ADIKAVI NANNAYA UNIVERSITY

UNIVERSITY COLLEGE OF SCIENCE & TECHNOLOGY

RAJAMAHENDRAVARAM – 533296

DEPARTMENT OF CHEMISTRY

M.Sc. ANALYTICAL CHEMISTRY SYLLABUS

(W.e.f 2019-2020 A.B)

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Aditya Degree College
KAKINADA

PROGRAM STRUCTURE

w.e.f. 2019-20 AB

S.No	Course Code	Course Title	Total Marks	Internal Exam Marks	Sem End Exam Marks	Teaching / Practical Hours/ week	Credits
SEMESTER I							
1		General Chemistry-I	100	25	75	4+1(T)	4
2		Inorganic Chemistry-I	100	25	75	4+1(T)	4
3		Organic Chemistry-I	100	25	75	4+1(T)	4
4		Physical Chemistry-I	100	25	75	4+1(T)	4
5		Inorganic Chemistry Practical-I	100	25	75	6	3
6		Organic Chemistry Practical-I	100	25	75	6	3
7		Physical Chemistry Practical-I	100	25	75	6	3
SEMESTER II							
8		General Chemistry-II	100	25	75	4+1(T)	4
9		Inorganic Chemistry-II	100	25	75	4+1(T)	4
10		Organic Chemistry-II	100	25	75	4+1(T)	4
11		Physical Chemistry-II	100	25	75	4+1(T)	4
12		Inorganic Chemistry Practical-II	100	25	75	6	3
13		Organic Chemistry Practical-II	100	25	75	6	3
14		Physical Chemistry Practical-II	100	25	75	6	3
SEMESTER III							
15		Separation methods-I	100	25	75	4+1(T)	4
16		Quality control and traditional methods of analysis-I	100	25	75	4+1(T)	4
17		Applied analysis-I	100	25	75	4+1(T)	4
18		Instrumental methods of analysis-I	100	25	75	4+1(T)	4
19		Practical-I Classical methods of analysis-I	100	25	75	9	4
20		Practical-II Instrumental methods of analysis-I	100	25	75	9	4

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SEMESTER IV							
21		Separation methods-II	100	25	75	4+1(T)	4
22		Traditional methods of analysis-II	100	25	75	4+1(T)	4
23		Applied analysis-II	100	25	75	4+1(T)	4
24		Instrumental methods of analysis-II	100	25	75	4+1(T)	4
25		Practical-II Classical methods of analysis-II	100	25	75	9	4
26		Practical-II Instrumental methods of analysis-I	100	25	75	9	4
27		Summer research Project (after second semester)	100	-	100		2
						Total credits	100

T -Tutorial Hour

BREAKUP DETAILS OF INTERNAL/LAB/PROJECT

For Ex: Internal Theory Examination marks be given in the following manner.

a. Two mid-exams average : 15 Marks
b. Attendance Marks : 05 Marks
b. Seminar Presentations/Assignments : 05 Marks

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PROGRAM OUTCOME

M.Sc. ANALYTICAL CHEMISTRY

The aim of the program is to impart to the students the ability to:

1. Think critically and analyze chemical problems.
2. Present scientific and technical information resulting from laboratory experimentation in both written and oral formats.
3. Work effectively and safely in a laboratory environment
4. Synthesize, separate and characterize compounds qualitatively and quantitatively using theoretical knowledge and standard laboratory techniques/instruments
5. Use technologies/instrumentation to gather and analyze data.
6. Be competent enough to teach Chemistry up to post-graduation level
7. Develop interest towards research and do the same by qualifying CSIR,GATE etc.
8. Work in teams as well as independently.
9. Apply modern methods of analysis to chemical systems in a laboratory setting. Helps in understanding the causes of environmental pollution and can open up new methods for environmental pollution control.

PROGRAM OBJECTIVES:

M.Sc. Analytical Chemistry is being offered by the department since 2016 with the following objectives:

1. To demonstrate broad knowledge of descriptive Analytical Chemistry.
2. To impart the basic analytical and technical skills to work effectively in the various fields of chemistry.
3. To motivate critical thinking and analysis skills to solve complex chemical problems, e.g., analysis of data, synthetic logic, spectroscopy, structure and modeling, team-based problem solving, etc.
4. To demonstrate an ability to conduct experiments in the above sub-disciplines with mastery of appropriate techniques and proficiency using core chemical instrumentation and modeling methods.
5. To demonstrate the ability to perform accurate quantitative measurements with an understanding of the theory and use of contemporary chemical instrumentation, interpret

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experimental results, perform calculations on these results and draw reasonable, accurate conclusions.

6. To develop skills in quantitative modeling of static and dynamic chemical systems.
7. To develop laboratory competence in relating chemical structure to spectroscopic phenomena.
8. To demonstrate the ability to synthesize, separate and characterize compounds using published reactions, protocols, standard laboratory equipment, and modern instrumentation.

SCHEME OF EXAMINATION

M.Sc.Analytical Chemistry
(W.e.f. 2019-20 Admitted batch)

S. No	Evaluation		Total marks
I	**Theory**		
	Internal assessment (Twomid-exams average) 15 Class tests/ assignments/ Seminar Presentation/Comprehensiveviva: 5 Attendance: 5	25	100
	Semester end examination	75	
II	**Practical/Lab**		
	Internal assessment	25	100
	Semester practical end examination	75	
III	Summer research Project (after second semester, for about 45 days)		100

Scheme of Examination at the end of each semester:

Theory passminimum - 40%
Practical pass minimum - 50%

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Courses having focus on Employability / Skill Development / Course Possess Entrepreneurship

S.No	Title	Course Possess Employability	Course Possess Skill Development	Course Possess Entrepreneurship
1	General Chemistry-I	√	.....	.....
2	Inorganic Chemistry-I	√	√	.....
3	Organic Chemistry-I	√	√	.....
4	Physical Chemistry-I	√	√	.....
5	General Chemistry-II	√	.....	.....
6	Inorganic Chemistry-II	√	√	.....
7	Organic Chemistry-II	√	√	.....
8	Physical Chemistry-II	√	√	.....
9	Separation methods-I	√	√	.....
10	Quality control and traditional methods of analysis-I	√	√	.....
11	Applied analysis-I	√	√	.....
12	Instrumental methods of analysis-I	√	√	√
13	Separation methods-II	√	√	.....
14	Traditional methods of analysis-II	√	√	.....
15	Applied analysis-II	√	√	.....
16	Instrumental methods of analysis-II	√	√	√
	LAB COURSE			
5	Inorganic Chemistry Practical-I	√	√	.....
6	Organic Chemistry Practical-I	√	√	.....
7	Physical Chemistry Practical-I	√	√	.....
12	Inorganic Chemistry Practical-II	√	√	.....
13	Organic Chemistry Practical-II	√	√	.....
14	Physical Chemistry Practical-II	√	√	.....
19	Classical methods of analysis-I	√	√	.....
20	Instrumental methods of analysis-I	√	√	.....
25	Classical methods of analysis-II	√	√	.....
26	Instrumental methods of analysis-II	√	√	√
27	Summer research Project (after second semester)	√	√	.....

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SEMESTER –I
COURSE– 1
General Chemistry-I

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Content:

- Quantum chemistry
- Molecular spectroscopy

Course outcomes:

After completing the course, the student will be able to:

1. Understand the limitations of classical mechanics at molecular length scales.
2. Understand the differences between the classical and quantum mechanics.
3. Account for the basic principles and concepts of quantum mechanics.
4. Apply the principles of quantum mechanics to simple model systems relevance within chemistry.
5. understand the bases behind interaction between light and matter and account for the most common spectroscopic methods and their possibilities and limitations for studies of molecules in the MW, IR and UV-Visible areas
6. Calculate different molecular parameters for simple molecules from their MW, IR, Raman and UV-Visible spectra.

After successful completion of the course, the students will be able to work effectively in teaching positions up to post-graduation and can get through state and national level competitive examinations like CSIR, GATE etc.

Course Objectives:

The course is taught with the following objectives:

1. To demonstrate general concepts of chemistry and to impart knowledge
2. To provide and understanding of the origin and applications of Quantum chemistry, Molecular spectroscopy
3. To enhance critical thinking and problem-solving skills for complex chemical problems, e.g. quantum chemistry, molecular spectroscopy.
4. To connect quantum chemistry and molecular spectroscopy to various branches of chemistry.

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UNIT-I:

Basic Quantum Chemistry-I

Wave equation-interpretation of wave function-properties of wave function-normalization and orthogonalization, Operators- linear and non-linear- commutators of operators. Postulates of quantum mechanics; setting up of operators to observables; Hermitian operator- Eigen values and Eigen functions of Hermitian operator; Expansion theorems. Eigen functions of commuting operators-significance. Simultaneous measurement of properties and the uncertainty principle.

UNIT-II:

Basic Quantum Chemistry-II

Wave mechanics of simple systems with constant potential energy, particle in one dimensional box- factors influencing color transition- dipole integral, Symmetry arguments in deriving the selection rules, the concept of tunneling- particle in three -dimensional box. Calculations using wave functions of the particle in a box- Orthogonality, measurability of energy, position and momentum, average values and probabilities. Rigid rotor, Wave mechanics of systems with variable potential energy-simple harmonic oscillator- solution of wave equation- selection rules.

UNIT-III:

Fundamentals of Molecular Spectroscopy-I

Microwave and IR- Spectroscopy- Rotational spectra of diatomic molecules- Rigid rotor-Selection rules- Calculations of bond length- Isotopic effect, Second order stark effect and its applications. Infrared spectra of diatomic molecules- harmonic and anharmonic oscillators-Selection rules- Overtones- Combination bands- Calculation of force constant, anharmonicity constant and zero-point energy. Fermi resonance, simultaneous vibrational-rotational spectra of diatomic molecules.

UNIT- IV:

Fundamentals of Molecular Spectroscopy-II

Raman and Electronic Spectra- Classical and quantum mechanical explanations- Rotational Raman and Vibrational Raman spectra. Electronic spectra of diatomic molecules- Vibrational Coarse structure- intensities of spectral lines- Franck-Condon principle- applications. Rotational Fine structure- band head and band shading. Charge transfer spectra.

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REFERENCES BOOKS/ TEXT BOOKS

1. C.N. Banwell, 2001, *Fundamentals of Molecular spectroscopy*, C.N. Banwell, 4th edition, McGraw Hill Education India.
2. B.K. Sharma, 1981, *Spectroscopy*, 1st edition, Goel Publishing house.
3. G. Aruldas, 2007, *Molecular Structure and Spectroscopy*, 2nd edition, PHI learning pvt. Ltd.,
4. A.K. Chandra, 1994, *Introductory Quantum Chemistry*, 4th edition, Tata Mc Graw Hill publishing company.
5. R.K. Prasad, 2006, *Quantum chemistry*, 3rd edition, New Age International(P) ltd.

SEMESTER –I
COURSE – II
Inorganic Chemistry-I

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Content:

- Theories of bonding
- Cage and ring compounds
- Coordination compounds and their bonding and properties

Course Outcomes:

On successful completion of this course, students will have the ability to:

1. Think critically and analyze chemical problems related to Inorganic Chemistry
2. Present scientific and technical information resulting from laboratory experimentation in both written and oral formats.
3. Work effectively and safely in a laboratory environment
4. Estimate elements qualitatively using theoretical knowledge and standard laboratory techniques/instruments and can synthesize and characterize compounds by using instrumentation
5. To teach Chemistry up to post-graduation level
6. Develop interest towards research and do the same by qualifying CSIR, GATE etc.

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After successful completion of the course, the students will be able to work effectively and skillfully in analysis labs such as water analysis, soil analysis and in teaching positions and can get through state and national level competitive examinations like CSIR, GATE etc.

