As per NEP 2020

M.Sc. in Chemistry

(Effective from Academic Year 2024-2025 onwards)

Ordinance & Syllabus

(As per NEP 2020)

Department of Chemistry

Pandit Deendayal Upadhyaya Shekhawati University

Sikar (Rajasthan) 332024

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Shekhawati University,
Sikar(Rajasthan)

Final Credit Summary

PG in Chemistry

Yr	Sem	Credits							Total
		DSC	DSE/ P/D	GEC	AEC	SEC	VAC	Seminar / Internship / Dissertation	
First	Pawas	16	4	---	---	---	2	---	22
	Vasant	16	4	---	---	---	2	---	22
Second	Pawas	8	14	---	---	---	2	---	26
	Vasant	4	8	---	---	---	---	8	20
		44	32	---	---	---	6	8	90

Proposed Distribution of Credits for PG Programme				
Courses	SEM I	SEM II	SEM III	SEM IV
Major DSC	DSC1(4) DSC2(4) DSC3(4) DSC4(4)	DSC5(4) DSC6(4) DSC7(4) DSC8(4)	DSC9(4) DSC10(4)	DSC11(4)
DSE	DSE1(4)	DSE2(4)	DSE3(4) DSE4(4) DSE5(4) DSE6(4)	DSE7(4) DSE8(4)
GEC	---	---	---	---
AEC	---	---	---	---
SEC	---	---	---	---
VAC	VAC1(2)	VAC2(2)	VAC3(2)	---
Seminar / Internship / Dissertation	---	---	---	Dissertation (8)
Total	22	22	26	20
	44		46	
	90			

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Curriculum Structure										
Session 2024-2025 onwards										
Name of the Programme: MSc in Chemistry										
Year: First							Semester:I (Pawas)			
	Course Code	Course Title	Contact Hrs per Week			Credits	Weightage (%)			
			L	T	P		CW$	MTE	ETE	
Pawas Semester I	Discipline Specific Core (DSC):									
	24MCH9101T	Inorganic Chemistry-I	4	0	0	4	10	20	70	
	24MCH9102T	Organic Chemistry-I	4	0	0	4	10	20	70	
	24MCH9103T	Physical Chemistry-I	4	0	0	4	10	20	70	
	24MCH9104P	Chemistry Core Laboratory-I	0	0	4	4	10	20	70	
	Discipline Specific Elective (DSE):									
	24MCH9105T	Spectroscopy-I	4	0	0	4	10	20	70	
	OR									
	24MCH9106T	Analytical Techniques	4	0	0	4	10	20	70	
	Value Added Course (VAC): * from central Pool									
			2	0	0	2	10	20	70	
	Seminar/Intership/Dissertation (S/I/D):									
	--	--	--	--	--	--	--	--	--	
		Total				22				

Summary: I Semester		
S.N.	Particulars	Credits
1.	Discipline Specific Core (DSC):	16
2.	Discipline Specific Elective (DSE):	04
3.	Value Added Course (VAC):	02
4.	Seminar/Intership/Dissertation(S/I/D):	--
	Total	22
$CW (Classwork): It would include attendance, assignments, class test/ quiz test/assignments, ppt, play, learn by fun activities, etc.		

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Curriculum Structure										
Session 2024-2025 onwards										
Name of the Programme: M.Sc. in Chemistry										
Year: First							Semester: II (vasant)			
	Course Code	Course Title	Contact Hrs per Week			Credits	Weightage (%)			
			L	T	P		CW$	MTE	ETE	
Vasant Semester II	**Discipline Specific Core (DSC):**									
	24MCH9201T	Research Methdology	4	0	0	4	10	20	70	
	24MCH9202T	Inorganic Chemistry- II	4	0	0	4	10	20	70	
	24MCH9203T	Organic Chemistry-II	4	0	0	4	10	20	70	
	24MCH9204P	Chemistry Core Laboratory-II	0	0	4	4	10	20	70	
	Discipline Specific Elective (DSE):									
	24MCH9205T	Spectroscopy-II	4	0	0	4	10	20	70	
	OR									
	24MCH9206T	Environmental Chemistry	4	0	0	4	10	20	70	
	Value Added Course (VAC): * from central Pool									
			2	0	0	2	10	20	70	
	Seminar/Intership/Dissertation (S/I/D):									
	--	--	--	--	--	--	--	--	--	
		Total				**22**				

Summary: II Semester		
S.N.	**Particulars**	**Credits**
1.	Discipline Specific Core (DSC):	**16**
2.	Discipline Specific Elective (DSE):	**04**
3.	Value Added Course	**02**
4.	Seminar/Intership/Dissertation(S/I/D):	--
	Total	**22**
$CW (Class work): It would include attendance, assignments, class test/quiz test/assignments, ppt, play, learn by fun activities etc.		

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M.Sc. Chemistry
Semester- I

INORGANIC CHEMISTRY-I **Credit-4 L T P**
24MCH9101T **4 0 0**
MaximumMark-100
ExternalExamination-70
Internal Assessment-30
Max. Time- 3 hrs.

Note: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of ten very short answer /MCQ-type questions (1x10=10), four short note-type questions (200 words Max.), (5x4=20), and four Long Questions (400 Words Max.), (4x10=40) covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.

Learning Objectives: The objective of the course is to provide students with a comprehensive understanding of Inorganic Chemistry. The course aims to develop their knowledge and skills in analyzing and solving problems related to these topics, using appropriate theoretical concepts and practical applications in Inorganic Chemistry.

Learning Outcomes: Comprehensive Knowledge: Students will gain a thorough understanding of the structure, bonding, and reactivity of inorganic compounds, including coordination and organometallic chemistry.

