5 Single Stage Synthesis from Salysaldehyde)
1. Salicylaldehyde to Salicylaldehyde phenylhydrazone
2. Salicylaldehyde with melanonitrile to 2-iminochromene by intramolecular cyclization.
3. Salicylaldehyde to 2-hydroxy-3,5-dinitrobenzaldehyde
4. Salicylaldehyde to o-Formylphenoxy acetic acid
5. Salicylaldehyde to catechol

SET-IV

A) Convergent Synthesis- 4 (Three Stage Synthesis)
1. Stage I: Benzene to actophenone (F.C acylation)
2. Stage II: 4-Nitrochlorobenzene into 4-amino chlorobenzene (Reduction by using hydrazine)
3. Stage III: Quinoline synthesis by using acetophenone, 4-amino chloro benzene and styrene (One pot synthesis: [3 + 2 + 1] cycloaddition reaction)

B). Divergent Synthesis-4 (5 Single Stage Synthesis from Acetophenone)
1. Acetophenone to Ethyl benzene by Wolf Kishner reduction
2. Acetophenone to m-Nitro acetophenone by nitration
3. Acetophenone to Chalcone using aromatic aldehyde
4. Acetophenone into Schiff base using aromatic amine
5. Acetophenone to Benzoic acid and Iodoform

B) SPECTRAL INTERPRETATION

Structure Elucidation of organic compounds on the basis of spectral data (UV, IR, ^{1}H and $^{13}CNMR$ and Mass) (Minimum 8-10 compounds are to be analysed during regular practicals).

References

1. Practical organic chemistry by Mann and Saunders
2. Text book of practical organic chemistry –by Vogel
3. The synthesis, identification of organic compounds –Ralph L. Shriner, Christine K.F.
4. Hermann, Terence C. Morrill and David Y. Curtin

Semester IV

Physical Chemistry Specialization Paper – II
Paper XV (Code: MCH4T03)

60h *(*4h*/*week*)* 15h*/*unit 60 Marks

Course Outcomes: At the end of the course students will be able to

1. Execute the chemical dynamical calculations and research applications
2. Understand the applications of electrochemistry in industrial as well as research applications
3. Analyze the applications of radiation chemistry
4. Gain the knowledge of battery technology and their operations so as to work in the concerned research field
5. Understand, analyze and execute the concepts of quantum mechanics in various fields

UNIT-I CHEMICAL DYNAMICS - II **15h**

A**)** Overview of Arrhenius rate law, Non**-**conventional equilibrium between reactants and activated complexes**.** Potential energy surfaces and reaction coordinate**.** Derivation of transition state theory-based equation for rate constant of bimolecular reaction**.** Prediction of rate constant using partition function and comparison with that given by collision theory**.** Arrhenius equation and activated complex theory**.** Transmission coefficient, quantum mechanical tunneling,

B) Reactions in solution: Cage effect, diffusion-controlled reactions, volume of activation its determination and correspondence with entropy of activation, Ionic reactions: Primary (Ionic strength) and Secondary salt effect and their nature.

UNIT II CORROSION AND CORROSION ANALYSIS 15h

A) Scope and economics of corrosion, causes (Change in Gibbs free energy), Electrochemical Series and Galvanic series, dry (atmospheric) and wet (electrochemical) corrosion, other types of corrosion-Pit, Soil, chemical and electrochemical, inter-granular, waterline, microbial corrosion, measurement of corrosion by different methods, factors affecting corrosion, passivity, galvanic series, protection against corrosion, design and material selection.

B) Thermodynamics of corrosion, corrosion measurements (Weight loss, OCP measurements, polarization methods), passivity and its breakdown, corrosion prevention (electrochemical inhibitor and coating methods).

UNIT – III: RADIATION CHEMISTRY AND BATTERY TECHNOLOGY 15h

A) Interaction of radiation with matter, radiation track spurs and γ-rays. Linear energy transfer, Bathe's equation for linear energy transfer, Bresstrahlung effect, Passage of neutron through matter, Interaction of γ -radiation with matter, photoelectric effect and Compton effect, pair production phenomena, units of measuring radiation absorption, Chemical Dosimeters, Fricke Dosimeter and Ceric Sulphate Dosimeter, Conversion of measured dose values, Radiolysis of water, Radiolysis of some aqueous solutions. Effect of radiation on biological substances, genetic effects, Radiation effects on organic compounds and Polymers.

