Rayat Shikshan Sanstha's

Karmaveer Bhaurao Patil College Vashi, Navi Mumbai

Autonomous College

[University of Mumbai]

M.Sc.-I in Chemistry

Sr. No.	Heading	Particulars
1	Title of Course	M.Sc.-I Chemistry
2	Eligibility for Admission	The B.Sc. degree examination of this university with chemistry 6 units or 3 units or degree of any other university recognized as equivalent
3	Passing Marks	Minimum 'D' Grade or equivalent minimum marks for passing at the Graduation level.
4	Ordinances/Regulations (if any)	
5	No. of Years/Semesters	One year/Two semester
6	Level	P.G. part-I
7	Pattern	Semester
8	Status	Revised
9	To be implemented from Academic year	2023-2024

AC – / / 2023
Item No:

Rayat Shikshan Sanstha's
KARMAVEER BHAURAO PATIL COLLEGE, VASHI.
NAVI MUMBAI
(AUTONOMOUS COLLEGE)

Sector-15- A, Vashi, Navi Mumbai - 400 703

Syllabus for M.Sc.-I in Chemistry
Program: M.Sc.
Course: M.Sc.-I Chemistry
(Choice Based Credit, Grading and Semester System
National Education Policy 2020
with effect from the academic year 2023-2024)

Preamble:

The purpose of post-graduate education in Science is to create highly skilled man power in specific areas, which will lead to generation of new knowledge and creation of wealth for the country. Chemistry is a fundamental science and has contributed immensely to the improvement of the life of human beings by providing many of human requirements and essentialities. It is seen that developments in chemistry are crossing the traditional boundaries of scientific disciplines; the more inclination is seen towards biological sciences. New branches of chemistry are emerging and gaining importance, such as bioorganic chemistry, materials chemistry, computational chemistry etc. The practice of Chemistry at industrial scale also is undergoing radical changes and is based on deep understanding the chemical phenomena. The aid of computers has not only accelerated growth in the practice of Chemistry, but revolutionized the entire field.

A Chemist cannot isolate himself from other disciplines. Thus, after a long span of more and more specialization in graduate and post-graduate syllabi, a symbiotic interdisciplinary approach now seems to be more relevant. The practice of Chemistry, as is witnessed, over a

span of more than a century has also created concomitant and perhaps unavoidable impacts of human environment. Though not a separate branch of Chemistry, Green Chemistry has emerged as a new approach to the practice of Chemistry on the background of sustainability. The Chemical industries now a days tries to develop eco-friendly processes and products which will reduce waste and prevent toxic substances fromentering the environment. The principles and applications of Chemistry should be learnton this background.

Thus this offers new chemical frontiers and tells us what benefits of taking up chemistry as a career. Chemists design reactions that will convert chemical substances around us into chemical substances that serve our needs today. Chemistry has become a crucial factor in the nation's economic well-being. The present Master's course is designed with an aim to prepare post graduates with the skills to solve problems requiring the application of chemical principles from each sub disciplines- organic, inorganic, physical, analytical chemistry. The Masters will have working knowledge of chemical instruments and laboratory techniques and be able to use those to design and carryout own research work or at industry level.

Syllabus for M.Sc-I Chemistry

Objectives of the Course:

1. To abreast the students about the current status and new developments in Chemistry.
2. To make the students aware of the impact of Chemistry on environment and imbibe the concept of sustainable developments
3. To educate the students with respect to skills and knowledge to practice chemistry in ways that are benign to health and environment.
4. To provide flexibility in selecting some of the courses as per the interest.
5. To make the students aware of resources and make them capable of mining the data.
6. To acquaint students with the specific areas of Organic, Inorganic& Analytical Chemistry
7. To develop analytical skills and critical thinking through application of theory knowledge into practical course
8. To enable students to understand chemistry and its industrial and social context

Program Specific Outcomes:

PO-1	**Disciplinary Knowledge and Skills:** Acquire the comprehensive and in-depth knowledge of various subjects in sciences such as Physics, Chemistry, Mathematics, Microbiology, Bio-analytical Science, Computer Science, Data Science, Information Technology and disciplinary skills and ability to apply these skills in the field of science, technology and its allied branches.
PO-2	**Communication and Presentation Skills:** Develop various communication skills including presentation to express ideas evidently to achieve common goals of the organization.
PO-3	**Creativity and Critical Judgement:** Facilitate solutions to current issues based on investigations, evaluation and justification using evidence based approach.
PO-4	**Analytical Reasoning and Problem-Solving:** Build critical and analytical attitude in handling the problems and situations.
PO-5	**Sense of Inquiry:** Curiously raise relevant questions based on highly developed ideas, scientific theories and its applications including research.
PO-6	**Use of Digital Technologies:** Use various digital technologies to explore information/data for business, scientific research and related purposes.
PO-7	**Research Skills:** Construct, collect, investigates, evaluate and interpret information/data relevant to science and technology to adapt, evolve and shape the future.

PO-8	**Application of Knowledge:** Develop scientific outlook to create consciousness against the social myths and blind faith.
PO-9	**Moral and Ethical Reasoning:** Imbibe ethical, moral and social values to develop virtues such as justice, generosity and charity as beneficial to individuals and society at large.
PO-10	**Leadership and Teamwork:** Work cooperatively and lead proactively to achieve the goals of the organization by implementing the plans and projects in various field-based situations related to science, technology and society at large.
PO-11	**Environment and Sustainability:** Create social awareness about environment and develop sustainability for betterment of future.
PO-12	**Lifelong Learning:** Realize that pursuit of knowledge is a lifelong activity and in combination with determined efforts, positive attitude and other qualities to lead a successful life.

Program Specific Outcomes (PSO)

PSO-1	**Scientific Problem solving skills:** Deep knowledge of the topic which can develop the problem solving skills using chemical principles.
PSO-2	**Analytical skills:** Develop analytical skills such as synthesizing, separating, characterizing chemical compounds and chemical reaction with the help of sophisticated instruments.
PSO-3	**Research skills:** Develop research skills through dissertation/Project work in different fields of chemistry such as organic, nanoscience, analytical, physical etc.

Scheme of examination for Each Semester:

Continuous Internal Evaluation: 40 Marks (Common Written Test-20 Marks & 20 Marks for- Seminar/Assignment, Projects, Group discussion, Open book test, online test etc.)