Practical Application: Students will be able to apply theoretical concepts to solve complex problems in inorganic chemistry, including the synthesis, characterization, and analysis of inorganic materials and their roles in various applications.

Unit I

Stereochemistry and Bonding in Main Group Compounds:

VSEPR theory and its limitations, Walsh diagrams (tri and penta-atomic molecules), dπ-pπ bonds, Bent rule and energetics of hybridization.

Metal-Ligand Bonding in Metal Complexes:

Crystal field theory for octahedral, tetrahedral and square planar complexes. Jahn-Teller distortion, limitations of crystal field theory. Molecular orbital theory applied to octahedral, tetrahedral and square planar complexes, π-bonding and molecular orbital theory.

Unit II

Electronic Spectra and Magnetic Properties of Transition Metal Complexes:

Spectroscopic ground states, correlation (d^2 and d^3 in octahedral and tetrahedral symmetry), Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states), calculations of Dq, B and β parameters using simplified T-S diagrams, charge transfer spectra, introduction about circular dichroism and optical rotatory dispersion, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information, anomalous magnetic moments, magnetic exchange coupling and spin crossover.

Unit III

Metal π-Complexes:

Metal carbonyls of Fe, Co & Ni, structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls.
Metal Clusters: Higher boranes: Wade's rule, styx numbers & structures, carboranes, metalloboranes, metallocarboranes.

Unit IV

Nuclear and Radiochemistry:

Laws of radioactive decay; Detection of radiations; Geiger-Nuttal rule; GM tubes and their characteristics, Ionization chamber, Proportional counters, Scintillation counters; Solid state detectors; Calibration of counting equipments; Determination of absolute disintegration rates.

Activation analysis:

Principles; Various methods of activation; Methodology: Advantages, limitations and applications.

Reference Books:

Inorganic Chemistry, Principles of structure and Reactivity, 4th Edition; James E.Huheey, Ellen A Keiter, Richard L. Keiter. Pearson

Advanced Inorganic Chemistry; F.A. Cotton and G. Wilkinson,
Concise Inorganic Chemistry; J.D. Lee, Wiley.

Concepts and Models in Inorganic Chemistry; Doughlas Mc Daniel

Physical Methods in Inorganic Chemistry, R. S. Drago

Chemistry of the Elements; N.N. Greenwood and A. Earushow, Pergamon, 1984.
Inorganic Electronic Spectroscopy; A.B.P. Lever, Elsevier, 1968.

Comprehensive Coordination Chemistry eds., G. Wilkinson, R.D. Gillas and J.A. Me Clevert, regamon, 1987; Vol. 2.

Inorganic chemistry; W.U. Malik, G.D. Tuli and R. D. Madan, S. Chand & company, New Delhi.

Essentials of Nuclear Chemistry, H. J. Amikar, 4th Eds. , New Age International: N Delhi, India, 2011

Nuclear and Radiochemistry: Fundamental and Applications, 2 Vols., Jens Volke Kratz and K Heinrich Lieser, 3rd Edn., John Wiley & Sons: UK, 2013.

M.Sc. Chemistry
Semester- I

ORGANIC CHEMISTRY-I
24MCH9102T
MaximumMark-100
ExternalExamination-70
Internal Assessment-30
Max. Time- 3 hrs.

Credit-4 L T P
4 0 0

Note: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of ten very short answer /MCQ-type questions(1x10=10), four short note-type questions (200 words Max.), (5x4=20), and four Long Questions (400 Words Max.), (4x10=40) covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.

Learning Objectives: The objective of the course is to provide students with a comprehensive understanding of Organic Chemistry. The course aims to develop their knowledge and skills in analyzing the structure, properties, and reactions of organic molecules, using appropriate theoretical concepts and practical techniques in organic synthesis and analysis.

Learning Outcomes: Comprehensive Knowledge: Students will gain a thorough understanding of the structure, mechanisms, and reactions of organic compounds, including functional groups, stereochemistry, and reaction mechanisms.
Practical Application: Students will be able to apply their knowledge to solve complex problems in organic synthesis, analysis, and reactivity, including the design and execution of organic reactions and the interpretation of spectroscopic data.

Unit I

Reaction Mechanism:

Structure and Reactivity A review of types of mechanisms and reactions, methods of determining reaction mechanism, thermodynamic and kinetic requirements for reaction, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett Principle, Isotope effects. Effects of structure on reactivity, resonance and field effects, steric effects. Quantitative treatment of the effect of structure on reactivity. The Hammett equation and linear free energy relationship, substituent and reaction constants, Taft equation. Aromaticity: Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons. Huckel's rule, energy level of π-molecular orbitals, annu lenes, anti-aromaticity, homo- aromaticity, PMO approach.

Unit II

Stereochemistry:

Optical activity and chirality, elements of symmetry, specification of configuration molecules with more than one chiral centre. D/L, R/S and Threo/Erythro nomenclature. E-Z Nomenclature. Interconversion of Fischer, Newman and Sawhorse projections. Prochirality, Homotopic and Heterotopic ligands and faces, Enantotopic and diastereotopic atoms, groups and faces, Re/Si Nomenclature. Stereospecific and stereoselective reactions. Racemic mixture and racemization. Resolution of racemic mixture. Optical activity in the absence of chiral carbon (biphenyls, allenes, spiranes). Chirality due to helicity. Chirality in the compounds containing N, S and P. Geometrical isomerism in cyclic and condensed systems, Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity.

Cram's, Prelog's and Horeau's rules. Circular birefringence, CD, ORD, Octant rule, Cotton effect. The axial haloketone rule. Determination of configuration (absolute and relative) and conformation.

