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SYLLABUS for M. Sc. CHEMISTRY  
Choice Based Credit System (Semester Pattern)  
Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur  
Effective from 2018-2019

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Candidates opting for this course are advised to go through the direction relating to the course “DIRECTION RELATING TO THE EXAMINATION LEADING TO THE DEGREE OF MASTER OF SCIENCE, SEMESTER PATTERN (CHOICE BASED CREDIT SYSTEM) AND DEGREE OF MASTER OF SCIENCE AND TECHNOLOGY (APPLIED GEOLOGY). SEMESTER PATTERN, (CHOICE BASED CREDIT SYSTEM) (FACULTY OF SCIENCE & TECHNOLOGY)” which is available on R. T. M. Nagpur University website.

The direction will provide details on admission criteria, rules for ATKT, scheme of examination, absorption scheme for CBS students into CBCS pattern, elective papers, foundation course papers, subject centric papers, coding pattern, pattern of question papers, practicals, distribution of marks, seminars, project work, internal assessment, calculation of SGPA and CGPA, etc.

## 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					
		Th	Pract	Total		Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks	
							External Marks	Internal Ass		Th	Pract
(1T1)	Paper 1: Inorganic Chemistry	4	-	4	4	3	80	20	100	40	
(1T2)	Paper 2: Organic Chemistry	4	-	4	4	3	80	20	100	40	
(1T3)	Paper 3: Physical Chemistry	4	-	4	4	3	80	20	100	40	
(1T4)	Paper 4: Analytical Chemistry	4	-	4	4	3	80	20	100	40	
Pract. (1P1)	Practical 1: Inorganic Chemistry	-	8	8	4	3-8*	100**	-	100		40
Pract. (1P3)	Practical 2: Physical Chemistry	-	8	8	4	3-8*	100**	-	100		40
Seminar 1 (1S1)	Seminar 1	2	-	2	1			25	25	10	
	TOTAL	18	16	34	25		520	105	625	170	80

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
(2T1)	Paper 5: Inorganic Chemistry	4	-	4	4	3	80	20	100	40	
(2T2)	Paper 6: Organic Chemistry	4	-	4	4	3	80	20	100	40	
(2T3)	Paper 7: Physical Chemistry	4	-	4	4	3	80	20	100	40	
(2T4)	Paper 8: Analytical Chemistry	4	-	4	4	3	80	20	100	40	
Pract. (2P2)	Practical 3: Organic Chemistry	-	8	8	4	3-8*	100**	-	100		40
Pract. (2P4)	Practical 4: Analytical Chemistry	-	8	8	4	3-8*	100**	-	100		40
Seminar 2 (2S1)	Seminar 2	2	-	2	1			25	25	10	
	TOTAL	18	16	34	25		520	105	625	170	80

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	
(3T1)	Paper 9: Special – I (Inorganic/ Organic / Physical / Analytical) Chemistry	4	-	4	4	3	80	20	100	40		
(3T2)	Paper 10: Special – II (Inorganic/ Organic / Physical / Analytical) Chemistry	4	-	4	4	3	80	20	100	40		
Elective 1 (3T3)	Paper 11: A) Nuclear Chemistry I (3T3A) ORB) Environmental Chemistry I (3T3B) ORC) Polymer Chemistry I(3T3C) ORD) Medicinal Chemisrty I(3T3D)	4	-	4	4	3	80	20	100	40		
Foundatio n Course 1 / Core Subject Centric 1 (3T4)	Paper 12: Applied Analytical Chemistry-I / Spectroscopy I	4	-	4	4	3	80	20	100	40		
Pract. Core 9 & 10 (3P1)	Practical 5: Special (Inorganic/ Organic / Physical / Analytical) Chemistry	-	8	8	4	3- 8*	100**	-	100		40	
Pract. Core Elective 1 (3P3)	Practical 6: A) Nuclear Chemistry I ORB) Environmental Chemistry I ORC) Polymer Chemistry I ORD) Medicinal Chemisrty I	-	8	8	4	3- 8*	100**	-	100		40	
Seminar 3 (3S1)	Seminar 3	2	-	2	1			25	25	10		
	TOTAL	18	16	34	25		520	105	625	170	80	

M. Sc. Chemistry Semester IV												
Code	Teaching scheme					Examination Scheme						

		(Hours / Week)										
		Th	Pract	Total			Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks	
								External Marks	Internal Ass		Th	Pract
(4T1)	Paper 13: Special – I (Inorganic/ Organic / Physical / Analytical) Chemistry	4	-	4	4	3	80	20	100	40		
(4T2)	Paper 14: Special – II (Inorganic/ Organic / Physical / Analytical) Chemistry	4	-	4	4	3	80	20	100	40		
Elective 2 (4T3)	Paper 15: A) Nuclear Chemistry II ORB) Environmental Chemistry II ORC) Polymer Chemistry II ORD) Medicinal Chemisrty II	4	-	4	4	3	80	20	100	40		
Foundati on Course 2 / Subject Centric 2 (4T4)	Paper 16: Applied Analytical Chemistry II / Spectroscopy II	4	-	4	4	3	80	20	100	40		
Pract. (4P1)	Practical 7: Special (Inorganic/ Organic / Physical / Analytical) Chemistry	-	8	8	4	3- 8*	100**	-	100		40	
Project (4PROJ1)	Project	-	8	8	4	3- 8*	100**	-	100		40	
Seminar 4 (4S1)	Seminar 4	2	-	2	1			25	25	10		
	TOTAL	18	16	34	25		520	105	625	170	80	

## NOTE Sem III &amp; 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 respective subjects.

Core (Subject Centric): Candidate can opt for this paper as shown in the semester III and IV in their main subject of postgraduation only. If the candidate decides to opt for Core (Subject Centric) papers in their main subject of

postgraduation then he/she shall not be eligible to opt for foundation course papers neither in their 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

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Total - 100 Marks

- General Scheme for Distribution of Marks in Project Examination in Chemistry

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

The examiners will evaluate the experimental project work taking into account the coverage of subject matter, presentation, references etc.

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

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Total - 100 Marks

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Semester I  
Paper – I (Code: 1T1)  
Inorganic Chemistry

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

80 Marks

## Unit-I

5h

A) Stereochemistry and Bonding in Main Group Compound: VSEPR-Shape of simple inorganic molecules and ions containing lone pairs, various stereo chemical rules and resultant geometry of the compounds of non-transitional elements, short coming 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. Limitation of crystal field theory. M.O. Theory for octahedral, tetrahedral & square planar complexes with and without  $\pi$ -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:

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  $SN^1$  &  $SN^2$ , Base hydrolysis, Conjugate base mechanism, Direct and indirect evidences in favour of conjugate mechanism, Anation reaction, reaction without metal-ligand bond breaking.

## Unit-III: Cluster- I

15h

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.

## Unit – IV: Cluster-2

A) Metal-Metal bonds:

10h

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) Isopoly, Heteropoly acids and their anions.

5h

## List of Books

- 1) S. F. A. Kettle, J. N. Murrell 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. Jathey 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. Jathey 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

## Paper II (Code: 1T2)

## Organic Chemistry

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

80 Marks

## Unit-I:

15 h

**A]** Nature and Bonding in Organic Molecule:Delocalized chemical bonding, conjugation, cross conjugation, resonance, hyper-conjugation, bonding in fullerenes. Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons Huckel's rule, energy level of  $\pi$ -molecules orbitals, annulenes, antiaromaticity, homo-aromoaticity. Aromatic character and chemistry of cyclopentadienyl anion, tropylium cation, tropone and tropolone. Bonds weaker than covalent-addition compounds, crown ether complexes and cryptands, inclusion compounds, cyclodextrins, catenanes and rotaxanes

**B]** Reactive Intermediates: Generation, structure, stability and chemical reactions involving carbocations, carbanions, free radical, carbenes, and nitrenes

## Unit-II:

15 h

**Streochemistry:** Conformational analysis of cycloalkanes (5-8 membered rings), substituted cyclohexanes, mono substituted, disubstituted and trisubstituted cyclohexanes, decalines, effect of conformation on reactivity, Cahn-Ingold-Prelog System to describe configuration at chiral centers. Elements of symmetry, chirality, molecules with more than one chiral center, meso compounds, threo and erythro isomers, method of resolution, optical purity, enantiotopic and distereotopic atoms, groups and faces, prochirality, addition-elimination reactions, stereospecific and



stereoselective synthesis. Asymmetrical synthesis, optical activity in absence of chiral carbon (biphenyl and allenes)

Unit-III: 15 h

- A] Reaction mechanism: Structure and Reactivity: Types of mechanism, Types of reaction, thermodynamics and kinetics requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle, Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotope effects, Hard and soft acids and bases.
- B] Aliphatic nucleophilic substitution: The  $S_N1$ ,  $S_N2$ , mixed  $S_N1$ ,  $S_N2$  and SET and  $S_Ni$  mechanisms. Nucleophilicity, effect of leaving group, ambient nucleophiles and ambient substrates regioselectivity, substitution at allylic and vinylic carbon atoms, phase transfer catalysis
- C] Concept of neighboring group participation Anchimeric assistance with mechanism, neighboring group participation by  $\pi$  and  $\sigma$  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, carbocation rearrangements and related rearrangements in neighboring group participation.

Unit IV: 15h

- A] Aromatic Nucleophilic Substitution  
A general introduction to different mechanisms of aromatic nucleophilic substitution  $S_NAr$ ,  $S_N1$ , benzyne and  $S_{RN}1$  mechanisms, arynes as reaction intermediate, Reactivity - effect of substrate structure leaving group and attacking nucleophile. The Von Richter, Sommelet-Hauser and Smiles rearrangements.
- B] 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 substituents, orientation in other ring system. Friedel-Crafts reaction, Vilsmeier-Hack reaction, Gatterman-Koch reaction, Pechman reaction, Reimer-Tiemann reaction, Diazonium coupling.
- 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.

List of books

- 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] Principles 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, Macmillan
- 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 (Longman), 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] New Trends in Green Chemistry –V. K. Ahluwalia and M. Kidwai, Anamaya publishers New Delhi  
 25] Organic Chemistry, J. Clayden, N. Greeves, S. Warren and P. Wothers, Oxford University Press  
 26] Organic Chemistry, 4th Edition, G Marc Loudon, Oxford University Press

## Semester I

## Paper III (Code: 1T3)

## Physical Chemistry

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

80 Marks

## UNIT I: CLASSICAL THERMODYNAMICS

15h

- A] Recapitulation of Laws of thermodynamics, Exact and inexact differentials, condition of exactness, Pfaff differential expression and equations, Applications of Pfaff differential equations to first and second law of thermodynamics, Carathéodory's principle and its equivalence to the Kelvin Planck 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.
- B] 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. Virial equation of state.

## UNIT II: GIBBS FUNCTION 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, Extent of advancement of reaction ( $\xi$ ), thermodynamic criteria of chemical equilibrium.
- B] Gibbs Phase rule and its derivation, calculation of degrees of freedom, reduced phase rule, construction of phase diagram, one component systems (Helium, carbon), 1<sup>st</sup> and 2<sup>nd</sup> 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, influence of temperature, systems with 1, 2, 3 pairs of partially miscible liquids, transition points.

## UNIT III: SURFACE PHENOMENA AND MACROMOLECULES

15h

- 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] Macromolecules: Definitions, Number and mass average molecular weights, molecular mass determination by Osmometry, Viscometry, Sedimentation, Diffusion, light scattering method, Numerical.

