Name of Program	**Master of Science(Chemistry)**
Abbreviation	**M.Sc.**
Duration	**2 Years**
Eligibility Criteria	**M.Sc. Chemistry** **(Organic/Inorganic/ Analytical/Physical)** ELIGIBILITY:(SC/ST- 35%, OPEN/SEBC-40%), A candidate who has obtained his/her Bachelor's Degree with chemistry shall be considered eligible for admission in M .Sc .Chemistry **M.Sc. (Organic Chemistry** ELIGIBILITY :(SC/ST- 35%, OPEN/SEBC-40%), A candidate who has obtained his/her Bachelor's Degree with chemistry shall be considered eligible for admission in M.Sc- Chemistry/Organic Chemistry. **M. Sc .Environmental Chemistry** ELIGIBILITY :(SC/ST- 35%, OPEN/SEBC-40%) A candidate who has obtained his/her Bachelor's Degree with chemistry shall be considered eligible for admission in M.Sc- Chemistry/Organic Chemistry (SF.)/ Environmental Chemistry (S.F.) Course. **M.Sc. Organic Chemistry (Evening)** ELIGIBILITY :(SC/ST- 35%, OPEN/SEBC-40%) A candidate selecting M.Sc. Evening course (2 years) with Organic Chemistry as specialization must have passed the Bachelor's Degree examination with Chemistry and English as compulsory subject. Those who are in service will have to produce minimum one year's experience certificate from the Employer.
Objective of Program	The core objective of the M.Sc. programme is to prepare the students for dynamic career in industry and academia by providing an excellent environment of teaching and research in the core and emerging areas of the discipline.
Program Outcome	PO1: To enhance the knowledge of chemistry domains and become master in respective branch of chemistry. To be able to communicate clearly and effectively with in and across disciplinary lines. PO2: Built up entrepreneurship ability by taking advantage of industrial hub in periphery of our university. PO3: Establishment of research center with the aid of interdisciplinary subject being run in university. PO4: Persuasion of doctoral degree in the concern subject and further study. PO5 : Development of related short term courses related to demanded subject in anticipation of strengthening knowledge and application PO6: Training/internship of students for employment in public sector, private sector and national laboratories. PO7: Participation in scientific discussions showing respect and lead interdisciplinary work with experts from other fields. PO8: To understand and adopt the best safety practices in chemical research.

	PO9: Participation in scientific discussions showing respect and lead interdisciplinary work with experts from other fields. PO10: To understand and adopt the best safety practices in research.
Program Specific Outcomes	Students need to build up foundation in the fundamentals & application of current chemical and scientific theories in the concerned branches of Inorganic, Organic, Analytical, Physical, Environmental and Pharmaceutical Chemistry. PSO1 : Develop scientific temper, communicate scientific information in a clear, concise and precise manner. PSO2 : Find job opportunities at all level of chemical industries(dyes & pharmaceutical), national laboratories & research centers. PSO3 : Apply the knowledge in sustainable and ecofriendly technologies. PSO4 : Inculcate logical thinking to addressess the problem and become result oriented. PSO5 : Development of research culture in persuasion of Ph.D. program at national & international institute/university. PSO6 : Participate in specific competitive examination conducted by various public service commission and other public sector. PSO7 : Develop and apply the fundamental knowledge to build small scale industry in context to Atma Nirbhar Bharat. PSO8 : Scale up the synthetic product to a pilot level plant and gradually to bulk. PSO9 : Enhance the scientific temperament among the students in anticipation of developing research culture and implementation of policies at global & local level. PSO10 : Communicate scientific information clear in both writing and orally. PSO11 : Students shall start to become better readers, thinkers and learners in their discipline by processing their ideas through writing. PSO12 : Will build new scientific understanding as it provides students the opportunity to articulate their thinking as they engage in the science practices during an investigation.
Mapping between POs and PSOs	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
PO1		■	■				■	■	■	■		
PO2	■		■		■		■	■	■	■		■
PO3	■		■	■	■				■	■	■	■
PO4	■	■	■	■			■		■	■	■	■
PO5		■	■	■			■			■		■
PO6	■		■	■	■				■	■		■
PO7		■	■	■	■			■		■		■
PO8	■	■		■		■	■	■	■		■	■

	PO9												
	PO10												
Medium of Instruction	English												

Structure of M. Sc, Syllabus
Semester-I

Sr. No.	Course Code	Course Title	L	T/C/S	Credit
1	1803080201010001	Inorganic Chemistry	4		4
2	1803080201020001	Organic Chemistry	4		4
3	1803080201030001	Physical Chemistry	4		4
4	1803080201040001	Instrumental and chemical analysis	4		4
5		Practicals + T/C/S	12	3	6 + 3
			28	3	25

Faculty Code: Science Subject code:
Level code:
Name of program: M. Sc. Subject: Chemistry
External Examination Time Duration: 03 hrs

Name of Exam	Semester	Paper No	Course group	Credit	Internal Marks	External Marks	Total Marks
M. Sc.	I	I	Core	04	30	70	100
		II	Core	04	30	70	100
		III	Core	04	30	70	100
		IV	Core	04	30	70	100
			Practical + T/C/S	06 +3	60	140	200
			Total	25	180	420	600

Master of Science, Inorganic Chemistry
M.Sc. Inorganic Chemistry, Semester I

Course Code	[1803080201010001]	Title of the Course	**INORGANIC CHEMISTRY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To understand concept of symmetry and group theory with its application. • To understand basics of Quantum mechanics, familiarize with various types of operators and implant the knowledge of orbital configuration. • To learn the inorganic reaction mechanism. Different types of reaction mechanism and also various types of transition state theory. • Understanding of concepts of metal cluster, classification of metal clusters, Wade's rule, Carboranes, low and high nuclearity carbonyl clusters.
Mapping between CO and PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■

Course Content		
Unit	Description	Weightage* (%)
1.	**SYMMETRY AND GROUP THEORY IN CHEMISTRY AND ITS APPLICATIONS** Representation of Group: preparation of matrices and vectors matrix notation for geometric transformation, Orthogonality theorem and its consequences, reducible and irreducible representation and their relation, preparation of character table for C_{2v} and C_{3v} point groups, applications of group theory transformation properties of atomic crystals.	25

2.	**QUANTUM MECHANICS** Discussion of solution of Schrodinger equation to same model system e.g. the one dimensional harmonic oscillator, two particle rigid rotator. Ordinary angular momentum, generalized angular momentum, Eigen functions of angular momentum, eigen values of angular momentum, different types of operators and their uses, addition of angular momentum, spin, Russell-Saunders terms and coupling scheme, term separation energies of the p^n and d^n configuration, magnetic effect: spin orbit coupling and Zeeman effect(splitting)	25
3.	**INORGANIC REACTION MECHANISM** Labile and inert complexes, factors responsible for lability and inertness of complexes. Reactivity of metal complexes, ligand replacement reaction: classification of mechanism and energy profile of reaction. Inert and labile complexes, interpretation of liability and inertness of transition metal complex on the basis of reaction rate, VBT and CFT. Transition state or activated complex, substrate, attacking regents electrophilic and nucleophilic, nature central atom. Kinetic application of CFT. Kinetics of octahedral substitution, acid hydrolysis, factor affecting acid hydrolysis, base hydrolysis conjugate base mechanism, direct and indirect evidences in favour of conjugate mechanism.	25
4.	**METAL CLUSTERS** Introduction, classification, carbonyl cluster, low nuclearity carbonyl clusters, high nuclearity carbonyl clusters, electron counting scheme for HNCCS, Wade's rules. Halides types clusters: dinuclear clusters, trinuclear clusters, tetranuclear clusters, hexanuclear cluster. Chevrel phases and zintl ions, Carboranes, metalloboranes, metallo carboranes, higher boranes(hexaborane-10, decaborane-14), number and types of bonds present in higher boranes.	25

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology comprise classroom teaching, use of e-resources, library books , IT tools, encouraging students to participate in seminars/ workshops, presentations by students, assignments etc.

Evaluation Pattern		
Sr.	Details of the Evaluation	Weightage

No.		
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand the of matrices and vectors matrix notations, reducible representation and their relation, applications of group theory
2.	Learn regarding quantum mechanics, angular momentum, understanding the solution of Schrodinger equation, Different types of operators and their uses
3.	Learn different types of inorganic reaction mechanism, acid hydrolysis, base hydrolysis . conjugate base mechanism their synthetic application
4.	Understand the introduction and classification of metal clusters, electron counting scheme for HNCCS and Wade's rule and their synthetic application

Suggested References:

Unit I:

1. Chemical applications of group theory by F.A Cotton (Second edition), Wiley Eastern Limited, 1976 New Delhi
2. Group theory and its application by P.K. Bhattacharya, Himalaya publishing hours, Mumbai, 1986
3. Group theory and symmetry by L. R. hall, McGraw hill, New York, 1989.
4. Quantum Chemistry by Ira N. Levine, Prentice-Hall of India Pvt. Lid, New Delhi, 1994.
5. Introductory Quantum Chemistry (Third edinion) by N. W. Hanna, Benjamin, Menlo Park, Cailf, 1988.
6. Quantum Chemistry and Spectroscopy by M. S. Pathania, Vishal Publications, India, 1981.
7. Kinetic and Mechanism' by A. A. Frost and R. G. Pearson, Wiley, New York, 1953, 1961.
8. Mechanism of Inorganic Reactions by F. Basolo and R.G. Pearson, Second Edition, Wiley Eastern Limited, New Delhi, 1977.
9. Advanced Inorganic Chemistry by F. A Cotton and R.G. Wilkinson, John Wiley & Sons, N. Y.
10. Principales of Inorganic Chemistry, by Puri. Sharma and Kalia, 33rd Edition, Vishal publishing Co. Jalandhar, Dehli, 2017.
11. Advanced Inorganic Chemistry by S. K. Agarwala and Keemtilal, Pragati Prakashan, Meerut.
12. Advanced Inorganic Chemistry, Volume-Il by Gurdeep Raj, Krishna Prakashan Media Lid., Meerut.
13. Inorganic Chemistry by Gary L Miessler and Donald A. Tarr, Pearson Education

International

On-line resources to be used if available as reference material

Master of Science, Inorganic Chemistry
M.Sc.Inorganic Chemistry, Practicals

Course Code	[1803081001050001]	Title of the Course	**INORGANIC CHEMISTRY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To impart basic knowledge of qualitative analysis of Inorganic mixture • To identify three anions and three cations including one rare earth element by group separation. • To impart knowledge of different radicals by confirmative test. • Preparation of inorganic metal salts and it's crystallization • To confirm the structure and prepare the relevant derivative.

Mapping between CO and PSO

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■
CO5	■	■	■	■			■		■	■	■	■

Course Content

1. Inorganic Qualitative Analysis: (Six elements including ONE rare element)

2. Inorganic Preparation.
    I. Hexa-ammine nickel (II) chloride
    II. Mohr's salt (Ferrous Ammonium sulphate)
    III. Sodium trioxalato ferrate trihydrate
    IV. Sodium cobaltinitrite
    V. Tetra amine cupric sulphate
    VI. Reineck's salt (Ammonium tetrathiocyanate diammine Chromate)

Teaching-Learning Methodology	Introduction, demonstration of handling equipments, reference books and frequent instruction according to the respective practical.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand basics analysis of Inorganic mixtures.
2.	Identify anions by dry test of the mixture.
3.	Separation of each anions by group test from mixture.
4.	Identify each cation and confirm it by confirmative test.
5.	Understand different methods of Preparations of inorganic salts.
6.	Appreciate good laboratory practices.

Suggested References:

1. Textbook of practical inorganic chemistry – A.I. Vogel
2. Practical Chemistry by Dr O. P. Pandey, D. N. Bajpai, Dr. S. Giri
3. Advance inorganic analysis by Agarwal, Keemti lal
4. Qualitative Inorganic analysis - Vogel
5. Inorganic practical by Chatwal and Anand

On-line resources to be used if available as reference material
On-line Resources

Master of Science, Organic Chemistry
M.Sc. Organic Chemistry, Semester I

Course Code	[1803080201020001]	Title of the Course	**ORGANIC CHEMISTRY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To understand concept of reactive intermediate and their application in organic synthesis. • To understand basics of pericyclic reaction, familiarize with various theories of pericyclic reaction to access the feasibility of various pericyclic reaction and implant the knowledge to predict stereo chemical outcome of various pericyclic reactions. • To learn anchimeric assistance, stereo chemistry and internal substitution reaction of aliphatic and allylic compounds. Aromatic nucleophilic substitution, cine substitution, elimination reactions, their stereo chemistry and mechanisms. • Understanding of concepts of chirality, topicity, prochirality, dynamic resolutions, types of stereo selective and stereo specific reactions, conformation of substituted and fused aromatic rings along with respective strains theories.
Mapping between CO and PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■