Unit III

Aliphatic Nucleophilic Substitution:

The SNI, SN2, mixed SN1-SN2 and SET mechanisms. The SNi mechanism. The neighbouring group mechanism, neighbouring group participation by π and σ bonds, anchimeric assistance. Classical and nonclassical carbocations, phenonium ions, norbornyl system. Application of NMR spectroscopy in the detection of carbocations. Nucleophilic substitution at the allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium. Ambident nucleophile. Regioselectivity.

Aromatic Nucleophilic Substitution:

The S_NAr, S_N1, benzyne and $S_{RN}1$ mechanisms. Reactivity- effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet -Hauser and Smiles rearrangements.

Unit IV

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Aliphatic Electrophilic Substitution

Bimolecular mechanisms - S_E2 and S_Ei. The S_E1 mechanism- electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and solvent polarity on reactivity.

Aromatic Electrophilic Substitution

The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, Ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction.

Reference Books:

Advanced Organic Chemistry: Reactions Mechanisms and Structure by Jerry March, McGraw Hill.
Mechanism and Structure in Organic Chemistry E. S. Gould (Holt, R nehart and Winston
Advanced Organic Chemistry Part-A. F.A. Carey and R.J. Sundberg, ith Ed. Springer (2007).

Physical Organic Chemistry - J. Hine.
A Guide Book to Mechanism in Organic Chemistry, Peter Sykes. Long nan

Organic Chemistry - J. Clayden, N. Greeves, S. Warren and P. Wother. Oxford University Press (2001)

Structure and Mechanism in Organic Chemistry. C.K. Ingold. Cornell University Press.
Organic Chemistry. R.T. Morrison and R N. Boyd. Prentice-Hall.

Modern Organic Reactions. HO House, Benjamin
Principles of Organic Synthesis, ROC Norman and I.M. Coxon. Blackie Academic & Professional.

Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh, Macmillan.

M.Sc. Chemistry
Semester- I

PHYSICAL CHEMISTRY-I **Credit-4 L T P**
24MCH9103T **4 0 0**
MaximumMark-100
ExternalExamination-70
Internal Assessment-30
Max. Time- 3 hrs.

Note: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of ten very short answer /MCQ-type questions(1x10=10), four short note-type questions (200 words Max.), (5x4=20), and four Long Questions (400 Words Max.), (4x10=40) covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.

Learning Objectives: The objective of the course is to provide students with a comprehensive understanding of Physical Chemistry. The course aims to develop their knowledge and skills in analyzing the physical principles underlying chemical systems, using appropriate mathematical and theoretical frameworks in thermodynamics, kinetics, quantum chemistry, and statistical mechanics.

Learning Outcomes: Comprehensive Knowledge: Students will understand the fundamental principles of physical chemistry, including thermodynamics, kinetics, quantum mechanics, and statistical mechanics, and their application to chemical systems.
Practical Application: Students will be able to apply mathematical models and theoretical concepts to analyze and predict the behavior of chemical systems, solve problems in thermodynamics and kinetics, and interpret experimental data.

Unit I

Quantum Chemistry -I

Introduction:

Postulates of Quantum Mechanics, Operators - Linear, Commutator, Hamiltonian, Hermitian and Angular Momentum Operators, Eigen Value and Eigen Functions, Schrodinger's equation, wave function, physical significance of ψ^2.

Application of Schrodinger's Equation to (i) particle in one dimensional box, (ii) particle in three-dimensional box, (iii) Simple Harmonic Oscillator, (iv) Rigid Rotor and (v) Hydrogen atom; Radial and angular wave functions, quantum numbers and their significance.

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Unit II

Quantum Chemistry -II

Angular Momentum:

Ordinary angular momentum, Eigen functions and Eigen values of angular momentum, Ladder Operator, Addition of Angular Momentum, Spin, antisymmetry and Pauli's exclusion principle.

Approximation Method:

The Variation theorem, linear variation principle, perturbation method (First order and nondegenerate). Application of variation method and perturbation method to Helium atom.

Molecular Orbital Theory:

Basic ideas, criteria of forming MO's, LCAO Concept. Huckel's Molecular Orbital (HMO) theory for conjugated organic systems. Application of HMO to ethylene, allylic, cyclopropenyl radical, butadiene and cyclobutadiene system.

Unit III

Surface Chemistry

Adsorption: Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation). Langmuir adsorption isotherm, B.E.T. adsorption isotherm (BET equation), estimation of surface area (BET method), Gibbs adsorption isotherm, surface films on liquids (Electro-kinetic phenomenon)

Micelles: Surface active agents, classification of surface-active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization -phase separation and mass action models, solubilization, micro emulsion, reverse micelles.

Unit IV

Electrochemistry:

Electrochemistry of solutions, Debye-Huckel-Onsager treatment and its extension, ion solvent interactions. Debye-Huckel-Jerum mode. Thermodynamics of electrified interface equations.

Derivation of electro capillarity, Lippmann equations (surface excess), methods of determination. Structure of electrified interfaces, Guoy-Chapman, Stern, Graham Devanathan -Mottwatts, Tobin, Bockris, Devanathan models, Over potentials, exchange, current density derivation of Butler Volmer equation, Tafel plot. Polarography theory, Ilkovic equation; half wave potential and its significance.

Reference Books:

Physical Chemistry by P.W. Atkins, ELBS.

Introduction to Quantum Chemistry, A.K. Chandra, Tata McGraw Hill.

Quantum Chemistry. Ira N. Levine, Prentice Hall.

Quantum Chemistry; R.K. Prasad, New Age International

Micelles, Theoretical and Applied aspects; V. Morai, Plenum Press.
Modern Electrochemistry Vol. I & II; J.O.M. Bockris and A.K.N. Reddy, Plenum Press, New York.
Physical Chemistry by Puri, Sharma and Pathania Vishal Publications.