Semester End Examination: 60 Marks will be as follows:

I.	**Theory:** The Semester End Examination for theory coursework will be conducted as per the following scheme.		
	Each theory paper shall be of two and half hour duration.		
	All questions are compulsory and will have internal options.		
	Q – I	From Unit – I (having internal options.) 12 M	
	Q – II	From Unit – II (having internal options.) 12 M	
	Q – III	From Unit – III (having internal options.) 12 M	
	Q – IV	From Unit – IV (having internal options.) 12 M	
	Q –V	Questions from all the FOUR Units with equal weightage of marks allotted to each Unit. 12 M	
II.	**Practical**	The Semester End Examination for practical course work will be conducted as per the following scheme.	
Sr. No.	**Particulars of Semester End Practical Examination**		**Marks%**
1	Laboratory Work		80
2	Journal		10
3	Viva		10
	TOTAL		**100**

M.Sc.-I Chemistry
Semester – I

Course Code	Unit	Topics	Credits	L/Week
CHE401 Fundamentals of Analytical Chemistry	I	Basic analytical chemistry, errors, treatments and statistics	2	2
	II	Quality in Analytical Chemistry		
	III	Optical Methods		
CHE402 Inorganic Chemistry	I	Chemical Bonding	2	2
	II	Solid state chemistry and Nanomaterials		
	III	Organometallic Chemistry of Transition metals		
CHE403 Organic Chemistry	I	Physical Organic Chemistry	4	4
	II	Nucleophilic substitution reactions and Aromaticity		
	III	Stereochemistry		
	IV	Oxidation and Reduction		
CHE404A Physical Chemistry	I	Thermodynamics-I	2	2
	II	Quantum Chemistry		
	III	Electrochemistry		
OR				
CHE404B Instrumental methods Analysis	I	Spectroscopic Methods of Analysis	2	2
	II	Electro analytical methods of Analysis		
	III	Chromatographic Methods of Analysis		
CHE405 Research Methodology	I	Fundamentals of Research Methodology	4	4
	II	Data Collection		
	III	Scientific Writing and Ethics in Research		
	IV	Intellectual Property Rights		
CHEP401 CHEP402 CHEP403 CHEP404	-	Practical Course	8	16

Semester – I
Paper I

Physical Chemistry: (2 credit)
Course Code: CHE401 [30 L]

Course Outcomes:

1. To understand the State function and exact differentials, different equation related to it.
2. To understand Joule Thomson experiment and other related concepts.
3. To study Third law of Thermodynamics, Entropy change for a phase transition.
4. Study of the classical mechanics comparison to quantum mechanics.
5. Concept of orbital with particle in one dimension box, Particle in a one, two and three dimensional box
6. To understand the different theories of Uni molecular reactions.
7. To understand the concept of Debye-Huckel theory of strong electrolytes, various factors affecting the conductance of strong electrolytes.
8. To study the various types of fuel cells.
9. To study various types of Batteries.

Unit - I

Thermodynamics-I [10]

State function and exact differentials. Maxwell equations, Maxwell thermodynamic Relations; it's significance and applications to ideal gases, Joule Thomson experiment, Joule Thomson coefficient, inversion temperature, Joule Thomson coefficient in terms of van der Waals constants. Third law of Thermodynamics, Entropy change for a phase transition, absolute entropies, determination of absolute entropies in terms of heat capacity, standard molar entropies and their dependence on molecular mass and molecular structure, residual entropy.

Unit II

Quantum Chemistry: [10L]

Introduction: Wave-particle duality of material and De Broglie's hypothesis, uncertainty principle, Schrodinger equation, wave function, conditions for acceptable wave functions and its interpretation, properties of wave functions, Operators and related theorem, algebra of operators, commutator, linear operators, Normalization and orthogonality, Eigen functions and Eigen values, postulate of quantum mechanics. Solutions of wave equation for a free particle and particle in a box problem, Transition dipole moment integral and selection rules, particle in abox application to electronic spectra of conjugated linear organic molecules. Linear and angular momentum operators, eigenfunction and eigen values of angular momentum operator, Ladder operator, addition of angular momenta. Spin angular momenta, symmetric and antisymmetric wavefunctions, Pauli Exclusion Principle, spectroscopic term symbols.

Unit III

Electrochemistry [10 L]

Recapitulation – basics of electrochemistry.

Debye-Hückel theory of activity coefficient, Debye-Hückel limiting law and it's extension to higher concentration (derivations are expected). Electrolytic conductance and ionic interaction, relaxation effect,. Debye-Hückel-Onsager equation (derivation expected). Validity of this equation for aqueous and non- aqueous solution, deviations from Onsager equation, Debye -Falkenhagen effect (dispersion of conductance at high frequencies), Wien effect. Electrochemical stroge Devices: Alkaline fuel cells, Phosphoric acid fuel cells, High temperature fuel cells [Solid –Oxide Fuel Cells (SOFC) and Molten Carbonate Fuel Cells]

[Note: Numerical and theoretical problems from each unit are expected]

References:

1. Peter Atkins and Julio de Paula, Atkin's *Physical Chemistry*, 7th Edn., Oxford University Press, 2002.
2. K.J. Laidler and J.H. Meiser, *Physical Chemistry*, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999.
3. Robert J. Silby and Robert A. Alberty, *Physical Chemistry*, 3rd Edn., John Wiley and Sons (Asia) Pte. Ltd., 2002.
4. Ira R. Levine, *Physical Chemistry*, 5th Edn., Tata McGraw-Hill New Delhi, 2002.
5. G.W. Castellan, *Physical Chemistry*, 3rd Edn., Narosa Publishing House, New Delhi, 1983.
6. S. Glasstone, *Text Book of Physical Chemistry*, 2nd Edn., McMillan and Co. Ltd., London, 1962
7. B.K. Sen, *Quantum Chemistry including Spectroscopy*, Kalyani Publishers, 2003.
8. A.K. Chandra, *Introductory Quantum Chemistry*, Tata McGraw – Hill, 1994.
9. R.K. Prasad, *Quantum Chemistry*, 2nd Edn., New Age International Publishers, 2000.
10. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964.
11. W.G. Davis, *Introduction to Chemical Thermodynamics – A Non – Calculus Approach*, Saunders, Philadelphia, 19772.
12. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.
13. Ira N. Levine, *Quantum Chemistry*, 5th Edn., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
14. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edn., Pearson Education Limited 2013.
15. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edn., 1992.
16. ***Bockris***, John O'M., ***Reddy***, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998.
17. Physical Chemistry by Gurtu and Gurtu
18. A Text book of Physical Chemistry by K L kapoor Vol 5 , 2nd Edn

Paper I

Physical Chemistry Practical

Course Code: CHEP401 (30L)

Course Outcomes:

1. To understand how to determine the heat of solution at different temperature.
2. To study ionic strength of various inorganic salts.
3. To evaluate kinetics of the reactions.
4. To understand various methods of graph plottings.
5. To understands various instrumental techniques.

Non – Instrumental:

1. To determine the heat of solution (ΔH) of a sparingly soluble acid (benzoic /salicylic acid) from solubility measurement at three different temperature.
2. To study the variation of calcium Sulphate with ionic strength and hence determine the thermodynamic solubility product of $CaSO_4$ at room temperature.
3. To investigate the reaction between acetone and iodine.