## 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, 8<sup>th</sup> 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. Glasstone and De 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. G. M. Barrow, Physical Chemistry, Tata Mc-Graw Hill, V edition 2003.
9. H. K. Moudgil, Text Book of Physical Chemistry, Pretice Hall of India, New Delhi, 2010.
10. G.M.Panchenkov and V.P.Labadev, “ Chemical Kinetics and catalysis”, MIR Publishing
11. E.A. Moelwyn- Hughes, “ Chemical Kinetics and Kinetics of Solutions”, Academic
12. K.J.Laidler, Chemical Kinetics, Third Edition (1987), Harper and Row, New York.
13. J.Raja Ram and J.C.Kuriacose, Kinetics and Mechanism of Chemical Transformations MacMillan IndianLtd., New Delhi (1993)
14. C. H. Bamford and C. F. H. Tipper, Comprehensive Chemical Kinetics, Vol 1., Elsevier Publications, New York, 1969.
15. C. H. Bamford and C. F. H. Tipper, Comprehensive Chemical Kinetics, Vol 2., Elsevier Publications, New York, 1969.
16. S. Glasstone, K. J. Laidler and H. Eyring, The Theory of Rate Processes, Mc-Graw Hill, New York, 1941.
17. A. Findley, The Phase Rule and its Applications, Longmans Green and Co., Mumbai.
18. K. S. Birdi, Surface Chemistry Essentials, CRC Press, New York, 2014.
19. Eric Keightley Rideal, An Introduction to Surface Chemistry, Cambridge University Press, 1926.
20. D. M. Ruthven, Principles of Adsorption and Adsorption Processes, John Wiley & Sons, NewYork, 1984.
21. A. W. Adamson, A. P. Gasi, Physical Chemistry of Surfaces, Wiley, 2007.
22. P. C. Hiemenz and R. Rajagopalan, Principles of Colloid and Surface Chemistry, CRC Taylor and Fransis, 2007.
23. P. D. Hede and S. P. Beier, Inorganic and Applied Chemistry, e-Book, 2007.
24. Santosh Kumar Upadhyay, Chemical Kinetics and Reaction Dynamics, Springer 2006.
25. E.M. Mc Cash, *Surface Chemistry*, Oxford University Press, Oxford (2001).
26. G. K. Agrawal, Basic Chemical Kinetics, Tata-Mc-Graw Hill, 1990.
27. N. B. Singh, N. S. Gajbhiye, S. S. Das, Comprehensive Physical Chemistry, New Age International, 2014.
28. K. L. Kapoor, Text Book of Physical Chemistry, Vol – I to Vol-VI, 2011.

## Semester I

## Paper IV (Code: 1T4)

## Analytical Chemistry

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

80 Marks

## 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.

*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: 1P1)

## Inorganic Chemistry

12 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. $[Co (Py)_2 Cl_2]$    | 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

- Copper (II) and Nickel (II)
- Copper (II) and Zinc (II)
- Nickel (II)—Zinc (II) and
- 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: 1P3)

## Physical Chemistry

12 h /week

Marks: 100

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

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

List of Books

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

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Semester I

Seminar-I (Code: 1S1)

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.

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M.Sc. Chemistry  
Semester II  
Paper V (Code: 2T1)  
Inorganic Chemistry

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

80 Marks

- 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  $10Dq$ ,  $B$ ,  $\beta$  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 planer 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 - I 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.

Unit – IV: Metal  $\pi$ -Complexes – II 15h  
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. Wilkinson's catalyst and Vaska's compound.

## List of Books

1. J.E. Huheey : Inorganic Chemistry
2. F.A. Cotton and 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 Chemistry Jones: Elementary Coordination chemistry.
10. B. N. Figgis: Introduction to Ligand field.
11. M.C. Day and J. Selbin: Theoretical 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: Theoretical principles of inorganic chemistry
19. A. B. P. Lever: Inorganic electronic spectroscopy.
20. R.C.Maurya: Synthesis and characterisation of novel nitrosyls compounds, Pioneer Pub. Jabalpur 2000.
21. R.H.Crabtree: The Organometallic 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 and G. Pearson: Inorganic Reaction Mechanism
25. Organometallics II and I complexes with transition metal- carbon bonds: Manfred Bochmann- Oxford Press.
26. Advanced Inorganic Chemistry Vol I and II – Satyaprakash, Tuli, Bassu and Madan- S Chand.
27. M. Tsusui, M. Nlevy, M. Ichikwa and K. Mori: Introduction to metal pi-complex chemistry, Plenum press, NY
28. A.E. Martel; Coordination Chemistry- Volland II, VNR.

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Semester II  
Paper VI (Code: 2T2)  
Organic Chemistry  
2T2

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

80 Marks

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, Michael reaction, Robinson annulation
- B]** Addition to carbon-hetero atom multiple bond: Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters, and nitriles, Addition of Grignard reagents, organozinc and organolithium reagents to carbonyls and unsaturated carbonyl compounds, Wittig reaction, Mechanisms of condensation reactions involving enolates- Aldol, Knoevengel, Claisen, Mannich, Benzoin, Perkin, Stobbe reaction, Hydrolysis of esters and amide.

Unit-II

15 h

- A]** Mechanism of molecular rearrangement: Classification and General mechanistic treatment of electrophilic, nucleophilic and free radical molecular rearrangement. Mechanism of the following rearrangement –Wagner-Meerwin, Pinacol-Pinacolone, Tiffenev –Demjnov ring expansion, benzil-benzilic acid, Favorski, Wolff, Arndt-Eistert synthesis, Curtius Lossen, Beckman, Hoffman, Schmidt rearrangement.
- B]** Elimination reactions: The E<sub>1</sub>, E<sub>2</sub> and E<sub>1</sub>CB mechanisms and 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

UNIT-III

Free radical reactions: Generation of free radicals, Type of free radical reactions, free radical substitution mechanism at an aromatic substrate, aliphatic substrate, reactivity at a bridgehead position. Neighbouring group assistance, reactivity for aliphatic and aromatic substrates, reactivity in attacking radicals, effect of solvent on reactivity. 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, Free radical rearrangement, Hunsdiecker reaction, iododecarboxylation, Barton reaction, Hoffmann-Loefer-Freytag reaction

#### Unit IV: Green chemistry

15 h

Green chemistry: Basic principles of green chemistry, calculation of atom economy of rearrangements, addition, substitution and elimination reaction with suitable examples, Case study of Bhopal gas tragedy and Seveso disaster, Synthesis involving basic principles of green chemistry- paracetamol, Ibuprofen, hydroquinone, adipic acid,  $\epsilon$ -caprolactum, styrene, urethanes, Free radical bromination, Multi-component reactions (Biginelli, Ugi and Passerini reaction), Prevention or minimization of hazardous products, choice of solvents. Sonochemistry, microwave induced reactions, polymer supported reagents, reactions in aqueous medium, zeolites and ionic liquid supported reaction, Solvent free reactions, electrochemical reactions, Biocatalysts in Organic synthesis.

#### List of books

- 1] Books as Suggested in Semester I for Organic Chemistry
- 2] A Textbook of organic chemistry- R.K. Bansal
- 3] New trends in green chemistry –V.K. Ahluwalia and M. Kidwai, Anamaya publishers New Delhi
- 4] Heterocyclic Chemistry, John Joule, Oxford University Press
- 5] Books as Suggested in Semester I for Organic Chemistry
- 6] A Textbook of organic chemistry- R.K. Bansal
- 7] New trends in green chemistry –V.K. Ahluwalia and M. Kidwai, Anamaya publishers New Delhi
- 8] Heterocyclic Chemistry, John Joule, Oxford University Press

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### Semester II Paper VII (Code: 2T3) Physical Chemistry

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

80 Marks

#### UNIT I: 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: Degeneracy in 3-Dimensional Box, Rigid Rotor, Potential Well of Finite Depth (Tunneling Effect), Simple Harmonic Oscillator, The Hydrogen Atom.

#### UNIT II: THERMODYNAMICS

15h

- A]** Ideal and Non-ideal Systems: Concept of fugacity, determination of fugacity, excess functions for non ideal solutions, Entropy of mixing, Enthalpy of mixing, 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, numericals.
- 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 III: SOLID STATE CHEMISTRY

15h

- 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, Numericals.
- B]** Crystal Defects and Non-stoichiometry: Perfect and imperfect crystals, point defects, line and plane defects. Thermodynamics of Schottky and Frenkel defect formation, colour centers, non-stoichiometry and defects.

#### 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 Einstein, Fermi Dirac statistics, comparison between three statistics.
- B]** Nuclear Chemistry: 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 Mcgraw 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, 8<sup>th</sup> 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.Prigogine, "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. Arnika, *Essentials of Nuclear Chemistry*, 4th Edition (1995), Wiley-Eastern Ltd., New Delhi.
28. C.Kittel, "Introduction to solid state Physics", Wiley
29. L.V.Azaroff, "Introduction to solids", McGraw Hill
30. L. E. Smart and E. A. Moore, *Solid State Chemistry-An Introduction*, CRC Tylor and Fransis, 2005.
31. D. D. Sood, A. V. R. Reddy, *Fundamentals of Radiochemistry*, Indian Association of Nuclear Chemists and Allied Scientists, 2007.
32. C. N. R. Rao and Gopalakrishnan, "New Directions in Solid State Chemistry " Second Edition, Cambridge University Press.
33. Anthony R. West, "Solid State Chemistry and its Applications" Wiley India Edition.
34. C. Kalidas and M. V. Sangaranarayana, *Non-Equilibrium Thermodynamics*.
35. D. K. Chakravorty, *Solid State*, New Age International.

## Semester II

## Paper VIII (Code: 2T4)

## Analytical Chemistry

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

80 Marks

Unit-I: Sampling and quantification

15h

**A]** *Sampling and sample treatment*: Criteria for representative sample. Techniques of sampling of gases (ambient air and exhaust gases), liquids (water and milk samples), solids (soil and coal samples) and particulates. Hazards in sampling. Safety aspects in handling hazardous chemicals. Sample dissolution methods for elemental analysis: Dry and wet ashing, acid digestion, fusion processes and dissolution of organic samples.

**B]** *Detection and quantification*: Concepts and difference between sensitivity, limit of detection and limit of quantification, role of noise in determination of detection limit of analytical techniques. Units in chemical analysis and their interconversion.

**C]** *Stoichiometry*: Stoichiometric and sub-stoichiometric reactions and calculations.

Unit-II: 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 III: 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  $\lambda_{\max}$ . 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-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, 2<sup>nd</sup> 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)

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Semester II  
Practical-III (Code: 2P2)  
Organic Chemistry

12 h /week

Marks: 100

**[A]** 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.

Purification of the compounds by crystallization, TLC and chromatographic techniques.

**[B]** Organic preparations: Student is expected to carry out minimum of 5-6 two stage organic preparation and 5-6 single stage preparation from the following lists.

- [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] Benzil → 2,4,5-triphenyl imidazole

- [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 preparation : Sulphanilic acid → Methyl orange  
 [13] Dye preparation : *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

## Semester II

## Practical-IV (Code: 2P4)

## Analytical Chemistry

12 h /week

Marks: 100

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<sub>2</sub>CO<sub>3</sub> in washing soda.
2. Determination of NaOH and Na<sub>2</sub>CO<sub>3</sub> 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<sub>4</sub>.
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<sub>3</sub>COOH 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  $\text{CH}_3\text{COOH}$  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  $\text{CH}_3\text{COOH}$  individually and in a mixture potentiometrically.
9. Determination of Fe(II) by potentiometric titration with  $\text{K}_2\text{Cr}_2\text{O}_7$ .
10. Determination of three dissociation constants of  $\text{H}_3\text{PO}_4$  by pH-metric/ potentiometric titration.

#### Optical methods

1. Determination of pK of indicator by colorimetry.
2. To estimate the amount of  $\text{NH}_4\text{Cl}$  colorimetrically using Nessler'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.

Note: One experiment from each section should be performed in the examination.

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#### Semester II

#### Seminar-II (Code: 2S1)

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  
INORGANIC CHEMISTRY SPECILIZATION  
Paper IX (Code: 3T1)  
Special I-Inorganic Chemistry

60 h (4 h per week): 15 h per unit  
Unit -I

80 Marks  
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 difficiency 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,  $\text{Na}^+ / \text{K}^+$  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 dignosis 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. B12, Structure of vitamin B12 Co-C bond cleavage, Mutaseactivity 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 (John Wiley).
5. Douglas, B. E. McDaniel, D. H. et al: Concept and Models of Inorganic Chemistry (4th ed.) 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  
 Paper X (Code: 3T2)  
 Special II-Inorganic Chemistry

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

80 Marks

Unit-I

15 h

Crystal Structure of Some Simple Compounds:

- 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) AB<sub>2</sub> type: Fluorite, antiferites, Rutile structures. Li<sub>2</sub>O, Na<sub>2</sub>O, CdCl<sub>2</sub>, CdI<sub>2</sub> structures.
- v) Ternary Compounds ABO<sub>3</sub> type: Perovskite, Barium titanate, lead titanate, CaTiO<sub>3</sub>, Tolerance factor, charge neutrality & deviation structures. FeTiO<sub>3</sub>.