M.Sc. Chemistry
Semester- I

CHEMISTRY CORE LAB-□ **Credit-4 L T P**
24MCH9104P **0 0 4**
MaximumMark-100
ExternalExamination-70
Internal Assessment-30
Max. Time- 3 hrs.

A. Qualitative analysis of mixture consisting of eight cationic / anionic radicals including:

a. Interfering anionic radical

b. Insolubles: oxides, sulphates and halides

c. Less common metal ions: TI, W, Mo, Se, Te, V, Th, Ti, Zr, Ce, Li

B. Purification techniques and Qualitative analysis

a. Demonstrations of purification, drying and storage of solvents using various techniques-distillation, steam distillation, vacuum distillation, etc.

b. Separation of Organic binary mixtures [(one liquid and one solid) or (two solids)) using H2O, HCI, NaOH, NaHCO3, Ether or other reagent and identification of components using chemical tests, IR spectra for functional group identification and preparation of derivatives.

C. Experiments based on surface tension

i. To study surface tension concentration relationship for solution (Gibbs equation).

ii. To determine the critical micelle concentration (CMC) of DS and CTAB by surface tension techniques.

Adsorption

i. Adsorption of Oxalic acid

ii. Acetic acid on charcoal

Viscosity, Solubility and Molecular weight determination

I. Experiments based on determination of viscosity of given liquid using Ostwald's viscometer.

ii. Study the variation of viscosity of pure liquid with temperature and determination of temperature coefficient of viscosity of the liquid.

iii.Determination of Solubility of various salts like NaCl, KCI, KNO_3 and $NaNO_3$ at different temperature and draw the solubility Curve.

iv. Determination of molecular weight of given polymer (Polyvinyl alcohol, polystyrene, methyl acrylate, etc.) using viscometer.

v. Determination of molecular weight of non-volatile and non-electrolyte/electrolyte by cryoscopic method and to determine the activity coefficient of an electrolyte.

M.Sc. Chemistry
Semester-I

SPECTROSCOPY-I
24MCH9105 T
MaximumMark-100
ExternalExamination-70
Internal Assessment-30
Max. Time- 3 hrs.

Credit-4 L T P
4 0 0

Note: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of ten very short answer /MCQ-type questions(1x10=10), four short note-type questions (200 words Max.), (5x4=20), and four Long Questions (400 Words Max.), (4x10=40) covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.

Learning Objectives:

Learning Outcomes:

Unit I

Introduction: Interaction of light with matter, mechanism of absorption' and emission of radiation.

Microwave Spectroscopy: Classification of molecules, rigid rotor model. effect of isotopic substitution on the transition frequencies, intensities, non-rigid rotor; stark effect, nuclear and electron spin interaction and effect of external field. Applications.

Vibrational Spectroscopy: Vibrational energies of diatomic molecules, zero-point energy, force constant and bond strengths; anharmonicity, Morse potential energy diagram, vibration-rotation spectroscopy. P.Q.R. branches, breakdown of Oppenheimer approximation; vibrations of polyatomic molecules; selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factors affecting the band positions and intensities, far IR region, metal ligand vibration.

Raman Spectroscopy: Origin, rotational and vibrational Raman Spectra of diatomic molecules.

Unit II

Electronic Spectroscopy

Atomic Spectroscopy: Energies of atomic orbitals, vector representation of momenta and vector coupling, spectra of hydrogen atom and alkali metal atoms.

Molecular Spectroscopy: Energy levels, molecular orbitals, vibronic transitions, vibrational progressions and geometry of the excited states, Franck-Condon principle, electronic spectra of polyatomic molecules. Emission spectra; radiative and non-radiative decay, internal conversion, spectra of transition metal complexes, charge-transfer spectra.

Photoelectron Spectroscopy: Photo-electric effect, ionization process, Koopman's theorem, photoelectron spectra of simple molecules, ESCA, chemical information from ESCA; Auger electron spectroscopy-basic idea.

Unit III

Magnetic Resonance Spectroscopy

Nuclear Magnetic Resonance: Basic Principle, Spin quantum number, interaction between Spin and a Magnetic Field, Larmor Precession, Relaxation Times; Continuous Wave NMR Spectroscopy, Fourier Transform NMR Spectroscopy; Introduction to Chemical Shift, Spin -spin coupling, Coupling constant. Nuclei other than hydrogen: Nuclei with spin ½ (13C, 19F, 31P etc.), Nuclei with spin greater than ½ (14N, 11B). Quadrupole effects; factors effecting chemical shift in inorganic compounds - geometry, electronegativity, charge, oxidation state, coordination number. Coupling tween two or more than two types of NMR active nucleus in a compound (e.g., CHFCl2, HPFCL OP(O)FH, HP(O)F2, BH4).

Electron Spin Resonance: Basic principles, zero field splitting and Kramer's degeneracy, Isotropic and anisotropic Hyperfine coupling, spin-orbit coupling and significance of g - tensors, factors affecting the 'g 'value, its applications to the study of free radicals & fast reactions and application in transition metal complexes.

Unit IV

Mossbauer Spectroscopy: Basic principles, spectral parameters and spectrum, display, applications of the techniques to the studies of (i) bonding and structures of Fe2+ and Fe3+ compounds including those of intermediate spin; (ii) Sn^{2}+and Sn4+ compounds, nature of M-L bond, coordination number, structure; and (iii) detection of oxidation state and in equivalent MB atoms.

Electron Microscopy: Basic principles of Electron Microscopy SEM. TEM, AFM; and their applications in structural analysis

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Reference Books:

1. Fundamentals of Molecular Spectroscopy, Banewell and McCash

2. Modern Spectroscopy, J.M. Hollas, John Wiley.

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3. Applied Electron Spectroscopy for Chemical Analysis D. H. Windawi and F.L. Ho, Wiley Interscience.