Course Objectives:

The course is taught with the following objectives:

5. To demonstrate basic concepts and to impart knowledge of Chemistry
6. To provide and understanding of the origin of Inorganic Chemistry from the discovery of elements in nature
7. To enhance critical thinking and analysis skills to solve complex chemical problems, e.g., Analysis, spectroscopy, structure and modeling, team-based problem solving, etc.
8. To demonstrate an ability to conduct qualitative experiments by applying appropriate techniques to find solutions to some natural phenomena and also to synthesize compounds of structural importance

UNIT-I:

Structure & Bonding

Applications of VSEPR, Valence Bond and Molecular orbital theories in explaining the structures of simple molecules- role of p and d orbitals in π-bonding. Application of MO theory to Tetrahedral $[CoCl_4]^{2-}$, Square planar ($[PtCl_4]^{2-}$) and Octahedral complexes ($[CoF_6]^{3-}$, $[Co(NH_3)_6]^{3+}$). Classification of ligands based on π-bonding using MO theory. Walsh diagram for H_2O molecule.

UNIT-II:

Inorganic cage and ring compounds

Preparation, structure and reactions of boranes, carboranes, metallocarboranes. Electron counting in boranes – Wades rules (Polyhedral skeletal electron pair theory). Heterocyclic inorganic ring systems: Boron–Nitrogen ($H_3B_3N_3H_3$), Phosphorus–Nitrogen ($N_3P_3Cl_6$) and Sulphur-Nitrogen (S_4N_4, $(SN)_x$) cyclic compounds. Cage Compounds: Phosphorous oxides and Phosphorous sulphides. Isopoly and heteropoly anions.

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UNIT-III:

Coordination compounds

Crystal field theory - crystal field splitting patterns in octahedral, tetrahedral, tetragonal, square planar, square pyramidal and trigonal bipyramidal geometries. Calculation of crystal field stabilization energies. Factors affecting crystal field splitting energies – Spectrochemical series – Jahn – Teller effect, nephelauxetic effect – ligand field theory. Term symbols – Russell – Sanders's coupling – derivation of term symbols for various configurations. Spectroscopic ground states.

UNIT- IV:

Electronic spectra of transition metal complexes

Types of electronic transitions – d-d transitions - Selection rules, breakdown of selection rules – Orgel and Tanabe-Sugano diagrams for d^1 –d^9 octahedral and tetrahedral transition metal complexes of 3d series – Calculation of Dq, B and β parameters. Charge transfer spectra. Magnetic properties of transition and inner transition metal complexes – spin and orbital moments – quenching of orbital momentum by crystal fields in complexes.

REFERENCE BOOKS /TEXT BOOKS:

1. F.A. Cotton and G. Wilkinson, 1980, *Advanced Inorganic Chemistry*, 4th Edition, John Wiley and Sons, New York.
2. J.E. Huheey, 1983, *Inorganic Chemistry*, 3rd Edition, Harper International Edition.
3. M.C. Day and J. Selbin, *Theoretical Inorganic Chemistry*, 2nd Edition, Affiliated East-West press Pvt. Ltd., New Delhi.
4. Shriver and Atkins, 1999, *Inorganic Chemistry*, 3rd edition, Oxford University Press.
5. Gary L. Miessler et al, *Inorganic Chemistry*, 5th Edition, Pearson Publications.

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SEMESTER -I
COURSE – III
Organic Chemistry-I

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Course Outcomes:

The course aims to provide to the students:

1. A basic idea about aromaticity
2. An idea about basic organic reaction mechanism concepts.
3. An understanding of Stereo Chemistry of Organic Molecules.
4. An idea about single step Organic Synthesis.
5. The ability to perform single step reactions independently.
6. The ability to use the basic operations of an organic chemistry laboratory including gravity & vacuum filtration, liquid-liquid extraction, distillation, reflux, recrystallization, drying of solids and solutions, and the theories behind these techniques

After successful completion of the course, the students will be able to work effectively and skillfully in pharma industry and in teaching positions and can get through CSIR, GATE etc.

Course Objectives:

1. To learn and understand the concept and definitions of aromaticity.
2. To learn about the basic concepts in Organic Chemistry.
3. To learn the basic concepts of Stereo Chemistry.
4. To learn about Recognition of stereochemistry and be able to apply the Cahn-Ingold-Prelog system to designation of stereochemistry (E/Z, R/S, *re/si*).
5. To apply stereochemical aspects to reaction mechanism.
6. To get the knowledge of departmental safety rules through their laboratory practice, including the ability to dispose of waste properly.
7. Students are expected to apply basic stoichiometric algorithms (such as calculating limiting reagents, theoretical yield and mole ratios) in the context of organic chemistry.
8. Students will be expected to demonstrate a command of the rules for assigning significant figures in their work, specifically in calculations and laboratory measurements and calculations.

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UNIT – I:

Nature of bonding in organic molecules and Aromaticity

(A)Electronic Effects and Reactive intermediates:-Inductive effect, Mesomeric effect (Resonance), Hyper conjugation, Steric effect, Tautomerism, Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes, nitrenes and arynes (B) Criteria of Aromaticity:- Huckle's rule and MO Theory, aromaticity in benzenoid non-benzenoid compounds, Aromaticity in Charged and Fused-Ring Systems, Hetero-aromatic Systems, Annulenes: Cyclobutadiene, Benzene,1,3,5,7 Cyclooctatetraene, [10] Annulenes-[12], [14], [16] and [18] annulenes, azulenes, fulvenes, fullerenes, ferrocene, antiaromaticity and homo-aromaticity.

UNIT – II:

Stereo Chemistry & Molecular representation of organic molecules (A) Molecular Symmetry and Chirality:-Symmetry elements, Definition and classification of Stereoisomers, Enantiomer, Diastereomer, Homomer, Epimer, Anomer, Configuration and Conformation, Configurational nomenclature: D,L and R, S nomenclature, Molecules with a single chiral center: Molecules with two or more chiral centers. (B) Geometrical Isomerism and Conformations of Cyclic Systems:- Cis-trans, E, Z- and Syn & anti nomenclature, Methods of determining configuration of Geometrical isomers using physical, spectral and chemical methods, Stability, Cis-trans inter conversion, Conformations of cyclobutane, cyclopentane, cyclohexane, mono and disubstituted cyclohaxanes. (C) Prochirality and Prostereoisomerism:- Homotopic ligands and faces; enantiotopic ligands and faces; diastereotopic ligands and faces; nomenclature of enantiotopic ligands and faces (Pro-R, Pro-S, Re, Si carbonyl compounds and Alkenes) (D) Stereoisomerism in molecules without chiral Center -Axial chirality Allenes, Alkylidene cycloalkanes, spiranes, nomenclature, Atropisomerism: Biphenyl derivatives, nomenclature. Planar chirality: Ansa compounds, paracyclophanes, trans-cyclooctene and Helicity.

UNIT – III:

Heterocyclic compounds

Importance of heterocyclic compounds as drugs. Nomenclature of heterocyclic systems based on ring size, number and nature of hetero atoms. Chemistry of heterocyclic compounds, synthesis and reactivity of the following systems: Quinoline, Isoquinoline, Indole, Pyrazole, Imidazole, Oxazole, Isoxazole, Pyridazine, pyrimidine and Pyrazine.

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UNIT – IV:

Chemistry of some typical natural products (Alkaloids and Terpenoids)

A study of the following compounds involving their isolation, structure elucidation, synthesis and biogenesis of Alkaloids: Atropine, Nicotine, and Quinine. Terpenoids: α- Terpeneol, α-Pinene and Camphor.

REFERENCE BOOKS /TEXT BOOKS:

1. Jerry March, 2015, *Advanced Organic Chemistry-Reactions, Mechanism and structure*, 6th edition, John Wiley & Sons Publishers.
2. Clayden. J, *Organic chemistry*, 2nd edition, Oxford Press.
3. Peter Sykes, 1985, *A Guide Book to Mechanism in Organic Chemistry*, 6th edition, Longman Publishers.
4. P.S. Kalsi, 2005, *Reaction Mechanism in Organic Chemistry*, 2nd edition, New Age International Publishers.
5. R. T. Morrison and R. N. Boyd, 1947, *Organic Chemistry*, 7th edition, Prentice-Hall publishers.
6. E.L. Eliel, 2008, *Stereochemistry to Organic Compounds*, John Wiley publications.
7. P.S. Kalsi, 2005, *Stereochemistry*, 5th Edition, New Age International Publisher.
8. J.A. Joule, K. Kills and G. F. Smith, 2010, *Heterocyclic Chemistry*, 5th edition, Wiley publications.
9. Raj. K. Bansal, 2005, *Heterocyclic Chemistry*, 4th edition, New Age International Publishers.
10. K.W. Bentley, 1991, *Chemistry of Natural Products*, 1st edition, Interscience publishers.
11. D. Nasipuri, 2018, *Stereochemistry to Organic Compounds*, 2nd edition, New Age International Publishers.
12. P.S. Kalsi, 1983, *Chemistry of Natural products*, Kalyani Publishers.

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SEMESTER - I
COURSE – IV
Physical Chemistry-I

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Content:

- Thermodynamics
- Colloids and polymers
- Chemical kinetics
- Photo chemistry

Course outcomes:

After completion of the course the student will able to

1. Apply principles and laws of equilibrium thermodynamics to multicomponent systems.
2. Calculate change in thermodynamic properties, partial molar quantities, chemical potential
3. Identify the dependency of temperature and pressure on phase transitions.
4. apply elementary laws of chemical kinetics and analyze reaction mechanisms.
5. plot equations and functions representing kinetic behavior of the chemical systems in the ground and excited states.

After successful completion of the course, the students will be able to work effectively in analysis laboratories and also in teaching positions upto post-graduation and can get through state and national level competitive examinations like CSIR, GATE etc.

UNIT-I:

Thermodynamics-I

Concepts of partial molar properties – partial molar volume and its significance; Determination of partial molar volume; Graphical method, intercept method and apparent molar volume method. Partial molar free energy, chemical potential, Variation of chemical potential with T and P. Gibbs-Duhem equation-derivation and significance. Phase equilibrium- Derivation of phase rule from the concept of chemical potential. Ideal solutions - Thermodynamic properties of ideal solutions mixing quantities; Vapour pressure- Raoult's law; Thermodynamic properties of ideally dilute solutions. Vapour pressure- Henry's law.

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Non-ideal systems -Concept of fugacity, fugacity coefficient. Determination of fugacity; Non ideal solutions. Activities and activity coefficients; Standard-state conventions for non-ideal solutions; Determination of activity coefficients from vapour pressure measurements. Activity coefficients of non-volatile solutes using Gibbs-Duhem equation. Chemical equilibrium- effect of temperature on equilibrium constant- Van't-Hoff equation

UNIT-II:

Micelles and Macro molecules

Surface active agents, classification of surface-active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization- phase separation and mass action models, Solubilization, micro emulsion, reverse micelles. Polymer- definition, types of polymers, electrically conducting, fire resistant, liquid crystal polymers, kinetics of free radical polymerization. Molecular mass- Number and mass average molecular weight, molecular weight determination -End group analysis, Osmometry, viscometry, ultracentrifugation and light scattering methods.

UNIT-III:

Chemical Kinetics

Theories of reaction rates- Collision theory- Limitations, Transition state theory. Effect of ionic strength - Debye Huckel theory -Primary and secondary salt effects; Effect of dielectric constant, effect of substituent, Hammett equation-limitations, Taft equation; Prediction of rate constants- Consecutive reactions, parallel reactions, opposing reactions (Uni molecular steps only, no derivation). Specific and general acid-base catalysis; Skrabal diagram; Fast reactions- different methods of studying fast reactions- flow methods, relaxation methods- temperature jump and pressure jump methods.

UNIT-IV:

Photochemistry

Electronic transitions in molecules, Franck-Condon principle. Electronically excited molecules- singlet and triplet states, spin-orbit interaction. Quantum yield and its determination; Actinometry - ferrioxalate and uranyl oxalate actinometers-problems. Derivation of fluorescence and phosphorescence quantum yields. Quenching effect- Stern Volmer equation. Photochemical equilibrium and delayed fluorescence - E type and P type.

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Photochemical primary processes, types of photochemical reactions-photodissociation, addition and isomerization reactions with examples.