Unit-II

15h

- A) AB<sub>2</sub>O<sub>4</sub> type- compounds: Normal & inverse, 2-3 and 4-2 spinel, packing of oxygen in tetrahedral & octahedral sites, sites occupancy number of site surrounding each oxygen, application of charge neutrality principles, site preferences in spinel, distorted spinel. Hausmannite (Jahn-Teller distortions), Factors causing distortion in spinel.
- 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. Electronic properties of Non-stoichiometric oxides.

Unit-III

15h

Glasses, Ceramics and composite: Glasses, Ceramics Composites and Nano-materials: Glassy state, glass formers and Glass Modifiers. Glasses, Ceramics, Clay products, Refractories with reference to: preparation, Properties and applications. Microscopic composites, dispersion, strengthened and particle reinforced, fibre reinforced Composites, microscopic composites, nanocrystalline phase, preparation procedure, special properties and applications.

Unit-IV

15 h

Liquid Crystals: Mesomorphic behaviour, thermotropic liquid crystals, positional order, bond orientational order, nematics & smectic mesophases; smectic-Nematic transition clearing temperature-homeotropic, planar & schlieren textures twisted nematics, chiral nematics, molecular arrangement in smectic A & smectic C phases, optical properties of liquid crystals. Dielectric susceptibility & dielectric constants. Lyotropic phases & their description of ordering in liquid crystals.

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. Charlott, G and Bezier, D.: Quantitative Inorganic Analysis (John Wiley).



5. Douglas, B. E. McDanirl, D. H. et al: Concept and Models of Inorganic Chemistry (4th ed.) 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).
10. Peter J. Collings, Liquid Crystals-Nature's delicate Phase of Matter, New Age International.
11. S. Chandrasekhar, Liquid Crystals, Cambridge University Press.

## Semester III

## Practical-V (Code: 3P1)

## Inorganic Chemistry Special

12 h /week

Marks: 100

## 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 ( $\text{KMnO}_4$ ) and chromium ( $\text{K}_2\text{Cr}_2\text{O}_7$ )
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 Methods 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: Analytical Chemistry
13. Skoog S.A. And West D. W.: Fundamental Of Analytical Chemistry
14. Dilts R.V.: Analytical 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 Chemical Analysis 6<sup>th</sup> Ed
18. Ramesh Rand Anbu M , Chemical Methods For Environmental Analysis : Water And Sediment , Macmillan 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 Wiley)
22. Douglas, B. E. McDaniel, D. H. Et Al : Concept And Models Of Inorganic Chemistry (4<sup>th</sup> 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 Chemistry (4<sup>th</sup> Ed) Addison-Wesley
26. Bertini, Et Al: Bioinorganic Chemistry (Viva)
27. Katakis, D. And Gordon, G : Mechanism Of Inorganic Reactions (J. Wiley)

Semester III  
ORGANIC CHEMISTRY SPECIALIZATION  
Paper IX (Code: 3T1)  
Special I-Organic Chemistry

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

80 Marks

## Unit I: 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 parabenzoquinones, photochemistry of Aromatic compounds with reference to isomerisation 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, Applications of photochemical methods in synthesis: Isocomene, Cedrene, Hirsutene

## Unit II: 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, conrotatory and disrotatory motion  $4n$  and  $(4n+2)$  systems, Cycloaddition reaction with more emphasis on  $[2+2]$  and  $[4+2]$ , Cycloaddition of ketones 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. Sigmatropic rearrangement, suprafacial, and antarafacial shift involving carbon moieties, retention and inversion of configuration,  $[3,3]$  and  $[3,5]$  sigmatropic rearrangements, Claisen, Cope, Sommelet-Hauser rearrangements, Ene reaction.

## Unit III

15 h

**A]** Oxidation: Oxidation of alkanes, aromatic hydrocarbons and alkenes, Dehydrogenation with S, Se, Fremy's salt, DDQ, chloranil and  $\text{PhI}(\text{OAc})_2$ , Oxidation with  $\text{SeO}_2$ , Epoxidation of olefins, Synthetic

application of epoxides, Sharpless asymmetric epoxidation, Dihydroxylation of olefins using  $\text{KMnO}_4$ ,  $\text{OsO}_4$ , Woodward and Prevost dihydroxylation, Oxidative cleavage of olefins, Ozonolysis

- a) Oxidation of alcohols: Chromium reagents, pyridinium chlorochromate (PCC), pyridinium dichromate (PDC), Collins and Jones reagent, Combination of DMSO with DCC,  $(\text{COCl})_2$ , NCS and  $(\text{CH}_3\text{CO})_2\text{O}$  for oxidation of alcohols, Oxidation with  $\text{MnO}_2$ , Oppenauer oxidation
- b) Oxidation of aldehydes and ketones, Conversion of ketones to  $\alpha$ ,  $\beta$ -unsaturated ketones and  $\alpha$ -hydroxy ketones, Baeyer-Villiger oxidation, Chemistry and synthetic applications of  $\text{Pb}(\text{OAc})_4$ , Dess-Martin periodinane, IBX
- B]** Reduction: 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.
- a) Reduction by dissolving metals, Reduction of carbonyl compounds, conjugated systems, aromatic compounds and alkynes. Birch reduction, Hydrogenolysis
- b) Reduction by hydride transfer reagents, Meerwein-Ponndorf-Verley reduction, Reduction with  $\text{LiAlH}_4$  and  $\text{NaBH}_4$ , stereochemical aspects of hydride addition, Derivatives of  $\text{LiAlH}_4$  and  $\text{NaBH}_4$ , Selectivity issues, Diisobutylaluminium hydride (DIBAL-H), Sodium cyanoborohydride, Reduction with boranes and derivatives Reduction with  $\text{Bu}_3\text{SnH}$ ., Reduction of carbonyl group to methylene, Reduction with diimide and trialkylsilanes

#### Unit IV: Chemistry of P, S, Si, and Boron compounds

15 h

- a) Phosphorus and sulphur ylides: Preparation and their synthetic application along with stereochemistry
- b) Umpolung concept: Dipole inversion, generation of acyl anion, use of 1,3-dithiane, ethylmethylthiomethylsulphoxide, bis-phenylthiomethane, metallated enol ethers, alkylidene dithiane, ketone thioacetals, 2-propenethiothiomethyl thioallyl anion, thiamine hydrochloride based generation of acyl anion
- c) Organoboranes- preparation and properties of organoborane reagents e.g.  $\text{RBH}_2$ ,  $\text{R}_2\text{BH}$ ,  $\text{R}_3\text{B}$ , 9-BBN, catechol borane. Tertiary borane, cyclohexyl borane,  $\text{ICPBH}_2$ ,  $\text{IPC}_2\text{BH}$ , Hydroboration-mechanism, stereo and regioselectivity, uses in synthesis of primary, secondary tertiary alcohols, aldehydes, ketones, alkenes, Synthesis of EE, EZ, ZZ dienes and alkynes. Mechanism of addition of  $\text{IPC}_2\text{BH}$ . Allyl boranes- synthesis, mechanism and uses
- d) Organosilicon compounds in organic synthesis,  $\text{Me}_3\text{SiCl}$ ,  $\text{Me}_3\text{SiH}$  and Paterson synthesis

#### List of books

- 1] Books as suggested in Semester I for organic chemistry
- 2] Organic Synthesis, The disconnection approach-S. Warren
- 3] Designing Organic Synthesis-S. Warren
- 4] Some Modern Methods of Organic Synthesis-W. Carruthers
- 5] Advance Organic Chemistry Part-B-F. A. Carey and R. J. Sundberg Plenum Press
- 6] Protective Group in Organic Synthesis-T. W. Greene and PGM
- 7] The Chemistry of Organo Phosphorous-A. J. Kirby and S.G. Warren
- 8] Organo Silicon Compound-C. Eabon
- 9] Organic Synthesis via Boranes-H. C. Brown
- 10] Organo Borane Chemistry-T. P. Onak
- 11] Organic Chemistry of Boron-W. Gerrard
- 12] Fundamentals of Photochemistry-K. K. Rohatgi-Mukharji, Wiley Eastern Limited
- 13] Photochemistry-Cundau and Gilbert
- 14] Aspects of Organic Photochemistry-W. M. Horspoot
- 15] Photochemistry-J. D. Calvert
- 16] Photochemistry-R. P. Wayne

Semester III  
Paper X (Code: 3T2)  
Special III-Organic Chemistry

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

80 Marks

## 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,  $\alpha$ -terpeneol, Menthol, Farnesol, Zingiberene, Santonin, Phytol, Abietic acid and  $\beta$ -carotene, Vitamin A Genesis of biological isoprene unit, Biosynthesis (ONLY) of the following terpenoids: myrcene, linalool, geraniol,  $\alpha$ -terpeneol, limonene, camphor,  $\alpha$ -pinene,  $\beta$ -pinene, farnesol,  $\beta$ -bisabolene and squelene
- B]** Porphyrins: Structure and synthesis of Haemoglobin and Chlorophyll

## Unit II

15 h

- A]** Alkaloids: Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants Structure, stereochemistry, and synthesis of the following: Ephedrine, (+)-coniine, Nicotine, Atropine, Quinine, Reserpine and Morphine, Biosynthesis (ONLY) of the followings: hygrine, tropinone, nicotine, pelletierine, conine
- B]** Prostaglandins: Occurrence, nomenclature, classification, biogenesis and physiological effects. Synthesis of PGE<sub>2</sub> and PGF<sub>2 $\alpha$</sub>

## 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 Shikimic acid pathway

## Unit IV:

15 h

- A]** Carbohydrate: Types of naturally occurring sugars, deoxy sugars, amino sugars, branched chain sugars, methyl ethers and acid derivatives of sugars, general methods of structure and ring size determination with reference to maltose, lactose, sucrose, Chemistry of starch and cellulose.
- 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, Solid phase peptide synthesis, end group analysis.

## List of books

- 1] Chemistry of Alkloids-S. W. Pelletier
- 2] Chemistry of Steroids-L. F. Fisher and M. Fisher
- 3] The Molecules of Nature-J. B. Hendricson
- 4] Biogenesis of Natural Compound - Benfield
- 5] Natural Product Chemistry and Biological Significance- J. Mann, R. S Devison, J. B. Hobbs, D. V. Banthripde and J. B. Horborne
- 6] Introduction to Flavonoids-B. A. Bohm, Harwood
- 7] Chemistry of Naturally Occurring Quinines-R. H. Thomson
- 8] The Systematic Identification of Flavonoids- Marby, Markham, and Thomos

- 9] Text Book of Organic Medicinal Chemistry-Wilson, Geswold
- 10] Medicinal Chemistry Vol I and II-Burger
- 11] Synthetic Organic Chemistry -Gurudeep Chatwal.
- 12] Organic Chemistry of Natural Products Vol I and II-O. P. Agrawal
- 13] Organic Chemistry of Natural Products -Gurudeep Chatwal
- 14] A Textbook of Pharmaceutical Chemistry-Jayshree Ghosh
- 15] Synthetic Dyes Series -Venkatraman
- 16] Chemistry Process Industries-Shreve and Brink
- 17] Principal of Modern Heterocyclic Chemistry-L. A. Paquelte
- 18] Heterocyclic Chemistry-J. Joule and G. Smith
- 19] Heterocyclic Chemistry-Morton
- 20] An Introduction to Chemistry of Heterocyclic Compound-J. B. Acheson
- 21] Introduction to Medicinal Chemistry-A. Gringuadge
- 22] Wilson and Gisvold Text Book of Organic Medicinal and Pharmaceutical Chemistry-Ed. Robert F Dorge
- 23] An Introduction to Drug Design-S. S. Pandey and J. R. Demmock
- 24] Polymer Science-V. Govarikar
- 25] Principle of Polymer Chemistry-P. J. Flory
- 26] An Outline of Polymer Chemistry-James Q. Allen
- 27] Organic Polymer Chemistry-K. J. Saunders

Semester III  
Practical-V (Code: 3P1)  
Organic Chemistry Special)

12 h /week

Marks: 100

**[A] Quantitative Analysis**

Student is expected to carry out following estimations (minimum 6 estimations.)