4. Physical Methods in Chemistry, R.S. Drago, Saunders College.

5. Chemical Applications of Group Theory, F.A. Cotton.

6. Introduction to Molecular Spectroscopy, G.M. Barrow, Mc Graw Hill.

7. Electronic Absorption Spectroscopy and related Techniques, D N Sathyanarayana

8. Basic Principles of Spectroscopy, R. Chang, Mc Graw Hill.

9. Theory and Application of UV Spectroscopy, H.H. Jaffe and M. Orel in, IBH-Oxford.

10. Introduction to Photoelectron Spectroscopy, P.K. Ghosh, John Wiley.

11. Introduction to Magnetic Resonance. A Carrington and A.D. Maclachalan, Harper & Row.

12. NMR Spectroscopy in Inorganic Chemistry, J.A. Iggo, Oxford Univesity Press: Oxford, 1999, pp 1- 21; 31-35.

13. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood.

M.Sc. Chemistry
Semester-I

ANALYTICAL TECHNIQUES **Credit-4**
24MCH9106 T
MaximumMark-100
ExternalExamination-70
Internal Assessment-30
Max. Time- 3 hrs.

Note: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of ten very short answer /MCQ-type questions(1x10=10), four short note-type questions (200 words Max.), (5x4=20), and four Long Questions (400 Words Max.), (4x10=40) covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.

Learning Objectives:

Learning Outcomes:

Unit I

Statistics-Introduction to Chemometrics

Limitations of analytical methods, Errors and classification, Determinant, constant and indeterminate. accuracy, precision, minimization of errors, significant figures and computation rules, mean and standard deviation, distribution of random errors, variance and confidence interval, paired t-test, least square method, correlation and regression, linear regression.

Unit II

Sampling in analysis

Definition, theory, basis and techniques of sampling, sampling statistic, sampling and physical state, crushing and grinding, hazards in sampling, techniques of sampling of gases, fluid, solids, and particulates, minimization of variables, transmission and storage of samples, high pressure ashing techniques (HPAT), particulate matter, its separation in gas stream, filtering and gravity separation, analysis of particulate matter like asbestos, mica, dust and aerosols etc.

Solvent extraction method in analysis

Principle, classification, theory, instrumentation and applications.

Unit III

Conductometry:

Important laws, definitions, relations, effect of dilution on conductivity, measurement of conductivity, types of conductometric titrations, its applications and limitations.

Potentiometry

Principle, instrumentation, types of potentiometric titrations and its applications, pH, measurements, determination of pH, ion selective electrodes, instrumentation and applications.

Unit IV

Coulometry: Introductions, principle, experimental details of coulometry at constant current and constant potential, titrational applications.

Atomic Absorption Spectroscopy:

Introduction, principle, Grotrian diagram, instrumentation, applications, detection limit, sensitivity and disadvantages.

References Books:

1. Mendham J., Denney R.C., Barnes J. D., Thomas M.J.K., Vogels' text book of quantitative chemical analysis, 6th edition, Prentice Hall, 2000.

2. Skoog Douglas A., Holler F. James, Nieman Timothy A., Principles of instrumental analysis, Saunders College Pub., 1998.

3. Day R. A and A. L. Underwood, Quantitative analysis, Prentice Hall, 1999.

4. Drago R. S., Physical methods in Chemistry, Saunders, 1999.

5. Peters D.G, J. M. Hayes and G. M. Hefige, A brief introduction to Modern chemical analysis, Philadelphia: Saunders, 1976.

6. Elan JAD Butter Worth, Photoelectron spectroscopy.

7. D. C. Das, Analytical Chemistry, Prentice Hall India.

M.Sc. Chemistry
Semester-II
Paper-I Research Methodology

Learning Objectives

- A basic understanding of how to pursue research.
- A basic understanding of how to learn mathematics.
- A basic understanding of set theory.
- A basic understanding of the software that supports the mathematical research.

Learning Outcomes:

After completion of this course, students will be able to

- Understand mathematics more efficiently and clearly.
- Understand how to write a basic mathematics article.
- Make students analyze a given fact or concept and how to reach a concept.
- Make students curious enough to read the most recent trends in mathematics.
- Understand the basic ideas of how to write an algorithm and related ideas.
- Understand the effective use of open-source software to write mathematical articles.

Course Title:	Research Methodology	Course Code: 24MCH9201T
Total Lecture hour 60		Hours
Unit I	Nature of Scientific Inquiry-Scientific Methods-Induction-Deduction-Hypothesis and Theory and their Interpretation- Nature and Scope of Social Research for Multi-Disciplinary Inter-Disciplinary Approach in Commerce. Planning of Research-Selection of a Problem for Research- Sample design-Census and Sample Surveys-Sampling Techniques-Sample size.	15
Unit II	Research Design-Important Aspects of Research Design. Methods of Data Collection-Sources of data Use of secondary data-Methods of collecting primary data-Observation-Interviews-Questionnaires and Schedules.	15

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Sikar(Rajasthan)

Unit III	Processing and Analysis of Data: Processing Operations – Types of Analysis-Presentation and Interpretation of Data- Editing, Classification and Tabulation-Interpretation. Preparation of a Report-Types of Report-Research Report-Format-Principles of Writing Reports-Documentation-Foonoters and Bibliography	**15**
Unit IV	Quantitative Tools-Measures of Central Tendency-Dispersion-Measures of Correlation-Simple and Multiple Correlation-testing of Hypothesis-Tests based on t-P, Z, and Chisquare-Time Series Analysis-Trend Measurement-Moving Averages	**15**