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1. Peter Atkins and Julio de Paula, 2006, *Physical Chemistry*, 8th edition, Oxford University Press.
2. G.W. Castellon, 2004, *Physical Chemistry*, 3rd edition Narosa Publishing House.
3. Samuel Glasstone, 2008, *Thermodynamics for Chemists*, East West press.
4. K.J. Laidler, 1987, *Chemical Kinetics*, 3rd edition, Pearson education.
5. K.K. Rohatgi and Mukherjee, 2017, *Fundamentals of Photochemistry*, 3rd edition, New Age International publishers.
6. Fred.W. Billmeyer, Jr, 2007, *Text book of Polymer Science*, 3rd edition, Weily publications.
7. V.R. Gowriker, N.V. Viswanadhan and J. Sreedhar, 2005, *Introduction to Polymer Science*, 1st edition, New Age International(P) ltd.
8. V. Moroi, 1992, Micelles, *Theoretical and applied aspects*, Plenum publishers.

SEMESTER-I
LABORATORY WORK (6 hrs/week)

PRACTICAL-1
INORGANIC CHEMISTRY PRACTICALS - I

I. Inorganic Synthesis: Preparation of

i. Tetra ammine copper(II) sulphate
ii. Potassium tris(oxalato)ferrate(III) trihydrate
iii. Tris(thiourea)copper(I) sulphate

II. Semi micro qualitative analysis of six radical mixtures

(One interfering anion and one less familiar cation for each mixture)

Anions: CO_3^{2-}, S^{2-}, SO_3^{2-}, Cl^-, Br^-, I^-, NO_3^-, SO_4^{2-}, CH_3COO^-, $C_2O_4^{2-}$, $C_4H_4O_6^{2-}$, PO_4^{3-}, CrO_4^{2-}, AsO_4^{3-}, F^-, BO_3^{3-}

Cations: Ammonium (NH_4^+)

1st group: Hg, Ag, Pb, Tl, W

2nd group: Hg, Pb, Bi, Cu, Cd, As, Sb, Sn, Mo

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3rd group: Fe, Al, Cr, Ce, Th, Ti, Zr, V, U, Be

4th group: Zn, Mn, Co, Ni

5th group: Ca, Ba, Sr

6th group: Mg, K, Li

REFERENCE BOOKS:

1. G. Svehla, *Vogel's textbook of semimicro qualitative analysis*, 5th Edition,Pearson Education Asia.

PRACTICAL-2

ORGANIC CHEMISTRY PRACTICALS -I

Preparation, recrystallization, and determination of melting point & yield of the following compounds:

i. Aspirin
ii. Nerolin
iii. Chalcone
iv. p-Nitro acetanilide
v. 2,4,6- Tribromoanilline
vi. m-Dinitrobenzene
vii. Phthalimide
viii. Diels-Alder adduct.

REFERENCE BOOKS /TEXT BOOKS:

1. J. Mendham, R. C. Denney, J. D. Barnes and M. J. Thomas, *Vogel's Text Book of Quantitative Chemical Analysis*, 4th & 6th Edition, Pearson Education Asia.
2. B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tatchell, *Vogel's Text Book of Practical Organic Chemistry*, 5 Edition. Longman Scientific & Technical.

PRACTICAL-3

PHYSICAL CHEMSITRY PRACTICALS -I

1. Determination of critical solution temperature of phenol-water system.
2. Effect of added electrolyte on the CST of phenol-water system.
3. Conductometric titration of Strong acid versus Strong base
4. Dissociation constant of weak acid (CH_3COOH) by conductometric method.
5. Conductometric titration of Weak acid vs Strong base.

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6. Determination of cell constant
7. Adsorption of acetic acid on animal charcoal or silica gel.
8. Acid-catalyzed hydrolysis of methyl acetate
9. Determination of partial molar volume of solute –H_2O system by apparent molar volume method.

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SEMESTER-II
COURSE – I
General Chemistry-II

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Content:

- Quantum chemistry
- Group theory
- Treatment of Analytical data
- FORTRAN programming

Course Outcomes:

After completion of the course, the student will able to:

1. Have an idea of structure of an atom, radial and angular probability distributions and shapes of atomic orbitals.
2. Determine the symmetry operations of any small and medium sized molecule and apply point group theory to the study of electrical, optical and magnetic properties and selection rules for absorption.
3. Apply the conceptual understanding of the statistical parameters to the analytical data.
4. Develop elementary programs in Fortran for performing scientific calculations.

After successful completion of the course, the students will be able to work effectively in teaching positions and can get through state and national level competitive examinations like CSIR, GATE etc.

UNIT-I:

Basic Quantum Chemistry-III

Hydrogen atom- solution of R(r), Φ (ϕ) and Θ (θ) equations. Probability density in orbitals- shapes of orbitals- Perturbation theory- Time independent perturbation theory (only first order perturbation is to be dealt with)- application to ground state energy of Helium atom- Variation principle- applications- calculation of zero-point energy of harmonic oscillator- many electron atom- Hartee-Fock self-consistent field method (qualitative treatment only)

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UNIT-II:

Molecular symmetry and Group Theory in chemistry

Basic concepts of symmetry and Group theory- Symmetry elements, symmetry operations and point groups- Schoen flies symbols- Classification of molecules into point groups- Axioms of Group theory- Group multiplication tables for C2v and C3v point groups- Similarity transformations- and classes- Representations- reducible and irreducible representations. Mullikan symbols, Orthogonality theorem and its implications. Character table and its anatomy.

UNIT-III:

Treatment of analytical data

Accuracy and precision- Classification of errors- Determinate and Indeterminate errors. Minimization of errors- Absolute and Relative errors, propagation of errors -Distribution of Indeterminate errors- Gaussian distribution- Measures of central tendency -Measures of precision- Standard deviation- Standard error of mean- student's t test- Confidence interval of mean- Testing for significance- Comparison of two means- F-test- Criteria of rejection of an observation- Significant figures and computation rules.

UNIT- IV:

Introduction to computer programming- FORTRAN 77

Basic structures and functioning of computer with P.C. as an illustrative example- Main memory- Secondary storage memory- input/output devices- computer languages- operating systems- principles of algorithms-and flow charts-constants and variables- Arithmetic expressions- Arithmetic statements Replacement statement- IF statement- logical IF and BLOCK IF statements- GOTO statements-subscripted variable and DIMENSION statement. DO statement- Rules for DO statement- Functions and subroutines- Development of FORTRAN statements for simple formulae in chemistry such as Vander Waals equation- pH of a solution- First order rate equation- Cell Constant-Electrode potential. Flowcharts and computer programs for a) Program for the calculation of Cell Constant, Specific Conductance and Equivalence. b) Rate Constant of First order reaction or Beer's law by linear least square method. c) Hydrogen ion concentration of a strong acid solution/Quadratic equation. d) Solution for Vander Waals equation or Hydrogen ion concentration of a monoprotic weak acid e) Standard deviation and Variance of univariant data

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REFERENCES/ TEXT BOOKS:

1. A.K. Chandra,1994, *Introductory Quantum chemistry*, 4th edition, Tata McGraw Hill publishing company ltd.
2. Group theory and its Chemical Applications, Himalaya publishing house, 2010.
3. P.K. Bhattacharya, 2005, *Chemical Applications of Group Theory*, F.A. Cotton, 3rd edition, Wiley publications.
4. George Davidson,1991, *Introductory Group theory for chemists*, Macmillan education.
5. Vogel, J. Mendham,2000, *Vogel's text book of quantitative chemical analysis*, 6th edition Pearson Education.
6. D.A. Skog, D.M. West, 2014, *Fundamentals of Analytical chemistry*, 9th edition, Cengage Learning.
7. V. Rajaraman, 2009, *Computer programming in FORTRAN 77*, PHI learning.

SEMESTER-II
COURSE – II
Inorganic Chemistry-II

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Content:

- Metal cluster compounds
- Organometallic compounds and homogeneous catalysis
- Stability of coordination compounds and Bio-inorganic Chemistry
- Inorganic reaction mechanism

Course Outcomes:

On successful completion of this course, students will have the ability to:

1. Apply advanced concepts of Inorganic Chemistry to analyze chemical problems related fields
2. Present scientific and technical information resulting from laboratory experimentation in both written and oral formats.
3. Work effectively and safely in a laboratory environment

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4. Estimate elements quantitatively using theoretical knowledge and standard laboratory techniques/instruments
5. To teach Chemistry up to post-graduation level
6. Develop interest towards research and do the same by qualifying CSIR, GATE etc.

After successful completion of the course, the students will be able to work effectively andskillfully in analysis labs such as water analysis, soil analysis and in teaching positions and can get through state and national level competitive examinations like CSIR, GATE etc.

Course Objectives

This course is taught with the following objectives:

1. To demonstrate advanced concepts of Chemistry, especially Inorganic Chemistry
2. To understand the role of Inorganic Chemistry and its principles in biological processes
3. To motivate critical thinking and analysis skills to solve complex chemical problems, eg. Analysis, spectroscopy, structure and modeling etc.
4. To demonstrate an ability to conduct quantitative experiments (Volumetry and gravimetry) in the disciplines with mastery of appropriate techniques to find solutions to some natural phenomena.

UNIT-I:

Metal cluster compounds

Definition – evidences for existence of M-M bonds - conditions favorable for formation of M-M bonds – preparation, structure and bonding of the following metal cluster compounds. $Re_2Cl_8^{2-}$, $Mo_2Cl_8^{4-}$, $Re_2(RCOO)_4X_2$, $Mo_2(RCOO)_4(H_2O)_2$, $Cr_2(RCOO)_4(H_2O)_2$, $Cu_2(RCOO)_4(H_2O)_2$, $Cr_2Cl_9^{3-}$, $Mo_2Cl_9^{3-}$, $W_2Cl_9^{3+}$, Re_3Cl_9, $Re_3Cl_{12}^{3-}$, $Mo_6C_{18}^{4+}$, $Nb_6X_{12}^{2+}$ and $Ta_6X_{12}^{2+}$. Polyatomic clusters – Zintle ions, Chevrel phases.

UNIT-II:

Organo metallic compounds

16 and 18 electron rules. Isoelectronic relationship - Synthesis, structure, bonding and reactions of carbon monoxide, dinitrogen and nitric oxide complexes. Isolobal relationship – H, Cl, CH_3, $Mn(CO)_5$; S, CH_2, $Fe(CO)_4$; P, CH, $Co(CO)_3$. Synthesis, structure, bonding and reactions of metallocenes with special reference to ferrocene. Catalysis by Organometallic

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compounds – Homogeneous Catalysis – Alkene hydrogenation – Wilkinson's catalyst, Hydroformylation.

UNIT-III:

Metal Ligand equilibria in solution

Stepwise and overall formation constants and their interaction– trends in stepwise constants – factors affecting the stability of metal complexes–Pearson's theory of hard and soft acids and bases (HSAB), chelate effect and its thermodynamic origin, determination of stability constants of complexes–spectrophotometric method and pH–metric method. Reactivity of metal complexes–inert and labile complexes. Explanation of lability on the basis of VBT & CFT. Bio-Inorganic Chemistry: Metalloporphyrins with special reference to Haemoglobin& Myoglobin. Biological role of alkali and alkaline earth metal ions with special reference to Ca^{2+}. Biological and abiological Nitrogen Fixation.

UNIT- IV:

Inorganic Reaction Mechanisms

Substitution reactions of metal complexes – D, I_d, I_a and A mechanisms – Ligand replacement reactions of octahedral complexes – Acid hydrolysis – factors affecting acid hydrolysis – Anation and Base hydrolysis of Cobalt(III) complexes. Ligand displacement reactions of square planar complexes of platinum (II). Factors affecting square planar substitution – trans effect (theories). Electron transfer reactions of complexes – concept of complementary and non-complementary reactions with examples. Inner and outer sphere mechanisms.

REFERENCE BOOKS /TEXT BOOKS:

1. F.A. Cotton and R.G. Wilkinson, 1980, *Advanced Inorganic Chemistry*, 4th edition, John Wiley and Sons, New York.
2. J.E. Huheey, 1983, *Inorganic Chemistry*, 3rd edition, Harper International Edition.
3. A. Singh and R.C. Mehrotra, 1991, *Organometallic Chemistry-A unified approach*, Wiley Eastern Ltd.
4. Shriver and Atkins, 1999, *Inorganic Chemistry*, 3th edition, Oxford University Press.
5. M.C. Day and J. Selbin, *Theoretical Inorganic Chemistry*, 2nd Edition, Affiliated East-West press Pvt. Ltd.