1. Estimation of Vitamin "C" Iodometry.
2. Estimation of Phenol by  $\text{KBrO}_3$ -KBr.
3. Estimation of Amine by Bromate/ Bromide solution.
4. Estimation of Formaldehyde 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] Isolation of Organic Compounds from Natural Source (Any six)**

- a) Isolation of caffeine from tea leaves.
- b) Isolation of casein from milk (the students are required to try some typical colour reactions of proteins)
- c) Isolation of lactose from milk (purity of sugar should be checked by TLC and PC and Rf value reported.)
- d) Isolation of nicotine dipicrate from tobacco
- e) Isolation of cinchonine from cinchona bark
- f) Isolation of piperine from black pepper
- g) Isolation of lycopene from tomatoes
- h) Isolation of  $\beta$ -carotene from carrots
- i) Isolation of cysteine from hair
- j) Isolation of oleic acid from olive oil (involving the preparation of complex with urea and separation of linoleic acid)
- k) Isolation of eugenol from cloves

l) Isolation of (+) limonine from citrus rinds

**[C] 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 10-12 mixtures to be analyzed.

Semester III  
PHYSICAL CHEMISTRY SPECIALIZATION  
Paper IX (Code: 3T1)  
Special I-Physical Chemistry

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

80 Marks

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 Lagrange's 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, Numericals.

UNIT II: ELECTROCHEMISTRY OF INTERFACES

15h

- A]** Electrode Interfaces: Quantum aspects of charge transfer at electrode-solution interfaces, quantization of charge transfer, tunneling. Semiconductor interfaces: Theory of double layer at semiconductor, electrolyte solution interfaces, structure of double layer interfaces, effect of light at semiconductor solution interface.
- B]** Electro catalysis: Comparison of electro catalytic activity, importance of oxygen reduction and hydrogen evolution reactions, and their mechanism, volcanoes.
- C]** Bio-electrochemistry: Threshold membrane phenomena, Nernst Planck equation, Hodges Huxley equations, core conductor models, electrocardiography.

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.
- B]** Fast Reactions: relaxation methods, flow methods, flash photolysis, magnetic resonance method, relaxation time and numericals.

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: photoreduction, photooxidation, photodimerization, photochemical substitution, photoisomerization, photosensitisation, chemiluminescence, photochemistry of environment: Green house 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 MacMillan 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, " Introduction 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 Elctrrochemistry". Wiley
21. S. Glasstone, "Introduction to Electrochemistry" Affilised East West Press, New Delhi.
22. D. R. Crow, " The Principle of electrochemistry", Chapman Hall
23. G. K. Agrawal, Basic Chemical Kinetics, Tata-Mc-Graw Hill Pvt., Ltd. 1990
24. K. L. Kapoor, Text Book of Physical Chemistry, Vol – I to Vol-VI, 2011.

## Semester III

## Paper X (Code: 3T2)

## Special II-Physical Chemistry

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

80 Marks

## UNIT-I: QUANTUM MECHANICS - II

15h

- A]** Applications of Quantum Mechanics: 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), perturbation theory, application of perturbation theory to helium atom, generation of the concept of resonance.
- B]** Electronic structure of atoms: Russel Sanders terms and coupling schemes, Slater determinants, 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, cyclobutadiene, cyclopropenyl radical.

## Unit II: 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, Characterization 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-III: ELECTROCHEMISTRY OF SOLUTION 15h

- A] Metal/Electrolyte interface: 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 layer, 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 IV: IRREVERSIBLE THERMODYNAMICS 15h

- A] Microscopic reversibility and Onsager reciprocity relation, phenomenological equations, Transformation of generalized fluxes and forces. The cyclic version of Clausius' inequality and its integrated form and their correspondence with time's arrow and irreversibility, Clausius' uncompensated heat. Derivation of the differential form of Clausius' inequality.
- B] Rate of entropy production and the concept of Chemical affinity and its application to the cases of chemical reactions, coupled reactions, electrochemical reactions. Derivation of Gibbs relation and its DeDonderian version (time rate form) for spatially uniform chemically reacting closed systems, entropy production in spatially non-uniform systems like heat flow, Electrokinetic effect – Saxen relation.

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 Mcgraw 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. S. Glasstone, An Introduction to Electrochemistry, East-West Press Pvt. Ltd., New Delhi, 2004.
9. D. Mcquarie and J. Simon, Physical Chemistry – A Molecular Approach, University Press, 2000
10. H. K. Moudgil, Text Book of Physical Chemistry, Pretice Hall of India, New Delhi, 2010.
11. S. O. Pillai, Solid State Physics, New Age International, New Delhi, 2102.
12. M. C. Day and J Selbin, Theoretical Inorganic Chemistry, Reinhold Pub. Corp., New York,
13. I Prigogine and R. Defay, Chemical Thermodynamics, Longmans, London, 1954.
14. S. R. DeGroot and P. Mazoor, Non-Equilibrium Thermodynamics, North-Holland Co., Amsterdam, 1969.
15. G. Lebon, D. Jou and Casa Vazquez, Understanding Non-equilibrium Thermodynamics, Springer, 2008.
16. I.Prigoggine, "An Introduction to Thermodynamics of Irreversible Processes," Wiley-Interscience.
17. R. P. Rastogi, Introduction to Non-equilibrium Physical Chemistry, Elsevier, Amsterdam, 2008.
18. J.O.M.Bokris and A.K.N.Reddy, "Modern Elctrchemistry". Wiley
19. S. Glasstone, "Introduction to Electrochemistry" Affilised East West Press, New Delhi.
20. D. R. Crow, " The Principle of electrochemistry", Chapman Hall



21. C.Kittel, "Introduction to solid state Physics", Wiley
22. L.V.Azaroff, "Introduction to solids", McGraw Hill
23. Santosh Kumar Upadhyay, Chemical Kinetics and Reaction Dynamics, Springer 2006.
24. N. B. Hannay, Treatise in Solid State Chemistry, 4<sup>th</sup> Edn,
25. N. B. Hannay, Solids,
26. Sulbha Kulkarni, Nanotechnology: Principles and Practices, Capital Publishing House, 2011.
27. T. Pradeep, Nano: The Essentials, Tata Mc-Graw Hill, 2012
28. K. L. Kapoor, Text Book of Physical Chemistry, Vol – I to Vol-VI, 2011.
29. N. B. Hannay, "Solid State Chemistry"
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.

Semester III  
Practical-V (Code: 3P1)  
Physical Chemistry Special

12 h /week

Marks: 100

## 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 tartrate 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<sub>2</sub>SO<sub>4</sub>, K<sub>2</sub>SO<sub>4</sub> etc. on the solubility of an organic acid (benzoic acid or salicylic acid).
5. To determine the heat of crystallization of CuSO<sub>4</sub>.5H<sub>2</sub>O
6. To determine the heat of reaction involving precipitation of a salt BaSO<sub>4</sub>
7. To determine transition temperature of CaCl<sub>2</sub> by thermometric method and to determine transition temperature of CaCl<sub>2</sub>, 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<sub>2</sub>O<sub>2</sub> catalysed by iodide ion. Also determination of activation energy of reaction.

## Conductometry:

11. Estimate the concentration of H<sub>2</sub>SO<sub>4</sub>, CH<sub>3</sub>COOH, CuSO<sub>4</sub>.5H<sub>2</sub>O in a given solution by carrying out conductometric titration against NaOH solution.
12. Determine the eq. conductance of strong electrolyte (KCl, NaCl, HCl, KNO<sub>3</sub>) at several concentration and hence verify Onsager's equation.
13. Carry out the following precipitation titration conductometrically. a. 50 ml.0.02N AgNO<sub>3</sub> with 1N HCl; b.50 ml.0.02N AgNO<sub>3</sub> with 1N KCl; c. 50 ml 0.004 N MgSO<sub>4</sub> with 0.1 N Ba(OH)<sub>2</sub>; d. 50 ml 0.002 N BaCl<sub>2</sub> with 1 N Li<sub>2</sub>SO<sub>4</sub>; e. 50 ml.0.02 N BaCl<sub>2</sub> with 1N K<sub>2</sub>SO<sub>4</sub>

## Potentiometry:

14. To prepare calomel electrode and to determine the potential of calomel electrode by potentiometry.

15. To determine stability constant of  $\text{Fe}^{3+}$  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 ( $\text{Fe}^{2+}/\text{Fe}^{3+}$ ,  $\text{Co}^{3+}/\text{Co}^{2+}$ ,  $\text{Cr}^{3+}/\text{Cr}^{2+}$ ,  $\text{MnO}_4^-/\text{Mn}^{2+}$  (any two) and equilibrium constant.
18. Study of complex formation by potentiometry e.g.  $\text{Ag}^+ - \text{S}_2\text{O}_3^{2-}$ ,  $\text{Fe}^{3+} - \text{SCN}^-$ ,  $\text{Ag}^+ - \text{NH}_3$  (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, 8<sup>th</sup> 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 Methods 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: AnalytiacI Chemistry
16. Skoog S.A. And West D. W.:Fundamental of Analytical Chemistry
17. Dilts R.V.: AnalytiacI 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 6<sup>th</sup> Ed

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#### Semester III

#### ANALYTICAL CHEMISTRY SPECIALIZATION

#### Paper IX(Code: 3T1)

#### Special I-Analytical Chemistry

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

80 Marks

#### Unit-I: Radioanalytical Chemistry-I

15h

Radioactivity-Radiation-Units-Curie, Becquerel, Gray, Rad, Sievert, RBE, REM, Half life, mixed half life, branching decay, different types of radiations and their interactions with matter, radioactive

equilibrium, Elementary principles of GM and proportional counters, Gamma Ray Spectrometer, Ionization chamber, HPGe detector, NaI(Tl) detector, calibration using standard sources, resolution, numericals.

Unit-II: Optical methods of analysis-III

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-III: 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-IV: Miscellaneous techniques-I

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.

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

Semester III

Paper X (Code: 3T2)

Special II-Analytical Chemistry

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

80 Marks

Unit-I: Organoanalytical Chemistry

15h

*Elemental analysis:* Outline of macro, semi-micro, micro and ultra-micro analysis, semi-micro determination of carbon, hydrogen, halogen, sulphur, nitrogen, phosphorous, arsenic, boron and metals in organic compounds.

*Functional group analysis:* Semi-micro determination of the following functional groups in organic compounds- hydroxyl, amino, nitro, nitroso, azo, N-acetyl, O-acetyl, methyl, aldehydes, ketones, thio, disulphide, sulphonamide, unsaturation and active hydrogen.

*KF reagent:* Karl Fischer reagent and its use in analysis of water in organic compounds.

**Unit-II: 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 III:**

15h

**Water pollution and analysis:** 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.

**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<sub>2</sub>, NO<sub>2</sub>, CO, CO<sub>2</sub>, particulates-SPM, RSPM, High Volume Sampler, Fabric Filters, Cyclones (direct and Reverse), ESP, ozone layer, Green house effect, Heat Islands, Acid Rain.

**List of books:**

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

**Semester III****Practical-V (Code: 3P1)****Analytical Chemistry Special**

12 h /week

Marks: 100

**pH-metry**

- Determination of percent Na<sub>2</sub>CO<sub>3</sub> in soda ash by pH-metric titration.
- Determination of isoelectric point of amino acid.
- Determination of three dissociation constants of phosphoric acid.