B) Battery Technology: basic concept, classification of batteries, primary, secondary and reserve batteries, Construction, working and application of Acid Storage batteries, Lithium -MnO_2 batteries, Nickel- Metal hydride batteries, Fuel Cells, Construction and working of $H_2O_2$and methanol-O_2 Cell.

UNIT IV: ELECTRICAL AND THERMAL PROPERTIES OF SOLIDS 15h

A) Classical free electron theory, electrical conductivity, thermal conductivity, Wiedemann-Franz Law, Lorenz number, Electronic distribution in solids using Fermi Dirac Statistics, The Fermi Distribution function and effect of temperature, Quantum theory of free electrons, periodic potential, The Kronig-Penney Model, Brillouin Zones, Distinction between metals, insulators and intrinsic semiconductors based on above theory.

B) Thermal Properties: Specific heat of solids, Classical theory, Einstein's theory of heat capacities, Debye theory of heat capacities or Debye T-cubed law.

Books Sugggested:

1) G.M.Panchenkov and V.P.Labadev, " Chemical Kinetics and catalysis", MIR Publishing
2) E.A. Moelwyn- Hughes, " Chemical Kinetics and Kinetics of Solutions", Academic
3) K.J.Laidler, Chemical Kinetics, Third Edition (1987), Harper and Row, New York
4) J.Raja Ram and J.C.Kuriacose, Kinetics and Mechanism of Chemical Transformations McMilllan IndianLtd., New Delhi (1993)
5) C. H. Bamford and C. F. H. Tipper, Comprehensive Chemical Kinetics, **Vol 1**., Elsevier Publications, New York, 1969.
6) Gholam-Abbas Nazri, Gianfranco Pistoia, Lithum Batteries-Science and Technology, Springer, 2003.
7) C. H. Bamford and C. F. H. Tipper, Comprehensive Chemical Kinetics, **Vol 2**., Elsevier Publications, New York, 1969.
8) S. Glasstone, K. J. Laidler and H. Eyring, The Theory of Rate Processes, Mc-Graw Hill, New York, 1941.
9) Santosh Kumar Upadhyay, Chemical Kinetics and Reaction Dynamics, Springer 2006.
10) D. Mcquarie and J. Simon, Physical Chemistry – A Molecular Approach, University Press, 2000
11) G. M. Barrow, Physical Chemistry, Tata Mc-Graw Hill, V edition 2003.
12) H. K. Moudgil, Text Book of Physical Chemistry, Pretice Hall of India, New Delhi, 2010.
13) S. O. Pillai, Solid State Physics, New Age International, New Delhi, 2102.

14) C.Kittel, " Introduction to solid state Physics",Wiley
15) L.V.Azaroff, " Introduction to solids", McGraw Hill
16) Santosh Kumar Upadhyay, Chemical Kinetics and Reaction Dynamics, Springer 2006.
17) N. B. Hanny, Treaties in Solid State Chemistry, 4th Edn,
18) N. B. Hanny, "Solid State Chemistry"
19) M. C. Day and J Selbin, Theoretical Inorganic Chemistry, Reinhold Pub. Corp., New York,
20) C.N.Rao. Nuclear Chemistry
21) B. G. Harvey, Introduction to Nuclear Physics and Chemistry, Prentice Hall, Inc. (1969).
22) H.J. Arnikar, Essentials of Nuclear Chemistry, 4th Edition (1995), Wiely-Eastern Ltd., New Delhi.
23) W. Loveland, D. Morrissey and G. Seaborg, Modern Nuclear Chemistry, Wiley-Interscience, 2006.
24) P. P. Milella, Fatigue and Corrosion in Metals, Springer, 2013.
25) Corrosion- Understanding the Basics, asminternational.org, 2000.
26) H. H. Uhlig, Corrosion and Corrsion Control – 3rd edn, John Wiley & sons, New York.
27) J. W. T. Spinks and R. J. Woods, An Introduction to Radiation Chemistry, John Wiley and sons., New Yoek, 1975.
28) K. L. Kapoor, Text Book of Physical Chemistry, Vol – I to Vol-VI, 2011.

Semester IV
Practical - VII (Code: MCH4L01)
Physical Chemistry Specialization

8 h /week Marks: 100

Course Outcomes: At the end of the course students will be able to

1. Inculcate the potential of establishing any new laboratory at UG or PG level.
2. Execute the theoretical principles in practical
3. Analyze and interpret the results of their performances
4. Inculcate the skills of preparing, maintaining and developing the chemicals and reagents
5. Understand the role of laboratory safety and preparedness

Adsorption:

1) To verify Freundlich adsorption isotherm.
2) To verify Langmuir adsorption isotherm.
3) To verify Gibbs adsorption isotherm and to find surface excess concentration of solute.
4) Study of variation of surface tension of solution of n-propyl alcohol with concentration and hence determine the limiting cross section area of alcohol molecule.