4. To study the variation in the solubility of $Ca(OH)_2$ in presence of NaOH and hence to determine the solubility product of $Ca(OH)_2$ at room temperature.
5. Graph Plotting of mathematical functions –linear, exponential and trigonometry and identify whether functions are acceptable or non-acceptable
6. Determination of radius of glycerol molecule by viscosity

Instrumental:

1. To determine the mean ionic activity coefficient of an electrolyte by e.m.f. measurement.
2. To study the effect of substituent on the dissociation constant of acetic acid conductometrically.
3. To determine pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode.
4. To verify Ostwald's dilution law and to determine the dissociation constant of a weakmono-basic acid conductometrically.
5. Verification of Onsagar Equation for 1:1 type strong electrolyte
6. Determination of atomic refractions of H, C and Cl atoms

References:

1 Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005.

2 Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rd Edn., Longman Group Ltd., 1974.

3 Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.

SEMESTER II

Paper II

Inorganic Chemistry:
Course Code: CHE402 (30 L)

Course Outcomes

1.To derive wave equations for sp,sp2 hybrid orbitals.(4)
2.To Construct MO diagrams of diatomic and polyatomic species of first transition series. (4)
3.To discuss the various aspects of materials chemistry, nanomaterials and co-ordination chemistry (2)
4.To calculate 16 and 18 electron count and predict structure and bonding in Organometallic compounds(4)

Unit I

Chemical Bonding: [10 L]

1.1 **Recapitulation of hybridization** Derivation of wave functions for *sp*, sp^2, *sp3* orbital hybridization types considering only sigma bonding.
1.2 Discussion of involvement of *d* orbitals in various types of hybridizations.
1.3 Critical discussion on Valence Bond Theory.
1.4 Molecular Orbital Theory for diatomic species of First transition Series.
1.5 Molecular Orbital Theory (LCAO-MO approach) for Electron deficient and Electron rich species.

1.6 Weak forces of attraction: Hydrogen bonding – concept, types, properties, methods of detection and importance. Van der Waal's forces, ion-dipole, dipole-dipole, London forces.

Unit II

Solid state chemistry and Nanomaterials : [10 L]

3.1 Solid State Chemistry

3.1.1. Recapitulation of basic solid state chemistry band theory, Fermi level, K Space

3.1.2. Structures of Compounds of the type: AB. Zinc Sulphide(ZnS) , [nickel arsenide (NiAs)], AB_2 [fluorite (CaF_2) and anti-fluorite structures, rutile (TiO_2) structure and layer structure [cadmium chloride and iodide ($CdCl_2$, CdI_2)].

3.1.3. Methods of preparation for inorganic solids: Ceramic method, precursor method, sol-gel method (applications in Biosensors), microwave synthesis (discussion on principles, examples, merits and demerits are expected)

3.2 Nanomaterials

3.2.1 Introduction to nanomaterials.

3.2.1. Preparative methods: Solvothermal, Microwave and Co-precipitation.

3.2.2. Applications in the field of semiconductors and biomedical field.

Unit–III

Organometallic Chemistry of Transition metals: [10 L]

3.1 Eighteen and sixteen electron rule and electron counting with examples.

3.2 Preparation and properties of the following compounds

(a) Sandwich compounds of Fe, Cr and

(b) Half Sandwich compounds of Cr, Mo.

3.3 Structure and bonding on the basis of VBT and MOT in the following organometallic compound Zeise's salt, bis(triphenylphosphine)diphenylacetylene platinum (0) [$Pt(PPh_3)_2(HC{\equiv}CPh)_2$], diallylnickel(II), ferrocene and bis(arene)chromium(0), tricarbonyl(η^2-butadiene) iron(0).

References:

Unit I

1. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, 2013-2014.
2. W. W. Porterfield, Inorganic Chemistry-A Unified Approach, 2nd Ed., Academic Press, 1993.
3. B. W. Pfennig, Principles of Inorganic Chemistry, Wiley, 2015.
4. C. E. Housecroft and A. G. Sharpe, Inorganic Chemistry, Pearson Education Limited, 2nd Edition 2005.
5. J. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry–Principles of Structure and Reactivity, 4th Ed., Harper Collins, 1993.
6. P. J. Durrant and B. Durrant, Introduction to Advanced Inorganic Chemistry, Oxford University Press, 1967.
7. R. L. Dekock and H.B.Gray, Chemical Structure and Bonding, The Benjamin Cummings Publishing Company, 1989.
8. G. Miessler and D. Tarr, Inorganic Chemistry, 3rd Ed., Pearson Education, 2004.
9. R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., 2001.
10. C. M. Day and J. Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 1985.
11. J. N. Murrell, S. F. A. Kettle and J. M. Tedder, The Chemical Bond, Wiley, 1978.

12. G. A. Jeffrey, An Introduction to Hydrogen Bonding, Oxford University Press, Inc., 1997.

Unit II

1. A. R. West, Solid State Chemistry and Its Applications, John Wiley & Sons, 1987.
2. L. V. Azaroff, Introduction to solids, Tata McGraw Hill Book Co, 1977.
3. H. V. Keer, Principles of Solid State, Wiley Eastern Ltd., 1993.
4. C. N. R. Rao and G. Gopalkrishnan, New Directions in solid state chemistry, 2nd Ed., Cambridge University Press, 1997.
5. Lesley E. Smart and Elaine A. Moore, Solid State Chemistry – An introduction, 3 rd Ed., Taylor and Francis, 2005.
6. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone, 2014. 7. S. K. Kulkarni, Nanotechnology-Principles and Practices, Capital Publishing Co., 2007.
8. G. Cao, Nanostructures and Nanomaterials- Synthesis, Properties and Applications, Imperial college Press, 2004.
9. C. N. R. Rao, A. Muller and A. K. Cheetham, The Chemistry of NanomaterialsSynthesis, Properties and Applications, Volume-I, Wiley VCH, 2004
10. Nano-Surface Chemistry, 2001, Morton Rosoff, ISBN: 0-8247-0254-9, Marcel Dekker Inc. New York.
11.The Chemistry of Nanomaterials, CNR Rao, Muller Cheetham, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2004.
12. Semiconductor Nanomaterials, Challa S.S.R. Kumar, ISBN: 978-3-527-32166-7, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2010.

Unit III

1.R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, 5thEd., Wiley Interscience, 2009.
2. R. C. Mehrotra and A. Singh, Organometallic Chemistry-A Unified Approach, 2ndEd., New Age International Pvt. Ltd., 2000.
3. G. O. Spessard and G. L.Miessler, Organometallic Chemistry, Prentice-Hall, 1977.
4. K. F. Purcell and J. C. Klotz, Inorganic Chemistry, Saunders, 1977.
5. B. Douglas, D. H. McDaniel and J. J. Alexander, Concepts and Models of Inorganic Chemistry, 2nd Ed., John Wiley & Sons, 1983.
6. J. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Ed., Harper Collins, 1993.
7. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Ed., Oxford University Press, 2010.