Reference Books:

1	डॉ. दीपक नगराळे, डॉ. राहुल महिरे, डॉ. जमातसिंग राजपूत, डॉ. समाधान जगताप Research Methodology For Chemistry,2021 Atharva Publication
2	A.K.Haghi ,Research Methodologies in Applied Chemistry with Multidisciplinary Perspectives: Innovations and Visions for the Future, 2020, Chemistry, Chemistry Research and Applications, Imprints, Nova, Science and Technology, Special Topics
3	Tanmoy Chakraborty, Lalita Ledwani, Research Methodology in Chemical Sciences Experimental and Theoretical Approach,2016,CRC Press.
4	Krishnaswami O.R.: Methodology of Research in SocialSciences, Himalaya Publishing House, 1993.
5	Menden HYall and Varacity: Reinmuth J.E.: Statistics forManagement and Economics (2nd Edition), 1982.
6	Courtis J.K. (ed.) Research and Methodology in Accounting &Financial Management, 1980.

Semester-II

INORGANIC CHEMISTRY-□
Credit-4
24MCH9202T
MaximumMark-100
ExternalExamination-70
Internal Assessment-30
Max. Time- 3 hrs.

Note: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of ten very short answer /MCQ-type questions(1x10=10), four short note-type questions (200 words Max.), (5x4=20), and four Long Questions (400 Words Max.), (4x10=40) covering the entire

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syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.

Learning Objectives:

Learning Outcomes:

UNIT-I

Symmetry and Group Theory in Chemistry

Symmetry elements and symmetry operation, definition of group, subgroup, conjugacy relation and classes. Point symmetry group. Schonflies symbols, representations of groups by matrices
(Representation for the C_n, C_{nv}, D_{nh} etc, groups to be worked out explicitly). Character of a representation. The great orthogonality theorem (without proof) and its importance. Character tables and their uses; spectroscopy derivation of character table for C_{2v} and C_{3v} point group.
Symmetry aspects of molecular vibrations of H_2O molecule.

UNIT-II

Molecular Rearrangement Processes

Electron transfer reactions (outer and inner sphere), HOMO and LUMO of oxidant and reductant, chemical activation. Precursor complex formation and rearrangement, nature of bridge ligands, fission of successor complexes, Two-electron transfers, Synthesis of coordination compounds using electron transfer reactions, mixed valence complexes and internal electron transfer.

UNIT-III

Inorganic Reaction Mechanism-I

Basic principles; lability, inertness, stability and instability of coordination compounds, general principles and mechanisms of substitution reactions of tetrahedral, square planar, trigonal
bipyramidal, square pyramidal and octahedral complexes; potential energy diagrams, transition states and intermediates, isotope effects, Berry's pseudo rotation mechanism, Swain -Scott equation.

UNIT-IV

Inorganic Reaction Mechanism- II

Substitution reactions of octahedral complexes; nature of substitution reactions; Theoretical

approach to substitution mechanisms; mechanism of substitution reaction of complexes of cobalt; acid hydrolysis and base hydrolysis of Co (III) complexes.

Substitution reactions of square planar complexes; reaction of Pt (II) complexes; trans effect and its applications to synthesis of complexes; theories of trans effect; mechanism of substitution - kinetics of substitution of Pt(II) complexes; factors affecting the reactivity of square planar complexes.

Reference books:

1. Inorganic Chemistry, Principles of Structure and Reactivity, 4th Edition, James E. Huheey: E A. Keiter, Richard L. Keiter.
2. Advanced Inorganic Chemistry. F.A. Cotton and G. Wilkinson.
3. Theoretical Inorganic Chemistry, Day and Selbin.
4. Concepts and Models in Inorganic Chemistry, Doughlas Mc Daniel.
5. Introductory Quantum Chemistry, A.K. Chandra (Tata McGraw Hill)
6. Chemical Applications of Group Theory, F.A. Cotton.

M.Sc. Chemistry
Semester-II

ORGANIC CHEMISTRY-□
24MCH9203T
MaximumMark-100
ExternalExamination-70
Internal Assessment-30
Max. Time- 3 hrs.

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Learning Objectives:

Learning Outcomes:

UNIT- I

Addition to Carbon-Carbon Multiple Bonds

Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophile and free radicals. Regio- and chemo selectivity. Orientation and reactivity. Addition to cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration, Michael reaction, Sharpless asymmetric epoxidation.

Addition to Carbon-Heteroatom Multiple Bonds

Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds. Wittig reaction. Mechanism of condensation reactions involving enolates - Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions.

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UNIT-II

Free Radical Reactions:

Types of free radical reactions, free radical substitution mechanisms, neighbouring group assistance, reactivity for aliphatic and aromatic substrates at a bridgeheadcarbon, reactivity in the attacking radicals, effect of solvents on reactivity, allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts, Sandmeyer reaction, Hunsdiecker reaction, free radical rearrangements.

Elimination Reactions:

E2, E1 and E1cB mechanisms and their spectrum, orientation of the double bond, reactivity effects of substrate structures, attacking base, leaving group and medium; mechanism and orientation in pyrolytic elimination.

UNIT-III

Rearrangements

General mechanistic considerations - nature of migration, migratory aptitude, memory effects. A detailed study of the following rearrangements: Pinacol-pinacolone, Wagner-Meerwein, Demjanov, Benzil-Benzillic acid, Favorskii, Arndt-Eistert synthesis, Neber, Beckmann, Hofmann, Curtius, Schmidt, Baeyer-Viliger, Shapiro reaction. Wolff rearrangement, Wittig rearrangement, Fritsch- Buttenberg-Wiechell rearrangement, Stevens rearrangement, Chapman rearrangement, Wallach rearrangement.