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6. D. Benson, *Mechanisms of Inorganic reactions in solution*, 1st edition, MC Graw Hill, London, 1968.
7. K.F. Purcell and J.C. Kotz, 1977, *Inorganic chemistry*, W.B. Saunders company, Philadelphia.
8. G.N. Mukherjee and Arabinda Das, 1993, *Elements of Bioinorganic Chemistry*, U.N. Dhur& sons Pvt. Ltd, Calcutta.

SEMESTER-II
COURSE – III
Organic Chemistry-II

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Course Outcomes:

The course aims to provide to the students:

1. A basic idea about protection and de-protection.
2. An idea about basic organic reaction mechanism concepts.
3. An understanding of Stereo Chemistry of Organic Molecules.
4. An idea about basic named reactions in Organic Chemistry
5. Ability to perform Organic mixtures separations independently.
6. An idea to prepare derivatives for organic compounds with specific functional groups.
7. An idea in the confirmation of functional groups present in the organic compounds

After successful completion of the course, the students will be able to work in teaching positions up to post-graduation and can get through state and national level competitive examinations like CSIR, GATE etc.

Course Objectives:

1. To learn and understand the concept and definitions of protection and deprotection.
2. To learn about the basic named reactions in Organic Chemistry.
3. To learn the basic rearrangements in organic chemistry.
4. To learn about basic principles of Organic Spectroscopy.
5. To apply stereochemical aspects to reaction mechanisms.

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6. To understand the reaction mechanism subjects in later stages of student study.
7. To understand the Organic Mixtures and their proper separation.
8. To learn about the preparation of organic compounds derivatives in solid form.

UNIT-I

Reaction Mechanism

(A) Aliphatic Nucleophilic Substitution and Nucleophilic Aromatic substitution: Stereochemistry of SN^2 and SN^1 mechanisms, Neighboring Group Participation (Anchimeric assistance), NGP by O, S, N; Aromatic Nucleophilic substitution: $S_N2(Ar)$ (Addition – Elimination), $S_N1(Ar)$ and benzyne mechanisms (Elimination - Addition); evidence for the structure of benzyne. Von Richter Sommelet-Hauser rearrangements. (B) Elimination Reactions: Type of elimination reactions, mechanisms, Stereochemistry and Orientation, Hofmann and Saytzeff rules, Syn elimination versus anti-elimination, competition between elimination and substitution, dehydration, dehydrogenation, dehalogenation, decarboxylative eliminations and pyrolytic eliminations.

UNIT-II:

Addition Reactions

(A) Addition to Carbon – Carbon Multiple Bonds: Mechanistic and stereo chemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, region and chemo selectivity, orientation and reactivity, Hydrogenation of double and triple bonds, hydrogenation of aromatic rings, Hydroboration. (B) Addition to Carbon-Hetero Multiple Bonds: Steric course of addition reactions to C=O and C=N, Aldol, Cannizzaro, Perkin, Knoevenagel, Claisen- Schmidt, Claisen, Dieckman, Benzoin and Stobbe condensations, Reformatsky reaction, Tollen's reaction, Prins reaction: Wittig, Grignard, Mannich, and Michael reaction.

UNIT-III:

Molecular Rearrangements

Types of molecular rearrangements, migratory aptitude; Rearrangements to electron deficient carbon: Pinacol-pinacolone, Wagner-Meerwein, Tiffeneau – Demjanov, Dienone – Phenol, Arndt-Eistert synthesis; Rearrangements to electron deficient nitrogen: Beckmann, Hofmann, Curtius, Schmidt and Lossen rearrangements; Rearrangements to electron deficient

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oxygen: Baeyer-villiger, Hydro peroxide rearrangement and Dakin rearrangements; Neber rearrangement, Benzil-Benzilic acid and Favorskii rearrangements

UNIT-IV:

Spectroscopy and Protecting Groups

A. i) U.V. Visible absorption laws, electronic excitations and absorption shifts ii) I.R.: Fundamental modes of vibrations in IR Spectroscopy, Finger Print Region and its importance. iii) NMR: Chemical shift and its importance, coupling constant and its importance, Factors affecting chemical shift and coupling constant, Deuteration-deuterium exchange and Deuterium Labeling. iv) Mass: Some useful terms used in Mass spectrometry: Molecular ion, Fragmentation, Cleavage, Rearrangement, Loss of small molecules, Isotope Abundance, Metastable ions, Even-electron rule, Nitrogen rule, Mc Lafferty Rearrangement.

B. Protection of carbonyl, Hydroxyl, carboxylic and Amine groups

REFERENCE BOOKS /TEXT BOOKS:

1. Jerry March, 2015, *Advanced Organic Chemistry-Reactions, Mechanism and structure*, 6th edition, John Wiley & Sons publishers.
2. Clayden J. 2012, *Organic chemistry*, 2nd edition Oxford press.
3. Wade, L.G. Jr., 2002, *Organic Chemistry*, 5th edition, Pearson publications.
4. Peter Sykes, 1985, *A Guide Book to Mechanism in Organic Chemistry*, 6th edition., Longman press.
5. P.S. Kalsi, 2005, *Reaction Mechanism in Organic Chemistry*, 2nd edition, New Age International publications.
6. E.L. Eliel, 2008, *Stereochemistry to Organic Compounds*, John Wiley publications.
7. Nasipuri, 2018, *Stereochemistry to Organic Compounds*, 2nd edition, New Age International publications.
8. P.S. Kalsi, 2005, *Stereochemistry*, 5th edition. New Age International publications.
9. D.H. Williams and I. Fleming, 1990, *Spectroscopic Methods in Organic Chemistry*, 4th edition, Tata - McGraw Hill Publishers, New Delhi.
10. W. Kemp, 1987, *Organic Spectroscopy*, 2nd edition, ELBS Macmillan press.
11. Thomas H. Lowry, Kathleen S. Richardson, Harper & Row, 1976, *Mechanism and Theory in Organic Chemistry*, 3rd edition, Pearson publications.

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SEMESTER -II
COURSE – IV
Physical Chemistry-II

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Contents:

- Physical methods of structural elucidation
- Statistical thermodynamics
- Electrochemistry

Course Outcomes:

After completion of the course students will be able to:

1. Recognize the fundamental principle of magnetic resonance through theory and implement them to simple examples.
2. Recognize the fundamental principles of statistical thermodynamics, their application for obtaining absolute values for thermodynamic parameters using partition functions.
3. Write equations representing electrochemical cell.
4. Calculate electrochemical cell parameters and certain thermodynamic parameters using emf data.

After successful completion of the course, the students will be able to work in teaching positions upto post-graduation and can get through state and national level competitive examinations like CSIR, GATE etc.

UNIT-I:

Physical methods of molecular structural elucidation

NMR: Principle and theory, Nature of spinning particle and its interaction with magnetic field. Chemical shift and its origin. Spin-Spin interaction, Application of NMR to structural elucidation- Structure of ethanol, dimethylformamide, styrene and acetophenone. Electron Spin Resonance: Principle and experimental technique- g-factor, line shapes and line widths-hyperfine interactions- applications of ESR studies.

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UNIT -II:

Thermodynamics-II

Brief review on entropy; entropy changes accompanying specific process – expansion, phase transition, heating, measurement of entropy. Nernst heat theorem; Third law of thermodynamics- Determination of the absolute entropy- Apparent exceptions to Third law of thermodynamics. Statistical Thermodynamics: Objectives of statistical thermodynamics, Concept of distributions, Types of ensembles. Thermodynamic probability, Most probable distribution Law – Partition Function, (Definition and significance); Molar and molecular partitions-translational, rotational, vibrational and electronic partition functions- Relation between thermodynamic functions (E, H, S, G and Cv) and the partition functions

UNIT-III:

Electrochemistry I

Electrochemical cell- Galvanic and electrolytic cell. Concentration cell with and without transference, Effect of complexation on redox potential- ferricyanide/ ferrocyanide couple, Iron (III) phenonthroline / Iron (II) phenonthroline couple. Determination of standard potential, solubility product equilibrium constant and activity coefficients from EMF data. Bjerrum theory of ion association (elementary treatment) Concept of activity and activity coefficients in electrolytic solutions. The mean ionic activity coefficient. Debye-Huckel theory of electrolytic solutions. Debye-Huckel limiting law (derivation not required). Calculation of mean ionic activity coefficient; Limitations of Debye-Huckel theory. Effect of dilution on equivalent conductance of electrolytes - Anomalous behavior of strong electrolytes. Debye Huckel-Onsagar equation – verification and limitations, Fuel Cells.

UNIT-IV:

Electrochemistry II

The electrode-electrolyte interface. The electric double layer. The Helmholtz-Perrin parallel-plate model, the Gouy-Chapman diffuse-charge model and the Stern model. Electrodics: Charge transfer reactions at the electrode-electrolyte interface. Exchange current density and over-potential. Derivation of Butler-Volmer equation. High field approximation, Tafel equation, Low field equilibrium, Nernst equation. Voltametry-Concentration polarization, experimental techniques

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REFERENCE BOOKS /TEXT BOOKS:

1. G.W. Castellon, 2004, *Physical Chemistry*, 3rd edition, Narosa Publishing House.
2. Peter Atkins and Julio de Paula, 2006, Physical Chemistry, 8th edition, Oxford University Press.
3. JOM Bockris& A.K.N. Reddy, 1998, *Modern Electrochemistry, Volume-1*, 2nd edition, Plenum Publishers.
4. JOM Bockris& A.K.N. Reddy, 1998, *Modern Electrochemistry*, Volume-2A, 2nd edition, Plenum Publishers.
5. S. Glasstone, 2008, *Introduction to Electrochemistry*, Affiliated East-West Press pvt. Ltd.
6. C.N. Banwell, 2001, *Fundamentals of Molecular Spectroscopy*, 4th edition, McGraw-Hill education (India) pvt. ltd.
7. M.C. Gupta, 2003, *Statistical thermodynamics*, 2nd edition, New Age International(P) limited Publishers, India.
8. Malcolm Dole, 1954, *Introduction to Statistical Thermodynamics*, Prentice-Hall publishers.

LABORATORY WORK (6 hrs/ week)

PRACTICAL-1

INORGANIC CHEMISTRY PRACTICAL – II

Quantitative analysis: Volumetric

1. Determination of Ferric iron by photochemical reduction
2. Determination of Nickel by EDTA
3. Determination of Calcium and Magnesium in a mixture by EDTA
4. Determination of Ferrocyanide by Ceric sulphate
5. Determination of Copper(II) in presence of iron(III) Gravimetric:
6. Determination of Zinc as Zinc pyrophosphate
7. Determination of Nickel from a mixture of Copper and Nickel.

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REFERENCE BOOKS /TEXT BOOKS:

1. G.H. Jeffery et al, *Vogel's textbook of quantitative chemical analysis*, 5th edition.

PRACTICAL-2

ORGANIC CHEMISTRY PRACTICAL – II

Systematic qualitative analysis of an organic mixture containing two compounds Identification of method of separation and the functional group(s) present in each of them and preparation of one solid derivative for the conformation of each of the functional group(s).

PRACTICAL-3

PHYSICAL CHEMISTRY PRACTICAL – II

1. Distribution of iodine between $CHCl_3$ and water
2. Distribution of I_2 between $CHCl_3$ and aq.KI solution- calculation of equilibrium constant.
3. Determination of Coordination number of cuprammonium cation.
4. Titration of mixture Strong acid and weak acid versus Strong base by conductometry.
5. Titration of Strong acid Vs Strong Base – pH – metry.
6. Titration of mixture of ($NaHCO_3$ + Na_2CO_3) Vs HCl – pH- metry.
7. Titration of Strong acid Vs Strong Base using Quinhydrone electrode.
8. Titration of Fe^{+2} Vs $K_2Cr_2O_7$ – potentiometry
9. Verification of Beer-Lambert's law by Iron-thiocyanate system –colorimetry.
10. Determination of single electrode potential of Cu^{2+}/Cu and estimate the given unknown concentration.