Course Content		
Unit	Description	Weightage* (%)
1.	**REACTION MECHANISM & REACTIVE INTERMEDIATES** Detailed study of organic reaction intermediates. Generation, structure, stability and reactions of – **Carbocations (Classical and non-classical):**Phenonium ion, norbornyl system, common carbocation rearrangements- Demjanov, Pinacole-Pinacolone, Rupe. **Carbanions:** Mechanism of condensation involving enolates - Aldol, Claisen, Mannich, Dieckmann, Michael and Shapiro reactions. **Carbenes:** Mechanism of Arndt-Eistert reaction, Reimer-Tiemann reaction and Bamford Steven's rearrangement reaction. **Free Radicals:**Allylic halogenation (NBS), coupling of alkenes and arylation of aromatic compounds by diazonium salts. Sandmeyer reactions. Free radical rearrangements, Hunsdiecker reaction.	25
2.	**PERICYCLIC REACTIONS** **Introduction** - Definition, Characteristics and Classification Molecular orbitals and symmetry propertiesofethylene, 1,3-butadiene, 1,3,5- hexatriene and allylsystems. **Electrocyclic Reactions:** Woodward-Hoffman Correlation diagram and derivation of selectionrules,Conrotatory and disrotatory motions, FMO and PMO approach for 4n and (4n+2)Πelectron system and allyl systems. **Cycloaddition Reactions** : Antarafacial and suprafacial additions. FMOand PMO approach for 4n and (4n+2)Πelectron Systems(No correlation diagram),Diels-Alder reaction, stereoselectivity,Effect of substituents. **Sigmatropicrearrangements:**Suprafacial and antarafacialshifts involving H & C moieties, retention and inversion of configurations. The Cope and Claisen rearrangements, Ene reaction, 1, 3- dipolar cydoadditions. Examples of electrocyclic, cycloaddition and sigmatropic rearrangements.	25
3.	**SUBSTITUTION AND ELIMINATION REACTIONS** **A: Aliphatic Nucleophilic Substitution:** The SN1 , SN2 , SNi mechanisms. Reactions of Allylic halides, neighbouring group participation by -OH, -NH2, -COO- , -RS, - halogen, aromatic ring. **B: Aromatic Nucleophilic Substitution:** The SN2 , SN1 and benzyne mechanisms, Reactivity - effect of substrate structure, leaving group and attaching nucleophile, The Von Richter rearrangement. **C: Elimination reaction:** Hoffmann and Zaitsev's rule of elimination, E1, E2 and E1CB Reaction mechanism and orientation.	25

4.	**STEREOCHEMISTRY:** Stereo chemical principles; Enantiomeric relationships; Distereomeric relationship; R-S and E-Z nomenclature; Dynamic stereochemistry; Chiral-Prochiral relationships; Stereo selective and Stereo specific reactions; Racemates and racemic modification, Resolution of racemic modification, Optical activity in the absence of chiral carbons biphenyl, allenes, spiranes. **B.** Confirmational Analysis: Interconversion of Fischer, Newman and Sawhorse projections. Newer method of asymmetric synthesis (including enzymatic and catalytic nexus), enantio and diastereo selective synthesis.Simple acyclic and cyclic (chair and boat cyclohexanes, Decalins, Perhydrophenanthrene)systems.Effects of conformation on reactivity in acyclic compounds and substituted cyclohexanes.	25

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology comprise classroom teaching, use of e-resources, library books , IT tools, encouraging students to participate in seminars/ workshops, presentations by students, assignments etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand generation of reactive intermediates, their mechanism, rearrangement based on each intermediate, application of reactive intermediate in organic synthesis and industries application.
2.	Recognise pericyclic reactions, understanding of thermal and photochemical reaction, determination of mechanistic pathway, symmetry properties, aromaticity based on mobius method, application of pericyclic reactions in organic synthesis.
3.	Learn difference between eliminations and addition reaction, concept of anchimeric assistance in various groups like sulphide, halogen, phenyl, hydroxyl, tosylates &

	mesilates, amino group etc, aromatic nucleophilic substitution through addition elimination, elimination addition, cine substitution and their synthetic application.
4.	Detect chirallity in moleculer structure, recognize the relationship between enantiomeric and diastereomeric structures, understand & distinguish stereoselective and stereospecific reactions, dynamic resolution, confirmative study of various substituted aromatic and fused aromatic rings and their application inn pharmaceutical industry.

Suggested References:

Unit I:

1. Carbenes, Benzynes and Nitrenes by Gilchrist, T. L. and Rees.
2. Advanced Organic Chemistry-Reactions, Mechanism and Strucuture, Jerry March, John Wiley.
3. Reaction Mechanism in Organic Chemistry by S. M. Mukherji and S. P. Singh (McMillan India Ltd., 1976).
4. Organic Chemistry (3/e) by J. B. Hendrickson, Donald J. Crem and George S. Rammond (McGraw-Hill Book Co. &Kogekusha Co. Ltd., 1970).
5. Organic Chemistry (5/e) by Morrison & Boyd (Prentice Hall).
6. Advanced Organic Chemistry by Carey &Sundberg (3rd edition).
7. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
8. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Plenum.
9. Organic chemistry 2nd ed. Jonathan clayden, Nick greeves, Stuart Warren.
10. Reaction Mechanism and Reagents in Organic Chemistry by C. R. Chatwal (Himalaya Publishing House, Bombay, 1987).

UNIT II:

1. March's Advanced Organic Chemistry Reactions, Mechanisms, And Structure 7th ed. 2013 Michael B. Smith. Wiley.
2. Mechanism AndTheory In Organic Chemistry-2007 by Thomas H. Lowry, Kathleen S. Richardson, Forbes.Harper& Row, Publishers. New York, Hagerstown, San Francisco, London.
3. Advanced Organic Chemistry Part A: Structure and Mechanisms by Carey &Sundberg (5th edition),2000, Springer.
4. Pericyclic Reactions, S. M. Mukherji, Macmillan, India.
5. Photochemistry AndPericyclic Reactions 3rd ed. by Jagdamba Singh 2010. New Age International Publishers Ltd. New Delhi.
6. Pericyclic Reactions A mechanistic and problem solving approach Sunil Kumar, Vinod Kumar, S.P.Singh Academic Press 2015

UNIT III:

1. Advanced Organic Chemistry-Reactions, Mechanism and Strucuture, Jerry March, John Wiley.
2. Reaction Mechanism in Organic Chemistry by S. M. Mukherji and S. P. Singh (McMillan India Ltd., 1976).
3. Organic Chemistry (3/e) by J. B. Hendrickson, Donald J. Crem and George S. Rammond (McGraw-Hill Book Co. &Kogekusha Co. Ltd., 1970).

4. Organic Chemistry (5/e) by Morrison & Boyd (Prentice Hall).
5. Advanced Organic Chemistry by Carey &Sundberg (3rd edition).
6. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
7. Physical organic chemistry by Jack Hyne
8. Reaction mechanism by Jagdambasingh.
9. organic chemistry - Reaction mechanism, by P.S. Kalsi, New age international publishers.

UNIT IV:

1. Advanced Organic Chemistry: Part A: Structure and Mechanisms; By Francis A. Carey, Richard J. Sundberg, fifth edition, Published by Springer.
2. Advanced Organic Chemistry: Part B: Reaction and Synthesis; By Francis A. Carey, Richard J. Sundberg, fifth edition, Published by Springer.
3. Stereochemistry of Carbon Compounds; By Ernest L. Eliel, Published by Tata McGraw-Hill Publishing Company Ltd.
4. Basic organic stereochemistry; By Ernest Ludwig Eliel, Samuel H. Wilen, Michael P. Doyle, Published by Wiley-Interscience.
5. Introduction to Stereochemistry; By Kurt Martin Mislow, Dover Publication INC.
6. Stereochemistry of Organic Compounds: Principles and Applications; By D. Nasipuri, New Age International (P) Ltd. Publisher.
7. Stereochemistry Conformation and Mechanism; By P.S. Kalsi, New Age International (P) Ltd. Publisher.
8. Basic Stereochemistry of Organic; By SubrataSen Gupta, First edition, Published by Oxford University Press.

On-line resources to be used if available as reference material

Master of Science, Organic Chemistry
M.Sc.Organic Chemistry, Practicals

Course Code	[1803081001050001]	Title of the Course	**ORGANIC CHEMISTRY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To impart basic knowledge for the separation of organic ternary mixture • To identify nature of mixture i.e., solid-solid, solid-liquid, liquid-

	liquid etc. • To impart knowledge of different purification techniques including distillation. • Separation and identification of component with their functional group test and M.P. /B.P. • To confirm the structure and prepare the relevant derivative.
Mapping between CO and PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■
CO5	■	■	■	■			■		■	■	■	■

Course Content

3. Mixture analysis: (Minimum eight mixtures) Ternary mixture to be given. (S+S+S), Semisolids or (L+L+L). Type, determination, Separation by physical and chemical methods. (both permitted in case of liquids)
4. Paper Chromatography

Teaching-Learning Methodology	Introduction, demonstration of handling equipments, reference books and frequent instruction according to the respective practical.

Evaluation Pattern

Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learnerwill be able to	
1.	Understand basics of separation of organic tertary mixtures.
2.	Identify and chemical nature of mixture.
3.	Separate of each component from mixture.
4.	Identify each component through their functional group test, elemental analysis and M.P/BP.
5.	Purify the compounds using different techniques including distillation, crystallization etc.
6.	Record physical constants for individual compounds.
7.	Appreciate good laboratory practices.

Suggested References:

1. A text book of practical organic chemistry – A. I. Vogel
2. Practical organic Chemistry – Mann and Saunders
3. A handbook of quantitative and qualitative analysis – H. T. Clarke
4. Comprehensive Practical Organic Chemistry : Qualitative Analysis V K Ahluwalia& S.
5. Dhingra.
6. 5.Comprehensive Practical Organic Chemistry : Preparations and Quantitative Analysis V
7. K Ahluwalia& R. Aggarwal Universities Press.
8. 6. An Advance Course in practical Chemistry, A K. Nad, B. Mahapatra and A. Ghoshal.

On-line resources to be used if available as reference material

On-line Resources

Master of Science, Physical Chemistry
M.Sc.Physical Chemistry, Semester I

Course Code	[1803080201030001]	Title of the Course	Physical Chemistry

Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To understand concept of thermodynamics in solution. • To understand type of interactions and orientation of molecules in solution. • To understand basic concept of statistical thermodynamics. • Understanding of concepts of kinetics of different types of chemical reaction. • To lean basic concept of synthesis of polymer and solution behaviour of polymer
Mapping between CO and PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1												
CO2												
CO3												
CO4												
CO5												

Course Content		
Unit	Description	Weightage* (%)
1.	**CHEMICAL KINETICS** Theories of Unimolecular gas reactions: Lindemann theory, Kinetics of some complex reactions (i)Reversible reactions(only first order opposed by first order) (ii)Consecutive reactions(A→B→C); Steady state treatment or approximation, Enzyme catalysed reactions, Kinetics of general Chain reaction, Kinetics of photochemical reactions(H_2-$Cl_2$and H_2-Br_2) , Kinetics , Mechanism ,determination of activation energy and chain length of some organic decomposition (i) decomposition of ethane (ii) decomposition of acetaldehyde, Effect of Ionic strength on rates of ionic reactions (Primary and secondary salt effect) Numerical.	25
2.	**THERMODYNAMICS** Introduction to Laws of thermodynamics, state and path functions and their applications, thermodynamic description of various types of	25

	processes,Maxwell's relations, Partial molar quantities, Calculation of partial molar quantities, determination of partial molar volume and partial molar enthalpy, Ideal and non-ideal liquid mixtures,Thermodynamics functions of mixing of non-ideal solutions (i) free energy of mixing (ii) entropy of mixing (iii) volume of mixing and (iv) enthalpy of mixing ,Excess functions(μ^E,G^E, S^E ,H^E and V^E) for non-ideal solutions and expression for excess thermodynamic functions. Numerical	
3.	**STATISTICAL THERMODYNAMICS** Basics of Statistical Thermodynamics (Assembly,Canonica l ensemble, occupation numberstatistical weight factor, probabilit y) , Thermodynamic probability,Probability and entropy, Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics. Lagrange's methods of multipliers, Partition function,Thermodynamic properties in term of partition functions(i) Internal energy (ii) Heat Capacity (iii) Third law of thermodynamics(iv) Helmholtz free energy (v) Enthalpy (vi) Gibb's free energy(vii) Chemical potential (viii) Equilibr ium constant Molecular partition functions for an ideal gas , Derivation for Translational, Rotationaland Vibrational partition functions Numerical.	25
4.	**POLYMER CHEMISTRY** Types of polymers, Stereochemistry of polymers, Kinetics of polymerization (Addition and Condensation),Thermodynamics of polymerization, Phase techniques of polymerization (Bulk, solution, suspension and emulsion), Number & Mass average Molecular mass, Polydispersity Index (P.D.I) Molecular mass determination by Viscometry and Osmometry, Thermal transitions in polymer: glass transition temperature and its significance, Numerical	25

Teaching-Learning Methodology	classroom teaching, use of e-resources, library books , IT tools, encouraging students to participate in seminars/ workshops, presentations by students, assignments etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course	
1.	Students learn thermodynamic terminology, fundamental thermodynamic properties, properties of solution, fundamental knowledge assist student to understand related topic in next semester.
2.	Understand kinetics of different types of reaction. Understand the factors responsible for behaviour of different kind of chemical reaction
3.	Learn relation between quantum chemistry and statistical thermodynamics. Understand basic terminology and their application in calculation of thermodynamic function.
4.	Understand the method for synthesis of polymer and their characterization

Suggested References:

Unit I:

1. Chemical Kinetics, Laidler K.J. TATAMcGRAW-HILL PUBLISHING COMPANY LTD
2. Principles of Chemical Kinetics, James E. House, Elsevier Publication
3. Kinetics and Mechanism of Chemical Transformations,Rajaraman, J. and Kuriacose, J., McMillan (2008)
4. Kinetics of chemical reactions, S.K. Jain, Vishal Publications
5. Engel, T. & Reid, P. Physical Chemistry, Pearson
6. Maron, S. & Prutton Physical Chemistry

UNIT II:

1. Thermodynamics for chemist Samuel Glasstone, East-West Press Pvt. Ltd. (2008)
2. Physical Chemistry, Volume 1: Thermodynamics and Kinetics (10th Edition) by Professor Peter Atkins, Julio De Paula
3. Principles of Physical ChemistryPuri B.R., Sharma L.R. and Pathania, M.S., Vishal Publishing Co
4 A Text Book of Physical chemistry K.L.Kapoor Vol-5 Macillan India Ltd. 2007
5 An Introduction to Chemical Thermodynamics R P Rastogi and R R Mishra VIKASH PUBLISHING HOUSE PVT LTD. 6th edition
6 Advanced Physical Chemistry D.N.Bajpai S.CHAND& COMPANY LTD. 2nd EDITION