**Conductometry**

- Displacement titration of CH<sub>3</sub>COONa with HCl.
- Precipitation titration of MgSO<sub>4</sub> and BaCl<sub>2</sub>.

3. Titration of mixture of  $\text{CH}_3\text{COOH}$ ,  $\text{H}_2\text{SO}_4$  and  $\text{CuSO}_4$  with  $\text{NaOH}$ .

#### Potentiometry

1. Estimation of  $\text{Cl}^-$ ,  $\text{Br}^-$  and  $\text{I}^-$  in a mixture.
2. Determination of percent purity of phenol by potentiometric titration with  $\text{NaOH}$ .
3. Estimation of acids in mixtures.

#### Coulometry

1. Estimation of nickel and cobalt by coulometric analysis at controlled potential.
2. Analysis of antimony (III) with  $\text{I}_3^-$ .

#### Polarography

1. Determination of  $E_{1/2}$  of  $\text{Cd}^{2+}$  and  $\text{Zn}^{2+}$  at DME.
2. Estimation of  $\text{Cd}^{2+}$  and  $\text{Zn}^{2+}$  in respective solutions by calibration curve and standard addition methods.
3. Determination of composition /stability constant of complex.

#### Cyclic voltammetry

1. Study of cyclic voltammograms of  $\text{K}_3[\text{Fe}(\text{CN})_6]$ .

#### Electrogravimetry

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

#### Polarimetry

1. Inversion of cane sugar in the presence of  $\text{HCl}$ .
2. Determination of percentage of two optically active substances (d-glucose and d-tartaric acid) in mixture.

#### Colorimetry/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 rock/ soil / water samples.

#### Turbidimetry and nephelometry

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

#### 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 ( $\text{Mn-56}$ ,  $\text{I-128}$ ,  $\text{In-116}$ )
3. Experiments based on radiation chemistry: G-value- $\text{G}(\text{NO}_2^-)$ .

#### Demonstrations

1. UV-spectrophotometry

### Semester III

#### Paper XI (Code: 3T3)

#### Elective- Nuclear Chemistry

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

80 Marks

#### 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 pair 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

## Semester III

## Practical VI—Elective (Code: 3P3)

## Nuclear Chemistry Practical

12 h per week

Marks-100

- Working of GM counter, plateau, statistics, geometry effects, dead time, energy of beta particle, back scattering
- Working of gas flow proportional counter, plateau, statistics, geometry effects, dead time, energy of beta particle
- Working with scintillation counter, gamma ray spectra, energy calibration and resolution, half life determination of single and composite nuclei.
- Radiochemical separation of  $^{234}\text{Th}$  from natural uranium salt and its half life determination
- Experiment on Neutron Activation Analysis by non-destructive method
- Dose measurement by Fricke and other chemical dosimeters
- Radiolysis of potassium nitrate, methyl iodide, carbon tetrachloride-iodine systems
- Szilard-Chalmers reactions with inorganic and organic systems, potassium permanganate and methyl iodide
- Some trace experiments like partition coefficient, solubility product, isotopic exchange, isotope dilution analysis, radiochromatography, ion exchange.

## List of books:

- H. J. Arnikar - Essentials of Nuclear Chemistry (Willey Eastern Ltd)
- G. Friendlander, J. W. Kennedy, E. S. Macias and J. M. Miller-Nuclear and Radiochemistry (Wiley Intersciences, New York)
- G. R. Choppin and J. Rydberg- Nuclear Chemistry-Principles and Applications(Pergamon press, London)
- B. G. Harvey-Introduction to Nuclear Physics and Chemistry(Prentice Hall of India)
- A. N. Nesmeyanov - Radiochemistry- (Mir Publications)
- M. N. Sastry-Introduction to Nuclear Science, Affiliated East-West Press, New Delhi
- G. Hughes- Radiation Chemistry- Oxford University Press, London



7. V. Verschinskii and A. K. Pikeav-Introduction to Radiation Chemistry, Israel Publication, Jerusalem-Robinson (Marcol Dekker)
8. Farhat Aziz and M. A. J. Radgers-Radiation Chemistry-Principles and Applications, VCH Publishers FRC.
9. M. Hassinsky-Nuclear Chemistry and its application, Addison Wesley

## Semester III

## Paper XI (Code: 3T3)

## Elective- Environmental Chemistry

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

80 Marks

Unit -I: Concept and scope of Environmental Chemistry 15 h

Biosphere, Lithosphere, Hydrosphere and Atmosphere, Ecological principles- aspects of ecology, classification, types of ecosystems. Biogeochemical cycles- carbon, nitrogen, phosphorous, oxygen, hydrogen, sulphur, iron, sodium, potassium, magnesium, cobalt, mercury, lead, zinc and cadmium. Thermal pollution—sources, harmful effects and prevention of thermal pollution. Noise pollution --- sources, effects and control of noise pollution.

Unit-II: Water 15 h

Origin, physico-chemical properties of water, sources of water, hydrological cycle, criteria of water quality, Water management- water shed management, rain water harvesting, water pollution- sources, consequences and harmful effects of water pollution, strategies for water pollution control.

Unit-III: Air 15 h

Major regions of the atmosphere, composition of the atmosphere, temperature inversion and air pollution episodes, photochemistry of the atmosphere, depletion of the stratospheric ozone, green house effect, green house gases, remedial measures for reversion of green house effect, acid rain, photochemical smog, particulate matter.

Unit-IV: 15 h

**Soil:** Chemical and mineralogical composition of soil, classification of soil, types of soil- saline and alkaline, physical properties – texture, bulk density, permeability, chemical properties—Ion exchange capacity, soil pH and micro and macro nutrient availability. Soil management— Management of saline and alkaline soil, soil indicator plants,  
**Radioactive Pollution:** Introduction to radiation chemistry, sources of radioactive pollution, effects of radioactive pollution, nuclear disasters in the two decades, protection from radiation, control of radiation.

## Semester III

## Practical VI—Elective (Code: 3P3)

## Environmental Chemistry Practical

12h per week

Marks-100

## 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

- 1 Determination of SO<sub>x</sub> and NO<sub>x</sub> 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

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#### Semester III

#### Paper XI (Code: 3T3)

#### Elective- Polymer Chemistry

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

80 Marks

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 15h

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 ( $T_g$ ), relationship between  $T_g$  and  $T_m$ , Effect of molecular weight, diluents, chemical structure, chain topology, branching and cross linking. Methods of determination of glass transition and crystallinity of polymers.

Unit IV: Commercial polymers 15h

A) Organic polymers: Commercial polymers, synthesis and application of polyethylene, Cellulose Acetate, PMMA, polyamides, polyesters, Urea resins and epoxy resins.

B) Functional polymers: Fire retarding polymers and conducting polymers, biomedical polymers.

### Semester III

#### Practical VI – Elective (Code: 3P3)

#### Polymer Chemistry Practical

12h per week

Marks-100

1. Synthesis of polymers:
  - a) Synthesis of Thiokol rubber (condensation)
  - b) Urea-formaldehyde (condensation)
  - c) Glyptal resin: glycerine phthalic acid (crosslinked Polymer Chemistry)
  - d) Polyacrylonitril (bulk polymerization)
  - e) Polyacrylonitril (emulsion polymerization)
  - f) Polymethylmethacrylate (emulsion of suspension Polymer Chemistry)
  - g) Nylon-66 (interfacial polycondensation)
  - h) Coordination polymers
  - i) Conducting polymer (electro- or peroxodisulphate oxidation)
2. Characterization of polymers:
  - a) End-group analysis
  - b) Viscosity and molecular mass
  - c) Density of polymer by flotation methods
  - d) IR spectra.
3. Purification and fractionation of polymer, polystyrene, Nylon 66, PMMA.
4. Magnetic and electrical properties of polymers, magnetic susceptibility and electrical conductivity of coordination and conducting polymers.
5. Thermal analysis and degradation of polymers:
  - i. TGA: Isothermal and non-isothermal;
  - ii. DTA: Glass transition temperature and melting point
6. Crystallinity of polymers by density measurement.
7. Swelling and solubility parameters of polymers.
8. Synthesis of Graft-Polymers and its characterization by density and IR spectra.
9. Dielectric behavior of polymers.
10. Kinetics of polymerization:
  - a) Polycondensation
  - b) Peroxide initiation polymerization.

List of books:

1. Textbook of polymer science: F.W. Billmeyer 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. Contemporary 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 XI Elective (Code: 3T3)

## Medicinal Chemistry

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

80 Marks

## UNIT-I:

15 h

## Drug Design:

Development of new drugs, factors affecting development of new drugs, sources of lead compounds, serendipity and drug development. 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-II:

15 h

**A]** Pharmacokinetics and pharmacodynamics: Introduction 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

**B]** Diuretics: Introduction, mode of action, loop diuretics. Synthesis of Bumetanide, Frusemide, Ethacrynic acid, clorexolone Quinethazone.

**C]** Analgesics and Antipyretics: Introduction, mode of action, evaluation of analgetic agents. Synthesis of: Aspirin, salsalate, phenacetin, phenylbutazone, Indomethacin, Analgin.

## UNIT-III:

15h

**A]** Cardiovascular Drugs: Introduction, cardiovascular diseases, Synthesis and uses of cardiovascular drugs; amyl nitrate, diltiazem, varapamil, methyldopa, atenolol, sorbitrate, quinidine, oxyprenolol

**B]** Antineoplastic Agent: Introduction, mechanism of tumor formation, treatment of cancer, types of cancer chemotherapy, role of alkylating agents and antimetabolites in treatment of cancer, carcinolytic antibiotics, mitotic inhibitors, hormones, natural products. Synthesis of melphalan, thiotepa, lomustine

## UNIT-IV:

15 h

**A]** Psychoactive drugs: Introduction, neurotransmitters, structure of nerve cell, chemical transmitters, CNS depressants, sedative and hypnotics, Synthesis of Barbiturates, Phenobarbital, thiopental sodium, diazepam, lorazepam, bromazepam, ethosuximide, general anaesthetic: Antianxiety drugs, synthesis of oxazepam, alprazolam, puspironone, antipsychotic drugs and antidepressant drugs, MAO inhibitors, antimanic drugs, synthesis of thiopental sodium, ethosuximide, glutethimide, trimethadione, phenytoin.

- B]** Coagulant and Anticoagulants: Introduction, factors affecting coagulant and anti-coagulant. Mechanism of Blood coagulation and Anticoagulation. Structure of Vitamin K1, Vitamin K2 and heparin. Synthesis of Coumarins and indanediones.

## Semester III

## Practical VI–Elective (Code: 3P3)

## Medicinal Chemistry Practical

12 h per week

Marks-100

1. Volumetric estimation of Ibuprofen.
1. Estimation of aspirin by volumetric and instrumental methods.
2. Analysis of ascorbic acid in biological/tablet sample.
3. Determination of paracetamol by colorimetry.
4. Analysis of ampicillin trihydrate.
5. Determination of vitamin B12 in commercial sample by spectrophotometry.
6. Determination of phenobarbitone in given cough syrup.
7. Determination of tetracycline in given capsule.
8. Determination of iron, calcium and phosphorus from milk or drug sample.
9. To perform I.P. monograph of tablet.
10. Estimation of chloride in serum and Urine.
11. Separation and determination of sulpha drugs in tablets or ointments.

Preparation of Drugs: Synthesis, purification and identification of (8-10) of the following drugs.