Paper II Inorganic Chemistry Practical

Course Code: CHEP402

Course Outcomes-

1. To analyse various ores and alloys for its metal content. (4)
2. To determine the electrolytic nature of inorganic compounds. [2]
3. Determination of equilibrium constants of inorganic compounds. [2]

Analysis of Ores and Alloys

1) Analysis of Devarda's alloy
2) Analysis of Cu – Ni alloy
3) Analysis of Tin Solder alloy
4) Analysis of Limestone.
5) Analysis of Haematite ore
6) Analysis of Galena Ore
7) Analysis of pyrolusite ore

Instrumentation

1. Determination of equilibrium constant by Slope intercept method for Fe^{+3}/ SCN^{-} system
2. Determination of Electrolytic nature of inorganic compounds by Conductance measurement.

References:

1. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn, 2010., U.N.Dhur & Sons Pvt Ltd
2. Inorganic Chemistry Practical Under UGC Syllabus for M.Sc. in all India Universities By: Dr Deepak Pant.
3. A. I. Vogel, Vogel's Text Book of Quantitative Inorganic Analysis, 6th Ed., Pearson Education, 2000.
4. J. D. Woolins, Inorganic Experiments, Wiley-VCH Verlag GmbH and Co., 2003.
5. W. G. Palmer, Experiments in Inorganic Chemistry, Cambridge University Press, 1954.
6. G. Raj, Advanced Practical Inorganic Chemistry,
7. G. Brauer, Handbook of Preparative Inorganic Chemistry, Vol. 1 and 2, Academic Press, 1967.
8. G. Marr and B. W. Rockette, Practical Inorganic Chemistry, Van Nostrnad Reinhond, 1972.
9. G. Pass and H. Sutcliffe, Practical Inorganic Chemistry, 2nd Ed., Chapman and Hall, 1985.

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Paper III

Organic Chemistry: (4 credits)

Course Code: CHE403 (60 L)

Course Outcomes

1.To apply the thermodynamic and kinetic requirements of a reaction (3).
2.To explain nucleophilic substitution reactions and aromaticity (2)
3.To determine stereochemistry of molecules with two or more chiral centres (2)
4.To predict the reaction mechanism by using various oxidizing and reducing reagents (4)

Unit I

Physical Organic Chemistry: (15 L)

1.1. Thermodynamic and kinetic requirements of a reaction: rate and equilibrium constants, reaction coordinate diagram, transition state (activated complex), nature of activated complex, Hammond postulate, Reactivity *vs* selectivity, Curtin-Hammett Principle, Microscopic reversibility, Kinetic *vs* thermodynamic control of organic reactions.

1.2. Determining mechanism of a reaction: Product analysis, kinetic studies, use of isotopes (Kinetic isotope effect – primary and secondary kinetic isotope effect). Detection and trapping of intermediates, crossover experiments and stereochemical evidence.

1.3. Acids and Bases: Factors affecting acidity and basicity: Electronegativity and inductive effect, resonance, bond strength, electrostatic effects, hybridization, aromaticity. Comparative study of acidity and basicity of organic compounds on the basis of pKa values, Acid and base catalysis – general and specific catalysis with examples.

Unit II

Nucleophilic substitution reactions and Aromaticity

2.1. Nucleophilic substitution reactions: (9 L)

2.1.1. Aliphatic nucleophilic substitution: S_N1, S_N2, S_N^i reactions, mixed S_N1 and $S_N2$and SET mechanisms. S_N reactions involving NGP - participation by aryl rings, α-and pi-bonds. Factors affecting these reactions: substrate, nucleophilicity, solvent, steric effect, hard-soft interaction, leaving group. Ambident nucleophiles. S_NcA, S_N1' and S_N2' reactions. S_N at sp^2 (vinylic) carbon.

2.1.2. Aromatic nucleophilic substitution: S_NAr, S_N1, benzyne mechanisms. Ipso, cine, tele and vicarious substitution.

2.2. Aromaticity: (6 L)

2.2.1. Structural, thermochemical, and magnetic criteria for aromaticity, including NMR characteristics of aromatic systems. Delocalization and aromaticity.

2.2.2. Aromatic and antiaromatic compounds up-to 18 carbon atoms. Homo aromatic compounds. Aromaticity of all benzenoid systems, heterocycles, metallocenes, azulenes, annulenes, aromatic ions and Fullerene (C_{60}).

Unit-III

Stereochemistry: (15 L)

3.1. Molecules with two or more chiral centers: Constitutionally unsymmetrical molecules: erythro-threo and syn-anti systems of nomenclature. Interconversion of Fischer, Sawhorse, Newman and Flying wedge projections. Constitutionally symmetrical molecules with odd and even number of chiral centers: enantiomeric and meso forms, concept of stereogenic, chirotopic, and pseudo asymmetric centers. R-S nomenclature for chiral centers in acyclic and cyclic compounds.

3.2. Axial and planar chirality: Principles of axial and planar chirality. Stereochemical features and configurational descriptors (R,S) for the following classes of compounds: allenes, alkylidene cycloalkanes, spirans, biaryls (buttressing effect) (including BINOLs and BINAPs), ansa compounds, cyclophanes, trans-cyclooctenes.

3.3. Prochirality: Chiral and prochiral centres; prochiral axis and prochiral plane. Homotopic, heterotopic (enantiotopic and diastereotopic) ligands and faces. Identification using substitution and symmetry criteria. Nomenclature of stereoheterotopic ligands and faces. Symbols for stereoheterotopic ligands in molecules with i) one or more prochiral centers ii) a chiral as well as a prochiral center, a prochiral axis iv) a prochiral plane v) pro-pseudoasymmetric center. Symbols for enantiotopic and diastereotopic faces.

Unit-IV

Oxidation and Reduction: (15 L)

4.1. Oxidation: General mechanism, selectivity, and important applications of the **followings**:

4.1.1. Dehydrogenation: Dehydrogenation of C-C bonds including aromatization of six membered rings using metal (Pt, Pd, Ni) and organic reagents (chloranil, DDQ).

4.1.2. Oxidation of alcohols to aldehydes and ketones: Chromium reagents such as $K_2Cr_2O_7/H_2SO_4$ (Jones reagent), CrO_3-pyridine (Collin's reagent), PCC (Corey's reagent) and PDC (Cornforth reagent), hypervalent iodine reagents (IBX, Dess-Martin periodinane). DMSO based reagents (Swern oxidation), Corey-Kim oxidation - advantages over Swern and limitations; and Pfitzner-Moffatt oxidation-DCC and DMSO and Oppenauer oxidation.

4.1.3. Oxidation involving C-C bonds cleavage: Glycols using HIO_4; carbon-carbon double bond using ozone, $KMnO_4$, CrO_3, $NaIO_4$ and OsO_4; aromatic rings using NaIO4.