UNIT-IV

Pericyclic Reactions

Characteristics and Classification of pericyclic reactions, thermal and photochemical reactions. Molecular orbital symmetry. Woodward-Hoffmann selection rules, Fukui's FMO approach, Woodward-Hoffmann's Conservation of orbital symmetry and correlation diagrams and PMO method.

Electrocyclic reactions: conrotatory and disrotatory motions, 4n, 4n+2 π electron and allyl systems.

Cycloadditions: antarafacial and suprafacial additions, 4n and 4n+2 π electron systems. Diels-Alder reaction-stereoselectivity (endo, exo), and regioselectivity; normal and inverse electron demand Diels-Alder reactions; asymmetric Diels-Alder reactions; retro-Diels-Alder reactions; 2+2 addition of ketenes, 1,3-dipolar cycloadditions. Cheletropic reactions.

Sigmatropic rearrangements: suprafacial and antarafacial shifts of C-H and C-C bonds. 3,3 and 5,5- sigmatropic rearrangements. Claisen, Cope and Aza-Cope rearrangements. Fluxional tautomerism. Ene reaction.

Reference books:

1. Advanced Organic Chemistry: Reactions Mechanisms and Structure by Jerry March, McGraw Hill.
2. Mechanism and Structure in Organic Chemistry E. S. Gould (Holt, Rinehart and Winston).

3. Advanced Organic Chemistry Part-A. F.A. Carey and R.J. Sundberg. Springer (2007).

4. Physical Organic Chemistry - J. Hine.

5. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes. Long nan

6. Organic Chemistry - J. Clayden, N. Greeves, S. Warren and P. Wothers. Oxford University Press (2001)

7. Structure and Mechanism in Organic Chemistry. C.K. Ingold. Cornell University Press.

8. Organic Chemistry. R.T. Morrison and R N. Boyd. Prentice-Hall.

9. Modern Organic Reactions. HO House, Benjamin.

10. Principles of Organic Synthesis, ROC Norman and I.M. Coxon. Blackie Academic & Professional.

11. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh, Macmillan.

12. S.M. Mukherji, Pericyclic Reactions: A Mechanistic study, Macmillan.

13. Ian Fleming, Pericyclic Reactions, Oxford Chemistry.

14. S. Sankararaman, Pericyclic reactions- A Textbook, Wiley-VCH

M.Sc. Chemistry
Semester-II

CHEMISTRY CORE LAB-□ **Credit-4 L T P**
24MCH9204P **0 0 4**
MaximumMark-100
ExternalExamination-70
Internal Assessment-30
Max. Time- 3 hrs.

A. Inorganic Preparations: Following selected inorganic compounds and their studies by IR spectra, Mössbauer, ESR and Magnetic susceptibility measurements. Handling of air and moisture sensitive compounds under vacuum.

i. Sodium thiosulphate, $Na_2S_2O_3.5H2O$

ii. $CuCl_2.2DMSO$

iii. Tetraamine cupric sulphate $[Cu(NH_3)_4SO_4].H2O$

iv. N,N-bis(salicylaldehyde)ethylenediamine, Salen H_2, Co(Salen.)

v. Copper glycine complex cis- and trans-bis(glycinato) Coppe. (II)

vi. Cis- and trans-dichlorobis(ethylenediammine)cobalt(III) chloride, $[Co(en)_2Cl_2]Cl$

vii. $Na[Cr(NH3)_2(SCN)_4]$

viii. $[Ni(NH_3)_6]Cl_2$

B. Two Step Organic Synthesis

i. Aniline → 2,4,6-Tribromoaniline → 1,3,5-Tribromobenzene

ii. Aniline → Diazoaminobenzene → p-Anainoazobenzene

iii. Phthalic anhydride → Fluorescein → Eosin

iv. Phthalic anhydride → Phthalimide → Anthranilic acid

v. Acetanilide → p-Nitroacetanilide → p-Nitroaniline

vi. More two step organic preparations involving general organic reactions may be carried out. The products to be characterized by m.pt/spectral techniques.

C. Experiments based on -

Chemical Kinetics

i. Determination of the primary salt effect on the kinetics of ionic reactions and testing of the Bronsted relationship (iodide ion is oxidized by persulphate ion).

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ii. Determination of the effect of (a) Change of temperature (b) Change of concentration of 11 reactant and catalyst and (c) Ionic strength of the media on the velocity constant of hydrolysis of an ester/ionic reactions.

iii. Determination of the velocity constant of hydrolysis of an ester/ionic reaction in micellar media

iv. Determination of the rate constant for the oxidation of iodide ions by peroxide studying the kinetics as an iodine clock reaction.

Thermodynamics

i. Determination of partial molar volume of solute (e.g. KCl) and solvent in a binary mixture ii.Determination of the temperature dependence of the solubility of a compound in two solvents
having similar intramolecular interactions (benzoic acid in water and in DMSO- water mixture) and calculate the partial molar heat of solution.

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M.Sc. Chemistry
Semester-II

SPECTROSCOPY-□
24MCH9T205
MaximumMark-100
ExternalExamination-70
Internal Assessment-30
Max. Time- 3 hrs.

Credit-4

Note: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of ten very short answer /MCQ-type questions(1x10=10), four short note-type questions (200 words Max.), (5x4=20), and four Long Questions (400 Words Max.), (4x10=40) covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.

Learning Objectives:

Learning Outcomes:

UNIT- I

Ultraviolet and Visible Spectroscopy

Various electronic transitions (185-800 nm) Beer-Lambert law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Woodward-Fieser rules for conjugated dienes and carbonyl compounds,
ultraviolet spectra of aromatic compounds. Steric effect in biphenyls.