Kinetics:

1) Clock reaction- activation energy of bromide-bromate reaction.
2) Temp dependence of persulfate-iodide reaction by iodine clock method and calculation of thermodynamic and Arrhenius activation parameters. Study of ionic strength effect on persulfate-iodide reaction.
3) Kinetics of B-Z reaction; Kinetics of modified B-Z reaction
4) Investigate the Autocatalytic reaction between potassium permanganate and oxalic acid.
5) Determination of pKa value of a weak acid by chemical kinetic method (formate-iodine reaction)

Potentiometry:

1) Transport number by potentiometry.
2) To determine degree of hydrolysis of aniline hydrochloride and hence to determine the hydrolysis constant of salt by potentiometry method.
3) To determine pK of weak acids, succinic acid, acetic acid, Malonic acids, (dibasic acids).
4) Complexation between $Hg^{2+}$and I^- conductometrically.

Conductometry:

1) To determine degree of hydrolysis of aniline hydrochloride and hence to determine the hydrolysis constant of salt by conductometric method.
2) To determine pK of weak acids, succinic acid, acetic acid, Malonic acids, (dibasic acids).

3) Complexation between $Hg^{2+}$and I^- conductometrically.
4) To determine solubility product of lead chromate.
5) Kinetic study of saponification ethyl acetate by conductometry.

Spectrophotometry:

1) To determine the stability constant of reaction between Ferric ion solution and SCN^- ion solution by Job's method.
2) To determine the stability constant between Fe^{3+} and SCN^- ion solution by Ostwald & Frank method.

Transport Number:

1) To determine transport number by Hittorff's method
2) To determine the transport number by moving boundary method

List of Books

1) Vogel A, 3rd Edition : A Textbook Of Quantitative Inorganic Analysis, Longman
2) Das and Behra, Practical Physical Chemistry
3) Carl W. Garland, Joseph W. Nibler and David P. Shoemaker, Experiments in Physical Chemistry, Mc-Graw Hill, 8th Edition, 2009.
4) Farrington Daniels, Joseph Howard Mathews, John Warren Williams, Paul Bender, Robert A. Alberty, Experimental Physical Chemistry, Mc-Graw Hill, Fifth Edition, 1956.
5) John W. Shriver and Michael George, Experimental Physical Chemistry, Lab Manual and Data Analysis, The University of Alabama in Huntsville, Fall 2006
6) Day And Underwood :Quantitative Analysis
7) Merits And Thomas:Advanced Analytical Chemistry
8) Ewing, G. W. : Instrumental Methods Of Chemical Analysis, Mcgraw-Hill
9) Drago, R.S:Physical Methoods In Inorganic Chemistry
10) Christain G.D:Analytical Chemistry
11) Khopkar S.M.:Basic Concept Of Analytical Chemistry
12) Koltath And Ligane:Polorography
13) Braun:Instrumental Methods Of Chemical Analysis
14) Willard, Merritt And Dean: Instrumental Methods Of Chemical Analysis ,Van Nostrand
15) Strouts,Crifi;Llan And Wisin: Analytiacl Chemistry
16) Skoog S.A. And West D. W.:Fundamental Of Analytical Chemistry
17) Dilts R.V.: Analytiacl Chemistry
18) Jahgirdar D.V :Experiments In Chemistry
19) Chondhekar T.K: Systematic Experiments In Physical Chemistry, Rajbog S.W., Aniali Pubn.
20) Wlehov G. J: Standard Methods Of Chemicalanalysis 6th Ed
21) Ramesh Rand Anbu M, Chemical Methods For Envirnmental Analysis : Watewr And Sedient , Macmillion India

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Semester IV
Specialization Paper – II
Analytical Chemistry
Paper XV (Code: MCH4T03)

60h *(*4h/week*)* 15h/unit 60 Marks

Course Outcomes: At the end of the course, student will be able to

1. Understand the fundamental principles forming basis for the instrumental methods of analysis.
2. Select most suitable technique for the desired analysis.
3. Identify experimental conditions necessary to carry out the analysis of different samples.
4. Formulate experiments based on optical and electroanalytical techniques.
5. Demonstrate working of each instrument used in analysis.