4.1.4. Oxidation involving replacement of hydrogen by oxygen: oxidation of $CH_2$to COby SeO_2,

4.1.5. Oxidation of aldehydes and ketones: with H_2O_2(Dakin reaction), with peroxy acid (Baeyer-Villiger oxidation)

4.2. Reduction: General mechanism, selectivity, and important applications of thefollowing reducing reagents:

4.2.1. Reduction of CO to CH_2 in aldehydes and ketones- Clemmensen reduction, Wolff-Kishner reduction.

4.2.2. Metal hydride reduction: Boron reagents ($NaBH_4$, $NaCNBH_3$, diborane, 9-BBN,$Na(OAc)_3BH$, . NH_2NH_2(diimide reduction)).MPV Reduction,

4.2.4. Dissolving metal reductions: Li/Na-liquid NH_3 mediated reduction (Birch reduction) of aromatic compounds and acetylenes.

Reference Books:

1. Physical Organic Chemistry, Neil Isaacs
2. Modern Physical Organic Chemistry, Eric V. Anslyn and Dennis A. Dougherty
3. Comprehensive Organic chemistry, Barton and Ollis, Vol 1
4. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press.
5. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A and B, Plenum Press.
6. Stereochemistry: Conformation and mechamism, P.S. Kalsi, New Age International, New Delhi.

Organic Chemistry Practical
Course Code: CHEP403(2 credit)
Course Outcomes

1.Planning of synthesis, effect of reaction parameters including stoichiometry, and safety aspects including MSDS should be learnt.

1. Purify the product by crystallization. Formation and purity of the product should be checked by TLC[2]

Report yield and melting point of the purified product.

One step preparations (1.0 g scale) (Any Ten)

1. Bromobenzene to p-nitrobromobenzene
2. Anthracene to anthraquinone
3. Benzoin to benzil
4. Anthracene to Anthracene maleic anhydride adduct
5. 2-Naphthol to BINOL
6. p-Benzoquinone to 1,2,4-triacetoxybenzene
7. Ethyl acetoacetate to 3-methyl-1-phenylpyrazol-5-one
8. *o*-Phenylenediamine to 2-methylbenzimidazole
9. *o*-Phenylenediamine to 2,3-diphenylqunooxaline
10. Urea and benzil to 5,5-diphenylhydantoin
11. Radical coupling reaction (Preparation of 1,1-bis-2-naphthol)
12. Pechmann condensation for coumarin synthesis (Clay catalyzed solid state synthesis of 7-hydroxy-4- methylcoumarin)

Reference:

1. Systematic Qualitative organic analysis, H. Middleton (Orient Longman)
2. A Handbook of Organic Analysis, H.T. Clark (Orient Longman)
3. Systematic Identification of organic compounds, R.L. Shriner (John Wiley, New York)
4. Practical Organic Chemistry by Mann and Saunders.
5. Advance Practical Organic Chemistry, N.K. Vishnoi, Vikas Publication

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FUNDAMENTALS OF ANALYTICAL CHEMISTRY
Paper Code: CHE404A

Course Outcomes

1.To apply the various spectroscopic techniques for qualitative and quantitative analysis
2.To understand various terms used in analytical chemistry and hyphenated techniques
3.To determine the concentration of unknown sample by spectroscopic methods.
4.To interpret the thermo-gravimetric curves of various samples

FUNDAMENTALS OF ANALYTICAL CHEMISTRY — 02 credit

I Basics of Analytical Chemistry, Errors, treatments and statistics **(10)**

a) Concepts of Analytical Chemistry:

Analytical perspective, Common analytical problems, terms involved in analytical chemistry (analysis, determination, measurement, techniques, methods, procedures and protocol) ,An overview of analytical methods, types of instrumental methods, instruments for analysis, data domains,

electrical and nonelectrical domains, detectors, transducers and sensors,.

b) Types and sources of error, determinate and indeterminate errors, Accuracy and precision Absolute and relative errors, Minimisation of errors, Significant figures, Mean, median and standard deviation, Least square method. Numerical problems.

II Quality in Analytical Chemistry 10

a) Quality Management System (QMS): Quality Management System: Quality management concepts and principles - Traceability, quality control, quality assurance, quality management and quality manual, calibration and test methods TQM in Chemical Industry: Applying Kaizen, Six Sigma approach and 5S to quality in industries. Quality audits and quality reviews, responsibility of laboratory staff for quality and problems.

b) Good Laboratory Practices: [4L]
GLP Principles, Documentation of laboratory work, Preparation of Standard Operating Procedures (SOPs), Validation of methods, reporting and documentation of results.

c) Accreditation of laboratories: [3L]
International organization for standardization, National accreditation board for testing and calibration laboratories. Scope of accreditation.

d)Safety in Laboratories: [3L]
Importance of Safety in Laboratories, classification of Personal Protection Equipment (PPE), Safety and health Standards: Indian Standards & codes for safety & health, OSHA standards, Types of Toxic Hazard (TH), Classification of Chemical Hazards and their control.

III Optical Methods 10

a. Ultraviolet and visible spectrophotometry (UV-VIS) [08]
Introduction, Electronic transitions, Terms used in UV spectroscopy, Beer Lambert's law, limitations of the law, molar absorption, molar extinction coefficient, chromophore -auxochrome theory, Solvent effect, Factors affecting on UV absorption band, calculation of "Lambda max" values of dienes, dienones and polyenes, applications. (wood-ward and Fischer rules)

b. Infrared Spectroscopy (IR) [07]
principle, instrumentation, sampling technique, Fundamental modes of vibrations, selection rules, Fundamental group region, Finger Print region, absorption of common functional groups. Factors affecting frequencies, applications.

FTIR Spectroscopy: Principle, instrumentation & its advantages

References:

1. Modern Analytical Chemistry, David Harvey, McGraw-Hill Higher Education, 2000.
2. Principles of Instrumental Analysis - Skoog, Holler and Nieman, 6th Edition, 2017
3. Fundamentals of Analytical Chemistry, By Douglas A. Skoog, Donald M. West, F. James Holler,Stanley R. Crouch, 9th Edition, 2004.
4. ISO 9000 Quality Systems Handbook, Fourth Edition, David Hoyle. (Free download).
5. Quality in the Analytical Laboratory, Elizabeth Pichard, Wiley India, 2007.

6. Safety and Hazards Management in Chemical Industries, M N Vyas, Atlantic Publisher.
7. Analytical chemistry: Problems & Solutions by S.M. Khopkar New Delhi, New AgeInternational (P) Ltd., 2002.
8. H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental Methods ofAnalysis,6th Edition, CBS Publisher, 1988.
9. R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill Publisher, 1985
10. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5th Edition, McGraw Hill Publisher,1960.
11. Vogel Quantitative Chemical Analysis, Pearson, 6th Edition, 2009.
12. Analytical Chemistry by Open Course: Thermal Methods by James W. Dodd & Kenneth H.Tonge.