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SEMESTER –III
COURSE – I
Separation Methods-I

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Course Outcome:

The course aims to introduce the students to:

1. Basic separation techniques such as Solvent Extraction, Ion Exchange and Chromatography
2. The basic components of the Instruments like GC, HPLC,etc.
3. The various applications of HPLC and GC.
4. ThePrinciple and Applications of Paper, TLC, HPTLC, Column Chromatography
5. The applications of Size Exclusion, affinity Chromatography Techniques and Counter Current Separation Techniques in Pharma and Bio Industries
6. The importance of Coupled Instruments like GC-MS and LC-MS
7. The concept of Liquid – Liquid Partition Chromatography, Crown Ethers in Extraction, super Fluid Chromatography etc.

After successful completion of the course, the students will be able to work effectively and skillfully in analysis labs such as water analysis, soil analysis, can get selected as chemist at analysis labs such as GSI, FSSAI etc. and in teaching positions and can get through state and national level competitive examinations.

Course Objectives:

1. The objective of the course is to provide the students with a broad understanding of the principles and applications of Analytical Chemistry.
2. They will be able to design and carry out scientific experiments as well as accurately record and analyze the results and experiments.
3. To enable them to work safely and competently in analytical laboratory setting.
4. Students will learn to communicate scientific information clearly and accurately both in oral and written forms.

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UNIT–I

Chromatography - 1

Chromatography: classification of different chromatographic methods, methods of development-Elution development, Gradient elution development, displacement development, and frontal analysis, Principles of chromatography, different migration, adsorption phenomena, partition, adsorption coefficient, retardation factor, retention time and volume, column capacity, temperature effects, partition isotherm. Dynamics of chromatography-efficiency of chromatographic column, zone spreading, High Equivalent Theoretical Plate (HETP), Van Deempter equation, resolution, choice of column, length and flow velocity, qualitative and quantitative analysis.

UNIT-II

Chromatography – 2

Column chromatography (adsorption chromatography):principles, general aspects, adsorption isotherms, chromatographic media, nature of forces between adsorbent and solutes, eluents (mobile phase), column chromatography without detectors and liquid chromatography with detectors and applications.

Gel Exclusion chromatography or Gel filtration chromatography:principles, properties of xerogels, apparatus and detectors, resolution of gel type, applications to organic compounds.

Capillary Electrophoresis: Principle, Details of the Instrument, Applications to Inorganic and Organic compounds.

UNIT–III

Chromatography – 3

Gas chromatography: Theory, Instrument description of equipment and different parts, columns (packed and capillary columns), detector specifications-thermal conductivity detector, flame ionization detector, electron capture detector, nitrogenphosphorus detector, photo ionization detector, programmed temperature gas chromatography; applications in the analysis of gases, petroleum products etc., other detectors used their Principles and Applications.

Inorganic molecular sieves:structure of zeolites, crystals, types of sieves, application in the separation of gases including hydrocarbons, ion exclusionprinciples and applications.

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Counter current chromatography-principles and application, Affinity chromatography-principles and applications

GC-MS – Introduction Instrumentation – GC – MS interface – Mass spectrometer (MS) Instrument operation, processing GC – MS data – ion chromatogram Library searching – Quantitative measurement – sample preparation Selected ion monitoring – Application of GC-MS for Trace constituents, Drugs analysis, Environmental analysis and others.

UNIT–IV

Chromatography – 4

Liquid-liquid partition chromatography:principle, supports, partitioning liquids, eluents, reverse phase chromatography, apparatus, applications

High performance liquid chromatography: Theory, Instrument description of the different parts of the equipment, columns, detectors-UV detector, refractometric detector, Fluorescence detector, Diode Array detector, applications in the separation of organic compounds, names of other detectors used their Principles and Applications.

LC-MS – Introduction – Instrumentation – liquid chromatography – Mass spectrometer Interface – Instrumental details – Processing LC-MS data – ion chromatograms – Library searching – Quantitative measurements. Sample preparation – selected ion monitoring. Application of LC-MS for Drug analysis, Environmental samples and others.

REFERENCES BOOKS/ TEXT BOOKS

1. R.P.W Scott, 1995,*Techniques and practice of Chromatography*,1st edition, Marel Dekker Inc., New York.
2. M.N. Sastri, 2006, *Separation methods*,1st edition, Himalaya Publishing Company, Mumbai.
3. E. Heftman, 2004,*Chromatography*,1st edition, Van Nostrand, Reinhold, New York.
4. E. Lederer and M. Lederer, 1954, *Chromatography*,1st edition,Elsevier, Amsterdam.
5. John A Dean, 1970, *Chemical separation methods*, Von Nostrand Reinhold, New York.
6. H.M Mc Nair and J. M. Miller, 2019,*Basic Gas Chromatography*,3rd edition,John Wiley, New York.
7. W. Jeumings, 1997, *Analytical Gas chromatography*, 2nd editionAcademic Press, New York
8. H. Eugelhardt, 1986, *Practice of HPLC* 1st edition,Springer Verrag, Berrin

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SEMESTER –III
COURSE – II
Quality Control and Traditional methods of Analysis-I

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Course Outcomes:

The course aims to provide to the students the knowledge of:

1. Identifying the quality of experimental measurements, defines the confidence limits and confidence levels. Compare the experimental mean with true value and identify the detection limits.
2. Theconcept of different dissolution techniques and their applications.
3. Understandingabout the applications and uses of Analytical Methods in Chemistry.
4. Theconcepts of different Organic Functional Group Analysis like Mercaptans, Amines, Carbonyl Compounds, and Diols etc.
5. Expressing and calculating the terms such as Mean, Standard Deviation, Variance, Relative standard deviation and Co efficient of Variance.
6. Theconcepts of Quality Control, Quality assurance and Total Quality Management.
7. Theconcepts of GLP, and elements and series of ISO 9000 and ISO14000.
8. Principlesand applications of different oxidant systems.

After successful completion of the course, the students will be able to work effectively and skillfully in Pharma labs as QC/QA, teaching positions and can get through state and national level competitive examinations.

Course Objectives:

Following are the objectives of the course:

1. To give firm foundation in the fundamentals and applications of Current Chemical and Scientific Theories in Analytical Chemistry.
2. Students will develop skills of problem solving, critical thinking and analytical reasoning as applied to scientific problems.
3. Explain to the students the broad role of Chemists in Quality Control and assessment of Experimental measurements and analytical tasks.

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4. To enable the students to apply the Scientific process including Statistical treatment of data in the conduct and reportives of chemical analysis.

UNIT – I:

Quality control in Analytical Chemistry

(a) Characteristics of an analysis:quality of an analytical procedure, limit of detection, sensitivity, safety, cost measurability, selectivity and specificity, quality controlprinciples of Ruggedness test, control charts, Youden plot, and ranking test.

(b) Evaluation and reliability of analytical data:limitation of analytical methods, accuracy, precision, errors in chemical analysis, classification of errors, minimization of errors, significant figures, computations and propagation of errors.

(c) Statistical analysis: Mean deviation, Standard deviation, coefficient of variance, normal distribution, F test, T test, rejection of results, presentation of data.

(d) Quality assurance and management systems:elements of quality assurance, quality assurance in design, development, production and services, quality and quantity management system, **ISO 9000** and **ISO 14000** series-meaning of quality, quality process model, customer requirement of quality calibration and testing, statistical process control, process control tools, control chart, statistical quality control, acceptance sampling. Good laboratory practices (GLP) – need for GLP, GLP implementation and organization, GLP status in India.

(e) Brief out line of ICH guide lines on drug substances and products.

UNIT – II:

Decomposition techniques in analysis

(a) Inorganic Compounds Principle of decomposition and Dissolution. Difference between dissolution / decomposition of Organic and Inorganic substances. Importance of Decomposition Techniques in Analysis. Principle of Dissolution of an inorganic substance. Decomposition of samples with acids – H_2O, HCl, HF, HNO_3, H_2SO_4 and $HClO_4$ Decomposition of samples by fusion, Principle and with two examples each Alkali Fusion--- Na_2CO_3, NaOH, Acidic Fusion--- Sodium Hydro Sulphate, Sodium Pyro Sulphate Oxidation Fusion---Na_2O_2, Sodium Chlorate Reductive Fusion Na_2CO_3 + Na_2BO_4 What is Sintering process, how is it different from Fusion. Fusion with alkali carbonates, alkali hydroxides, Sodium Peroxide Decomposition of samples by sintering with sodium peroxide, sodium carbonate. Principles of decomposition at high temperatures, high pressures. Principles of Microwave and ultrasonic decomposition techniques.

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(b) Organic Compounds Principles of solubility of organic compounds, non-polar, polar solvents. Recrystallisation methods and application of solubility and Recrystallisation.

UNIT – III:

Oxidant systems – Principles and applications in analysis

Analytical chemistry of some selected oxidant systems – formal, standard and normal potentials in various media, species responsible for the oxidation properties, stability of the solutions, standardization, requirement for the selections of the oxidants, selection of suitable indicators for Oxidant systems.

a) Inorganic Systems Mn (III), Mn (VII), Ce (IV), Cr (VI), V (V), periodate, iodate,

b) Organic Systems chloramine-T.

UNIT – IV:

Organic Functional group analysis

Classification of functional groups with suitable examples.

Determination of:

1) Functional groups imparting acidic nature – thiol, enediol, phenolic hydroxyl.

2) Functional groups imparting basic nature – Aliphatic and Aromatic primary, secondary and tertiary amines – hydrazine derivatives.

3) Functional groups which impart neither acidic nor basic nature – Aldehydes, Ketones, Nitro, Methoxy, Olifinic.

REFERENCES BOOKS/ TEXT BOOKS

1. Griffin, 1927, *Technical methods of analysis*, 2nd edition, Mc Graw Hill Book Co.
2. D.G Peters, John M.Haves, 1974, *Chemical Separation and measurements*, 2nd edition, Sanders Co.
3. H.A Laitinan, 1960, *Chemical analysis*, 2nd edition, Mc Graw Hill Book Co.
4. Berka, Zyka and Vulterin, 1965, *Newer redox titrants*, 1st edition, Pergamon Press.
5. I.M Kolthoff and R. Belcher, 1957, *Volumetric Analysis*, Vol III, 1st edition, Interscience Public, NewYork.
6. J. Bassett et al., 2000, *Vogel's Text Book of Inorganic Quantitative Analysis*, 6th edition, Pearson education, ELBS.
7. S. Siggia, 1954, *Organic functional groups*, 2nd edition, Wiley, New York.

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8. D.A Skoog, D.M West and F.J Holler, 2011, *Analytical Chemistry, An Introduction*,1st edition, Sanders College Publishing, New York.
9. K.V.S.G Murali Krishna, 2006, *An Introduction ISO 9000, ISO 1400 Series, Environmental Management*, Savera publishing house.
10. Prof. Y.Anjaneyulu, 2018 *Quality Assurance and Good Laboratory Practices*,1st edition,In Now Publication, New York.
11. G.Kateman and F.W Pijpers, 1993, *Quality Assurance in Analytical Chemistry*Volume 60, John Wiley and Sons, New York.
12. I.M Kolthoff, E.B Sandel, E.J Meehan, S. Bruckenstein, 1969, *Quantitative Chemical Analysis*1st edition, Macmillan Company, London.
13. J.Doleal, P.Povondra,1963.*Decomposition Techniques in Inorganic Analysis*,1st edition, American Elsevier.

SEMESTER –III
COURSE – III
Applied Analysis-I

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Course Outcomes:

After completion of this course the students will be able to:

2. Getsoverall knowledge about the analysis of Finished Products in various industries like Steel, Cosmetics and Paints.
3. Know about Water Quality Parameters such as D.O., BOD, and COD.
4. Knowthe basic concepts of Sampling, dissolution, separation and estimation of the constituents present in samples such as Ores, Fluxes, refractory Materials
5. Knowabout the analysis of different Industrial Products like Oils, soaps, and face powder.
6. Aboutclassification and effects of different water pollutants on human health.
7. know about different types of ores and their composition.
8. Learnthe analysis of different toxic metals present in waste water.
9. Learnabout various methods for the analysis of cations and anions.