UNIT III:

1. Statistical Thermodynamics BY M. C. Gupta New Age International, 2007
2. An Introduction to Statistical Thermodynamics, Terrell L. Hill, ADDITION WESLAY PUBLISHING COMPANY
3. Principles of Physical Chemistry Puri B.R., Sharma L.R. and Pathania, M.S., Vishal Publishing Co
4. A Text Book of Physical chemistry K.L.Kapoor Vol-5 Macillan India Ltd. 2007

UNIT IV:

1. Polymer science by V.R.Gowarikar. WILEY EASTERN LTD
2. Principal of polymer chemistry by A. Ravve, Springer
3. A Textbook of Polymer Chemistry, M S Bhatnagar, S Chand Publications.
4. Principles of Physical Chemistry Puri B.R., Sharma L.R. and Pathania, M.S., Vishal Publishing Co

Master of Science, Physical Chemistry
M.Sc. Physical Chemistry, Practicals

Course Code	[1803081001050001]	Title of the Course	**PHYSICAL CHEMISTRY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To study the physical chemistry parameters for reaction between acid and base. • To study the behaviour of surfactant in aqueous solution • To determine the concentration of solution by colorimetry • To understand the conductivity behaviour of electrolytes solution. • Partitioning behaviour of component in two phases
Mapping between CO and PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12

CO1	
CO2	
CO3	
CO4	
CO5	

Course Content

1. Determine the dissociation constant and strength of borax solution pH-metrically.
2. Determine the velocity constant of the hydrolysis of ethyl acetate with sodium hydroxide at room temperature by conductance measurements.
3. Determine the solubility of silver chloride in water potentiometrically.
4. To determine the concentration of given components in a mixture colorimetrically.
5. Determine the equilibrium constant of the reaction I- + I2 = I3- by distribution method.
6. Investigation the reaction between H2O2 and HI at two different temperatures and calculate the energy of activation for the reaction
7. Determine the formula of a complex between Cu+2and NH3 by distribution method.
8. Determine CST of Phenol -Water system
9. Determine CST of Phenol –NaCl system

Teaching-Learning Methodology	Introduction, explanation of theory and procedure of the experiments and interpretation of results.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learnerwill be able to	
1.	Understand preparation of solutions.
2.	Qualitative analysis of compound
3.	calculate the concentration of unknown solution by pH, potentiometer and colorimeter
4.	Understand behaviour of surfactant and polymer
5.	Separation of solvent using phase diagram

Suggested References:

1. Advanced Practical Physical Chemistry by Yadav J. B., Krishna Prakashan Media
2. Practical Physical Chemistry, Dr. M. Satish Kumar Sankalp Publication
3. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd.
4. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson

On-line resources to be used if available as reference material
On-line Resources

Master of Science, Instrumental and Chemical Analysis
M.Sc. Analytical Chemistry, Semester I

Course Objectives:	• To understand concept of electromagnetic radiation, auxochrome, chromophores, various factors affect the UV-Visible spectra and impart the knowledge to understand the spectra. • To understand basics of concepts of chromatography, their classification and importance as well as working of various parts of the chromatography instruments. Use of this TLC and GC in various application.

	• To learn the different types of errors occur in qualitative and quantitative and the validation of result obtained in experiments with the help of Q test and Students' t test. • To learn the thermal methods, their instrumentation, various factors effect on the experimental results and their application in various field.
Mapping CO and PSO between	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■

Course Code	[18030802010040001]	Title of the Course	**Instrumental and Chemical Analysis**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Content		
Unit	Description	Weightage* (%)
1.	**UV-VISIBLE SPECTROPHOTOMETRY** Types of electronic transition, auxochrome, chromophore, Bathochromic effect, Hypso chromic effect, Hyper chromic effect, Hypo chromic effect, Factor affecting λ_{max} like resonance, hyper conjugation, hydrogen bonding, steric effect, Woodward's rules for α, β-unsaturated ketones, Diene systems, aromatic system, Effect of solvent on absorption bands, law of absorption with derivation, Elementary idea of double beam automatic recording, Spectrophotometer, Application.	25
2.	**CHROMATOGRAPHY**	25

	Thin-Layer Chromatography: Selection of stationary and mobile phase, Detection techniques – Elementary idea of HPTLC **Gas Chromatography:** Selection of mobile phase – Selection of stationary phase in GLC and GSC – Detectors: FID (with modifications), TCD and ECD, Their comparison, Packed column, WCOT, SCOT (advantages and disadvantages) –Temperature programming – Derivatisation in GC – Quantitative Analysis.	
3.	**CHEMICAL MATHEMATICS** Errors in Chemical analysis, classification of errors, nature and origin of errors, Propagation of error, Accuracy and precision, Average deviation and standard deviation and its physical significance, Normal Distribution curve and its properties. Confidence limit and probability, Statistical treatment for error analysis, students't' test, rejection criteria and Q test, method of least square	25
4.	**THERMAL METHODS OF ANALYSIS** **(A) THERMOGRAVIMETRY** Thermogravimetry, Instruments for TGA- thermobalace and furnace, Calibration of temperature scale, Factors affecting TGA results instrumental and experimental, Applications. **(B) THERMOMETRIC TITRATION:** Thermometric Titration (TT), Advantages, Instrument, Applications of TT in Neutralization Titration, Precipitation Titration, Complexometry Titration and Redox Titration.	25

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology comprise classroom teaching, use of e-resources, library books, IT tools, encouraging students to participate in seminars/ workshops, presentations by students, assignments etc.

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand the basic concept of electromagnetic radiation and their interaction with the matter and use of UV-Visible spectrophotometer in structure identification and quantitative determination.
2.	Recognize the use of different stationary and mobile phase for the separation of organic molecule and identify the problems and their solution during the analysis and learn the use of the chromatography for those whose don't identified by the techniques.

3.	Learn difference between different types of errors observed during analysis and use of statistical treatment of data. Also learn to accept and reject the data with help of different type of tests.
4.	Use of the thermometric techniques when the other methods are failed. The requirement of the techniques and identified the problems arise during the analysis.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Suggested References:

1. Fundamental of molecular spectroscopy, C. N. Banwell, Tata McGraw Hill Pub. Camp.
2. Spectrometric Identification of Organic Compounds (4th edition/5th edition), Silverstein, Bassler & Morril, John Wiley & Sons.
3. Introduction to Molecular Spectroscopy, G. M. Barrow, McGraw – Hill.
4. Modern Spectroscopy, J.M.Hollas, John Wiley.
5. Basic Principles of Spectroscopy, R.Chang, McGraw-Hill.
6. Modern Methods of Chemical Analysis (2nd ed.), Pecsok, Shields, Cairns & McWilliom, John Wiley & Sons.
7. Instrumental Analysis by R. D. Braun, McGraw-Hill.
8. Mathematics for Chemistry, Doggett and Sucliffe, Longman.
9. Mathematical preparation for Physical Chemistry, F. Daniels, McGraw Hill.
10. Introduction to Instrumental Analysis by R. D. Brawn, McGraw-Hill Book.
11. Fundamentals of Analytical Chemistry: Skoog D. R. and West D. M. (Holt, Rinehart & Winston, New York).
12. Chemical Analysis in Industry (in Gujarati) by M. N. Desai.
13. Instrumental Methods of Analysis by G. W. Ewing.
14. Modern Method of Chemical Analysis by Pecsok, Shield, Cairns, McWilliam, John Wiley and Sons.
15. Quantitative Analysis, 6th Ed., R. A. Day and A. L. Underwood, Prentice – Hall of India, 1993.
16. Instrumental Analysis: G. D. Caristian and J. E. O'Reilly (Allyn & Bacon Inc., New York, 2nd edition.
17. Instrumental Methods of Chemical Analysis: G. W. Ewing (McGraw-Hill, New York), 5th edition.
18. Instrumental Methods of Analysis: H. R. Willard, L. L. Merrit, J. A. Dean, F. A. Settle (Van Nostrand Reinhold Co., New York), 6th edition.

19. Modern Methods of Chemical Analysis: Pecsok, Shield & Cairns (John Wiley), 2nd edition.
20. Introduction to Instrumental Analysis (1987), R. D. Braun (McGraw-Hill Book Company), New Delhi.
21. Analytical Chemistry: Principles and Techniques: Larry G. Hargis (Prentice-Hall International edition).
22. Introduction to Modern Liquid Chromatography: L. R. Shyder & J. J. Kirkland (John Wiley & Sons, New York).
23. Treatise on Analytical Chemistry: I. M. Kohthoff & P. J. Elving (John Wiley & Sons, New York).
24. Handbook of Analytical Chemistry: L. Meites (McGraw-Hill, New York).

On-line resources to be used if available as reference material

Structure of M. Sc, Syllabus
Semester-II

Sr. No.	Course Code	Course Title	L	T/C/S	Credit
1	1903080202010001	Inorganic Chem	4		4
2	1903080202020001	Organic	4		4
3	1903080202030001	Physical	4		4
4	1903080202040001	Instrumental and chemical analysis	4		4
5		Practicals + T/C/S	12	3	6 + 3
			28	3	25

Faculty Code: Science Subject code:
Level code:
Name of program: M. Sc. Subject: Chemistry
External Examination Time Duration: 03 hrs

Name of Exam	Semester	Paper No	Course group	Credit	Internal Marks	External Marks	Total Marks
M. Sc.	II	I	Core	04	30	70	100
		II	Core	04	30	70	100
		III	Core	04	30	70	100

		IV	Core	04	30	70	100
			Practical + T/C/S	06 + 3	60	140	200
			Total	25	180	420	600

Master of Science, Inorganic Chemistry
M.Sc.Inorganic Chemistry, Semester II

Course Code	[1903080202010001]	Title of the Course	**INORGANIC CHEMISTRY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To learn the properties of non-transition metal elements. • To learn the synthesis, bonding, properties and applications of main group elements. • To understand the Bio inorganic chemistry of Hemoglobin, Myoglobin, Ferritin and Transferrin • To understand the metal complexes in Medicine and anticancer activity of Platinum complexes
Mapping between CO and PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■

Course Content		
Unit	Description	Weightage* (%)
1.	**ELEMENTS OF MAGNETOCHEMISTRY** Definitions of magnetie properties, type of magnetic bodies, the source of paramagnetism, diamagnetism and pascal's constant, Example of pascals constant.	25

	Curie and Curie-Weiss law, Magnetic Properties of transition elements. Determination of magnetic susceptibility: (a) Gouy method (b) Faraday method (s) Null deflection method Application of magnetic susceptibility measurements, Temperature independent paramagnetism (TIP), Orbital contribution to magnetic moment	
2.	**METAL π - COMPLEXES** **Metal carbonyls:** Introduction, classification of metal carbonyls, structure and bonding. vibrational spectra studies for bonding and structure elucidation. Preparation of metal carbonyls by (1) Direct synthesis and (2) From metal compounds. preparation Properties and structure of $Ni(CO)_4$ $Fe_2(CO)_9$ and $Co_2(CO)_8$, 18-electron rule and EAN of metal carbonyls **Metal Nitrosyls**: Introduction, coordination compounds of metal nitrosyls, preparation properties of nitrosyl compounds like nitrosyl halides, nitrosyl cyanides, hydroxides and nitrosyl aquo compounds Complex of NO^+ iron, EAN and structures of nitrosyls.	25
3.	**INORGANIC POLYMERS** Definition of polymers and their depiction. Characteristics of inorganic polymer. Characterization of inorganic polymers (physical properties) by molecular weight, number average and weight average. Structural features of polymers: (1) Backbone bonding (2) Branching and cross-linking (3) Chemical and Stereo chemical variability Classification of inorganic polymers, synthesis, properties, structures uses and application of polyphosphazenes and polysiloxanes.	25
4.	**COORDINATION COMPOUNDS** Classification of coordination compounds, Werner's theory of coordination, Electronic interpretation of coordination compounds, Factors effecting the formation of complex ions, Detection of complex ion in solution, Chelation, Factors influencing the stability of metal chelates, Importance of chelates, Role of metal chelates in living system and polynuclear complexes, Determination of composition of complex ions	25

Teaching-Learning	To meet the effective teaching and the learning requirements, teaching-learning methodology comprise classroom teaching, use of e-resources,

Methodology	library, IT tools, encourages students to participate in seminars/ workshops, presentations by students, assignments etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand the definitions of magnetic properties, type of magnetic bodies, determination of magnetic susceptibility and its applications.
2.	Understand, classification of metal carbonyls and nitrosyls, structure and bonding. Vibrational spectra studies for bonding and structure elucidation, preparation of metal carbonyls and nitrosyls.
3.	To learn the characteristics of inorganic polymer and characterization of physical properties by molecular weight, number average and weight average. Structural features of polymers by different bonding.
4.	Understand the classification of coordination compounds, Werner's theory, Electronic interpretation, factors effecting the formation of complex ions, detection of complex ion in solution, stability of metal chelates and Importance of chelates, role of metal chelates in living system

Suggested References:

1. Magneto chemistry by R. L Carlin
2. Element of Magnetochemistry by A. Syamal and R. L. Dutta, Affileted East-West press, new Delhi, 1993.
3. Introduction to metal pi-complex chemistry by M. Tsusui, M. lchikwa, K. Mori, Plenum press, New york
4. Introductory polymer chemistry by G. S Mishra, Wiley Eastern Ltd,1993.
5. Phosphorous-Nitrogen Compounds, H. R. Allock, Academic, New York, 1972.
6. Advanced in Inorganic Chemistry by S. K. Agarwal, Keemtilal, Pragati prakashan, Meerut

7. Coordination Chemistry by Ajaykumar, Aaryush Education publication, Thind publication
8. Principles of inorganic chemistry by Puri, Sharma and Kalia, Vishal publication Co. Jalandhar, Delhi
9. Coordination Chemistry by Gurdeep Chatwal, M.S. Yadav, Himalaya Publishing house
10. inorganic polymers by Prof G. R. Chatwal, Himalaya Publishing House

On-line resources to be used if available as reference material
On-line Resources

Master of Science, Inorganic Chemistry
M.Sc.Inorganic Chemistry, Practicals

Course Code	[19030811002050001]	Title of the Course	**INORGANIC CHEMISTRY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To impart basic knowledge for carrying out analysis of alloy. • Understand the types of complexometric titrations • To understand and calculate the percentage purity of salt. • Determination of physical constant and confirmation of product. • Concept of estimation and determination of each radical quantitatively and qualitatively.