CHEP404A **Practical**

FUNDAMENTALS OF ANALYTICAL CHEMISTRY **(CREDITS – 02)**

Course Outcomes

1. Determination of assay of compounds.

2. To understand spectrophotometric analysis of the various organic and inorganic compounds.

Practicals

1. To carry out assay of the sodium chloride injection by Volhard's method. (Statistical method)
2. To determine (a) the ion exchange capacity (b) exchange efficiency of the given cation exchange resin.
3. To determine amount of Cr(III) and Fe(II) individually in a mixture of the two by titration with EDTA.
4. To determine the breakthrough capacity of a cation exchange resin.
5. To determine the lead and tin content of a solder alloy by titration with EDTA.
6. To determine amount of Cu(II) present in the given solution containing a mixture of Cu(II) and Fe(II).
7. To determine number of nitro groups in the given compound using $TiCl_3$.
8. Determination of sulphanilic acid from the given sulpha drug sample.
9. To determine the iodine from iodized salt.
10. To estimate the amount of calcium from the plaster of Paris.

Reference:

G H Jeffery, J Bassett, J Mendhem, R C Denney, Vogel's Textbook Of Quantitative ChemicalAnalysis, 3rd Edition, Longman Scientific & Technical,1989

CHE404B :INSTRUMENTAL METHODS OF ANALYSIS 02

Course Outcomes

1.To study Concepts of Philosophy of Quality assurance and regulatory affairs.
2.To understand the mechanism of Good manufacturing practices and safety operations in Laboratory.
3.To understand the mechanism of Quality control Laboratory.

UNIT I SPECTROSCOPIC METHODS OF ANALYSIS **(15)**

(a) UV-Visible Spectroscopy: Introduction to UV-Visible spectroscopy, deviation from Beer's law; Instrumentation- single and double beam spectrophotometers, sources of radiation, filters and monochromators, sample cells, detectors. Principle of diode array spectrophotometers, Principle of UV-visible diffuse reflectance spectrophotometer, spectrophotometric titrations, applications- general precautions in colorimetric determinations, colorimetric determination of Fe2+, Fe3+, Al3+, NH4+, Cr6+, Co3+, Cu2+, Ni2+, NO2 -and PO4 3- using suitable reagents, simultaneous determinations of dichromate and permanganate in a mixture, determinations of aromatic primary amines, riboflavin and paracetamol.

UNIT II ELECTRO ANALYTICAL METHODS OF ANALYSIS **(15)**

(a)Voltammetry and polarographic analysis : Classification of voltametry, principle of polarography, residual current, migration current, diffusion current, half-wave potential, Ilkovic equation, instrumentation, Dropping mercury electrode (DME), advantages and disadvantages of DME, DC polarography, AC polarography, Pulse polarography-Nornalpulse,triangular pulse and squarewave pulse; qualitative and quantitative analysis of inorganic ions-Cu, Bi, Pb, Cd, Zn, AC polarography, pulse polarography

(b)Anode stripping voltammetry: 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 I2 liberations and Ce^{4+} liberation in solutions

UNIT III CHROMATOGRAPHIC METHODS OF ANALYSIS **(15)**

a. **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, nitrogen-phosphorus detector, photo ionization detector, programmed temperature gas chromatography; applications in the analysis of gases, petroleum products etc., other detectors used their Principles and Applications.
b. **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.

Reference Books:

1. Applications of ICP-MS, A.R Date and A.L Glay, London (Eds),Blackie, London
2. A. Moutaser and D.W Gologhtly (Eds), ICP in Analytical Atomic Spectrometry, VeH Publishers, New York
3. G.I Moore, Introduction to ICP emission Spectrometry in Analytical Spectroscopy, Elsevier, Amsterdam
4. Infrared and Raman Spectra of Inorganic and Coordination Compounds,KazuoNakamoto, 5th ed., John Wiley & Sons,1995.
5. Instrumental methods of Analysis – Chatwal and Anand
6. 16. Mass Spectrometry-A Textbook by Jürgen H. Gross, Springer-Verlag Berlin Heidelberg 2004, Printed in Germany
7. Instrumental Methods of Analysis (CBS) H. H. Willard; L.L Merit; J. A. Dean & F. A. Settle.
8. Principles of Instrumental Analysis- D. Skoog and D. West

CHEP404B:
Practical

Course Outcomes

1. To study the ion exchange capacity and its applications.
2. Determination of nitro compounds use volumetric method.

ANALYTICAL CHEMISTRY (CREDITS – 02)

1. To carry out assay of the sodium chloride injection by Volhard's method. (Statistical method)
2. To determine (a) the ion exchange capacity (b) exchange efficiency of the given cation exchange resin.
3. To determine amount of Cr(III) and Fe(II) individually in a mixture of the two by titration with EDTA.
4. To determine the breakthrough capacity of a cation exchange resin.
5. To determine the lead and tin content of a solder alloy by titration with EDTA.
6. To determine amount of Cu(II) present in the given solution containing a mixture of Cu(II) and Fe(II).
7. To determine number of nitro groups in the given compound using $TiCl_3$.
8. Determination of sulphanilic acid from the given sulpha drug sample.
9. To determine the iodine from iodized salt.
10. To estimate the amount of calcium from the plaster of Paris.

CHE405:RESEARCH METHODOLOGY AND IPR

Unit 1

Fundamentals of Research Methodology (15 L)

1.1 Introduction to Research Methodology

- Meaning and objectives of research
- Research process
- Terminology
- Types of research
- Importance's of research
- Design research (Determine sample design)

1.2 Defining the research problem

- What is a research problem
- Selecting the problem
- Technique involved in defining problem
- Problem encountered by Research in India

1.3 Hypothesis

- Meaning, significance and characteristics of hypothesis
- Basic concepts concerning testing of hypotheses
- Hypothesis development
- Steps in formulation of hypothesis

Unit 2

Data Collection **(15 L)**

2.1 Experimental data collection

- Types of data
- Methods of primary data collection (observation, experimentation, questionnaire, schedules, interviewing, case, pilot study)
- Methods of secondary data collection (internal, external)
- Selection of appropriate method for data collection
- Data Interpretation

2.3 Methods of data collecting by different software

- Information and resources: Sources and their authenticity,
- methods for collecting information- search Engines,
- Google scholar, Scifinder, Web of Science, Scopus;
- Features of Chemdraw and its uses; searching of chemical resources, reactions, reagents
  and their chemical and physical properties.