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After successful completion of the course, the students will be able to work effectively and skillfully in water and soil analysis labs, teaching positions and can get through state and national level competitive examinations.

Course Objectives:

The objective of the course is to educate the students to:

1. Explorenew areas of research in both chemistry and allied fields of science and technology
2. Understand the important Titrimetric Methods like Acid-Base, Complexometric and Red-ox Titrations
3. Designand carryout scientific experiments as well as accurately record and analyze the results and experiments
4. Appreciatethe central role of Analytical chemistry and use this as a basis for ethical behavior in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing in our society

After completion of this course student can get an opportunity to work as Production Chemist in Oil, Soaps & Painting Industries.

UNIT – I:

Analysis of Ores

(a) General techniques of analysis applied to complex materials - Scope of metallurgical analysis - General methods of dissolution of complex materials - Various chemical methods for the effective separation of the constituents in the complex materials.

(b) Analysis of ores: Iron ore- Analysis of the Constituents – Moisture , loss of ignition, Total Iron, ferrous Iron ,Ferric Iron, alumina , silica, Titania, Lime, Magnesia, Sulphur, phosphrous, manganese, alkalies, combined water, Carbon in blast furnace, flue dust and sinter.

(c) Manganese Ore - Analysis of the Constituents – Total Manganese, MnO_2, SiO_2, BaO, Fe_2O_3, Al_2O_3, CaO, P and S.

(d) Chromite Ore - Analysis of the Constituents – Chromium, SiO_2, FeO, Al_2O_3,CaO&MgO.

(e)Phosphate rock Ore - Analysis of the Constituents - CaO,P_2O_5, F, SiO_2,CO_2,S, Na_2O, Al_2O_3, Fe_2O_3, MgO,K_2O,Cl,MnO, Organic carbon, Moisture, Loss of ignition.

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*(f)*Aluminium Ore (Bauxite) - Analysis of the Constituents – Silica, Alumina, Fe_2O_3,Titania, MnO, P_2O_5, CaO, MgO, vanadium, zirconium, and alkalis.

UNIT-II:

Analysis of Finished Products – I

(a) Analysis of steel for C, Si,S, P, Mn, Ni, Cr, Mg and analysis of blast furnace slag.

(b) Analysis of refractory materials: fire clay, flour spar, and magnesite.

(c) Analysis of fluxes - limestone and dolomite.

UNIT–III:

Analysis of Finished Products – II

(a) Chemical Analysis of cement-silica, NH_4OH group, ferric oxide, alumina, lime, magnesia, Sulphide Sulphur, K_2O,Na_2O, free CaO in Cement and Clinker.SO_3 and loss on ignition.

(b) Analysis of oils - saponification number, iodine number, and acid number.

(c) Analysis of soaps - moisture, volatile matter, total alkali, total fatty matter, free caustic alkali or free fatty acids, sodium silicate , chloride.

(d) Analysis of paints-vehicle and pigment, $BaSO_4$,total lead and lead chromate

UNIT-IV:

Assessment of water Quality

Sources of water, classification of water for different uses, types of water pollutants and their effects, Analytical methods for the determination of the following ions in water:

Anions: CO_3^{2-} , HCO_3^- , F^-, Cl^-, SO_4^{2-} , PO_4^{3-} , NO_3^- , NO_2^- , CN^-, S^{2-}

Cations: Fe^{2+} , Fe^{3+}, Ca^{2+}, Mg^{2+}, Cr^{3+}, As^{5+}, Pb^{2+}, Hg^{2+}, Cu^{2+}, Zn^{2+}, Cd^{2+}, Co^{2+}

Determination of Dissolved oxygen (D.O), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), standards for drinking water.

REFERENCES BOOKS/ TEXT BOOKS

1. Harrison John,1979.*Handbook of Analytical Control of Iron and Steel Production.*Weily publications.
2. Welcher, 1963, *Standard methods of Chemical Analysis,*Volume 1, Forgotten books.
3. Griffin, 1927,*Technical Methods of Analysis,*2nd edition, Mc Graw Hill.

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4. Foster Dee Sneel and Frank M. Griffin, 1944, *Commercial Methods of Analysis*,1st edition, Mc Graw Hill Book Co.
5. Lund H.F., 1966, *IndustrialWater Pollution*, Mc Graw Hill.
6. Anil Kumar De, 2017,*Environmental Chemistry*,9th edition, New Age International publishers.
7. S.M.Khopkar, 2011, *Environmental Pollution Analysis*,2nd edition, Newage publications.
8. M.Ash and I.Ash, 1977, *A formulary of Cosmetic Preparation*, 1st edition,Chemical publishing Co., US.

SEMESTER –III
COURSE – IV
Instrumental Methods of Analysis-I

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Course Outcome:

After completing the course, the student will be able to:

1. Understand the basic components of Instruments like XRD, IR, NMR, ESR etc.
2. Students should know about various applications of NMR, IR, Colorimetric, and Fluorimetry etc.
3. Knowthe importance of electro analytical methods such as Voltammetry, Coulometry and Polarography
4. Knowthe importance of Thermal Methods of analysis in various industries and advanced analytical Instruments like AAS,ICP-OES, ICP-MS
5. Apply the principle of UV-Visible Spectroscopy in identifying and estimating the colored compound, Mixed Colored Compounds and Transition Metals
6. To understand the structure and Analysis of different Vitamins by Spectroflourimetry.
7. Know about structural elucidation of different Organic Compound using IR and Raman Spectrometers.
8. Knowabout the differences of various technique such as NMR, ESR, IR, Raman etc.
9. Understand the applications of Radiometric methods of analysis in investigating of lunar surface

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After completion of this course student can get an opportunity to work as Chemical Scientist in Pharma& allied Industries.

Course Objectives:

The course is offered with the following objectives:

1. Students will have thorough theoretical and practical Understanding of advanced Analytical Instruments
2. They will be able to employ a variety of Analytical and Instrumental Methods to Prepare, Separate and Quantify Samples from various Matrices
3. Students can apply the Scientific process including Statistical treatment of data in the conduct and reportives of chemical analysis
4. Students will know how to develop and apply methods to Instruments and strategies to obtain information and nature of matter in space.

UNIT – I:

Spectroscopic Methods - 1

(a) UV-Visible Spectroscopy: laws of absorption, deviation from Beer's law, single and double beam spectrophotometers-instrumentation, sources of radiation, detectors, qualitative analysis by absorption measurements, general precautions in colorimetric determinations, determination of certain metal ions by using ligands – Fe^{2+}, Fe^{3+}, Al^{3+}, NH_4^+, Cr^{3+}, Cr^{6+}, Co^{3+}, Cu^{2+}, Ni^{2+} and anions–NO_2^-, PO_4^{3-} using suitable reagents, simultaneous determinations of dichromate and permanganate in a mixture, spectrophotometric titrations, principle of diode array spectrophotometers.

(b) Spectrofluorimetry: Theory of fluorescence, phosphorescence, factors affecting the above, quenching, relation between intensity of fluorescence and concentration, instrumentation, application with reference to Al^{3+}, chromium salts, fluorescence, thiamin (B1) and riboflavin (B2) in drug samples.

UNIT – II:

Spectroscopic Methods - 2

(a) Infrared spectroscopy: units of frequency, wavelength and wave number molecular vibrations, factors influencing vibrational frequencies, instrumentation, sampling techniques, detectors, characteristic frequencies of organic molecules, qualitative and quantitative

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analysis with reference to (petroleum refinery and polymer industry), selected molecules like CO, CO_2, non-destructive IR method for the analysis of CO and other organic compounds, principles of Fourier transform IR.

(b) Raman Spectroscopy: Raman effect and spectra, differences between Raman spectra and IR spectra, instrumentation, Raman spectra of CO, CO_2, N_2O, H_2O.

UNIT – III:

Spectroscopic Methods -3

(a) NMR Spectroscopy: resonance condition, origin of NMR spectra, instrumentation, chemical shift, factors affecting chemical shift, shielding, spin-spin splitting, mechanism for spin-spin coupling, interpretation of NMR spectra of typical organic compounds, factors influencing NMR spectra, fast chemical reactions, magnitude of I, nuclei with quadrupole moments, FT NMR, study of isotopes other than proton- ^{13}C, ^{15}N, ^{19}F, ^{31}P, ^{11}B, double resonance, spin tickling, shift reagents, applications.

(b) ESR Spectroscopy: principle, g-value, hyper fine splitting, qualitative analysis, Krammer's degeneracy, fine splitting, instrumentation, introduction to double resonance technique, difference between ESR and NMR spectra, quantitative analysis, application to study of free radicals and other analytical applications.

UNIT – IV:

Spectroscopic Methods -4

(a) Mass Spectroscopy: Principle, basic instrumentation, energetics of ion formation, types of peaks observed, resolution, qualitative analysis, molecular weight determination, quantitative analysis, advantages.

(b) X-ray Spectroscopy (XRF): chemical analysis by X-ray spectrometers, energy dispersive and wavelength dispersive techniques, evaluation methods, instrumentation, matrix effects, applications.

REFERENCES BOOKS/ TEXT BOOKS

1. H.H Willard, Meritt Jr. and J.A Dean, 2004, *Instrumental methods of analysis*, 7th edition, CBS Publications.
2. Skoog and West, 1971, *Principles of instrumental analysis*, 1st edition, Holt, Rinehart and Winston.

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3. J. Basset, R.C. Denney, G.H Jefferey and J.Madhan, *Vogels Textbook of Quantitative Inorganic analysis*, 5th edition, Longman publishers.
4. B.K Sarma, 2005, *Instrumental methods of analysis*, 24th revised edition, Goel Publishing House, Meerut.
5. Chatwal and Anand, 2019,*Instrumental methods of Analysis*, 5th edition, Himalaya publications.
6. Ewing, Gallen.W., 1985, *Instrumental methods of Analysis*, 5nd edition, Mc Graw Hill Inc., US.
7. MichaelThompson, 1989, *Handbook of ICP*,2nd edition, Springer Publications.
8. A.R Date and A.L Gray, 1989, *Applications of ICP-MS*, Blackie, London.
9. A. Montaser and D.W Golightly, 1992, *ICP in Analytical Atomic Spectrometry*, (Eds), 2nd edition, VCH Publishers, New York.
10. G.L. Moore, 1989, *Introduction to ICP emission Spectrometry in Analytical Spectroscopy*, 1st edition,Elsevier, Amsterdam.

LABORATORY COURSE-1(9 hrs/week)

Classical Methods of Analysis-1

1. Water analysis

i. Determination of total hardness (Ca^{2+} and Mg^{2+}) of water samples
ii. Determination of chloride (Cl^-) present in water samples
iii. Determination of dissolved oxygen (DO) of drinking water and sewage water

2. Complexometric titrations

i. Determination of the concentration of calcium in milk powder by complexometric titration (EDTA)
ii. Determination of Calcium and Magnesium in limestone or dolomite samples using EDTA.

3. Fertilizer analysis

i. Determination of ammonia from ammonia containing fertilizer
ii. Determination of phosphate from fertilizer

4. Analysis of iron ore

i. Complete analysis of iron ore
ii. Determination of percentages of Fe (II) and Fe (III) present in iron ore sample

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5. **Analysis of Coal**

i. Determination of moisture content of coal sample
ii. Determination of volatile matter of coal sample
iii. Determination of fixed carbon of coal sample
iv. Determination of ash content of coal sample

LABORATORY COURSE-2 (9 hrs/week)

Instrumental Methods of Analysis-1

1. pH metry

i. Determination of alkalinity of a colored effluent using pH metric titration.
ii. Determination of purity of commercial HCl using pH metric titration.
iii. Determination of purity of commercial H_2SO_4 using pH metric titration.

2. Potentiometry

i. Determination of Cr(VI) with Fe(II) using potentiometric end point
ii. Determination of Fe (II) using ceric sulphate by potentiometric end point
iii. Determination of a mixture of Ce(IV) and V(V) with Fe(II) by potentiometric end point
iv. Determination of KSCN with $AgNO_3$ by potentiometric end point.