Mapping between CO and PSO

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■
CO5	■	■	■	■			■		■	■	■	■

Course Content

Quantitative Analysis :

1. Analysis of Solder and Type metal (Alloy Analysis)
2. Determine the amount of Ca as $CaC_2O_4H_2O$ or as $CaCO_3$, in limestone
3. Estimation of Cu^{+2} as CUSCN
4. Estimation of Iron in Iron ore
5. Estimation of available chlorine in bleaching powder
6. Estimation of Ca^{+2} and Pb^{+2} in Admixture
7. Determine the amount of Fe^{+3} and Cr^{+3} Present in given Admixture
8. Determine the percentage purity of the given sample of Manganese salt
9. Estimation of Aluminium by back titration.

Teaching-Learning Methodology	Introduction, interaction with students in calculation of mole ratios, Carrying out experiments at each step according to the respective practical.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand the analysis of alloy and ore and calculation of molarity and mole ratio.
2.	Learn to methods to find copper, zinc gravimetrically and volumetrically.
3.	Learn to find available chlorine bleaching powder.
4.	Learn to determine calcium, lead, Iron and chromium in admixture,
5.	Appreciate good laboratory practices.

Suggested References:

1. A textbook of practical inorganic chemistry - A.L.Vogel
2. Practical Chemistry by Dr.O.P.Pandey, D.N.Bajpai, Dr.S.Giri
3. Advance inorganic analysis by Agarwal, Keemti lal
4. Qualitative Inorganic analysis – Vogel
5. Inorganic practical by Chatwal and Anand

On-line resources to be used if available as reference material
On-line Resources

Master of Science, Organic Chemistry
M.Sc.Organic Chemistry, Semester II

Course Code	1903080202020001	Title of the Course	**ORGANIC CHEMISTRY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To learn transition metal catalyst based on C-C, C-N coupling reaction, formylation reaction, various acid base catalyzed condensation reactions, reactions which changes configuration etc. and their mechanism. • To learn aromaticity based on different concept, measurement of aromaticity through various parameters, annulenes, azzulene and types of aromaticity. • To understand the role of chemical reactants in oxidation, reduction, dehydration, cyclisation and transformation of various organic functional groups. • To understand photochemistry, various types of its reaction, photochemical cleavage of carbonyl compounds, their mechanism and application in synthesis.

Mapping between CO and PSO

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1												

	CO2 ■ □ ■ □ ■ □ ■ ■ ■ ■ □ ■ CO3 ■ □ ■ ■ ■ □ □ □ ■ ■ ■ ■ CO4 ■ ■ ■ ■ □ □ ■ □ ■ ■ ■ ■

Course Content		
Unit	Description	Weightage* (%)
1.	**Organic Name Reactions** General nature, method, mechanism and synthetic applications of the following reactions: (i) Heck reaction (ii) Dakin reaction (iii) Darzen'sglycidic ester synthesis (iv) Leuckart reaction (v) Suzuki reaction (vi) Willgerodt reaction (vii) Buchwald-Hartwig reaction (viii) H. V. Z reaction (ix) Vilsmeyer-Hack reaction (x) Mitsunobu reaction (xi) Sonagashira reaction (xii) Dickmann reaction.	25
2.	**AROMATICITY** A. Aromaticity and Aromatic character; structure and stability of benzene, Frost circle diagram, concept of aromaticity; Resonance and chemical stabilization; criteria to checkaromatic character-IR, NMR, heat of hydrogenation; Huckel's rule; HMO method B. Antiaromaticity, homoaromaticity, nonaromaticity; aromaticity in benzanoid compounds: naphthalene, pyrene, acepleialdelene. C. Aromaticity non-benzenoid compounds: azulene, tropolones, charged rings,annulenes fullerenes, and hmesoionic compounds.	25
3.	**ORGANIC TRANSFORMATION AND REAGENTS** I. Sharplessepoxidation II. Umpolung reagent (1,3-dithiane) III. Dess martin periodinane IV. DDQ V. Tri-n-butyltinhydride (C4H9)3SnH VI. Diisobutyl aluminum hybride (DIDAL-H) VII. Lithium disoprpyl amide (LDA) VIII. OZONE / IX. K3Fe(CN)6and DMSO X. Merrifield Peptide Synthesis\	25

	XI. Crown ethers XII. Wilkinson's Catalyst	
4.	**PHOTO CHEMISTRY** A. Energy of molecules, photochemical energy, electronic excitation, Jablonski diagram, laws of photochemistry, quantum efficiency. B. Photochemistry of carbonyl compounds- α- cleavage of acyclic, cyclicand α-β unsaturated cleavage of carbonyl compounds, β-cleavage of, inter and intramolecularhydrogen abstraction, addition to carbon- carbon doublr bond, photo reduction of carbonylcompounds. C. Photo induce rearrangement of enones, dienones and alkenes. Photochemistry of alkenesand aromatic compounds- isomerization, dimerization and addition reactions D. Photochemistry of visiob, singletoxygenoxygenations,solar energy conversion and storage	25

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology comprise classroom teaching, use of e-resources, library, IT tools, encourages students to participate in seminars/ workshops, presentations by students, assignments etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand the role of transition metal in organic synthesis by studying Heck, Suzuki, Sonogashira and Buchwald Hartwing reaction, formylation by Villsmayer Heck reaction, substituted amines, amides formation reaction, cyclisation through condensation reaction and inverted configuration through Mitsunobu reaction.
2.	Understand aromaticity, various parameters for the measurement of aromaticity, frost circle method and calculation of energy for the determination of aromaticity.

	Aromaticity measurement through NMR, types of aromaticity and aromaticity measurement in fused rings, annulenes and azulenes etc
3.	To learn the chemistry involved in oxidation-reduction reactions by employing numerous reagents & appropriate chemo-selectivity of the reagents, suggest use of miscellaneous reagents in organic synthesis including Wilkinson catalyst, DIBAL-H, PTC-crown ether, 1,3-Dithiane etc.
4.	Get one self familiarize with usual photochemical reactions, terms of photochemistry, understanding fluorescence, phosphorence by photoexcitation decay/discipation of energy. Types photochemical reactions like Norrish type-I & II, Paterno-Buchi etc., Photodimensation and their application in organic synthesis.

Suggested References:

1. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
2. Reaction Mechanism in Organic Chemistry by S. M. Mukherji and S. P. Singh (McMillan India Ltd., 1976).
3. Organic Chemistry (3/e) by J. B. Hendrickson, Donald J. Crem and George S. Rammond (McGraw-Hill Book Co. &Kogekusha Co. Ltd., 1970).
4. Organic Chemistry (5/e) by Morrison & Boyd (Prentice Hall).
5. Advanced Organic Chemistry by Carey &Sundberg (3rd edition).
6. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
7. Name Reactions by A. R. Parikh &H.A.Parikh
8. Name reaction: A collection of detailed reaction machanisms by Jie Jack Li
9. Reaction Mechanism and Reagents in Organic Chemistry by C. R. Chatwal (Himalaya Publishing House, Bombay, 1987).
10. Organic Chemistry-Reactions and Mechanism by P S Kalsi
11. Advanced Organic Chemistry : Reactions and Mechanisms byM.S. Singh
12. Organic chemistrybyCram, Hammond, Pine and Handrickson
13. Photochemistry and Pericyclic Reactions by Jagdamba Singh
14. Pericyclic reactions: A text book by S. Sankararaman
15. Excited states in Organic Chemistry by J. D. Coyle and J. A. Barltrop
16. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure by Michael B. Smith
17. Advanced Organic Chemistry: Part B: Reaction and Synthesis byCarey & Francis
18. Organic Chemistry byJonathanClayden

On-line resources to be used if available as reference material
On-line Resources

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Master of Science, Organic Chemistry
M.Sc.Organic Chemistry, Practicals

Course Code	[19030811002050001]	Title of the Course	**ORGANIC CHEMISTRY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To impart basic knowledge for carrying out preparation. • Understand nature of reaction and establishment of reaction condition with mechanism. • To understand calculation of mole and mole ratio for each reaction. • Isolation of product from individual step and purification by crystallization. • Determination of physical constant and confirmation of product. • Concept of estimation and determination of each component quantitatively.
Mapping between CO and PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■
	■	■	■	■			■		■	■	■	■

Course Content

Preparation of organic compounds :

i) Nitration
ii) Bromination
iii) Acylation
iv) Reduction
v) Oxidation
vi) Condensation reaction

vii) Diazotization reaction
viii) Friedl-Craft's reaction
ix) Cannizzaro reaction
x) Aldol condensation

Quantitative Estimations
a. Estimation of ester + acid
b. Estimation of formaldehyde
c. Estimation of glycine
d. Estimation of amide + acid

Teaching-Learning Methodology	Introduction, interaction with students in calculation of mole ratios, Carrying out experiments at each step according to the respective practical.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learnerwill be able to	
1.	Understand the basics to carry out reactions, nature of reaction and calculation of mole and mole ratio.
2.	Establish mechanism and monitora reaction at specified condition.
3.	Work-up after the completion of reaction and purification.
4.	Confirmation of product through the references.
5.	Appreciate good laboratory practices.

Suggested References:

1. A text book of practical organic chemistry – A. I. Vogel
2. Practical organic Chemistry – Mann and Saunders
3. A handbook of quantitative and qualitative analysis – H. T. Clarke

4. Comprehensive Practical Organic Chemistry : Qualitative Analysis V K Ahluwalia & S. Dhingra.
5. Comprehensive Practical Organic Chemistry : Preparations and Quantitative Analysis V K Ahluwalia& R. Aggarwal Universities Press.
6. An Advance Course in practical Chemistry, A K. Nad, B. Mahapatra and A. Ghoshal.

On-line resources to be used if available as reference material
On-line Resources

Master of Science, Physical Chemistry
M.Sc. Physical Chemistry, Semester II

Course Code	[1903080202030001]	Title of the Course	**PHYSICAL CHEMISTRY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To learn conductivity behaviour of strong electrolytes in solution, factors affecting electrolysis process. • To learn basics and application of colloids. • To understand the basics of surface chemistry. • To understand basics of molecular spectroscopy.
Mapping between CO and PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■

Course Content

Unit	Description	Weightage* (%)
1.	**UNIT-I:THEORIES OF ELECTROLYTIC CONDUCTANCE AND OVER VOLATEGE** Debye-Huckel theory of strong electrolytes, relaxation effect and electrophoretic effect, Debye Falkenhagen effect, Weineffect.Ionic strength and its determination ,Debye-Huckel limiting law. Activity and activity coefficient, determination of activity coefficient by (i) solubility (solubilit y product principle) (ii) EMF method (cell without transference), Determination of dissociation constant of monobasic acid by conductance method and approximate EMF method, Electrolytic polarization, Dissolution and Decomposition potential, Concentration polarization, Decomposition potential and its determination, over voltage, determination of over voltage,theories of over voltage:combination of atom as slow process (Tafel theory) Numerical.	25
2.	**UNIT-II: SURFACE CHEMISTRY** Adsorption Multilayer Adsorption, the BET adsorption isotherms, derivation of BET equation, determination of surface area and area of cross section of molecules by BET equation.Derivation of Langmuir equation from BET equation. Explanation of different adsorption isotherms, Change in enthalpy ,entropy and free energy of adsorption, Adsorption at the surface of liquid : Gibbs adsorption isotherms (derivation).Thermodynamic treatment of adsorption,Surface –Active substances, orientations of surfactants on the surface of solution , surface inactive substances, surface pressure,Insoluble surface films on liquid Numerical	25
3.	**UNIT-III: COLLOIDS:** Types of colloidal systems, preparation of lyophobic colloidal, Properties of Colloidal systems: (i) electrical properties origin of charges on colloidal, electrical double layer, Zeta potential and its determination by electrophoresis, factor affecting zeta potential, explanation on DLVO theory of colloid stability (ii) Electrokinetic properties: Electrophoresis, elecroosmosis. Surface active agents, critical micellar concentration (CMC), factors affecting the CMC of surfactants, thermodynamics of micellization: mass action and phase separation model, solubilisation, emulsion, types of emulsion, methods for determination of types of emulsion, microemulsion, types of microemulsion, theories of microemulsion.	25
4.	**UNIT IV: MOLECULAR SPECTROSCOPY**	25

	Molecular spectra, Microwave spectroscopy (Rotational spectroscopy): The Rotation of molecules, Linear molecule, Symmetric tops ,Spherical tops, Asymmetric tops, Rotational spectra of rigid diatomic molecule ,Intensities of spectral lines , Effect of isotopic substitution, Techniques and instrumentation of rotational spectrum, IR Spectroscopy: Classical frequency of harmonic oscillator,The classical potential energy of harmonic vibration of a diatomic molecule, Quantum expression of potential energy, energy level diagram, Relative population of energy levels ,Mechanism of interaction with radiation, selection rule, determination of force constant, Amplitude of vibration, The anharmonicvibrationor oscillator , Morse potential , Vibrational energy of diatomic molecule following the Morse potential, energy level diagram, vibrational transitions. Vibrational –Rotational spectra of diatomic molecule(CO molecule) Application of Vibrational rotational spectra Numerical	

Teaching-Learning Methodology	classroom teaching, use of e-resources, library, IT tools, encourages students to participate in seminars/ workshops, presentations by students, assignments etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learnerwill be able to	
1.	Understand the electrolytes in conductance of solutions. Importance of polorization decomposition potential and over voltage in electrolysis process and in industries
2.	Understand physical phenomena of surface chemistry. Application of surface active substance and factor affecting surface chemistry, adsorption of surface active materials
3.	Understand the solution behaviour of surfactants. Colloidal chemistry explain the importance of micelle formation for colloidal industry

4.	Identify the molecular interactions and concentration and identification of componds

Suggested References:

UNIT : 1.