Unit-I: **Optical methods of analysis-IV** **15h**

Inductively coupled plasma-atomic emission spectroscopy: Principle, atomization and excitation. Plasma source and sample introduction. Instrumentation. Comparison of ICP-AES with AAS. Applications.

X-ray fluorescence spectroscopy: Principle. Instrumentation: wavelength and energy dispersive devices. Sources and detectors. Comparison between wavelength and energy dispersive techniques. Sample preparation for XRF. Matrix effects in XRF. Applications in qualitative and quantitative analysis.

Electron microscopy: Principle, instrumentation and applications of scanning electron microscopy (SEM) and transmission electron microscopy (TEM)

Unit-II: **Electrochemical methods of analysis-IV** **15h**

Ion selective electrodes: Theory of membrane potential. Types of ion-selective electrodes. Construction of solid state electrodes, liquid membrane electrodes, glass membrane electrodes and enzyme electrodes, Selectivity coefficients, Glass electrodes with special reference to H^+, Na^+ and K^+ ions. Applications of ISE in analysis of environmentally important anions like F^-, Cl^-, Br^-, I^-, NO_3^- and CN^-. Advantages of ISE.

Coulometry: Principle. Coulometry at constant potential and constant current. Instrumentation. Applications and advantages of coulometric titrations.

Electrochemical microscopy: Introduction to scanning probe microscopy (SPM), scanning tunneling microscopy (STM), atomic force microscopy (AFM) and scanning electrochemical microscopy (SECM).

Unit-III: **Thermal methods of analysis** **15h**

Introduction to different thermal methods, Thermogravimetry (TG and DTG), Static thermogravimetry, quasistatic thermogravimetry and dynamic thermogravimetry, Instrumentation-Balances, X-Y recorder, Stanton-Redcroft TG-750, Thermogram, Factors affecting thermogram, Applications of thermogravimetry, Differential Thermal Analysis (DTA)-Theories, DTA curves, Factors affecting DTA curve, Applications of DTA, simultaneous determination in thermal analysis, Differential Scanning Calorimetry (DSC)- Introduction, Instrumentation, DSC curves, factors affecting DSC curves, applications, Thermogravimetric titration-Theory, Instrumentation and applications.

Unit-IV: **Air pollution and analysis** **15h**

Air pollution and analysis-classification of air pollutants, sources of air pollution and methods of control, sampling of aerosols and gaseous pollutants and their effects, SO_2, NO_2, CO, CO_2, particulates-SPM, RSPM, High Volume Sampler, Fabric Filters, Cyclones (direct and Reverse), ESP, ozone layer, Green house effect, Heat Islands, Acid Rain.

Semester IV
Practical - VII (Code: MCH4L01)
Analytical Chemistry Specialization

8 h /week Marks: 100

Course Outcomes: At the end of the course, student will be able to

1. Understand the principles involved in organic elemental analysis and estimation of organic compounds.
2. Estimate ion exchange capacity of different resins.
3. Design solvent extraction experiment for desired metal ions.
4. Separate various components in a mixture for quantitative anlaysis.
5. Analyze various ground and surface water samples.
6. Establish the thermal stability of various organic and inorganic compounds.

Organo-analytical chemistry

1. Estimation of sulphur, nitrogen, phosphorous, chlorine in organic compound.
2. Estimation of phenol.
3. Estimation of aniline.

Ion exchange

1. Determination of ion exchange capacity of resin.
2. Separation and estimation of zinc and magnesium/cadmium in a mixture on anion exchanger.
3. Separation and estimation of chloride and iodide in a mixture on anion exchanger.

Solvent extraction

1. Estimation of Copper using Na-DDC.
2. Estimation of Iron using 8-hydroxyquinoline.
3. Estimation of Nickel using DMG.
4. Estimation of Cobalt using 8-hydroxyquinoline.
5. Estimation of Nickel by synergistic extraction with 1,10-phenanthroline and dithizone.

Theremogravimetry

1. Recording and analysis of thermogram of $CuSO_4.5H_2O$.
2. Recording and analysis of thermogram of CaC_2O_4.
3. Recording and interpretation of thermogram of polymers.

Applied analytical

1. Analysis of ores: Ca and Mg in Dolomite, Mn in Pyrolusite.
2. Analysis of cement: Silica, alumina, ferric oxide, calcium and magnesium oxide, sodium and potassium oxide.
3. Analysis of oils: Carbon residue, Acid value, Saponification value, Iodine value, Viscosity, Flash point, Cloud point, Aniline point.
4. Analysis of drugs: Fe in capsule, ascorbic acid in vitamin-C tablet, Mg in milk of magnesia tablet/syrup.
5. Bleaching powder: Available chlorine.
6. Polymer analysis: Molecular weight, Saponification value, Iodine value.
7. Food: Phosphoric acid in cola beverages by pH titration.