2.2 Spectral data bases

- NMR data bases, CCDC, PDB, JCPDS, NIST.
- Recording of experiments: Log book and lab notebook, accuracy, precision, fitting of data, error bar, noise and data
- IUPAC guidelines of presentation of data for experimental and theoretical studies.
- Figures, legends, tables, foot notes, abbreviations, references,
- Typesetting, templates, formulas and equations, reference formats, supplementary data

Unit-3

Scientific writing and Ethics in research (15 L)

3.1 Writing style

- Abstract, report, dissertation, thesis, manuscript, monographs, books, research proposals.
- Types of publications: letters, communications, perspectives, research articles, reviews, accounts. Outline, drafting, refinement, common errors, editing services, proof reading
- Writing a Research Paper
- Writing a Review Article

3.2 Research Metrics

- Types of Research Metrics
  1. Journal impact factor
  2. H-index (i-index, i-10 index)
  3. g-index
  4. Eigenfactor score
  5. Altmetrics (alternative metrics)
- Ranking: journals, institutes (e.g. NIRF),
- Author identification: ORCID and RESEARCHER IDs, ISSN and ISBN

3.3 Ethics in research and publication

- Importance's of ethics
- Research ethics
- Publication ethics: definition, Introduction, Importance's
- Research ethics principles
- Violation of Publication ethics
  Authorship and Contributorship
- Publication Misconduct
  1. Introduction
  2. Causes of Publication Misconduct
- Types of Publication Misconduct
  1. Plagiarism, checking of plagiarism
  2. Fabrication
  3. Falsification5
  4. duplicate and redundant publications
- Unethical Behaviour in Publication
- Ethical issue in India

Unit 4

Intellectual Property Rights

4.1 General Regime of Intellectual Property Rights

1. Concept of Intellectual Property
2. Types of Intellectual Property- Origin and Development- An Overview.
3. Intellectual Property Rights as Human Right.
4. Role of International Institutions

4.2 Copyright and Neighboring Rights

1. Introduction to Copyright

(a) Conceptual Basis

(b) International Protection of Copyright and Related rights- An Overview (International Convention/Treaties on Copyright)

2. Indian Copyright Law

4.3 Trademarks

1. Introduction to Trademarks
2. Need for Protection of Trademarks Kinds of Trademarks
3. International Legal Instruments on Trademarks
4. Trademark Laws

References

1. Research Methodology: C.R. Kothari Second edition.
2. P. Narayanan (Eastern Law House), Intellectual Property Law.
3. Research Methodology -A Step by step Guide for Beginners 2nd edn R.K. Nagarjan, Intellectual Property Law.
4. Ganguli (Tata Megraw), Intellectual Property Rights.
5. N.S. Gopalakrishnan & T.G. Agitha, Principles of Intellectual Property (2009), Eastern Book Company, Lucknow.
6. Dr. B.L. Wadhera, Law Relating to Patent, Trademarks, Copyright Patent: Jeffrey G. Sheldon, How to Write a Patent Application, Third Edition, Practising Law Institute, 2016.
7. Introduction to Research & Research Methodology M. S. Sridhar.
8. Computer Software Application in Chemistry Peter C. Jurs, John - Wiley.
9. The Oxford Book of Modern Science Writing, Richard Dawkins (Editor), Oxford, 2009.

M.Sc.-I Chemistry
Semester - II

Course Code	Unit	Topics	Credits	L/Week
CHE451 Physical Chemistry	I	Chemical Thermodynamics II	2	2
	II	Quantum Chemistry II		
	III	Statistical Thermodynamics		
CHE452 Inorganic Chemistry	I	Inorganic Reaction Mechanism	2	2
	II	Molecular Symmetry and Group Theory:		
	III	Environmental Chemistry		
CHE453 Organic Chemistry	I	Introduction to molecular orbital theory for organic chemistry	4	4
	II	Reactions and Rearrangements		
	III	Alkylations of Nucleophilic Carbon Intermediates		
	IV	NMR Spectroscopy and Mass Spectroscopy		
CHE454A Chromatography and Spectroscopic Techniques	I	Introduction to chromatography and spectroscopic Techniques	2	2
	II	Spectroscopic Methods		
	III	Surface Analytical Techniques and Atomic Spectroscopy		
CHE454B Environmental Analytical Chemistry	I	Soil and radioactive pollution	2	2
	II	Water Pollution		
	III	Heavy Metal Pollution		
CHE455		Internship	4	4
CHEP451 CHEP452 CHEP453 CHEP454	-	Practical Course	8	16

Paper I

Physical Chemistry: (2 Credit)

Course Code: CHE 451 (30 L)

Course Outcomes:

1) To understand the concept of Fugacity, Equilibrium Constant of Real gases, Gibb's energy of mixing and Entropy of mixing of ideal gases.
2) To understand the concept of Chemical Potential, excess functions, the Partial molar volume and Partial molar enthalpy of non-ideal gases and to study Gibb's Duhem Margules equation.
3) To study the thermodynamics of Curved surfaces, Laplace & Kelvin equation.
4) To study free energy changes in biochemical reactions.
5) To study the Kinetic of elementary reaction in solutions, Enzyme catalyzed reactions and Solid state reactions.
6) To study the different types Phase Equilibria in Two component and three component systems.

Unit I

Chemical Thermodynamics II [10 L]

Fugacity of real gases, Determination of fugacity of real gases using graphical method and from equation of state. Equilibrium constant for real gases in terms of fugacity. Gibbs energy of mixing, entropy and enthalpy of mixing.

Real solutions: Chemical potential in non-ideal solutions excess functions of non-ideal solutions calculation of partial molar volume and partial molar enthalpy, Gibbs Duhem Margules equation.

Unit II

Molecular Spectroscopy [10 L]

Recapitulation: Width and intensity of spectral transitions, Fourier transform, Signalto-noise ratio, Microwave spectroscopy, rotation spectra of diatomic molecules-rigid and non-rigid molecules, Stark effect. Infra- red spectroscopy: Harmonic and anharmonic oscillator, types of vibrational spectra of diatomic molecules, application Electronic spectroscopy of molecules: Born – Oppenheimer approximation, electronic spectra of diatomic molecules, application.

Unit III Statistical Thermodynamics [10 L]

Probability and distribution, Stirling Approximation, Weights and configurations, the most probable configuration, Ensembles, ensemble average and time average of property. Statistical equilibrium, thermodynamic probability, Maxwell-Boltzmann (MB) distribution law. Partition function and its significance. Rotational, translational, vibrational and electronic partition functions. Relationship between partition function and thermodynamic properties. thermodynamic probability and entropy: Boltzmann – Planck equation, Partition function and third law of thermodynamics, Application to monoatomic gases - Sackur tetrode equation, applications to diatomic molecules, Statistical expression for equilibrium constant, Limitations of Maxwell-Boltzmann statistics, Numerical Problems.