1. Atkins, P.W., Physical Chemistry, W.H. Freeman (2017) 10 th editon
2. Samuel Glasstone, Introduction to Electro chemistry, East-West Press Pvt. Ltd. (2008)
3. Puri, B.R., Sharma, L.R., and Pathania, M.S., Principles of Physical Chemistry, Vishal Publishing Co.
4. Engel, T. & Reid, P. Physical Chemistry, Pearson
5. Barrow, G.M. Physical Chemistry Tata McGraw Hill (2007)
6. Maron, S. & Prutton Physical Chemistry, Collier Macmillan Ltd

UNIT : 2

1. Puri, B.R., Sharma, L.R., and Pathania, M.S., Principles of Physical Chemistry, Vishal Publishing Co.
2. Engel, T. & Reid, P. Physical Chemistry, Pearson
3. Barrow, G.M. Physical Chemistry Tata McGraw Hill (2007)
4. Maron, S. & Prutton Physical Chemistry, Collier Macmillan Ltd

UNIT : 3

1. Puri, B.R., Sharma, L.R., and Pathania, M.S., Principles of Physical Chemistry, Vishal Publishing Co.
2. Engel, T. & Reid, P. Physical Chemistry, Pearson
3. Maron, S. & Prutton Physical Chemistry, Collier Macmillan Ltd
4. Colloid Science: Principles, Methods and Applications by T Cosgrove
5. Physical Chemistry of Surfaces" by A W Adamson and A P Gast

UNIT 4

1. Fundamentals of Molecular Spectroscopy C N Banwell TATA McGRAW-HILL15th edition

2. Handbook of Molecular Spectroscopy, by D.N. Sathyanarayana
3. Introduction to Spectroscopy by Donald L. Pavia, George S. Kriz, Gary M. Lampman, James R. Vyvyan
4. Fundamentals of molecular spectroscopy by Walter S. Struve
5. Barrow, G.M. Physical Chemistry Tata McGraw Hill (2007)

On-line resources to be used if available as reference material
On-line Resources

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Master of Science, Physical Chemistry
M.Sc. Physical Chemistry, Practicals

Course Code	[19030811002050001]	Title of the Course	**PHYSICAL CHEMISTRY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To study the physical chemistry parameters for reaction between acid and base. • To study the behaviour of surfactant in aqueous solution • To determine the concentration of solution by colorimetry • To understand the conductivity behaviour of electrolytes solution. • Partitioning behaviour of component in two phases
Mapping between CO and PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1												
CO2												

	CO3 ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ CO4 ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ CO5 ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■

Course Content

1. Determine the dissociation constant and strength of borax solution pH-metrically.
2. Determine the velocity constant of the hydrolysis of ethyl acetate with sodium hydroxide at room temperature by conductance measurements.
3. Determine the solubility of silver chloride in water potentiometrically.
4. To determine the concentration of given components in a mixture colorimetrically.
5. Determine the equilibrium constant of the reaction I- + I2 = I3- by distribution method.
6. Investigation the reaction between H2O2 and HI at two different temperatures and calculate the energy of activation for the reaction
7. Determine the formula of a complex between Cu^{+2} and NH_3 by distribution method.
8. Determine CST of Phenol -Water system
9. Determine CST of Phenol –NaCl system

Teaching-Learning Methodology	Introduction, explanation of theory and procedure of the experiments and interpretation of results.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand preparation of solutions.
2.	Qualitative analysis of compound
3.	calculate the concentration of unknown solution by pH, potentiometer and colorimeter
4.	Understand behaviour of surfactant and polymer
5.	Separation of solvent using phase diagram

Suggested References:

1. Advanced Practical Physical Chemistry by Yadav J. B., Krishna Prakashan Media
2. Practical Physical Chemistry, Dr. M. Satish Kumar Sankalp Publication
3. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd.
4. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson

On-line resources to be used if available as reference material
On-line Resources

Master of Science, Instrumental and Chemical Analysis
M.Sc. Analytical Chemistry, Semester II

Course Code	1903080202040001	Title of the Course	**INSTRUMENTAL AND CHEMICAL ANALYSIS**
Total Credits of the Course	[1903080202040001]	Hours per Week	4 hrs

Course Objectives:	• To understand theory and instrumentation of infra-red spectroscopy with working of various parts of instruments. Structure elucidation is also learnt with help of IR spectra. • To learn liquid-liquid chromatography with special focus on the instrumentation of high-pressure liquid chromatography and their application in various field. • To understand the basic concept twelve principle and green solvents and their application. Also learn the uses of various instrumental and classical method in the analysis of water for removal of toxicants. • To understand units of solution their uses in numerical and solution preparation. To understand the uses of non-aqueous titration when aqueous titration fails and also analysis of C, H, N, O, S with various techniques.
Mapping between CO and PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1												
CO2												
CO3												
CO4												

Course Content		
Unit	Description	Weightage* (%)
1.	**IR SPECTROSCOPY*:*** Introduction: Theory, Instrumentation: single beam, double beam spectrophotometers, FTIR: principle , instrument design, and function of beam splitter, radiation sources, sample cells, monochromators, detectors, sample handling, Resolution, wave number measurement, Advantages of FTIR vs. IR. Useful terms: IR region, types of vibrations: fundamental and overtones, linear and nonlinear molecule, equation for vibrational frequency, selection rule, coupling interactions, hydrogen bonding information, Fermi resonance. IR spectra: group frequency, group frequency region, finger print region, spectra interpretations and structure elucidation.	25
2.	**LIQUID CHROMATOGRAPHY**	25

	Principle of Liquid – Solid chromatography, Comparison with GC, Column chromatography, Gradient elution, Displacement chromatography, Principle of HPLC, Instrument and significance of each component, Pumps, Guard column Criteria in selection of mobile phase, Stationary phases (solid, liquid), Bonded phase supports, Detectors: UV absorption, RI detectors – Normal phase and Reversed phase. Method of introducing sample.	
3.	**GREEN CHEMISTRY AND WATER ANALYSIS** **(A) Green Chemistry** Twelve principles, green solvents and their applications: Ionic liquids, types, properties and applications, ILs as solvents, Supercritical fluids, Supercritical CO_2, its properties and applications in dry cleaning and decaffeination of coffee. **(B) Water analysis** Sources of water pollution, Sewage and industrial effluents, Analysis of water pollutants, Sampling, Preservation, Measurement of parameters such as COD, BOD, DO, TDS, suspended solids, TCC, phenols, fluoride.	25
4.	**TITRIMETRIC METHODS AND ELEMENTAL ANALYSIS** **Solution and Their Concentration:** Molarity, Molality, Normality, ppm, ppb, ppt, %w/v, %w/w, %v/v, Formality, Primary and Secondary standard, Acid Value, Density and Specific Gravity, Numerical. **Non-Aqueous Titration:** Protic and Aprotic Solvent, Solvent system, Dielectric constant, Titrant, Titration Curve, Determination of Equivalence point, Karl Fisher Titration, Numerical. **Elemental Analysis:** Step on Analysis, C and H Analysis, N Analysis, Halogen Analysis and Sulpher Analysis, Numerical.	25

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology comprise classroom teaching, use of e-resources, library books, IT tools, encouraging students to participate in seminars/ workshops, presentations by students, assignments etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written Examination (As per CBCS R.6.8.3)	30%

3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand the basic concept of Infrared radiation and their interaction with the matter and use of FTIR spectrophotometer in structure identification and quantitative determination.
2.	Recognize the use of different stationary and mobile phase for the separation of organic molecule in liquid chromatography and identify the problems and their solution during the analysis.
3.	Learn different principles of green chemistry and their use in various techniques, also learn the determination of various pollutants in water by different techniques available such as classical and instrumental techniques.
4.	Understand the making of different solution with the help of different concentration and learn the non-aqueous titration when aqueous titration fails. Also learn the determination of various elements in organic compounds.

Suggested References:

1. Fundamental of molecular spectroscopy, C.N. Banwell, Tata McGraw Hill Pub. Camp.
2. Spectrometric Identification of Organic Compounds (4th edition/5th edition), Silverstein,Bassler&Morril,JohnWiley&Sons.
3. IntroductiontoMolecularSpectroscopy,G.M.Barrow, McGraw – Hill.
4. Modern Spectroscopy, J.M.Hollas, John Wiley.
5. Basic Principles of Spectroscopy, R.Chang, McGraw-Hill.
6. ModernMethodsofChemicalAnalysis(2nd ed.),Pecsok,Shields,Cairns&McWilliom, JohnWiley&Sons.
7. Instrumental Analysis byR. D. Braun, McGraw-Hill.
8. Mathematics for Chemistry, Doggett and Sucliffe, Longman.
9. Mathematical preparation for Physical Chemistry, F. Daniels, McGrawHill.
10. Introductionto Instrumental Analysis by R. D. Brawn, McGraw-Hill Book.
11. FundamentalsofAnalyticalChemistry:SkoogD.R.andWestD.M.(Holt,Rinehart&Winston, New York).
12. Chemical Analysis in Industry(in Gujarati) by M. N. Desai.
13. Instrumental Methods of Analysis by G. W. Ewing.
14. ModernMethodofChemicalAnalysisbyPecsok,Shield,Cairns,McWilliam,John Wiley and Sons.
15. Quantitative Analysis, 6th Ed.,R.A.DayandA.L.Underwood, Prentice– Hall of India, 1993.
16. Instrumental Analysis: G. D. Caristian and J. E. O'Reilly (Allyn& Bacon Inc., NewYork, 2nd edition.

17. Instrumental Methods of Chemical Analysis: G. W. Ewing (McGraw-Hill, NewYork), 5thedition.
18. Instrumental Methods of Analysis: H. R. Willard, L. L. Merrit, J. A. Dean, F. A. Settle (Van Nostrand Reinhold Co., New York), 6thedition.
19. Modern Methods of Chemical Analysis: Pecsok, Shield & Cairns (John Wiley), 2ndedition.
20. Introduction to Instrumental Analysis (1987), R. D. Braun (McGraw-Hill Book Company), New Delhi.
21. Analytical Chemistry: Principles and Techniques: Larry G. Hargis (Prentice-Hall International edition).
22. Introduction to Modern Liquid Chromatography: L. R. Shyder& J. J. Kirkland (John Wiley & Sons, New York).
23. Treatise on Analytical Chemistry: I. M. Kohthoff& P. J. Elving (John Wiley & Sons, New York).
24. Handbook of Analytical Chemistry: L. Meites (McGraw-Hill, New York).
25. Environmental Chemistry: B. R. Sharma, H. Kaur (Goel Publishing House, Meerut).
26. Environmental Chemistry by A.K.de
27. Spectrometric Identification of Organic Compounds; By Robert M. Silverstein, Francis X. Webster, David J. Kiemle, David L. Bryce, Eight edition, Published by Wiley
28. Introduction to Spectroscopy; By Donald L. Pavia, Gary M. Lampman, George S. Kriz, James A. Vyvyan,Fourth edition, Published by Brooks cole.
29. Spectroscopic Methods in Organic Chemistry; By D.H Williams, I. Fleming, Sixth edition, Published by Tata Mcgraw Hill Education.
30. Spectroscopy of Organic Compounds; By P S Kalsi, Sixth edition, Ne Age International Publisher.
31. Organic Spectroscopy: Principles and Applications; By Jag Mohan, Second edition, Published by Alpha Science International Ltd.
32. Organic Spectroscopy (NMR, IR, Mass and UV); By Dewan S.K.,First edition, CBS Publisher & Distributors Pvt Ltd.
33. Basic Principles of Spectroscopy; By Raymond Chang, Published by McGraw-Hill Inc.
34. Elementary Organic Spectroscopy; By Y R Sharma, S. Chand & Company Pvt. Ltd.
35. Organic Spectroscopy; By William Kemp, Published by Palgrave Macmillan.

36. Green chemistry by V. K. Ahluwalia, Narosa Pub New Delhi
37. Green Chemistry, Theory and Practice, P. T. Anastas and John C. Warner, Oxford University Press, 2000, New York, USA.
38. Green Chemistry: An Introductory Text, Mike Lancaster, Green Chemistry Network, University of York, RSC, 2002.

On-line resources to be used if available as reference material
On-line Resources

M.Sc. Semester-III (ENVIRONMENT CHEMISTRY)

Sr. No.	Course Title	L	T/C/S	Credit
1	Fundamentals of environment and ecology	4	1	4
2	Environmental pollution	4	1	4
3	Waste, waste management and toxicology	4	1	4
4	Environmental studies-instrumental techniques	4	1	4
5	Practicals	12		8
		28	4	24

External Examination Time Duration: 03 hrs

Name of Exam	Semester	Paper No	Course group	Credit	Internal Marks	External Marks	Total Marks
M. Sc.	III	I	Core	04	30	70	100
		II	Core	04	30	70	100
		III	Core	04	30	70	100
		IV	Core	04	30	70	100
			Practical	08	60	140	200
			Total	24	180	420	600

Master of Science, Environment Chemistry
M.Sc. Environment Chemistry, Semester III
PAPER-I

Course Code	[1903080203010005]	Title of the Course	**FUNDAMENTALS OF ENVIRONMENT AND ECOLOGY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To understand the fundamentals of environmental principles, the scope of environmental science and to learn their importance through studying various components of environment which will helpful to be aware of Global environmental problems.