Semester IV
Core Subject Centric - II
Applied Analytical Chemistry
Paper XVI (Code: MCH4T04)

60h *(*4h/week*)* 15h/unit 60 Marks

Course Outcomes: At the end of the course, student will be able to

1. Compare various methods of water treatment for hardness removal.
2. Interpret the nature of corrosion involved in various metals under environmental conditions.
3. Identity the methods of corrosion inhibition based on type of corrosion.
4. Elaborate the steps involved in metallurgy of commercially important metals.
5. Develop own method of clinical anlaysis analysis.
6. Validate various methods of clinical analysis.

Unit-I: Water treatment **15h**

Hardness of water and types of hardness. Problems due to hardness. Removal of hardness by lime-soda process, Zeolite process and synthetic ion-exchange resins. Principle, instrumentation and comparison of these three processes. Numericals based on hardness removal. Desalination of sea-water.

Unit-II: Corrosion and corrosion analysis **15h**

Definition, drawbacks and theories of corrosion. Dry and wet corrosion, Different types of corrosion-Pit, Soil, chemical and electrochemical, intergrannular, waterline, microbial corrosion, measurement of corrosion by different methods, factors affecting corrosion, passivity, galvanic series, protection against corrosion, design and material selection.

Unit-III: Metallurgy **15h**

Ores and minerals, General principles of extraction of metals from ores. Steps involved in metallurgical extraction. Purification and concentration of ores. Extraction of crude metal from concentrated ore-pyrometallurgy, hydrometallurgy and electrolytic processes. Refining of metal. Thermodynamic aspects of metallurgical processes and Ellingham diagram. Furnaces in metallurgy. Metallurgy of Cu, Ag, Au, Al and Fe.

Unit-IV: Clinical analysis **15h**

General composition of blood, Collection and storage of blood samples, Estimation of chloride, calcium, sodium, potassium and bicarbonate in blood sample. Qualitative tests for reducing sugar. Estimation of blood glucose, urea, serum albumin, serum creatinine, serum phosphate, serum bilirubin, Radioimmunoassay (RIA).

List of books

1. Lynch's medical laboratory technology: S. S. Raphel
2. Basic Food Chemistry: F. Lee (AVI publishing company)
3. Industrial chemistry: B. K. Sharma
4. Parikh's text book of medical jurisprudence, forensic medicine and toxicology: C.K.Parikh (CBS publishers)
5. A Practical Course in polymer chemistry: S. J. Punea (Pergamon press).
6. The Text book on Petrochemical by Dr. B. K. Bhaskar Rao (Khanna Publishers).
7. Analytical chemistry: Alka Gupta (Pragati Prakashan)
8. Applied Chemistry: Vermani and Narula (New Age International)
9. Applied Chemistry I and II: V. M. Balsaraf (I K International)
10. Corrosion analysis: Michael Dornbusch (CRC press)
11. Corrosion and Corrosion Control: An Introduction to Corrosion Science and Engineering: R. Winston (Wiley)
12. A lab manual of polymers: Ashraf, Ahemad, Riaz (I K International)
13. Experiments and calculations in engineering chemistry: S. S. Dara, (S. Chand)

Semester IV
Core Subject Centric - II
Environmental Chemistry
Paper XVI (Code: MCH4T04)

60h *(*4h/week*)* 15h/unit 60 Marks

Course Outcomes: At the end of the course, student will be able to

1. Understand the principles involved in toxicant analysis in environmental samples.
2. Estimate various analytical parameters of different samples.
3. Interpret the results obtained by subjecting them to statistical analysis.
4. Elaborate water, air and soil quality parameters and their significance.
5. Explain the methods of reducing various types of pollution.

Unit-I: Water Pollution **15h**

Pollutants- Types of pollutants, sources of water pollution, sampling, preservation and storage of water sample, physico –chemical, organoleptic and chemical analysis of water, electro-analytical, optical (UC-visible spectrophotometry, AAS, flame photometry, XRF, ICPAES), chromatographic (GC and HPLC) and neutron activation methods of analysis of Co, Ni, Cu, Fe,

Mn, Zn, Cd, Pb, Hg, As, Cl^-, F^-, $SO4^{--}$, PO_4^-, NO_3^-. Historical development of detergents, chemistry of soaps and detergents.