1. Benzocaine from p-nitrobenzoic acid.
2. Dapsone from diphenyl sulphone.
3. Paracetamol from p-nitro phenol.
4. Uracil from sulphanil amide.
5. Diphenyl hydantion from benzoin.
6. Aluminium aspirin from salicylic acid.
7. 4,6-diphenyl-thiazine from chalcone.
8. 6/8 nitro coumarin from resorcinol.
9. Copper aspirin from salicylic acid.
10. N-acetyl parabanic acid.
11. Nerolin from 2-naphthol
12. Phenothiazine from diphenylamine
13. Umbelliferon from resorcinol
14. Benzylidene from benzaldehyde and aniline
15. 1-phenyl-1,2-pentadine-3-one from benzaldehyde
16. 1,5 diphenyl-1,3-pentadiene-2-one from benzaldehyde
17. 1,3-diphenyl-prop-2-ene-1-one
18. 3-methy pyrazol-5-one from ethylacetoacetate
19. 6-methyl uracil
20. Sulphanilamide from acetanilide

List of books:

1. Text book of organic medicinal chemistry-Wilson,Geswold
2. Medicinal chemistry Vil I and II-Burger
3. A textbook of pharmaceutical 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

## Paper XII (Code: 3T4)

## Foundation Course - I Applied Analytical Chemistry– I

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

80 Marks

## Unit-I: Analysis of Pesticides and Fertilizers 15h

*Pesticides:* General introduction, analysis of pesticides in general with reference to DDT, Dieldrin, Malathion, Parathion, BHC by different analytical methods such as titrimetric, colorimetric, chromatography and electroanalytical methods.

*Fertilizers:* Sampling and sample preparation, determination of water, total nitrogen, urea, total phosphates, potassium, acid or base forming quality.

## Unit-II: Forensic chemistry 15h

Introduction. Classification of poisons on the basis of physical states, mode of action and chemical properties with examples of each type. Methods of administration. Action of poisons in body. Factors affecting poisoning. Study of some common poisons used for suicide. Signs and symptoms of As, Pb, Hg and cyanide poisoning. Poisonous effects of kerosene and cooking gas.

## Unit-III: 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-IV: Analysis of alloys 15h

Definition of alloy. phase diagrams of Fe-C, Pb-Sn, Pb-Ag systems and their applications. Types of steel: hypoeutectic, hypereutectic steels, mild steel, and stainless steel. Uses of steel. Composition and uses of brass, bronze and soldering alloy. Analysis of iron, nickel, chromium and manganese in steel. Analysis of copper and zinc in brass, lead and tin in soldering alloy. Industrial applications of alloys.

OR

## Semester III

## Paper XII (Code: 3T4)

## Core Subject Centric - I: Spectroscopy– I

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

80 Marks

## 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, McLafferty 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 anti-Stokes 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 Morrill, John Wiley
- 2] Introduction to NMR spectroscopy-R. J. Abraham, J. Fisher and P Loftus Wiley
- 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 Delpenck, 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

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Semester III  
Seminar-III (Code: 3S1)

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  
 INORGANIC CHEMISTRY SPECIALIZATION  
 Paper XIII (Code: 4T1)  
 Special I-Inorganic Chemistry

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

80 Marks

## Unit-I

15h

- A) Nanoparticals & Nanostructural materials :Introduction, methods of preparation, physical properties, and chemical properties. Molecular Precursor routes to inorganic solids:- Introduction, sol-gel chemistry of metal alkoxide, hybrid organic-inorganic compounds. Nanoporous Materials: Introduction, Zeolites & molecular sieves, determination of surface acidity, porous lamellar solids, composition-structure, preparation & applications.
- B) Solid State Reaction: General principles, reaction rates, reaction mechanism, reaction of solids, factors influencing reactivity, photographic process.

## 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

Catalysis: Basic principles, thermodynamic and kinetic aspects, industrial requirements, classification, theories of catalysis, homogeneous and heterogeneous catalysis .Introduction, types & characteristics of substrate-catalyst interactions, kinetics and energetic aspects of catalysis, selectivity, stereochemistry, orbital symmetry and reactivity. Catalytic reactions of coordination and Organometallic compounds including polymerization activation of small molecules, addition to multiple bonds, hydrogenation Zeigler-Natta polymerization of olefins, hydroformylations, oxidations, carbonylations and epoxidation.

Name organic reaction involving inorganic compounds: Suzuki Coupling, Heck Reaction, Negishi reaction and Sonogirhra reaction

## Unit-IV

15h

- A) Optical sensor for metal Ions: Chelates ligand (Multidentates, Ruthenium bipyridyls, calixarenes, Lanthanide ion); Macrocyclic ligands (Flexible Macrocycles, Azamacrocycles, Cryptands, porphyrins); Crown ether and Cryptands( Napthalene and Anthracene crowns, Cryptands, structural features)
- B) Thin films and languir-Biodgett films: Preparation technique, evaporation/spultering, chemical processe MOCVD, solgel etc. Languir-Biodgett(LB) film, growth techniques, photolithography properties and applications of thin and LB films.

## 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

## Paper XIV (Code: 4T2)

## Special II-Inorganic Chemistry

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

80 Marks

## Unit-I

15 h

- A) Basics of Photochemistry: Absorption, excitation, photochemical laws, quantum yield, electronically excited states-life times-measurements of the times. Flash photolysis, stopped flow techniques, Energy dissipation by radiative and non-radiative processes, absorption spectra Frank-Condon principles; photochemical stages-primary & secondary processes.
- B) Properties of excited states: Photochemical kinetics, Calculation of rates of radiative processes.
- 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-II

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, lifetime of these processes. Application of redox processes of electronically excited states for catalytic purposes, transformation of low energy reactants into high energy products, chemical energy into light.

## Unit-III

15h

Organotransition Metal Chemistry: Alkyls and Aryls of Transition Metals: Types, routes of synthesis, stability & decomposition pathways of alkyls & aryls of transition metals. Organocopper in Organic synthesis. Compounds of Transition Metal – Carbon Multiple bonds: Alkylidenes, alkylidynes, low valent carbenes & carbynes—synthesis, nature of bond, structural characteristics, nucleophilic & electrophilic reactions on ligands, role in inorganic synthesis.

## 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. Elschenbroich Ch. and Salzer A.: Organometallics, VCH, Weinheim, NY.
2. Balzani V. and Cavasanti V.: Photochemistry of Coordination compounds, AP, London
3. Purcell K.F. and Kotz J.C., An Introduction to Inorganic Chemistry, Holt Rinehart, Japan.
4. Rohtagi K.K. and Mukharjee, Fundamentals of Photochemistry, Wiley eastern
5. Calvert J.G. and Pitts J.N., Fundamental of Photochemistry, John Wiley
6. Wells, Inorganic Solid State Chemistry, Oxford University, 4th Edition
7. Paulson, Organometallic Chemistry, Arnold
8. Rochow, Organometallic Chemistry, Reinhold
9. Zeiss, Organometallic Chemistry, Reinhold
10. Gilbert A. and Baggott, J., Essential of Molecular Photochemistry, Blackwell Sci. Pub.
11. Turro N.J. and Benjamin W.A., Molecular Photochemistry



12. Cox A and Camp, T. P. Introductory Photochemistry, McGraw-Hill
13. Kundall R. P. and Gilbert A., Photochemistry, Thomson Nelson Coxon J and Halton B., Organic Photochemistry, Cambridge University Press.
14. Optoelectronic Properties of Inorganic Compounds, D. Max Roundhill and John P. Fakler, Jr. Plenum Press, New York

Semester IV  
 Practical-VII (Code: 4P1)  
 Inorganic Chemistry Special Practical

12 h /week

Marks: 100

- 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 tetrathiocyanatocobaltate(II)
  - 2 Preparation of Iron (II) oxalate & potassium trioxalatoferrate (III) trihydrate
  - 3 Preparation of cis & trans potassium dioxalato diaquochromate (III)
  - 4 Preparation of hexa-aminocobalt(III) chloride
  - 5 Preparation of hexa-aminenickel(II) chloride
  - 6 Preparation of tris (acetylacetonato ) manganese (III)
  - 7 Preparation of N-N bis (salicyldehyde ) ethylene diamine nickel (II)
  - 8 Preparation of trinitrotriaminocobalt(III)
  - 9 Preparation of chloropentamine 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 dipyridine iodine (I) nitrate
  - 14 Preparation of ammonium nickel(II) sulphate
- B SOLID STATE
- 1 Preparation of oxides and mixed oxides ( $\text{MnO}_2$ ,  $\text{NiO}$ ,  $\text{Cu}_2\text{O}$ ,  $\text{Fe}_3\text{O}_4$ ,  $\text{ZnFe}_2\text{O}_4$ ,  $\text{ZnMn}_2\text{O}_4$ ,  $\text{CuMnO}_4$  and  $\text{NiFe}_2\text{O}$ )
  - 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 SEPARATION 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  $\text{UO}_2^{2+}$  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 & Rockett
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 XIII (Code: 4T1)

## Special I-Organic Chemistry

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

80 Marks

Unit I:**A]** Carbanions in organic Chemistry

15 h

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, LDA, hydrolysis of haloforms, use of malonic and acetoacetic esters, Aldol, Mannich, Cannizzaro, Darzens, Dieckmann, Claisen Baylis-Hillman reactions, Knoevenagel, benzoin condensation, Julia olefination, alkylation of enolates and stereochemistry thereof, Conjugate additions, enamines in organic synthesis

**B]** Organometallic reagents -I

Synthesis and applications of organo Li and Mg reagents, nucleophilic addition to aldehyde, ketones, ester, epoxide, CO<sub>2</sub>, CS<sub>2</sub>, isocyanates, ketenes, imines, amides, lactones, Stereochemistry of Grignard addition to carbonyl compounds, *o*-metallation of arenes using organolithium compounds.

Unit II:

15 h

**A]** Organometallic reagents-II: Organozinc reagents: Preparation and applications, Reformatsky reaction, Simon-Smith reaction.

Organocopper reagents: Preparation and applications in C-C bond forming reaction, mixed organocuprates, Gilman's reagent. Organo Hg and Cd reagents in organic synthesis.

**B]** Transition metals in organic synthesis: 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<sub>2</sub>(CO)<sub>8</sub>, Ni(CO)<sub>4</sub>, Fe(CO)<sub>5</sub> in organic synthesis. Wilkinson catalyst of Ruthenium and Rhodium – synthesis and uses its use in hydrogenation reactions-deallylation, C-C, C-O, C-N bond cleavages. Olefin metathesis by I<sup>st</sup> and II<sup>nd</sup> generation catalyst, reaction mechanism and application in the synthesis of homo and heterocyclic compounds

Unit III:

15 h

**A]** Advanced Stereochemistry: Conformation of sugars, monosaccharides, disaccharides, mutarotation, Recapitulation of Stereochemical concepts- enantiomers, diastereomers, homotopic and heterotopic ligands, 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]** Protection and Deprotection of functional groups: Protection and deprotection of functional groups like, hydroxyl, amino, carbonyl and carboxylic acids groups, Solid phase peptide synthesis.

Unit IV: 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 organic synthesis, 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 and carbonyl compounds, regioselectivity, alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis

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

List of books

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

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Semester IV

Paper XIV(Code: 4T2)

Special II-Organic Chemistry

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

80 Marks

Unit I: Enzyme chemistry

15h

**A]** Enzymes: Introduction, chemical and biological catalysis, remarkable properties of enzymes like catalytic 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 catalyzed reactions

**B]** Mechanism of Enzyme Action: Transition-state theory, orientation and steric effect, acid-base catalysis, 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<sup>+</sup>, NADP<sup>+</sup>, FMN, FAD, lipoic acid, biotin as CO<sub>2</sub> carrier. Mechanisms of reactions catalyzed by the above cofactors.

Unit II: Heterocycles

15h

- A] Azoles: Structural and chemical properties; Synthesis of pyrazole, isothiazole and isoxazole; Synthesis of imidazoles, thiazoles and oxazoles; Nucleophilic and electrophilic substitutions; Ring cleavages, 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 B<sub>6</sub>, Ondansetron, Serotonin, Indometacin, Cyanamid, fentiazac, trimethoprim, papaverine

Unit III: 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.
- B] Lipids: Fatty acids, essential fatty acids, structures and functions of triglycerols, glycerophospho lipids, 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,  $\beta$ -Oxidation of fatty acids
- C] Vitamins: Structure determination, and synthesis of vitamin A, E and H.