3. Spectrophotometry

i. Determination of Fe (III) using potassium thiocyanate
ii. Determination of Iron(II) using ortho- phenanthroline
iii. Determination of phosphate in fertilizer and cola drinks by Molybdenum bluemethod
iv. Determination of Manganese (II) -periodate method

4. Flame photometry

i. Determination of sodium present in bread samples
ii. Determination of sodium and potassium in a given sample of fertilizer

5. Thin layer chromatography: Determination of Rf values and identification of organic compounds in a given mixture by TLC

i. Separation of mixture of benzil and 2-nitrophenol
ii. Mixture of benzophenone and naphthalene
iii. Mixture of 2-nitrophenol and 4-nitrophenol

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REFERENCES BOOKS/ TEXT BOOKS

1. A. I. Vogel, 1961, *A Text Book of Quantitative Inorganic Analysis, including Instrumental methods of Analysis* 3rd edition, Wiley publications.

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SEMESTER –IV
COURSE – I
Separation Methods-II

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Course Outcome:

The course aims to impart to the students the knowledge and understanding of:

1. Basic separation techniques such as Solvent Extraction, Ion Exchange and Chromatography.
2. Thebasic components of the Instruments like GC, HPLC,etc.
3. Thevarious applications of HPLC and GC.
4. The Principle and Applications of Paper, TLC, HPTLC, Column Chromatography.
5. The applications of Size Exclusion, affinity Chromatography Techniques and Counter Current Separation Techniques in Pharma and Bio Industries.
6. The importance of Coupled Instruments like GC-MS and LC-MS.
7. The concept of Liquid – Liquid Partition Chromatography, Crown Ethers in Extraction, super Fluid Chromatography etc.
8. The Dynamics of Chromatography

After completion of this course student can get an opportunity to work as Chemist in Pharma and other analysis Industries.

Course Objectives:

The objective of the course is providing to students, a broad understanding of the principles and applications of Analytical Chemistryto design and carry out scientific experiments as well as record accurately and analyze the results and experiments. Work safely and competently in analytical laboratory setting, and to communicate scientific information clearly and accurately both in oral and written forms.

UNIT – I:

Chromatography - 5

(a) Paper chromatography:principle, papers as a chromatographic medium, modified papers, solvent systems, mechanism of paper chromatography, experimental technique, different development methods-ascending, descending, horizontal, circular spreading,

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multiple development, two-dimensional development, reverse phase paper chromatographic technique-visualization and evaluation of chromatograms, applications.

(b) Thin layer chromatography:principle, chromatographic media-coating materials, applications, activation of adsorbent, sample development, solvent systems, development of chromatoplate, types of development, visualization methods, documentation, applications in the separation, HPTLC-principle, technique, applications.

UNIT – II:

Chromatography - 6

(a) Ion Exchange:principles of ion-exchange systems, synthetic ion-exchange resins, properties of anion and cation exchange resins, ion-exchange mechanism, ion-exchange equilibria, selectivity, ion-exchange capacity, applications of ion-exchangers in different fields.

(b) Ion exchange chromatography: Principle, Equipment, Application Specifically Separations of Lanthanides, Actinides, amino acids.

(c) Ion chromatography:principles of separation, instrumentation, detectors, separation of cations and anions, applications in the analysis of water and air pollutants.

UNIT – III:

Sampling of Solids, Liquids and Gases

Sampling: Basis of sampling, purpose of sampling, homogeneous and heterogeneous samples, statistical criteria for good sampling, sample size, sampling unit, gross sample, laboratory sample. Sampling of Solids: Cone and Quartering method, Long pile and alternative shovel method, precautions in preservation of solid samples, sampling of metals and other solids rods, wires, sheets, plates, especially Gold, Silver, Iron and other metals. Sampling of different types of liquids: different sampling techniques, sampling of drinking water, industrial effluents, precautions in sampling and preservation of collected liquid samples.Sampling of gases: sampling and Preconcentration by adsorption or absorption method, instantaneous monitoring, sampling in samplers and subsequent monitoring, different types of gas samplers, precautions in preservation of samples, systematic sampling and random sampling.

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UNIT – IV:

Importance of Analytical chemistry & Solvent Extraction

(a) Importance of Analytical Chemistry to Industrial Research: Importance of Qualitative and Quantitative analysis in research and development, industries and other branches of science. Development and validation of an analytical method, units, concentrations, calculations, standards, chemical reactions, expressions of concentrations, importance of separation methods with examples.

(b) Solvent Extraction: principles and processes of solvent extraction, Distribution Law and Partition coefficient, nature of partition forces, different types of solvent extraction systems – Batch extraction, Continuous extraction, Counter current extraction, solvent extraction systems, applications in metallurgy, general applications in analysis and pre-concentration, special extraction systems like crown ethers, super fluid and surfactant extractions-examples.

REFERENCES BOOKS/ TEXT BOOKS

1. R.P.W Scott, 1995,*Techniques and practice of Chromatography*, 1st edition, Marel Dekker Inc., New York.
2. M.N. Sastri, 2006, *Separation methods*,1st edition, Himalaya Publishing Company, Mumbai.
3. E. Heftman, 2004,*Chromatography*,1st edition, Van Nostrand, Reinhold, New York.
4. E. Lederer and M. Lederer, 1954, *Chromatography*,1st edition, Elsevier, Amsterdam.
5. John A Dean, 1970, *Chemical separation methods*, Von Nostrand Reinhold, New York.
6. E.Stahl, 1969,*Thin layer chromatography*, 2nd edition, Springer.
7. James G.Tarter,1987, *Ion chromatography*,1stedition,Marcel Dekker Inc. Publications.

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SEMESTER –IV
COURSE – II
Traditional methods of Analysis-II

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Course Outcome:

After completing the course, the students will be able to:

1. Interpretdifferent Gravimetric Analysis Methods, Solves Problems related to Gravimetric Methods and its applications
2. Identifythe quality of experimental measurements, defines the confidence limits and confidence levels, Compare the experimental mean with true value and identify the detection limits
3. Estimate the types and sources of errors in Chemical analysis.
4. To develop an understanding about the range and uses of Analytical Methods in Chemistry
5. Knowabout Crystal Behavior, Formation, Impurities formed during the precipitation process
6. Knowthe concepts of different Organic Functional Group Analysis like Mercaptans, Amines, Carbonyl Compounds, Diols etc.
7. Express and calculate the terms such as Mean, Standard Deviation, Variance, Relative standard deviation and Co efficient of Variance.
8. Know the concepts of Quality Control, Quality assurance and Total Quality
9. Management, GLP, and importance of ISO 9000, ISO14000

After completion of this course student can get an opportunity to work as Chemist in Pharma& Allied Industries.

Course Objectives:

The course is to impart the students with the objectives of:

1. Providing firm foundation in the fundamentals and applications of Current Chemical and Scientific Theories in Analytical Chemistry
2. enhance skills in problem solving, critical thinking and analytical reasoning as applied to scientific problems

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3. Explaining the broad role of Chemists in Quality Control and assessment of Experimental measurements and analytical tasks
4. Applying the Scientific process including Statistical treatment of data in the conduct and reportives of chemical analysis

UNIT – I:

Precipitation methods - 1

(a) Crystal habit and super saturation, nucleation and crystal growth, homogeneous and heterogeneous nucleation, solubility and particle size, colloids, completeness of precipitation, effect of excess precipitant, pH, complex formation, temperature, purity of precipitates, aging.

(b) Co-precipitation and post precipitation:theory of adsorption of salts having an ion in common with the main precipitate, co-precipitation in colloidal precipitates, adsorption of solvents, mixed crystal formation by occlusion and entrapment, reprecipitation with examples, post-precipitation – theory of post-precipitation, examples of post-precipitation, conditions for obtaining pure and quantitative precipitates.

(c) **Precipitation Titrations**: Principle, Indicators for precipitation titrations, determination of halides.

UNIT – II:

Precipitation methods – 2:

(a) Precipitation from Homogeneous Solution (PFHS):theory of PFHS, methods of PFHS – increase in pH, decrease in pH, cation release, anion release, reagent synthesis, change in oxidation state, photochemical reactions, precipitation from mixed solvents. Applications of PFHS methods.

(b) Gravimetric determinations:nature of species, preparation of solutions, limitations, interferences, inorganic precipitants-chloride and sulphate, organic precipitants dimethyl glyoxime (DMG), oxine, benzidine, salicylaldoxime, benzoin oxime, sodium tetraphenyl boron, tetraphenyl arsonium chloride.

(a) Electro-gravimetric analysis:principle, important terms in electrogravimetry, decomposition voltage or decomposition potential, over voltage and their importance, instrumentation, electrolysis at constant current, determination of Cu^{2+} by constant current

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electrolysis, electrolysis at controlled potentials, determination of Cu, Pb, Sn in brass and bronze by controlled potential electrolysis.

UNIT – III:

Reductant system – Principles and applications in analysis

Analytical chemistry of some selected reductant systems – formal, standard and normal potentials in various media, stability of the solutions, species responsible for the reduction properties, standardization, requirement for the selection of the reductants, selection of suitable indicators for various reductant systems,

(a) Inorganic Systems – Cr (II), V (II), Ti (III), Sn (II), Fe (II) in H_3PO_3 and hydrazine,

(b) Organic Systems – Hydroquinone and Ascorbic acid.

UNIT – IV:

Analysis of some selected Drugs:

Basic considerations of drugs – Classification

Determination of the following Drugs:

1. Acetyl salicylic acid (Antipyretic – Analgesic)
2. Testosterone, progesterone and cortisone (Steroids and corticoids)
3. Sulphadiazine (sulphadrugs)
4. Phenobarbitone (Barbituric acid derivatives)
5. Chloramphenicol, Benzyl penicillin and Tetracycline (Antibiotics)
6. Thiamine (B1), Riboflavin (B2) and ascorbic acid (c) [Vitamins]
7. Isoniazid (Antimicrobacterial agents)
8. Methlydopa (Antihypertensive agents)
9. Metronidazole (Antiamoebic agents).

REFERENCES BOOKS/ TEXT BOOKS

1. Griffin, 1927,*Technical Methods of Analysis*, 2nd edition, Mc Graw Hill.
2. D.G Peters, John Marion Hayes, 1974, *Chemical Separation and measurements*, 1st edition, Sanders Co.
3. H.A Laitinan, 1960, *Chemical analysis*, 2nd edition, Mc Graw Hill Book Co.
4. Berka, Zyka and Vulterin, 1965, *Newer redox titrants*, 1st edition, Pergamon Press.

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5. I.M Kolthoff and R. Belcher, 1957, *Volumetric Analysis*, Vol III, 1st edition, Interscience Public, New York.
6. J. Bassett et al., 2000, *Vogel's Text Book of Inorganic Quantitative Analysis*, 6th edition, Pearson education, ELBS.
7. T. Higuchi,J.I.Bodin, 1961, *Pharmaceutical analysis*,1st edition, Willey Black well publishers.
8. D.A Skoog, D.M West and F.J Holler, 2011, *Analytical Chemistry: An Introduction*, 1st edition, Sanders College Publishing, New York.
9. I.M Kolthoff, E.B Sandel, E.J Meehan, S. Bruckenstein, 1969, *Quantitative Chemical Analysis* 1st edition, Macmillan Company, London.

SEMESTER –IV
COURSE – III
Applied Analysis-II

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Course Outcome:

After completing this course, the students will acquire knowledge of

1. Theanalysis of Finished Products in various industries like Steel, Fertilizers, Cement and Paints
2. Water Quality Parameters such as D.O.,BOD, COD and Air Quality Parameters such as CO_X, NO_X, SO_X and Ozone
3. Thebasic concepts of Sampling, dissolution, separation and estimation of the constituents present in samples such as Ores, Fluxes, refractory Materials
4. Kinetic methods of analysis and its applications
5. Calculation of moisture content of different Drugs by using KF Reagent
6. Theanalysis of different Industrial Products like Oils, soaps, and Coal.
7. Water Pollution and Air Pollution
8. Thedifferences between aqueous and Non-aqueous Titrations

After completion of this course student can get an opportunity to work as Chemist in Coal, Cement & Soil Industries.