	• To study the natural resources and its associated problems, the renewable and non-renewable sources and to learn various resources of natural resources of ecosystem • To understand the concept, structure and function of ecosystem, the components of ecosystem that leads to grasp the knowledge of ecological succession and to understand the characteristic features and function of various type of ecosystem. • To learn the causes, effect, prevention, correction and protection of various natural hazards.
Mapping of CO And PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1												
CO2												
CO3												
CO4												

Course Content		
Unit	Description	Weightage* (%)
1.	**ENVIRONM EN TAL SCIENCE** • Environmental Science: An Interdisciplinary Science *Fundamentals, Definition, principles, scope and importance • **Environmental components:** ▪ Atmosphere ▪ Lithosphere ▪ Hydrosphere ▪ Biosphere • Global Environmental Problems, Man and Environment	25
2.	**NATUR AL RESOURC E** tural Resources: Renewable and non renewable sources: tural resources and associated problems both • Forest resources • Water Resources • Mineral resources • Land Resources • Energy Resources - Energy flow, Fossil Fuels,	25

	Geothermal energy, Nuclear, Wind, Solar and Biomass energy , Hydro power, Ocean Thermal Energy Conversion, Tidal power. • Food Resources - Agriculture-fertilizer and the green revolution, Environmental degradation, Nutrition energy and calories, protein, minerals and vitamins, antioxidants.	
3.	**ECOSYSTEMS** • Concepts of an ecosystem • Structure and function of an ecosystem • Producers, Consumer and decomposers • Ecological succession • Food chains, Food webs and ecological pyramid • Types, Characteristic features, structure and function of the ecosystems: Forest ecosystem, Grassland ecosystem , Dessert ecosystem	25
4.	**NATURAL HAZARDS:** • **River flooding:** Causes, Nature and frequency of flooding, Nature and extent of flood hazard, urbanization and flooding, Environmental effects of flooding, Flood mitigation methods. • **Landslides:** Causes, human use and landslides, Prevention and correction. • **Costal Hazards:** Tropical cyclone and tsunamis, Costal erosion, Sea level changes and its impacts on costal areas. • **Earthquakes:** Causes, Intensity and magnitude of earthquakes, Nature of destruction, Ground Subsidence, Protection from earthquake hazards. • **Volcanism:** Nature, extent and causes of volcanism, Volcanism and climate.	25

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology comprise classroom teaching, use of e-resources, library, IT tools,, encourages students to participate in seminars/ workshops, presentations by students, assignments etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%

3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Thoroughly understand the principles, fundamental, definition, scope and importance of environmental science, obtains the knowledge of various environmental components and learns the global environmental problem.
2.	Establish the knowledge of various natural resources like renewable and non-renewable sources, develops the grip of various natural resources and its associated problems.
3.	Gain an understanding of Ecosystem, its concept, structure, components and functions, through which leads to understand the importance of ecological succession and learns the characteristic features and function of different ecosystem.
4.	Know about the various Natural hazards such as river flooding, landslides, Costal hazard, earthquake, volcanism and their causes, protection and prevention.

Suggested References:

Reference Books Recommended:

1. Environmental Chemistry by Dr. A. K. De
2. Environmental Chemistry, Goel Publishing house meerut, by B. K. Sharma and H. Kaur.
3. Basic Concept of environmental Chemistry by Des. W. Connell.
4. Chemistry for environmental engineering and science, 5th Ed., by sawyer, McCarty and Parkin.
5. Environmental Chemistry, 7th Ed., By S. E. Manahan.
6. Chemistry for environmental Engineering 4th Ed., By sawyer, McCarty and Parkin.
7. Instant note in ecology by Mackenzie, Ball and virdee.
8. Marin biology: An Ecological approach, 2nd Ed., By James W. Nybakken.
9. Chemistry of Environment, 2nd Ed., By Thomas G. Spiro and William M. Stigliani.

On-line resources to be used if available as reference material
On-line Resources

Master of Science, Environmental Chemistry
M.Sc. Environmental Chemistry, Semester III
PAPER-II

Course Code	[1903080203020005]	Title of the Course	**ENVIRONMENTAL POLLUTION**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To understand and familiarize with classification, properties, sources of air pollution and learn chemistry of ozone and climate. • To learn about various pollution-water & air and effluent treatment. Contamination of water through heavy minerals, halogens, pathogens, air pollution, detection of various components and hydrocarbons, effluent treatment of sugar, peeper & pulp and distilleries. • To understand basic concepts of air and soil, their properties and analysis of various pollutants and minerals present in soil by various methods. • To understand the properties of sound waves, nuclear concepts and Thermal pollution.
Mapping of CO And PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■

Course Content		
Unit	Description	Weightage* (%)
1.	**AIR POLLUTION** • Definition, Chemical composition and Air quality, Classification	25

	and Properties of air pollutants, Sources of air pollutants. • Ozone Chemistry formation and destruction, Ultraviolet Protection by Ozone, Catalytic Destruction of Ozone hydroxyl radical, chlorine and bromine, nitric oxide, Polar Ozone Destruction, Ozone Projections. • Climate- Radiation balance, Albedo- particles and clouds, Greenhouse Effect-IR absorption and molecular vibrations, greenhouse gas trends. • Global Warming, Acid Rain, Vehicular pollution, Photochemical smog, Radiation, Effects of Air pollution on health, Vegetation and Materials.	
2.	**WATER POLLUTION** • Characteristics of bodies of water, Aquatic life- Eutrophication, Water pollution- Definition, Sources, Categories, Nature and Types and sources of water Pollution, Types of Water Pollutants -Inorganic pollutants, Elemental Pollutants, Heavy Metals, Metalloids, Organically Bound Metals and Metalloids, Inorganic Species, Organic Pollutants: Pesticides in Water, Polychlorinated Biphenyls, Radionuclides in the Aquatic Environment, • Effect of oil pollution in marine water • Adverse effects of water pollution.	25
3.	**SOIL POLLUTION:** • Nature and Composition of soil • Characterization of Soil • Soil Contaminants- Sources and Chemical Nature • Important environmental Properties of Soil Contaminants • Ecological and Health effects of soil Contaminants	25
4.	**NOISE, RADIATION AND THERMAL POLLUTION:** • **Noise Pollution**-Basic Properties of sound waves-Plane and spherical waves, Sound Pressure and intensity levels, Decibel, Effects of meteorological parameters on sound propagation, Measurement and analysis of sound. A weighted sound level, Noise pollution level, Sound exposure level, Traffic noise index, Day-Night level, Noise criteria curves, Noise sources, Noise control and abatement measures. • **(B) Radiation Pollution**- Introduction: Definition, Sources, Nuclear concepts and terminology and ecological importance, Maximum Permissible limit, Effects of radiation- Acute, Chronic and Genetic. • **(C)Thermal Pollution**- Introduction-Definition, Sources of thermal pollution, Biological and other effects of thermal pollution, hazardous effects, Thermal Stratification, Management of waste heat.	25

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology comprise classroom teaching, use of e-resources, library, IT tools, encourages students to participate in seminars/ workshops, presentations by students, assignments etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	To learn the about air pollution and its adverse effects. Learn about ozone layer and Global Warming.
2.	Learn water & air pollution, basic concepts of Eutrophication, water contamination with heavy materials, halogens, hydrocarbons and water purifying techniques and purification of water, sewage treatment, determination of air pollutants SOX, NOX, COX and hydrocarbons. Development of technologies to compart gaseous pollutants, effluent treatment of various paper pulp & distillation.
3.	To understand the basic concept about soil and to derive the different characteristics and composition of soil. Understand fundamental & theory of the sources and available minerals in soils. Also learn the different approaches and classical as well as instrumental techniques used for the analysis.
4.	Understand the chemistry involved in noise, radiation and thermal pollution and their hazardous effects.

Suggested References:

Reference Books Recommended:

1. Basic Concept of environmental Chemistry by Des. W. Connell.
2. Environmental Chemistry, 7th Ed., By S. E. Manahan.
3. Environmental Chemistry by Dr. A. K. De

On-line resources to be used if available as reference material
On-line Resources

Master of Science, Environmental Chemistry
M.Sc. Environmental Chemistry, Semester III
PAPER-III

Course Code	[1903080203030005]	Title of the Course	**WAST E, WAST E MANAGE ME NT AND TOXIC OLOGY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To understand different types of hazardous waste and recycling it by different methods. Basic concepts of the physical and chemical properties of hazardous waste. • To learn about radioactive waste and new waste technologies for reduction of radioactive waste. Through study of properties of the nuclear waste • To understand what e-waste is and various wastewater treatments. . To understand the environmental guidelines and standards for management. • To study the different toxic effects of different metals and gases and to understand genotoxicity.
Mapping of CO And PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
	■		■	■	■				■	■	■	■

	CO4

Course Content		
Unit	Description	Weightage* (%)
1.	**SOLID AND HAZARDOUS WASTE** • Sources of solid waste (Domestic, Industrial, Municipal, Hospital, Nuclear, Agriculture), • Characteristic of Solid waste- Physical, Chemical and Biological Properties • Processing - Physical, Chemical and Biological treatment of solid waste o Recycling of waste o Disposal of solid waste Methods, Site selection of disposals Solid waste management and handling rules. • Classification and sources of Hazardous Wastes - Flammable and Combustible Reactive and Corrosive Substances, Physical Forms and Segregation of Wastes, Hazard Ranking System, Physical and Chemical Properties of Hazardous Wastes, Transport, Effects, and Fates of Hazardous Wastes	25
2.	**A. Radioactive Waste** • Nuclear or Radioactive Waste- Principles of radioactivity, Sources of radioactivity in environment, Characteristics of nuclear waste, Radioactive materials and its decay, Half-life, Health effects of ionizing Radiation, Safety standards. **B. Disposal and Analysis of radioactive waste** • Detection and Analysis of radioactive materials, Mining and Recovery, Low-level Radioactive waste, High-level radioactive waste, transport of Radioactive Materials, Storage and Disposal of radio active waste, New waste reduction technologies	25

3.	**[A] Biomedical and e-waste** Introduction, characterization of biomedical waste, handling and disposal of biomedical waste, medical waste treatment techniques, Biomedical waste: Environment standards and guidelines for management, Management and disposal of electronics waste, Basel convention. **[B] Waste treatment Technologies** Waste destruction technologies, waste concentration technologies, TSDF, cradle to grave concepts, solidification and stabilization technologies, biological treatment, bio treatment by sequencing batch reactors, thermal processes, storage and leak detection- underground storage tanks, leak detection and remediation.	25
4.	**TOXICITY** • **[A] Chemical Toxicology-** Introduction, Principles of toxicology, Types of Toxic pollutants, TLV (Threshold limiting Value), Common toxic effects, Dosage-potency **VS** Toxicity, Lethal dosage (LD),Toxic chemicals in the environment, Biochemical Effects of Metals and gases(Pb, Cd, Hg, As, Cr, CO, NOx and SO_2, Cyanide, Pesticides, Carcinogens, Bio-Warfare Agents, • **[B] Genotoxicity-** Teratogens and Teratogenesis,Teratogens (Alcohol, Methyl mercury, Rubella, Thalidomide), Mutagens and Mutagenesis, Carcinogens.	25

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology comprise classroom teaching, use of e-resources, library, IT tools, encourages students to participate in seminars/ workshops, presentations by students, assignments etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand the source, classification, characteristics and disposal of hazardous waste.
2.	Learn radioactive waste and principle of radioactivity, its decay, health effects of ionization, to storage , transport and disposal of radioactive waste.
3.	Understand introductory part of biomedical waste and its disposal by different methods
4.	Understand about chemical toxicity and genotoxicity in detail.

Suggested References:

Reference Books Recommended

1. Environmental Chemistry, 7th Ed., By S. E. Manahan.
2. Chemistry for environmental Engineering 4th Ed.,By Sawyer, McCarty and Parkin.
3. The Chemistry of Industrial Toxicology; By Hervey B. Elkins, John Wiley & Sons, New York. (2nd Edit.)