Unit IV: 15h

- A] Dyes: General Introduction, classification on the basis of structure and methos of application dying mechanism, methods of dying, such as direct dying, vat dying, dispersive dying, formation of dye in fibre, dying with reactive dyes, study of quinoline yellow, cyamine dye, ethyl red, methylene blue, Alizarin, cyamine-green, fluorescein, cosin, erythrosine, Rhodomines and Indigo.
- B] Pharmaceutical chemistry: History, medical terms in pharmaceutical chemistry, classification of drugs, antibacterial and antifungal drugs, specific clinical applications, Synthesis and applications of: Benzocaine, Methyl dopa, dilantin, ciprofloxacin, acyclovir, terfenadine, salbutamol
- C] Polymer chemistry: Importance of polymers, Basic concepts: monomers, repeat units, degree of polymerization. Linear, branched and network polymers. Classification of polymers. Polymerization: condensation, addition, radical chain-ionic and co-ordination and co-polymerization and their mechanisms, Polymerization in homogeneous and heterogeneous systems. Ziegler-Natta polymerization with mechanism, Stereo regulated polymers, syndiotactic, isotactic and atactic polymers

List of books

- 1] Textbook of Polymer Science, F. W. Billmeyer Jr, Wiley
- 2] Polymer Science, V. R. Gowarikar, N. V. Viswanathan and J. Sreedhar, Wiley-Eastern
- 3] Functional Monomers and Polymers, K. Takemoto, Y. Inaki and R. M. Ottanbrite
- 4] Bioorganic Chemistry: A Chemical Approach to Enzyme Action, Hermann Dugas and C. Penny, Springer-Verlag
- 5] Understanding Enzymes, Trevor Palmer, Prentice Hall
- 6] Enzyme Chemistry: Impact and Applications, Ed. Collin J. Suckling, Chapman and Hall
- 7] Enzyme Structure and Mechanism, A. Fersht, W. H. Freeman
- 8] Introduction to Medicinal Chemistry, A. Gringuage, Wiley-VCH
- 9] Wilson and Gisvold's Text Book of Organic Medical and Pharmaceutical Chemistry, Ed Robert F. Dorge
- 10] Burger's Medicinal Chemistry and Drug Discovery, Vol-1, Ed. M. E. Wolff, John Wiley
- 11] Strategies for Organic Drug Synthesis and Design, D. Lednicer, John Wiley
- 12] The Organic Chemistry of Drug Design and Drug Action, R. B. Silverman, Academic Press

Semester IV  
Practical-VII (Code: 4P1)  
Organic Chemistry Special Practical

12 h /week

Marks: 100

**A] Quantitative Analysis based on classical and instrumental technique (any 9-10)**

- 1] Estimation of nitrogen.
- 2] Estimation of halogen.
- 3] Estimation of sulphur.

**Spectrophotometric/calorimetric and other instrumental methods of estimation**

- 1] Estimation of streptomycin sulphate.
- 2] Estimation of vitamin B-12.
- 3] Estimation of amino acids.
- 4] Estimation of proteins.
- 5] Estimation of carbohydrates.
- 6] Estimation of Ascorbic acid.
- 7] Estimation of Aspirin.
- 8] Solvent extraction of oil from oil seeds and determination of saponification value, iodine value of the same oil.

**B] Organic multi-step preparations (Two/Three steps): Minimum 10-12 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] Benzoin → 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

**[C] SPECTRAL INTERPRETATION**

Structure Elucidation of organic compounds on the basis of spectral data (UV, IR, <sup>1</sup>H and <sup>13</sup>CNMR and Mass) (Minimum 12 compounds are to be analysed during regular practicals).

Paper XIII (Code: 4T1)  
Special I-Physical Chemistry)

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

80 Marks

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

15h

- A] Interaction of radiation with matter, radiation track spurs and  $\alpha$ -rays. Linear energy transfer, Bathe's equation for linear energy transfer, Bresstrahlung effect, Passage of neutron through matter, Interaction of  $\alpha$ -radiation with matter, photoelectric effect and Compton effect, pair production phenomena, units of measuring radiation absorption, Radiolysis of water, Radiolysis of some aqueous solutions. Effect of radiation on biological substances, genetic effects, Radiation effects on organic compounds and Polymers.

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 Suggested:

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 MacMillan IndianLtd., New Delhi (1993)
5. C. H. Bamford and C. F. H. Tipper, Comprehensive Chemical Kinetics, Vol 1., Elsevier Publications, New York, 1969.
6. C. H. Bamford and C. F. H. Tipper, Comprehensive Chemical Kinetics, Vol 2., Elsevier Publications, New York, 1969.



7. S. Glasstone, K. J. Laidler and H. Eyring, *The Theory of Rate Processes*, Mc-Graw Hill, New York, 1941.
8. Santosh Kumar Upadhyay, *Chemical Kinetics and Reaction Dynamics*, Springer 2006.
9. D. Mcquarie and J. Simon, *Physical Chemistry – A Molecular Approach*, University Press, 2000
10. G. M. Barrow, *Physical Chemistry*, Tata Mc-Graw Hill, V edition 2003.
11. H. K. Moudgil, *Text Book of Physical Chemistry*, Preitice Hall of India, New Delhi, 2010.
12. S. O. Pillai, *Solid State Physics*, New Age International, New Delhi, 2102.
13. C.Kittel, “Introduction to solid state Physics”, Wiley
14. L.V.Azaroff, “Introduction to solids”, McGraw Hill
15. Santosh Kumar Upadhyay, *Chemical Kinetics and Reaction Dynamics*, Springer 2006.
16. N. B. Hanny, *Treaties in Solid State Chemistry*, 4<sup>th</sup> Edn,
17. N. B. Hanny, “Solid State Chemistry”
18. M. C. Day and J Selbin, *Theoretical Inorganic Chemistry*, Reinhold Pub. Corp., New York,
19. C.N.Rao. *Nuclear Chemistry*
20. B. G. Harvey, *Introduction to Nuclear Physics and Chemistry*, Prentice Hall, Inc. (1969).
21. H.J. Arnika, *Essentials of Nuclear Chemistry*, 4th Edition (1995), Wiely-Eastern Ltd., New Delhi.
22. W. Loveland, D. Morrissey and G. Seaborg, *Modern Nuclear Chemistry*, Wiley-Interscience, 2006.
23. P. P. Milella, *Fatigue and Corrosion in Metals*, Springer, 2013.
24. *Corrosion- Understanding the Basics*, asminternational.org, 2000.
25. H. H. Uhlig, *Corrosion and Corrsion Control – 3<sup>rd</sup> edn*, John Wiley & sons, New York.
26. J. W. T. Spinks and R. J. Woods, *An Introduction to Radiation Chemistry*, John Wiley and sons., New Yoek, 1975.
27. K. L. Kapoor, *Text Book of Physical Chemistry, Vol – I to Vol-VI*, 2011.

## Semester IV

## Paper XIV (Code: 4T2)

## Special II-Physical Chemistry

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

80 Marks

## 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, numericals.

## 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: LIQUID STATE AND INTERFACES

15h

- A]** Theory of liquids: - Theory of liquids, partition function method or model approach, single cell models, communal energy and entropy, significant structure model.



- B]** Liquid gas and liquid interfaces: Surface tension, methods of determination of surface tension, surface tension across curved surfaces, vapor pressure of droplet (Kelvin equation), surface spreading, spreading coefficient, cohesion and adhesion energy, contact angle, constant angle hysteresis, wetting and detergency.

Unit IV: IONIC LIQUIDS AND BATTERY TECHNOLOGY 15h

- A]** Supercooled and ionic liquids: Supercooled and ionic liquids, theories of transport properties, non Arrhenius behavior of transport properties, Cohen-Turnbull free volume model, configurational entropy model, Macedo- Litovitz model, glass transition in supercooled liquids.
- B]** Battery Technology: basic concept, classification of batteries, primary, secondary and reserve batteries, Construction, working and application of Acid Storage batteries, Lithium - MnO<sub>2</sub> batteries, Nickel- Metal hydride batteries, Fuel Cells, Construction and working of H<sub>2</sub>O<sub>2</sub> and methanol-O<sub>2</sub> Cell.

List of books

1. S. O. Pillai, Solid State Physics, New Age International, New Delhi, 2102.
2. D. Mcquarie and J. Simon, Physical Chemistry – A Molecular Approach, University Press, 2000
3. G. M. Barrow, Physical Chemistry, Tata Mc-Graw Hill, V edition 2003.
4. H. K. Moudgil, Text Book of Physical Chemistry, Prentice Hall of India, New Delhi, 2010.
5. M. C. Day and J Selbin, Theoretical Inorganic Chemistry, Reinhold Pub. Corp., New York,
6. A. Kokorin, Ionic Liquids: Theory, Properties and New Approaches, Intech, Croatia, 2011.
7. Gholam-Abbas Nazri, Gianfranco Pistoia, Lithium Batteries-Science and Technology, Springer, 2003.
8. N. H. March and M. P. Tosi, Introduction to Liquid State Physics, World Scientific, London, 2002.
9. George Kackson, Liquid State Theory,
10. C.Kittel, " Introduction to solid state Physics", Wiley
11. L.V.Azaroff, " Introduction to solids", McGraw Hill
12. Santosh Kumar Upadhyay, Chemical Kinetics and Reaction Dynamics, Springer 2006.
13. N. B. Hannay, Treatise in Solid State Chemistry, 4<sup>th</sup> Edn,
14. N. B. Hannay, Solids,
15. H. Y. Erbil, Surface Chemistry of Solid and Liquid Interfaces, Blackwell Publishing, 2013.
16. N. B. Hannay, "Solid State Chemistry"

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Semester IV

Practical-VII (Code: 4P1)

Physical Chemistry Special Practical

12 h /week

Marks: 100

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:

5. Clock reaction- activation energy of bromide-bromate reaction.
6. 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.
7. Kinetics of B-Z reaction; Kinetics of modified B-Z reaction
8. Investigate the Autocatalytic reaction between potassium permanganate and oxalic acid.
9. Determination of pK<sub>a</sub> value of a weak acid by chemical kinetic method (formate-iodine reaction)

Potentiometry:

10. Transport number by potentiometry.

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

Conductometry:

14. To determine degree of hydrolysis of aniline hydrochloride and hence to determine the hydrolysis constant of salt by conductometric method.
15. To determine pK of weak acids, succinic acid, acetic acid, Malonic acids, (dibasic acids).
16. Complexation between  $\text{Hg}^{2+}$  and  $\text{I}^-$  conductometrically.
17. To determine solubility product of lead chromate.
18. Kinetic study of saponification ethyl acetate by conductometry.

Spectrophotometry:

19. To determine the stability constant of reaction between Ferric ion solution and  $\text{SCN}^-$  ion solution by Job's method.
20. To determine the stability constant between  $\text{Fe}^{3+}$  and  $\text{SCN}^-$  ion solution by Ostwald & Frank method.

Transport Number:

21. To determine transport number by Hittorff's method
22. To determine the transport number by moving boundary method

List of Books

1. Vogel A, 3<sup>rd</sup> 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, 8<sup>th</sup> 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 Methods 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: AnalytiacI Chemistry
16. Skoog S.A. And West D. W.:Fundamental Of Analytical Chemistry
17. Dilts R.V.: AnalytiacI 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 6<sup>th</sup> Ed
21. Ramesh Rand Anbu M, Chemical Methods For Envirmental Analysis : Watewr And Sedient , Macmillion India

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Semester IV  
ANALYTICAL CHEMISTRY SPECIALIZATION  
Paper XIII(Code: 4T1)  
Special I-Analytical Chemistry

60h (4h/week) 15h/unit	80
Marks	
Unit-I: Radioanalytical Chemistry-II	15h
Preparation of some commonly used radioisotopes ( $^{22}\text{Na}$ , $^{60}\text{Co}$ , $^{131}\text{I}$ , $^{65}\text{Zn}$ , $^{32}\text{P}$ ), Use of radioactive isotopes in analytical and physico-chemical problems, Industrial applications, Neutron sources, Neutron Activation Analysis, Isotope Dilution Analysis, Radiometric titrations (Principle, Instrumentation, applications, merits and demerits), Radiochromatography, Carbon dating, Numericals based on above.	
Unit-II: Optical methods of analysis-IV	15h
<i>Inductively coupled plasma-atomic emission spectroscopy</i> : Principle, atomization and excitation. Plasma source and sample introduction. Instrumentation. Comparison of ICP-AES with AAS. Applications.	
<i>X-ray fluorescence spectroscopy</i> : 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.	
<i>Particle induced X-ray emission (PIXE)</i> : Basic principle, Instrumentation and applications.	
<i>Electron microscopy</i> : Principle, instrumentation and applications of scanning electron microscopy (SEM) and transmission electron microscopy (TEM)	
Unit-III: Electrochemical methods of analysis-III	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 $\text{H}^+$ , $\text{Na}^+$ and $\text{K}^+$ ions. Applications of ISE in analysis of environmentally important anions like $\text{F}^-$ , $\text{Cl}^-$ , $\text{Br}^-$ , $\text{I}^-$ , $\text{NO}_3^-$ and $\text{CN}^-$ . Advantages of ISE.	
Coulometry: Principle. Coulometry at constant potential and constant current. Instrumentation. Applications and advantages of coulometric titrations.	
<i>Electrochemical microscopy</i> : Introduction to scanning probe microscopy (SPM), scanning tunneling microscopy (STM), atomic force microscopy (AFM) and scanning electrochemical microscopy (SECM).	
Unit-IV: 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.	