Infrared Spectroscopy

Characteristic vibrational frequencies of aromatic compounds, alcohols, ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen
bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance.

UNIT II

Mass spectrometry

Introduction, ion production - EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds common functional groups, molecular ion peak, metastable peak. McLafferty rearrangement. Ring rule, Nitrogen rule. High resolution mass spectrometery. Examples of mass spectral

fragmentation of organic compounds with respect to their structure determination.

UNIT- III

Proton Magnetic Resonance Spectroscopy

Chemically nonequivalent protons, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides and mercapto). Chemical exchange, effect of deuteration. Complex spin-spin
interaction between two, three, four and five nuclei (first order spectra). Stereochemistry, hindered rotation. Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra- nuclear magnetic double resonance, NMR shift reagents, solvent effects. Fourier transform technique, nuclear overhauser effect (NOE).

UNIT- IV

Carbon-13 NMR Spectroscopy

General consideration, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants. Two-dimension NMR spectroscopy COSY, NOESY, DEPT, INEPT, APT and INADEQUATE techniques.

Applications of Spectroscopy - Problems based on UV, IR, NMR spectroscopy and. Mass spectrometry for structural elucidation of organic compounds.

Reference books:

1. Spectrometric Identification of Organic Compounds, R.M. Silverstein. G.C. Hassler and T.C. Morbi John Wiley.

2. Fundamentals of Spectroscopy by Banwell and McCash

3. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P.Lofitus, Wiley.

4. Application of Spectroscopy of Organic Compounds, J.R. Dyer, Prentice Hall.

5. Spectroscopic Methods in Organic Chemistry D.H. Williams, I. Fleming, Tata McGraw-Hill:

6. Organic Spectroscopy, William Kemp. Macmillan.

M.Sc. Chemistry
Semester-II

ENVIRONMENTAL CHEMISTRY **Credit-4**
24MCH9T206
4MaximumMark-100
ExternalExamination-70
Internal Assessment-30
Max. Time- 3 hrs.

Note: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of ten very short answer /MCQ-type questions(1x10=10), four short note-type questions (200 words Max.), (5x4=20), and four Long Questions (400 Words Max.), (4x10=40) covering the entire syllabus. Two questions will be asked from each unit. Students will have to attempt one question from each unit. Each question shall carry equal marks.

Learning Objectives:

Learning Outcomes:

Unit-I

Atmospheric Chemistry

Atmospheric layers. Vertical temperature profile, heat radiation, budget of the earth atmosphere systems. Properties of troposphere, thermodynamic derivation of lapse rate. Temperature inversion.
Calculations of Global mean temperature of the atmosphere. Pressure variation in atmosphere and scale height. Biogeochemical cycles of carbon, nitrogen, sulphur, phosphorus and oxygen. Residence times. Sources of trace atmospheric constituents: nitrogen oxides, sulphur dioxide and other sulphur compounds, carbon oxides, chlorofluorocarbons and other halogen compounds, methane and other hydrocarbons.

Tropospheric Photochemistry:

Mechanism of photochemical decomposition of NO_2 and formation of ozone. Formation of oxygen atoms, hydroxyl, hydroperoxy and organic radicals and hydrogen peroxide. Reactions of hydroxyl radicals with methane and other organic compounds. Reactions of OH radicals with SO_2 and NO_2. Formation of nitrate radical and its reactions. Photochemical smog, meteorological conditions and chemistry of its formation.

Unit-II

Air Pollution: Air pollutants and their classification. Aerosols sources, size distribution and effect on visibility, climate and health,

Acid Rain: Definition, acid rain precursors and their aqueous and gas phase atmospheric oxidation reactions. Damaging effects on aquatic life, plants, buildings and health. Monitoring of SO_2 and NO_2 , acid rain control strategies.

Urban Air Pollution: Exhaust emissions, damaging effects of carbon monoxide. Monitoring of CO. Control strategies.

Unit-III

Aquatic Chemistry and Water Pollution

Redox chemistry in natural waters. Dissolved oxygen, biological oxygen demand, chemical oxygen demand, determination of DO, BOD and COD. Aerobic and anaerobic reactions of organic sulphur and nitrogen compounds in water, acid-base chemistry of fresh water and sea water. Aluminium,
nitrate and fluoride in water. Eutrophication. Sources of water pollution. Treatment of waste water and sewage. Purification of drinking water, techniques of purification and disinfection.

Unit-IV

Environmental Toxicology

Toxic Heavy Metals - Mercury, lead, arsenic and cadmium. Causes of toxicity. Bioaccumulation, sources of heavy metals. Chemical speciation of Hg, Pb, As and Cd. Biochemical and damaging effects.

Toxic Organic Compounds - Pesticides, classification, properties and uses of organochlorine and organophosphorus pesticides, detection and damaging effects.

Polychlorinated Biphenyls - Properties, uses and environmental contamination and effects.

Polynuclear Aromatic Hydrocarbons - Sources, structures and as pollutants.

Soil and Environmental Disasters

Soil composition, micro and macronutrients. soil pollution by fertilizers, plastic and metals. Methods of remediation

of soil.

Bhopal gas tragedy, Chernobyl, Three-mile Island, Minamata Disease, Seveso (Italy), London smog.

References Books:

1. Environmental Chemistry. Colin Baird, W.H. Freeman Co. New York. 1098.

2. Chemistry of Atmospheres. R.P. Wayne. Oxford.

3. Environment Chemistry, A.K. De, Wiley Eastern, 2004.

4. Environmental Chemistry, S.E. Manahan, Lewis Publishers.

5. Introduction to Atmospheric Chemistry, P.V. Hobbs, Cambridge.