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Course Objectives:

The course is imparted with the objectives of enabling the students:

1. Toexplore new areas of research in both chemistry and allied fields of science and technology
2. To cover important Titrimetric Methods like Acid-Base, Complexometric and Red-ox Titrations
3. Todesign and carryout scientific experiments as well as accurately record and analyze the results and experiments
4. To appreciate the central role of Analytical chemistry and use this as a basis for ethical behavior in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing in our society

UNIT – I:

Analysis of raw materials

(a) Analysis of non-ferrous alloys:

(i) Brass – Analysis of the constituents – Cu, Zn, Sn, Pb and Fe.

(ii) Bronze - Analysis of the constituents – Cu, Sn, Zn, Pb and Fe.

(iii) Solder - Analysis of the constituents – Sn, Pb and Sb.

(b) Analysis of Ferro alloys:

(i) Ferro silicon - Analysis of the constituents – Si, C, P,S

(ii) Ferro vanadium - Analysis of the constituents – V, C, P, S, Si, Al.

(iii) Ferro manganese - Analysis of the constituents – Mn, S, C, P, Si

(iv) Silico manganese -Analysis of the constituents – Mn, S, C, P, Si

(v) Ferro chromium - Analysis of the constituents – Cr, C, Si.

UNIT – II:

Analysis of Soil, Fertilizer and Fuel

(a) Analysis of soils: sampling, determination of moisture, total N, P, Si, lime, humus nitrogen, alkali salts, soil absorption ratio.

(b) Analysis of fertilizers: ammonical fertilizers, Phosphate fertilizers, Nitrate fertilizers.

(c) Analysis of fuels: solid fuels-coal, proximate analysis, ultimate analysis, heating value, grading of coal based on Ultimate Heat Value(UHV).

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UNIT – III:

Assessment of Air Quality

Composition of pure air, classification of air pollutants, toxic elements present in dust and their sources – collection of air samples. Sources, effects, control of pollution and chemical analysis for the following.

(a)Primary pollutants:

(i) Carbon compounds - Carbon monoxide (CO) and Carbon dioxide (CO_2).

(ii) Sulphur compounds- sulphur dioxide (SO_2), Sulphur trioxide (SO_3) and Hydrogen Sulphide (H_2S).

(iii) Nitrogen compounds - nitric oxide (NO),and nitrogen dioxide (NO_2).

(iv) Hydrocarbons - Aliphatic hydrocarbons and polycyclic aromatic hydrocarbons (PAH).

(v) Particulate matter - Repairable and Suspended particulate matter, Inorganic and Organic particulates.

(b)Secondary pollutants - ozone (O_3), peroxy acetyl nitrate (PAN), peroxy benzyl nitrate (PBN)

(c) Standards for ambient air quality.

UNIT- IV:

Kinetic Methods of Analysis & Non aqueous Titrimetry

(a) Kinetic methods of analysis: introduction, slow reactions, catalyzed reactions, methods of determination of catalyst concentration, extrapolation method for the determination of catalyst, variable time method, fixed time method, examples for the determination of toxic metals and anions using some typical kinetic reactions.

(b) Non aqueous titrimetry: Classification of solvents and titrations for non-aqueoustitrmetry-Types of reactions - Indicators.

(i) Determination of acids

(ii) Determination of bases

(iii) Karl-Fisher reagent for the determination of moisture content in drugs and other samples.

REFERENCES BOOKS/ TEXT BOOKS

1. H.A Laitinan, 1960, *Chemical analysis* –Mc Graw Hill Book Co.
2. Welcher, 1963, *Standard methods of Chemical Analysis*, Volume 1, Forgotten books.
3. Griffin, 1927, *Technical Methods of Analysis*, 2nd edition, Mc Graw Hill

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4. Foster Dee Snell and Frank M. Griffin, 1944, *Commercial Methods of Analysis*, 1st edition, Mc Graw Hill Book Co.
5. Anil Kumar De, 2017, *Environmental Chemistry*, 9th edition, New Age International publishers.
6. S.M.Khopkar, 2011, *Environmental Pollution Analysis*, 2nd edition, Newage publications.
7. Trivedi and Kudesia, 1992, *Environmental Air Analysis*, 1st edition, AkashdeepPub.

SEMESTER –IV
COURSE – IV
Instrumental Methods of Analysis-II

Teaching hours per week	Credits	Internal marks	External marks	Maximum marks
4+1(T)	4	25	75	100

Course Outcomes:

The course aims to provide to the students the knowledge and understanding of

1. Thebasic components of Instruments like XRD, IR, NMR, ESR etc.
2. Variousapplications of NMR, IR, Colorimetric, and Flourimetry etc.
3. Theimportance of electro analytical methods such as Voltammetry, Coulometry and Polarography
4. Theimportance of Thermal Methods of analysis in various industries and advanced analytical Instruments like AAS,ICP-OES, ICP-MS
5. Application of the principle of UV-Visible Spectroscopy in identifying and estimating the colored compound, Mixed Colored Compounds and Transition Metals
6. Thestructure and Analysis of different Vitamins by Spectro Flourimetry
7. Structurallelucidation of different Organic Compound using IR and Raman Spectrometers
8. Thedifferences of various technique such as NMR, ESR, IR, Raman etc.
9. Theapplications of Radiometric methods of analysis in investigating of lunar surface

After completion of this course student can get an opportunity to work as Chemical Scientist in Pharma & allied Industries.

Course Objectives:

The course is imparted with objectives of: enabling the students to:

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1. Have thorough theoretical and practical Understanding of advanced Analytical Instruments
2. Employ a variety of Analytical and Instrumental Methods to Prepare, Separate and Quantify Samples from various Matrices
3. Apply the Scientific process including Statistical treatment of data in the conduct and reportives of chemical analysis
4. To develop and apply methods to Instruments and strategies to obtain information and nature of matter in space.

UNIT – I:

Spectro-analytical Methods of Analysis

(a)Flame photometry:theory, instrumentation, combustion flames, detectors, and analysis of Na, K, Ca, Mg

(b)Atomic Absorption Spectrometer:theory, instrumentation, flame and non-flame techniques, resonance line sources, hollow cathode lamp, instrumentation, chemical and spectral interferences, applications with special reference to analysis of trace metals in oils, alloys and toxic metals in drinking water and effluents

(c)Inductively coupled plasma spectrometer (ICP-AES, ICP-MS):principles, instrumentation, plasma, AES detectors, quadrupole mass spectrometers, difference between the two detectors, analysis methods for liquids and solids, applications in the analysis of trace and toxic metals in water, geological and industrial samples.

(d) Arc and Spark spectrographic Direct analysis of solid for metals.

UNIT – II:

Thermal methods of Analysis

(a) Thermo gravimetry-theory, instrumentation, applications with special reference to $CuSO_4.5H_2O$, $CaC_2O_4.2H_2O$, $CaCO_3$, $(COOH)_2.2H_2O$

(b) Differential thermal analysis-principle, instrumentation, difference between TG and DTA - applications with special reference to the clays and minerals, coals (fuels)

(c) Differential scanning calorimetry-principle, instrumentation, applications to inorganic materials like chlorates and per chlorates, ammonium nitrate, organic compounds and Drugs.

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UNIT- III:

Electro analytical Methods of Analysis - 1

(a) Voltametry and polarographic analysis:principle of polarography, residual current, migration current, diffusion current, half-wave potential, Ilkovic equation, instrumentation, Dropping mercury electrode (DME), advantages and disadvantages of DME, qualitative and quantitative analysis of inorganic ions-Cu, Bi, Pb, Cd, Zn, AC polarography, pulse polarography

(b) Anode stripping voltametry:principle, instrumentation, Hanging mercury drop electrode, application in the analysis of Pb and Cd in environmental samples, principle of cathode stripping voltametry.

(c) Coulometric analysis:principles of coulometric analysis with constant current, coulometric analysis with controlled potential, applications of coulometric methods for the analysis of cations-As (III), Fe (II) and I-and S^{-2} by using I_2 liberations and Ce^{4+} liberation in solutions

UNIT – IV

Electro Analytical and Radio chemical methods of analysis - 2

(a) Ion Selective Electrodes:reference electrodes - hydrogen electrode, calomel electrode, silver chloride electrode; indicator electrodes – hydrogen and glass electrodes, theory of membrane potentials and liquid junction potentials, types of ion selective electrodes, basic properties, potentials and construction, calibration of ion selective electrodes, ion selective electrodes with fixed membrane sites, silver, lead, cadmium, sulfide, fluoride, cyanide and glass electrodes, applications in the analysis of air and water pollutants, principles of liquid membrane, gas sensing and enzyme based electrode

(b) Radio chemical methods of analysis:detection and measurement of radioactivity, introduction to radioactive tracers, applications of tracer technique, isotope dilution analysis - applications, activation analysis – application, advantages and disadvantages, radio carbon dating technique.

REFERENCES BOOKS/ TEXT BOOKS

1. H.H Willard, Meritt Jr. and J.A Dean. 2004, *Instrumental methods of analysis*, 7th edition, CBS Publications.

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2. Skoog and West, 1971, *Principles of instrumental analysis*, 1st edition, Holt, Rinehart and Winston.
3. J. Basset, R.C Denney, G.H Jefferey and J.Madhan, *Vogels Textbook of Quantitative Inorganic analysis*, 5th edition, Longman publishers.
4. B.K Sarma, 2005, *Instrumental methods of analysis*, 24th revised edition, Goel Publishing House, Meerut.
5. Chatwal and Anand, 2019, *Instrumental methods of Analysis*, 5th edition, Himalaya publications.
6. Ewing, Gallen W., 1985, *Instrumental methods of Analysis*, 5nd edition, Mc Graw Hill Inc., US.

LABORATORY COURSE-1(9 hrs/week)

Classical Methods of Analysis-2

1. Water analysis

(i) Determination of alkalinity (CO_3^{2-}, HCO_3^-) of water samples.

(ii) Determination of chemical oxygen demand (COD) of drinking water and sewage water

(iii) Determination of biological oxygen demand (BOD)of drinking water and sewage water

2. Redox titrations

(i) Determination of oxalate in kidney stones by permanganometric titration.

(ii) Determination of Fe(II) present in an Iron tablet using $KMnO_4$

3. Fertilizer analysis

(i) Determination of nitrate from fertilizer

(ii) Determination of sulfur (as sulfate) from sulfur containing fertilizer.

4. Analysis of oils and soaps

(i) Determination of saponification value, acid value and iodine value of oil sample

(ii) Determination of moisture content and total alkali of soaps

5. Separation and determination of ions by ion-exchanger resins

(i) Determination of $Na^+$by cation exchanger resin

(ii) Determination of $Na^+$and K^+in a mixture by cation exchanger resin

(iii)Determination of Cl and Br in a mixture by anion exchanger resin

LABORATORY COURSE-2(9 hrs/week)

Instrumental Methods of Analysis-2

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1.pH metry

(i) Determination of purity of commercial $H_3PO_4$by pH metric titration

(ii) Determination of CH_3COOH by pH metric titration.

(iii)Determination of stability constant of copper glycinate

2. Potentiometry

(i) Determination of Fe(II) using Mn(VII) of by potentiometric titration

(ii) Determination of Fe (II) using V(V) of by potentiometric titration

(iii)Determination of a mixture of Mn(VII) and V(V) with Fe(II) using potentiometric end point

(iv)Determination of a mixture of bromide and chloride with $AgNO_3$using potentiometric end point

3.Spectrophotometry

(i) Determination of nitrite in drinking water samples by diazotization method

(ii) Determination of nitrate -phenoldisulphonic acid method

(iii)Simultaneous Determination of Cr(VI) and Mn(VII) in a mixture without separation

(iv)Determination of Cu(II) using EDTA – Photometric titration method.

4.Flame photometry

(i) Determination of Lithium by flame photometry

(ii) Determination of calcium fr

om milk samples using flame photometry

5.Thin layer chromatography

(i) Separation and identification of the given mixture of colorless compounds

(Diphenylamine, Benzophenone and Naphthalene)

(ii) Separation and identification of the given mixture of colored compounds

REFERENCE BOOKS/TEXT BOOKS:

1. A. I. Vogel, 1961, *A Text Book of Quantitative Inorganic Analysis, including Instrumental methods of Analysis*, 3rd edition, Wiley publications.

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