On-line resources to be used if available as reference material
On-line Resources

Master of Science, Environmental Chemistry
M.Sc. Environmental Chemistry, Semester III
PAPER-IV

Course Code	[1903080203040005]	Title of the Course	**ENVIRONM EN TAL STUDIES AND INSTRUM EN TAL TECHNIQU ES**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To learn spectroscopic determination of compounds by ^{13}C NMR, ^{1}H NMR, and ^{2}D NMR and important concepts like chemical shift, coupling constants for different types of compounds. • To understand different types of spectroscopic techniques for water analysis. • To separate the various substances that make up a mixture. The applications range from a simple verification of the purity of a given compound to the quantitative determination of the components of a mixture. • To learn principles of different electrical techniques like coulometry, voltammetry etc. and Supercritical Fluid Chromatography.
Mapping of CO And PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■

Course Content		
Unit	Description	Weightage* (%)
1.	**NMR Spectroscopy** **(i) ^{1}H NMR Spectroscopy** Proton resonance condition, Aspects of PMR spectra – number of signals, chemical shift, factors influencing chemical shift, deshielding, chemical shift values and correlation for protons bonded to carbons (aliphatic, olefinic, aldehydic, aromatic) and other nuclei (alcohols, phenols, enols, acids, amides and mercaptans), effect of deuteration, spin- spincoupling, (n+1) rule, factors effecting coupling constant "J" **(ii) ^{13}C NMR spectroscopy** Types of ^{13}C NMR Spectra: proton coupled and decoupled ^{13}C spectra, chemical shift, calculations of chemical shifts of aliphatic, olefinic, alkyne, aromatic, hetero aromatic and carbonyl carbons, factors affecting chemical shifts	25
2.	**INSTRUMENTAL TECHNIQUES FOR AIR AND WATER ANALYSIS**	25

	(A) Spectroscopic Technique for Water Analysis – U.V. – Visible spectroscopy FT-IR, Mass Spectroscopy, Flame Photometry, X-ray Fluorescence, ICP-OES, Chemiluminescence methods. **(B) Atomic Absorption and Atomic Fluorescence Spectrometry** Sample Atomization and Atomic Absorption Instrumentation, Interference AAS, Atomic Fluorescence Spectroscopy. Applications **(C) Atomic Emission Spectrometry-** Emission Spectroscopy based on plasma sources, Emission Spectroscopy Based Arc and Spark Sources	
3.	**CHROMATOGRAPHIC TECHNIQUES:** **(A)** GC, HPLC, Headspace GC, GC-MS, LC-MS **Ion Exchange Chromatography-** Resins used – Principle of exchange Factors affecting the exchange – Capacity of resin and its determination, Techniques – IEC with eluent suppressor columns – Applications. **(B) Capillary Electrophoresis** Types of electrophoresis, The basis of electrophoresis Separations, Capillary zone and gel electrophoresis, Application.	25
4.	**(A) Supercritical Fluid Chromatography -** Introduction, Supercritical Fluid Chromatography- Instrumentation and Operating Variables, Comparison of Supercritical to other types of Chromatography, Advantages, Applications of Supercritical Fluid Chromatography. **(B) Electrical Techniques** Coulometry, Anodic Stripping Voltammetry, Ion Selective Electrodes Principle and Applications.	25

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology comprise classroom teaching, use of e-resources, library, IT tools, encourages students to participate in seminars/

	workshops, presentations by students, assignments etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand fundamental & basic terms involved in ^{1}H NMR, 13C NMR , know effects of various factors on the spectra, interpretation from spectral data, identify structure of organic compounds by using combined spectral data, distinguish isomers and other closely related compounds by using spectral techniques.
2.	Able to understand spectroscopic techniques, Atomic Absorption and Atomic Fluorescence Spectrometry, Atomic Emission Spectrometry for water analysis.
3.	Recognize the use of different stationary and mobile phase for the separation of organic molecule and identify the problems and their solution during the analysis and learn the use of the chromatography for those whose don't identified by the techniques.
4.	Understand the basic theory of coulometer, voltammetry electrogravimetry and their working. Also learn in-depth of coulometry methods and their application in various titration, Supercritical Fluid Chromatography and ion selective electrodes

Suggested References:

Reference Books Recommended

1. Instrumental Analysis by R. D. Braun, McGraw-Hill.
2. Modern Methods of Chemical Analysis (2nd ed.), Pecsok, Shields, Cairns & McWilliom, John Wiley & Sons.
3. Principles of Instrumental Analysis (5th ed.) by Skoog, Holler and Nieman (Saunders College Publishings).
4. High Performance Liquid Chromatography, Dr. P.D. Sethi.
5. Practical NMR Spectroscopy, M.L. Martin, J.J. Delpeuch and G.J. Martin, Heyden.
6. Spectrometric identification of Organic compounds, R.M. Silverstein, G.C. Bassler and T.C. Morrill, John Wiley.
7. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Loftus, Weily.

8. Application of Spectroscopy of Organic compounds, J.R. Dyer, Prentice Hall.
9. Spectroscopy Methods in Organic Chemistry, D.H. Williams, I. Fleming,Tata McGraw-Hill.
10. Spectroscopy of Organic compounds, P.S. Kalsi, New Age International Ltd.
11. Environmental Chemistry, De A.K.
12. Spectroscopy by Jagmohan
13. Analytical Chemistry by Gary D. Christian, Sixth Edition, Wiley Sons.
14. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Analytical Chemistry – An Introduction,
7th ed(2000), S. C. Publishing, Philadelphia, London.

On-line resources to be used if available as reference material
On-line Resources

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Master of Science, Environmental Chemistry
M.Sc. Environmental Chemistry, Practical
Semester- III

Course Code	[1903080203050001]	Title of the Course	**ENVIRONMENTAL CHEMISTRY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To impart basic knowledge for carrying out analysis of some environmental water sample. • Understand the importance of various instrumental techniques in analysis. • To learn about the calculation in analysis. • To learn about the stoichiometry used in analysis of compounds. • Preparation of solution used in determination of various compounds.

Mapping of CO And PSO

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■
CO5	■	■	■	■			■		■	■	■	■

Course Content

1	Major Exercise	4- Credit
2	Viva-Voce	
3	Minor Exercise	4- Credit
4	Minor Exercise	

Major Experiments

1. Removal of hazardous dyes/metals by Cloud Point Extraction using non-ionic surfactant.[TX-100]
2. Determination of the Chemical Oxygen Demand (COD) value of KHP sample using conventional method.
3. Determination of the Dissolved Oxygen (DO) in given water sample.
4. Analysis of water sample.
5. Determination of Ksp of AgI and AgCl and find out amount of KCl and Ki in a given (KI + KCl) using potentiometric titration.
6. Determination of total salt content by ion exchange chromatography.
7. Determination of pKIn of Methyl red indicator.
8. Determination of pKIn of Bromo Phenol Blue Indicator.
9. Ion-Exchange separation of Fe^{+3} and Co^{+2} and determination Fe^{+3} by Spectrophotometer.

Minor Experiments

10. Precipitation Titration: Determination of Chloride by the Mohr's Method.
11. Determination of Aniline.
12. Determination of % purity of Aspirin in given tablet.
13. Determination of sulphate using complexometric titration.
14. Determination of the Rf value of amino acids in a given mixture by the technique of ascending out descending Paper chromatography.
15. Spectroscopic determination of Ni^{+2} with D.M.G.
16. Conductometric determination of vanillin in Vanilla.

17. Analysis of Insecticides: Analysis of BHC.
18. Colorimetric estimation of titanium in the given solution by hydrogen peroxide.
19. Estimation of amino acids by colorimetry.
20. Electro gravimetric determination of Cu^{+2} in given unknown/Brass solution.
21. Determination of the amount of As_2O_3 in the given solution by coulometric titration.
22. Determination of the amount of PO_4^{-3} in given sample of soil by spectrophotometrically.
23. Determination of the Iodine value of given fat sample.
24. Determination of saponification value of given oil fat sample.

Note:

- Practical examination will be for **2 days in each semester.**
- **6** hours duration on each day.

Teaching-Learning Methodology	Introduction, interaction with students in calculation of mole ratios, carrying out experiments at each step according to the respective practical.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand the basics to carry out practical.
.	Done the titration or instrumental method for quantitative analysis.
3.	Done the stoichiometry of the reaction involved in titration.
4.	Draw the graph and find out the unknown concentration by comparision with known compound.
5.	Appreciate good laboratory practices.

Suggested References:

Reference Books Recommended

1. Quantitative Inorganic Analysis including Elementary Instrumental analysis, By A. I. Vogel, 3ed, ELBS, 1964.
2. Vogel's Quantitative Chemical Analysis; J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar; Pearson Publication.
3. Analytical Chemistry; Gary D. Christian; Willey India Pvt. Ltd.
4. Evironmental Pollution, A.K. De
5. Evironmental Pollution, B.K. Sharma & H. Kaur
6. Quantitative Analysis by R.A. Day and A. L. Underwood, (Sixth Edition)
7. Standard methods of chemical analysis, Sixth Edition, F.J. Welcher.
8. Standard Methods of Chemical Analysis: Vol. I & II (6th edition), D. Van Nostrand Co. Inc. (London).
9. Official Methods of Analysis: Published by Association of Official Analytical Chemists, Washington.
10. Advance practical physical chemistry by J. B. Yadav
11. Advanced University Practical chemistry by P.C. Kamboj (Part-1)
12. Advance Practical Chemistry by R. Mukhopadhyay and P. Chatterjee
13. Official Methods of Analysis: Published by Association of Official Analytical Chemists, Washington.
14. APHA Standard methods 21st Edition.

On-line resources to be used if available as reference material
On-line Resources

M.Sc. Semester-IV (ENVIRONMENT CHEMISTRY)

Sr. No.	Course Title	L	T/C/S	Credit
1	Water and Soil Analysis and Pollution Remedies	4	1	4
2	Air analysis and Pollution control methods	4	1	4
3	Green Technology	4	1	4

4	Audit, laws and case studies	4	1	4
5	Practical	12		8
		28	4	24

External Examination Time Duration: 03 hrs

Name of Exam	Semester	Paper No	Course Group	Credit	Internal Marks	External Marks	Total Marks
M. Sc.	IV	I	Core	04	30	70	100
		II	Core	04	30	70	100
		III	Core	04	30	70	100
		IV	Core	04	30	70	100
			Practical	08	60	140	200
			Total	24	180	420	600

Master of Science, Environmental chemistry
M.Sc. Environmental Chemistry, Semester IV
Paper 1

Course Code	[2003080204010005]	Title of the Course	**WATER AND SOIL ANALYSIS AND POLLUTION REMEDIES**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To understand the detailed analysis of water on the basis of Color, pH, Test, Odour, Hardness, TDS, Alkalinity, Chloride, Fluoride, Sulphate, Ammoniac Nitrogen, Nitrite, Nitrate, Phosphate, Iron, Fluoride Heavy Metals, Silica. • To understand different treatments methods for wastewater classified in primary, secondary and tertiary wastewater treatment. • To learn which problems arise with industrial wastewater and remedies. • To Understand fundamental & theory of the sources and available minerals in soils. Also learn the different approaches and classical as well as instrumental techniques used for the analysis.

Mapping of CO And PSO

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■

Course Content

Unit	Description	Weightage* (%)
1.	**ANALYSIS OF WATER POLLUTANTS** • **Sampling Methods And Preservation** DO, BOD and COD- Signification, Analytical Methods, Interferences and their elimination, Modifications Color, pH, Test, Odour, Hardness, TDS, Alkalinity, Chloride, Fluoride, Sulphate, Ammonical Nitrogen, Nitrite, Nitrate, Phosphate, Iron, Fluoride Heavy Metals, Silica	25
2.	**WATER TREATMENT** **(A)Water purification;** Natural Water Purification Processes- Treatment for Potable Water, Preliminary treatment, Primary treatment: Sedimentation, Flocculation Secondary treatment: Trickling filters, Activated Sludge, Tertiary treatment: Chlorination, Wet Oxidation, adsorption, Reverse Osmosis, Electro dialysis Ion exchange and water disinfection. A. **Sewage treatment-** Removal of Solids, metals (Ca, Fe, Mn), Removals of dissolved organic and inorganic compounds, Sludge dewatering and disposal. **(C)Water management-**Water Reuse and Recycling, Rainwater harvesting	25
3.	**INDUSTRIAL WATER POLLUTION PROBLEMS AND REMEDIES** • **Industrial water pollution-** Site of pollution and remedies with flowcharts in o Pharmaceutical Industry o Fertilizers Industry o Pulp and Paper Industry	25

	○ Sugar Industry ○ Distillery Industry ○ Textile Industry.	
4.	**SOIL ANALYSIS** • pH • Lime requirement of soil • Nitrogen analysis • Phosphorous analysis • Exchangeable Cation Analysis • Micro nutrient analysis • Trace element in soil analysis • Analysis of pesticides- Standard and polarographic analysis	25

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology comprise classroom teaching, use of e-resources, library, IT tools, encourages students to participate in seminars/ workshops, presentations by students, assignments etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learnerwill be able to	
1.	Understand Sampling methods and preservation DO, BOD and COD- Signification, Analytical Methods, Interferences and their elimination, Modifications
2.	To learn various water purification methods, sewage treatment, and water management
3.	Water pollution occurs in different industries like Pharmaceutical IndustryFertilizers Industry, Pulp and Paper Industry, Sugar Industry, Distillery Industry, Textile Industry and its remedies with flowchart diagram.

4.	Understand the analysis of soil on the basis of pH, Lime requirement of soil, Nitrogen analysis, Phosphorous analysis,Exchangeable Cation Analysis, Micro nutrient analysis.

Suggested References:

Reference Books Recommended:

1. Environmental Chemistry by Manhanan.
2. Environmental Pollution Monitoring and control by S. M. Khopkar
3. Introduction to Environmental Analysis by Roger N. Reere. John Wiley & Sons.
4. Industrial Safety and Pollution control handbook. Published by National Safety Council and Associate (Data) Publishers Pvt. Ltd.
5. Environmental Chemistry, Goel Publishing house meerut, by B. K. Sharma and H. Kaur
6. APHA Standard Methods 21st Edition

On-line resources to be used if available as reference material
On-line Resources

Master of Science, Environmental Chemistry
M.Sc. Environmental Chemistry, Semester IV
Paper I1

Course Code	[2003080204020005]	Title of the Course	**AIR ANALYSIS AND POLLUTION CONTROL METHODS**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To study the analysis of gaseous air pollutants, air sampling methods, preservation of ssamples. • To learn Air pollution Control Methods and Equipments: Source, Collection methods, cleaning of gaseous effluent, particulate emission, absorption, adsorption, Odour control units • To study the Removal, Recovery and Destruction of SO2, NO2, H2S, Organic Vapours and Particulates matters from production houses • To detailed study about bioremediation process.