Unit-II: Air Pollution **15h**

Natural versus polluted air, air quality standards, air sampling, analysis and control of Particulates, Chemistry and analysis of SOx, NOx, CO, ozone, hydrocarbons, CFCs. Chemistry of gaseous, liquid and solid fuels- gasoline and additives, antiknock agents. Air pollution control—control of automobile emission and control measures in thermal power stations.

Unit-III: Soil Pollution **15h**

Types and sources of soil pollution, classification of soil pollutants, impact of soil pollution on air quality, Specifications for disposal of sewage and effluent on land for irrigation and ground water recharge. Methodology of waste water disposal on land in India. Impact of usage of land for solid waste disposal both municipal solid waste and industrial solid wastes (fly ash from thermal power station, lime sludge from paper and pulp industry), cause of soil erosion, effects of soil erosion, conservation of soil, control of soil pollution.

Unit-IV: Solid waste and management **15h**

Sources, types and consequences, classification of wastes- domestic, industrial, municipal, hospital, nuclear and agricultural and their methods of disposal. Transfer and transport, Recycle, reuse, recovery, conversion of solid wastes -energy / manure. Analysis and monitoring of pesticides. Microplastics in environment. e-waste.

Impact of toxic chemicals on enzymes, Biochemical effects of As, Cd, Pb and Hg, their metabolism, toxicity and treatment.

Semester IV

Core Subject Centric - II

Biomolecules and Medicinal Chemistry

Paper XVI (Code: MCH4T04)

60h *(*4h/week*)* 15h/unit 60 Marks

Course Outcomes: At the end of the course students would be able to

1. Understand the way how drug can be administrated, absorbed, distributed and metabolized
2. Understand the relation of drug with different types of receptors, chemical messengers, binding site and DNA.
3. Draw the structures of essential biomolecules
4. Understand the role of biomolecules in various life processes

Unit I: **15 h**

A) Carbohydrate: Types of naturally occurring sugars, deoxy sugars, amino sugars, branched chain sugars, methyl ethers and acid derivatives of sugars, configurations of aldoses and ketoses, general methods of structure and ring size determination with reference to maltose, lactose, sucrose, Structural features and applications of inositol, starch, cellulose, chitin and heparin

B) Amino acids, protein and peptides: Amino acids, structural characteristics, acid base property, stereochemistry of amino acids, optical resolution, Stecker synthesis, peptide and proteins structure of peptide and protein, primary, secondary, tertiary and quaternary structure. Reaction of polypeptide, structure determination of polypeptide, end group analysis, strategy of peptide bond synthesis: *N*-Protection and *C*-Activation, Solid phase peptide synthesis

Unit II: **15h**

A) Nucleic Acids: Primary, secondary and tertiary structure of DNA; DNA replication and heredity; Structure and function of mRNA, tRNA and rRNA. Purines and pyrimidine bases of nucleic acids and their preparation, Biosynthesis of DNA and RNA, Polymerase Chain Reaction (PCR) and RTPCR

B) Lipids: Fatty acids, essential fatty acids, structures and functions of triglycerols, glycerophospholipids, spingolipids, lipoproteins, composition and function, role in atherosclerosis Properties of lipid aggregates, micells, bilayers, liposomes and their biological functions, biological membranes, fluid mosaic model of membrane structure, Lipid metabolism, β-Oxidation of fatty acids

UNIT-III: **15 h**

Drug Design: Development of new drugs, factors affecting development of new drugs, sources of lead compounds, serendipity and drug development.Stereochemistry and biological activity,Concept of QSAR, QSAR methods and parameters, procedure followed in drug design, structure activity relationship)SAR(method, Free and Wilson analysis, Hansch analysis, concept of prodrugs and softdrugs, SOFT DRUGS, isosterism, bioisosterism, drug receptors, theories of drug action, types of reversible enzyme inhibitors, some special inhibitors and design of inhibitors.

UNIT-IV: **15 h**

Pharmacokinetics and pharmacodynamics: Indroduction drugs absorption, distribution and disposition of drugs, excretion and elimination, Pharmacokinetics of elimination and Pharmacokinetics in drug development process.
Pharmacodynamics: Introduction, enzyme stimulation, enzyme inhibition, membrane active drugs, drugs metabolism, biotransformation and significance of drug metabolism.