## Semester IV

## Paper XIV(Code: 4T2)

## Special II-Analytical Chemistry

60h (4h/week) 15h/unit	80 Marks
Unit-I: Pharmaceutical and clinical analysis	15h
Requirements of a quality control laboratory for pharmaceutical units.	
Structures, category, identification (qualitative) and assay (quantitative) of following drugs	
1. Antibiotics: Amoxicillin, Azithromycin, Cefixime, Levofloxacin	

2. Antihistamine: Cetirizine, Cinnarizine
3. Vitamins: Thymine hydrochloride (Vitamin-B<sub>1</sub>) Riboflavin (Vitamin-B<sub>2</sub>), Ascorbic acid (Vitamin-C)
4. Analgesics: Diclofenac, paracetamol, Aspirin.

Composition of blood, sample collection for blood and urine, clinical analysis, Immuno Assay-RIA, Setting up of RIA and applications, Fluorescence Immunoassay, Enzyme immunoassay, Blood gas analyzer, Trace elements in the body.

Unit-II: Soil analysis and coal analysis 15h

*Soil analysis*- Classification and composition, pH and conductivity, analysis of constituents such as nitrogen, phosphorous, potassium and microconstituents (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-III: Corrosion and corrosion analysis 15h

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

Unit-IV: Automation in analytical chemistry 15h

Automation in the laboratory, Principle of automation, automated instruments, classification, continuous analyzer, automatic instruments, semiautomatic instruments GeMSAEC Analyzer, Flow Injection Analysis (FIA), Dispersion coefficient, Factors affecting Peak Height, microprocessor based instruments, Numericals based on above.

*Hyphenated techniques*: Introduction to GC-MS, LC-MS, ICP-MS and MS-MS (Tandem) spectrometry.

#### Semester IV

#### Practical-VII (Code: 4P1)

#### Analytical Chemistry Special Practical

12 h /week

Marks: 100

#### A. Organoanalytical chemistry

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

#### B. Separation techniques

##### *Ion exchange*

1. Separation and estimation of zinc and magnesium/cadmium in a mixture on anion exchanger.
2. Separation and estimation of chloride and iodide in a mixture on anion exchanger.
3. Determination of total cation concentration in water.

##### *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.

##### *Paper chromatography*

1. Separation and estimation of copper and nickel in a mixture.
2. Separation and estimation of cobalt and nickel in a mixture.

##### *Thin layer chromatography*

1. Separation and estimation of bromophenol blue, congo red and phenol red in a mixture.

2. Separation and estimation of metal ions in mixture.
- C. Water analysis
1. *Mineral analysis*: Temperature, pH, conductivity, turbidity, solids, alkalinity, chloride, fluoride, sulphate, hardness
  2. *Demand analysis*: DO, COD
  3. *Heavy metals*: Fe, Cd and Pb
- D. Demonstrations
1. Gas chromatography
  2. HPLC
- 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. Thermal analysis: Blazek (translated by J. F. Tyson, Van Nostrand)
  4. Instrumental Methods of Analysis: Willard, Meriit and Dean(Van Nostrand)
  5. Instrumental Methods of Analysis: G. Chatwal and S. Anand (Himalaya Publishing House)
  6. Vogel's Text Book of Quantitative inorganic Analysis: Bassett, Denney, Jeffery and Mendham (ELBS)
  7. Advanced Analytical Chemistry: Meites and Thomas (McGraw-Hill)
  8. Atomic Absorption Spectroscopy: Robinson (Marcel Dekker)
  9. Instrumental Methods of chemical Analysis: Braun (Tata McGraw-Hill)
  10. Radiochemistry: A. N. Nesmeyanov (Mir Publications)
  11. Analysis of Water: Rodier
  12. Ion selective electrods: Koryta (Cambridge University Press)
  13. Instrumentation in analytical chemistry: Borman (American Chemical Society)
  14. Industrial Chemistry: Arora and Singh (Anmol Publications)
  15. Diffraction Methods: John Wormald (Clarendon Press)
  16. Electroanalytical Chemistry: Bard (Dekker)
  17. Analytical Chemistry by Open Learning (Wiley)
  18. An Introduction to Electron Diffraction: Beeston (North Holand Publishing Co.)
  19. Material Science and Engineering: V. Raghavan (Printice-Hall of India)
  20. Practical Physical Chemistry: J. B. Yadav (Goel Publishing House)
  21. Indian Pharmacoepia, Vol-I, II and III.

## Semester IV

## Paper XV (Code: 4T3)

## Elective- Nuclear Chemistry

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

80 Marks

## 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, Radiopharmaceuticals, classification of products, preparations, quality control aspects, $^{99}\text{Mo}$ - $^{99\text{m}}\text{Tc}$ generator, Cyclotron based products, PRT studies, Therapeutic applications, Radiotherapy	

## Semester IV

## Paper XV (Code: 4T3)

## Elective- Environmental Chemistry

60 h (4 h per week): 15 h per unit	80 Marks
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 (UV-visible spectrophotometry, AAS, flame photometry, XRF, ICP-AES), chromatographic (GC and HPLC) and neutron activation methods of analysis of Co, Ni, Cu, Fe, Mn, Zn, Cd, Pb, Hg, As, $\text{Cl}^-$ , $\text{F}^-$ , $\text{SO}_4^{2-}$ , $\text{PO}_4^{3-}$ , $\text{NO}_3^-$ . 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 $\text{SO}_x$ , $\text{NO}_x$ , 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 pollution	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. Impact of toxic chemicals on enzymes, Biochemical effects of As, Cd, Pb and Hg, their metabolism, toxicity and treatment.	

## Semester IV

## Paper XV (Code: 4T3)

## Elective- Polymer Chemistry

60 h (4 h per week): 15 h per unit	80 Marks
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.

Semester IV  
 Paper XV (Code: 4T3)  
 Elective- Medicinal Chemistry

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

80 Marks

UNIT-I: 15 h

- A] Drug rules and drug acts, Overview of Intellectual property right, Indian and International framework for patent protection.  
 B] Statistical method: For sampling and interpretation of results, Statistic in quality control, T-Test, F-Test, Validation of analytical methods as defined proceeding USP Radio immune analysis, Investigational drugs.  
 C] Antidiabetic Agents- Type-I and Type-II diabetes, Insulin, thiazolidinediones, Synthesis of ciglitazone.

UNIT-II: 15 h

- A] Anti-Viral agents: Inroduction, viral diseases, viral replication, and transformation of cells, investigation of antiviral agents,. Chemotherapy for HIV. Synthesis of: Idoexuidine, acyclovir ,amantadine and cytarabin.  
 B] Anti-malarial agents: Introduction, malarial parasite, and its life cycle, development of antimalarials, chemotherapy of malaria. Synthesis of: Chloroquin, primaquin, proguanil, and Quinacrine  
 C] Local Anti-infective drug: Introduction and general mode of action. Synthesis of sulphonamides, ciprofloxacin, norfloxacin, dapsone ,amino salicylic acid, isoniazid, ethionamide, ethambutal, econazole, griseofulvin.

UNIT-III: 15 h

- A) Histamines and Antihistamic agents: Introduction, histamine H1-receptor antagonists. Inhibitors of histamine release. Synthesis of: alkyl amines, phenothiazines, piperzines derivatives.  
 B) Antibiotics: Introduction,  $\beta$ -lactam antibiotics, classification, SAR and chemical degradation of penicillin, cephalosporins-classification , tetracycline antibiotics-SAR,miscellaneous antibiotics. Synthesis of ampicillin, cephradine, methacycline, chloramphenicol

UNIT-IV: 15 h

- A) Anthelminitics and antiameobic drugs: Introduction to Helminthiasis, Anthelminitics, drugs used in cestode infection, drugs used in trematode infection, origin of antiameobic drug, drugs used in nematode infection. Synthesis of: Clioquinol, Iodoquinol, Haloquinol, Dichlorphen, Niclosamide.  
 B) Anti-inflammatory drugs: Introduction, etiology of inflammatory diseases. The inflammatory response, biochemical response. Synthesis of: Phenyl butazone and its derivatives, pyrazolone derivatives, pyrole and indole acetic acid derivatives.

Semester IV  
 Paper XVI (Code: 4T4)  
 Foundation Course–II Applied Analytical Chemistry-II

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

80 Marks

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: Polymer chemistry and leather analysis** 15h  
 Polymer chemistry: Definition, classification, co-polymers, conducting polymers, determination of acid value, saponification value, iodine value, molar mass by end group analysis- amide and hydroxyl, molecular weight by viscosity method, glass transition temperature of polymers, TGA and DTA studies of polymers.  
 Analysis of leather: Determination of moisture, acid, free sulphur, total ash, chromic oxide in leather, tensile strength and stretch of leather.

**Unit-III: Metallurgy**  
 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-II: 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, uric acid, blood urea-nitrogen, total serum protein, serum albumin, serum creatinine, serum phosphate, serum bilirubin, serum cholesterol. Radioimmunoassay (RIA).

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OR

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Semester IV

Paper XVI (Code: 4T4)

Core Subject Centric – II Spectroscopy – II

60 h (4 h per week): 15 h per unit 80 Marks  
 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 Woodward 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<sup>st</sup> order spectra), stereochemistry, variations of coupling constant with dihedral angle, electronegativity, Karplus equation etc., classification of molecules as AX, AX<sub>2</sub>, AMX, A<sub>2</sub>B<sub>2</sub>, Shift reagents. NMR studies of <sup>13</sup>C, chemical shift in aliphatic, olefinic, alkyne, aromatic, heteroatomic and carbonyl compounds, <sup>19</sup>F, <sup>31</sup>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 ( $^1\text{H}$  and  $^{13}\text{C}$  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

- 1] Spectroscopic identification of organic compound-RM Silverstein,GC Bassler and TC Morrill, 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] Practical NMR Spectroscopy-ML Martin, JJ Delpenck, and DJ Martyin
- 7] Spectroscopic Methods in Organic Chemistry-DH Willson, I Fleming
- 8] Fundamentals of Molecular Spectroscopy-CN Banwell
- 9] Spectroscopy in Organic Chemistry-CNR Rao and JR Ferraro
- 10] Photoelectron Spectroscopy-Baber and Betteridge
- 11] Electron Spin Resonance Spectroscopy-J Wertz and JR Bolten
- 12] NMR –Basic Principle and Application-H Guntur
- 13] Interpretation of NMR spectra-Roy H Bible
- 14] Interpretation of IR spectra-NB Coulthop
- 15] Electron Spin Resonance Theory and Applications-W gordy
- 16] Mass Spectrometry Organic Chemical Applications, JH Banyon
- 17] Spectroscopy- H. Kaur

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Semester IV  
Practical VIII (Code: 4PROJ1)  
Project

12 h/week

100 Marks

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.

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Semester IV  
Seminar-IV (Code: 4S1)

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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