Mapping of CO And PSO		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
	CO1												
	CO2												
	CO3												
	CO4												

Course Content		
Unit	Description	Weightage* (%)
1.	**ANALYSIS OF AIR POLLUTANTS** Sampling of Particulate matter and Gaseous air pollutants- Sedimentation, HVS, Tape Sampler Impingement, Electrostatic precipitation, Adsorption in Liquid and solids, Thermal precipitation, Stack sampling system (Train), Preservation of samples. Analysis of Oxides of Sulphur, Nitrogen Oxygen and Carbon, H2S, Mercaptons, Hydrocarbons and Organics, Elemental Analyser Analysis of Particulate Matter, Direct Spectrophotometric Analysis of Gaseous Air Pollutants Atmospheric Monitoring	25
2.	**AIR POLLUTION CONTROL METHODS AND EQUIPMENTS** Air pollution Control Methods and Equipments: Source, Collection methods, cleaning of gaseous effluent, particulate emission, absorption, adsorption, Odour control units, Limestone injection and fluidized bed combustion, Desulfurization;, Gravity settling chamber, Centrifugal collectors- cyclone collector and dynamic precipitators; Electrostatic precipitators; wet and dry Scrubbers, filters, Fabric filters. Combustion, Absorption and Adsorption Devices, Catalytic converter and control of vehicular emission	25
3.	**INDUSTRIAL AIR POLLUTION PROBLEMS AND REMEDIES**	25

	Removal, Recovery and Destruction of SO2, NO2, H2S, Organic Vapours and Particulates matters from production houses. Microbial cleaning. Petroleum refinery, Cement industries, Fertilizers Industry, Thermal power plants Iron and Steel industries, Chemical Process industries-Mineral Acid manufacturing and Chloralkali Plants, Microbial cleaning of gases (Bio-filtration and bio-scrubbing)	
4.	**BIOREMEDIATION** • Microbial systems of bioremediation; factors influencing bioremediation (Environmental, Physical and chemical actors) • Application of genetically engineered microorganisms for waste management • Microbial aerobic and anaerobic biotransformations • Bioremediation systems and processes (Solid, Liquid and Slurry phase) • Microbial detoxification of specialty chemicals (Insecticides, Herbicides, Fungicides, Polychlorinated biphenyls, Heavy metals	25

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology comprise classroom teaching, use of e-resources, library, IT tools, encourages students to participate in seminars/ workshops, presentations by students, assignments etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to

1.	Understand the Analysis of Oxides of Sulphur, Nitrogen Oxygen and Carbon, H2S, Mercaptons, Hydrocarbons and Organics in different air sampling and compare the samples of different polluted areas.
2.	Learn about the different equipments like cyclone collector and dynamic precipitators; Electrostatic precipitators; wet and dry Scrubbers, filters, Fabric filters.
3.	Learn the different air pollutants from Petroleum refinery, Cement industries, Fertilizers Industry, Thermal power plants Iron and Steel industries, Chemical Process industries-Mineral Acid manufacturing and Chloralkali Plants.
4.	Study about bioremediation process, systems, applications and Microbial detoxification of specialty chemicals (Insecticides, Herbicides, Fungicides,
Suggested References:	

Reference Books Recommended:

1. Basic Concept of environmental Chemistry by Des. W. Connell.
2. Chemistry for environmental Engineering 4th Ed., By Sawyer, McCarty and Parkin.
3. Environmental Pollution Monitoring and control by S. M. Khopkar.
4. C.S. Rao, Environmental Pollution Control Engineering. Wiley Eastern Ltd. 1991.
5. John H. Seinfeld Air pollution: Physical and Chemical Fundamental McGraw Hill1, 998.
6. M.N. Rao and H.V. Rao Air Pollution, Tata Mcgraw Hill Book Co. 1989.
7. Hand book of Air Pollution, Prevention and control: Nicholas P. Cheremisinoff Elesvier 2nd edition.
8. C.S. Rao, Environmental Pollution Control Engineering. Wiley Eastern Ltd. 1991.
9. John H. Seinfeld Air pollution: Physical and Chemical Fundamental McGraw Hill1998.
10. M.N. Rao and H.V. Rao Air Pollution, Tata Mcgraw Hill Book Co. 1989.
11. Hand book of Air Pollution , Prevention and control: Nicholas P. Cheremisinoff Elesvier 2nd edition

On-line resources to be used if available as reference material
On-line Resources

Master of Science, Enviromnmental Chemistry
M.Sc. Enviromnmental Chemistry, Semester IV
Paper III

Course Code	[2003080204030005]	Title of the Course	**GREEN TECHNOLOGY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• The goal of green tech is to protect the environment, repair damage done to the environment in the past, and conserve the Earth's natural resources • Its foremost objective is to protect and preserve the environment. Examples include technologies that recycle waste, purify water, or reduce pollution in water sources and air. But these aren't limited to industrial use and may apply to household items as well • Green nanotechnology has two goals: producing nanomaterials and products without harming the environment or human health, and producing nano-products that provide solutions to environmental problems. • To use biocatalysis, to produce green buildings and use less hazardous substances in technology.
Mapping of CO And PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■

Course Content		
Unit	Description	Weightage* (%)

1.	**GREEN TECHNOLOGY** Overview of green chemistry, principles of sustainable and green chemistry. Basic principles of green technology, concepts of atom economy and carbon trading, tools of green technology. Waste minimization and climate change, Zero waste technology, concept of environmentally balanced industrial complexing and industrial ecology	25
2.	**GREEN SYNTHETIC METHODS AND DESIGNS** Catalytic methods in green synthesis, safer chemicals – different basic approaches; selection of auxiliary substances (solvents, separation agents), green solvents, solventless processes, immobilized solvents and ionic liquids; energy requirements-use of microwaves, ultrasonic energy; selection of starting materials; use of blocking/protecting groups, catalytic reagents; designing of biodegradable products.	25
3.	**GREEN NANOTECHNOLOGY** Introduction to Nanomaterials and green nanotechnology, Fullerene, carbon nanotubes, Nanoparticles; Green nanoparticle production and characterization; Biocompatibility; Nanomedical applications of green nanotechnologies; use of nanotechnologies and materials impact on biodiversity, resource conservation, ecosystems and human.	25
4.	**GREEN TECHNOLOGY APPLICATIONS** Biocatalysis, green chemistry in industries, fuel cell and electric vehicles, solar energy and hydrogen production, energy from alternate sources; Solar photovoltaic technology, Biofuel production (bio-ethanol and biodiesel), Biomass, prevention/minimization of hazardous/ toxic products. Agricultural related practices and food processing, Production of biodegradable materials, concept of green building and Pollution free engineering processes.	25

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology comprise classroom teaching, use of e-resources, library, IT tools encourages students to participate in seminars/

	workshops, presentations by students, assignments etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Study Overview of green chemistry, principles of sustainable and green chemistry. Basic principles of green technology, concepts of atom economy and carbon trading, tools of green technology
2.	Understand the Catalytic methods in green synthesis, use of green solvents and solvent less processes,
3.	Understand Nanomaterials and green nanotechnology, Fullerene, carbon nanotubes, Nanoparticles and its characterization.
4.	Understand how green technology is applicable in industries and other production methods, fuel cell and electric vehicles, solar energy and hydrogen production

Suggested References:

Reference Books Recommended:

1. Lynn Goldman, Christine Coussens, Implications of nanotechnology for environmental health research, National Academic Press, Washington, 2007
2. Matlack, A. S. Introduction to Green Chemistry. Marcel Dekker: New York,2001
3. Anastas, P. T.; Warner, J. C. Green Chemistry: Theory and Practice. Oxford Univ. Press:Oxford,
4. Caye Drapcho, Nhuan Phú Nghiêm, Terry Walker (2008). Biofuels Engineering Process Technology. [McGraw-Hill].

On-line resources to be used if available as reference material
On-line Resources

Master of Science, Environmental chemistry
M.Sc. Environmental Chemistry, Semester IV
Paper IV

Course Code	[2003080204040005]	Title of the Course	**AUDIT, LAWS AND CASE STUDIES**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• To learn definition and terminologies of Environmental Impact Assessment • To understand Pollution control boards, EPA-US, The Environment (Protection) Acts enacted by CPCB-India for water, air, noise and waste management • To study the rules and acts for hazardous waste management. • To study the Environmental Movements and Case Studies
Mapping of CO And PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■

Course Content		
Unit	Description	Weightage* (%)

1.	**ENVIRONMENTAL IMPACT ASSESSMENT** Definition and terminologies, Basic Description of EIA processes. Biosolid management practices and regularity requirements. Environmental facility and assessment and Audit	25
2.	**ENVIRONMENTAL PROTECTION LEGISLATIONS** Pollution control boards, EPA-US, The Environment (Protection) Acts enacted by CPCB-India for water, air, noise and waste management. GPCB, Legislation and legal aspects: Water (Prevention and control of Pollution) Act 1974, Air (Prevention and control of Pollution) Act 1981,Wild Life protection act, 1972, The India Forest Act, 1927, The Environment protection Act, 1986	25
3.	**HAZARDOUS WASTE MANAGEMENT :** Description of the Environmental settling, Prediction and Assessment of impact on air, water, Noise and Biological environment. Laws and regulations, E- waste management and Handling Rule 2011, Plastic Manufacture, Sale, Usage sale Rule 2011, 2016 and issues involved in enforcement of environmental legislation.	25
4.	**ENVIRONMENTAL MOVEMENTS AND CASE STUDIES** Chernobyl disaster, The Exxon Valdez Oil Spill, Bhopal gas Tragedy, Movements related to Environment Sacred groves, Bishnoi tradition, Chipko movement, Tehridam, Sardar Sarovar, Narmada dam, Almatti dam, Silent Valley. Supreme Court Cases – Ratlam Municipality, Ganga Action Plan, Taj Trapezium, Delhi CNG, Tamil Nadu Tanneries, Doon Valley, Span motels private limited case, Oleum gas case.	25

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology comprise classroom teaching, use of e-resources, library, IT tools, encourages students to participate in seminars/ workshops, presentations by students, assignment etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Study detailed description about ENVIRONMENTAL IMPACT ASSESSMENT
2.	To study the various acts for ENVIRONMENTAL PROTECTION LEGISLATIONS
3.	To understand Description of the Environmental settling, Prediction and Assessment of impact on air, water, Noise and Biological environment
4.	To understand the case studies of Movements related to Environment Sacred groves, Bishnoi tradition, Chipko movement, Tehridam, Sardar Sarovar, Narmada dam, Almatti dam, Silent Valley.

Suggested References:

Reference Books Recommended

1. Environment impact assessment: David P Lawrence, Wiley inter science 2003.
2. Environment impact assessment handbook: Barbara Carroll, Trevor Turpin, Thomas Telford 2003.
3. Case Studies in the Environment Editor-in-Chief: Wil Burns, Vol 3, 2019,ISSN: 2473-9510

On-line resources to be used if available as reference material
On-line Resources

Master of Science, Environmental Chemistry
M.Sc. Enviromnmental Chemistry, Practicals
Semester - IV

Course Code	[2003080204050001]	Title of the Course	**ENVIROMNMENTAL CHEMISTRY**
Total Credits of the Course	4	Hours per Week	4 hrs

Course Objectives:	• Understand the importance of various instrumental techniques in analysis. • To learn about the calculation in analysis. • To learn about the stoichiometry used in analysis of compounds. • Preparation of solution used in determination of various compounds.
Mapping of CO And PSO	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12
CO1		■	■				■	■	■	■		
CO2	■		■		■		■	■	■	■		■
CO3	■		■	■	■				■	■	■	■
CO4	■	■	■	■			■		■	■	■	■

Course Content

1	Major Exercise	4- Credit
2	Viva-Voce	
3	Minor Exercise	4- Credit
4	Minor Exercise	

Major Experiments

1. Analysis of dolomite ore by gravimetry.
2. Determination of the amount of Fe in Cement by optical method.
3. Analysis of Portland cement for the major constitute.
4. Separation of Zn^{+2} & Mg^{+2} ion by an anion exchange resin.

5. Potentiometric determination of Chloride, Bromide and Iodide in a mixture.
6. Analysis of Pyrolusite ore for the major constitute.
7. Separation and determination of total pigment in a paint sample.
8. Determination of volatile thinner in a paints sample.
9. Determination of Cr and Mn in a steel sample photospectrometry.
10. Determination of the total salt amount content in given Water using Ion Exchange Chromatography (IEC). (Dowex cation).

Minor Experiments

11. Determination of the thiosulphate in a given solution.
12. Analysis of dye intermediate containing $-NH_2$ by Potentiometric titration.
13. Determination of Nitrite spectrophotometrically.
14. Biuret in the sample of urea
15. Determination of fluoride in a given solution / tooth paste by Zirconyl-Alizarin red method colorimetrically
16. Analysis of organic materials: Glycerol, Glycine, phenol.
17. Determination of the % of Ca & Mg both combined volumetrically.
18. Estimation of Fe by colorimetry.
19. Determination of the concentration of Cr^{+3} and Co^{+2} in a given mixture using spectrophotometer.
20. Titrimetric determination of L-ascorbic acid. (Vitamin C)
21. Determination of the individual concentration of $Cu^{+2}$and Ca^{+2} in a mixture using by EDTA solution and complexometric titration.
22. Determination of Ka1 and Ka2 of phosphoric acid.
23. Determination of Ca present in $CaCO_3$ with Vitamin D_3 tablet using EDTA by volumetrically.
24. Paper Chromatography.

Note:

1. Practical examination will be for **2 days in each semester.**
2. **6** hours duration on each day.

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology comprise classroom teaching, use of e-resources, library books, IT tools, encouraging students to participate in seminars/ workshops, presentations by students, assignments etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	30%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand the basics of practical.
2.	Understand reaction and monitoring specified reaction condition.
3.	Learn to work-up after the completion of practical.
4.	Confirm the results with the references.
6.	Understand the calculation with reference to respective factors.
7.	Appreciate good laboratory practices.