List of books

1) Bioorganic Chemistry: A Chemical Approach to Enzyme Action, Hermann Dugas and C. Penny, Springer-Verlag
2) Understanding Enzymes, Trevor Palmer, Prentice Hall
3) Enzyme Chemistry: Impact and Applications, Ed. Collin J. Suckling, Chapman and Hall
4) Enzyme Structure and Mechanism, A. Fersht, W. H. Freeman
5) Introduction to Medicinal Chemistry, A. Gringuage, Wiley-VCH
6) Wilson and Gisvold's Text Book of Organic Medical and Pharmaceutical Chemistry, Ed Robert F. Dorge
7) Burger's Medicinal Chemistry and Drug Discovery, Vol-1, Ed. M. E. Wolff, John Wiley
8) Strategies for Organic Drug Synthesis and Design, D. Lednicer, John Wiley
The Organic Chemistry of Drug Design and Drug Action, R. B. Silverman, Academic Press

Semester IV
Core Subject Centric - II
Nuclear Chemistry
Paper XVI (Code: MCH4T04)

60h *(*4h/week*)* 15h/unit 60 Marks

Course Outcomes: At the end of the course, student will be able to

1. Convert various radiation units into each other.
2. Compare various dosimeters with their applications, merits and demerits.
3. Elaborate the hot atom chemistry with different effects involved.
4. Calculate recoil energy of various radiochemical processes.
5. Quantitate the concentrations of desired elements in samples using NAA, IDA etc.
6. Explain the application of radiochemistry in pharmaceutical anlaysis.

Unit-I: Radiation Chemistry, Radiolysis **15h**

Measurement of dose. Dosimetric terms and units (Roentgen, REM, Rad, Gray, Sievert), inter conversions, calculation of absorbed dose-various types of dosimeters, chemical dosimeters (Fricke, Ceric sulphate and FBX), experimental methods, TLD badges, Radiolysis-definition, process, Radiolysis of water and aqueous solutions, hydrated electron,

Effect of radiation on biological substances, genetic effects, radiation effects on organic compounds (Halides-carboxylic acids), polymers, nitrates and solid thermoluminescence.

Unit-II: Hot Atom Chemistry and Radiochemistry **15h**

Recoil energy and calculations, Szilard Chalmers effects, Kinetics, primary and secondary retention-effect of various factors on retention and its uses, Mossbauer effect- principle, instrumentation and chemical applications,

Unit-III: Radioanalytical techniques **15h**

Neutron sources, Neutron activation analysis, principle, methodology and application for trace analysis, Isotope dilution analysis-principle and application, Isotopic exchange reaction, mechanism and application in use of radioisotopes and tracers, radioactive dating based on carbon-14 and lead isotopes.

Unit-IV: Radiopharmaceuticals **15h**

Radioimmunoassay (RIA), discovery, principle, set up of RIA, Principle of Immunoradiometric assay (IRMA), principle and set up, Radiopharmaceuticlas, classification of products, preparations, quality control aspects, ^{99}Mo-^{99m}Tc generator, Cylotron based products, PRT studies, Therapeutic applicatyions , Radiotherapy.

List of books:

1. H. J. Arnikar - Essentials of Nuclear Chemistry (Willey Eastern Ltd)
2. G. Friendlander, J. W. Kennedy,E. S. Macias and J. M. Miller-Nuclear and Radiochemistry (Wiley Intersciences, New York)
3. G. R. Choppin and J. Rydberg- Nuclear Chemistry-Principles and Applications(Pergamon press, London)
4. B. G. Harvey-Introduction to Nuclear Physics and Chemistry(Prentice Hall of India)
5. A. N. Nesmeyanov - Radiochemistry- (Mir Publications)
6. M. N. Sastry-Introduction to Nuclear Science, Affiliated East-West Press, New Delhi
7. G. Hughes- Radiation Chemistry- Oxford University Press, London
8. V. Verschinskii and A. K. Pikeav-Introduction to Radiation Chemistry, Israel Publication, Jerusalem- Robinson (Marcol Dekker)
9. Farhat Aziz and M. A. J. Radgers-Radiation Chemistry-Principles and Applications, VCH Publishers FRC.
10. M. Hassinsky-Nuclear Chemistry and its application, Addison Wesley

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Semester IV
Core Subject Centric - II
Polymer Chemistry
Paper XVI (Code: MCH4T04)

60h (4h/week) 15h/unit 60 Marks

Course Outcomes: At the end of the course, student will be able to

1. Understand the principles involved in polymerization processes.
2. Classify the need of techniques required for polymerization.
3. To characterize the various polymers.

4. Elaborate specific polymers and their utility at various places.

Unit I: Polymerization **15h**

Types of polymerization, addition-chain, free radical, ionic polymerization, step polymerization, electropolymerization, ring-opening polymerization.

Unit II: Techniques of polymerization **15h**

Techniques of polymerization-suspension, emulsion and bulk polymerization, coordination, polymerization mechanism of Ziegler Natta polymerization, stereospecific polymerization, interfacial polycondensation, mechanism of polymerization.

Unit III: Characterization of polymers **15h**

Electronic, IR and NMR spectral methods for characterization of polymers (Block and Graft) Thermal methods-TGA, DTA, DSC, thermomechanical and X-ray diffraction study, Block and Graft copolymers, random, block, graft co-polymers, methods of copolymerization.

Unit IV: Specific polymers **15h**

A) Biomedical polymers: Contact lens, dental polymers, artificial heart, kidney and skin.

B) Inorganic polymers: Synthesis and application of silicon, phosphorous and sulphur containing polymers.

C) Coordination polymers: Synthesis and applications of coordination polymers.

List of books:

1) Textbook of polymer science: F.W. Billmayer Jr. Wiley.
2) Polymer science: V.R. Gowarikar, N. V. Viswanathan and J. Sreedhar, Wiley-Eastern.
3) Fractional monomers and polymers: K Takemoto, Y. Inaki, and R.M. Ottam Brite.
4) Contemporaty polymer chemistry: H.R. Alcock and F. W. Lambe, Prentice Hall.
5) Principles of polymer Chemistry: Flory, Cornell Univ. press.
6) Introduction to polymer chemistry: R. B. Seymour, McGraw Hill.
7) Principles of polymerization: Odian.
8) A first course in polymer chemistry: A. Strepikheyew, V. Derevistkay and G. Slonimasky, Mir Publishers, Moscow.
9) Laboratory preparation of macro chemistry: EMM effery, McGraw Hill Co.
10) A practical course in polymer chemistry: S.J. Punea , Pergamon Press.

Semester IV
Paper XVI Foundation Course - II (Code: MCH4T04)
Instrumental methods - II

60 h (4 h per week): 15 h per unit **60 Marks**

Course Outcomes: At the end of the course, student will be able to

1. Understand the principles involved in electrochemical methods of analysis.
2. Explain sources and detectors used in X-ray spectroscopy.
3. Discuss the principles involved in modern chromatographic techniques.
4. Predict the NMR spectra of various organic molecules.
5. Interpret the NMR spectra of various organic molecules.

Unit – I **15 h**

Electrochemical methods: Principle, instrumental and applications of Conductometry and potentiometry.

Unit – II **15 h**

X-ray diffraction and X-ray fluorescence: Principle, instrumentation and applications.

Unit – III **15 h**

Modern Chromatographic methods: Principle, instrumentation and applications of gas chromatography and liquid chromatography.

Unit – IV **15 h**

NMR spectroscopy: Principle, instrumentation and applications.

Semester IV
Practical VIII (MCH3P01)
Project

8 h/week 100 Marks

Course Outcomes: At the end of the course, student will be able to

1. Carry out detailed literature survey on selected project topic.
2. Identify the gap in literature to design a project proposal.
3. Carry out experiments to obtain necessary information.
4. Put all the obtained results in systematic manner in the form of a project report.
5. Present the project report in front of audience in the form of PowerPoint presentation.
6. Write own research paper based on project.

Project is a part of practical examination. Project should be carried out by the student under the supervision of Guide/Teacher. The examination shall be conducted by External and Internal Examiners. Students are supposed to present their work either on LCD Projector / OHP or blackboard.

The division of marks will be as follows:

For written Project Work	: 40 Marks	- Evaluated jointly by External and Internal Examiners
Presentation	: 20 Marks	- Evaluated jointly by External and Internal Examiners
For Viva-Voce	: 20 Marks	- Evaluated by External Examiner
Internal Assessment	: 20 Marks	- Evaluated by Internal Examiner

Note: One external examiner shall be appointed for evaluation of group of 6 students.

Semester IV
Seminar-IV (Code: MCH4S01)

2 h /week Marks: 25

Seminar of 30 minutes duration will be a part of internal assessment for 25 marks (1 Credit). Seminar should be delivered by the student under the guidance of concerned teacher on the topic allotted by the teacher. The topic will be related to the syllabus. Marks will be allotted by a group of teachers.

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