References

1. Peter Atkins and Julio de Paula, Atkin's *Physical Chemistry*, 7th Edn., Oxford University Press, 2002.
2. K.J. Laidler and J.H. Meiser, *Physical Chemistry*, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999.
3. Robert J. Silby and Robert A. Alberty, *Physical Chemistry*, 3rd Edn., John Wiley and Sons (Asia) Pte. Ltd., 2002.
4. Ira R. Levine, *Physical Chemistry*, 5th Edn., Tata McGraw-Hill New Delhi, 2002.
5. G.W. Castellan, *Physical Chemistry*, 3rd Edn., Narosa Publishing House, New Delhi, 1983.
6. S. Glasstone, *Text Book of Physical Chemistry*, 2nd Edn., McMillan and Co. Ltd., London, 1962.
7. Principles of Chemical Kinetics, 2nd Ed., James E. House, ELSEVIER, 2007.
8. B.K. Sen, *Quantum Chemistry including Spectroscopy*, Kalyani Publishers, 2003.
9. A.K. Chandra, *Introductory Quantum Chemistry*, Tata McGraw – Hill, 1994.
10. R.K. Prasad, *Quantum Chemistry*, 2nd Edn., New Age International Publishers, 2000.
11. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964.
12. W.G. Davis, *Introduction to Chemical Thermodynamics – A Non – Calculus Approach*, Saunders, Philadelphia, 19772.
13. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.
14. Ira N. Levine, *Quantum Chemistry*, 5th Edn., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
15. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edn., Pearson Education Limited 2013.
16. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edn., 1992.
17. Solid State Chemistry [An Introduction], 3rd Ed., Lesley E. Smart & Elaine A.
18. The Physics and 'Chemistry of Solids, Stephen Elliott, Willey India, 2010
19. Principles of the Solid State, H.V. Keer, New Age International Publishers, 2011.
20. Solid State Chemistry, D.K. Chakrabarty, New Age International Publishers, 1996.
21. Principles of physical Chemistry , Marrown and Prutton 5th edition
22. Essentials of Physical Chemistry , Arun Bahl, B. S Bahl, G. D.Tulli , S Chand and Co. Ltd , 2012 Edition.
23. Introduction of Solids L.V Azaroff , Tata McGraw Hill .
24. A Text book of physical Chemistry ; Applications of thermodynamics vol III, Mac Millan Publishers India Ltd ,2011
25. New directions in solid state Chemistry, C.N.R. Rao and J Gopalkrishnan , Cambridge University Press.

Physical Chemistry Practical
Course Code: CHEP451 (2 Credit)

Learning objectives:

1) To understand plotting of various orbitals on graph paper
2) To study kinetics of various reactions.
3) To understand concept of phase diagram.
4) To know use of various instrument for analysis .

Non – Instrumental:

1) To study the influence of ionic strength on the base catalysed hydrolysis of ethyl acetate.
2) To study phase diagram of three component system water – chloroform /toluene - acetic acid.
3) To determine the rate constant of decomposition reaction of diacetone alcohol by dialtometric method.
4) Determine the Transition temperature of sodium Sulphate decahydrate by solubility method
5) Polar plots of atomic orbitals such as 1*s*, 2P_y and 3d_z2orbitals by using angular part of hydrogen atom wave functions.
6) To determine Hydrolysis constant of aniline hydrochloride by pH Measurements

Instrumental:

1) To determine the formula of silver ammonia complex by potentiometric method.
2) To determine CMC of sodium Lauryl Sulphate from measurement of conductivities at different concentrations.
3) To determine Hammette constant of *m*- and *p*- amino benzoic acid/nitro benzoic acid by pH measurement.
4) To determine the Michaelis – Menten's constant value (Km) of the enzyme Beta Amylase spectrophotometrically.
5) Determination formal redox potential of system(Fe2+,Fe3+)
6) To determine CMC of sodium Lauryl Sulphate from measurement of conductivities at different concentrations.

References:

4 Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005.

5 Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rd Edn., Longman Group Ltd., 1974.

6 Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.

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Paper II: Inorganic Chemistry(2 Credit)
Course Code: CHE452 (30 L)

Course Outcomes

1. To apply concept of Mechanism of trans-effect and write substitution reactions of square planar complex reactions.
2. To demonstrate complimentary and non-complimentary reactions.
3. To illustrate Isomerization and racemization in Stereochemistry of substitution reactions of octahedral complexes.

Unit I

Inorganic Reaction Mechanism: [10 L]

1.1 Ligand substitution reactions of:

a) Octahedral complexes without breaking of metal-ligand bond (Use of isotopic labeling method)

b) Square planar complexes, trans-effect, its theories and applications. Mechanism and factors affecting these substitution reactions.

1.2 Redox reactions: inner and outer sphere mechanisms, complimentary and non-complimentary reactions.

1.3 Stereochemistry of substitution reactions of octahedral complexes. (Isomerization and racemization reactions and applications.)

Unit II

Molecular Symmetry and Group Theory: [10L]

2.1. A systematic procedure for symmetry classification of molecules.

2.2. Concepts of Groups, Sub-groups, Classes of Symmetry operations, Group Multiplication Tables. Abelian and non-Abelian point groups.

2.3. Representation of Groups: Matrix representation of symmetry operations, reducible and irreducible representations. The Great Orthogonality Theorem and its application in construction of character tables for point groups C_2v and C_3v, structure of character tables.

2.4. Applications of Group Theory

(a) Symmetry adapted linear combinations (SALC), symmetry aspects of MO theory, sigma bonding in AB_n (H_2O, CH_4) molecule.

(b) Mullikan's notations for irreducible representations.

(c) Reduction of reducible representations using reduction formula.

Unit-III

ENVIRONMENTAL CHEMISTRY [10L]

3.1. Conception of Heavy Metals: Critical discussion on heavy metals

3.2 Chemical Toxicology: toxic chemicals in the environment, biochemical effects and speciation , control and treatment. of toxic elements like arsenic, lead, mercury and cadmium;

3.**3 Radiation pollution**: Sources and biological implication of radioactive pollutants.

3.4. **Power from other sources**: Hydro power, Wind power, Geothermal energy, Ocean thermal energy conversion (OTEC), Tidal power.

References:

Unit I.

1. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Ed., Oxford University Press, 2010.

2. D. Banerjea, Coordination Chemistry, Tata McGraw Hill, 1993.

3. W. H. Malik, G. D./ Tuli and R. D. Madan, Selected Topics in Inorganic Chemistry, 8th Ed., S. Chand & Company ltd.

4. M. L. Tobe and J. Burgess, Inorganic Reaction Mechanism, Longman, 1999.

5. S. Asperger, Chemical kinetics and Inorganic Reaction Mechanism, 2nd Ed., Kluwer Academic/ Plenum Publishers, 2002

6. Gurdeep Raj, Advanced Inorganic Chemistry-Vol.II, 12th Edition, Goel publishing house, 2012.

7. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2ndEd., Wiley, 1967

8. R. Gopalan and V. Ramlingam, Concise Coordination chemistry, Vikas Publishing house Pvt Ltd., 2001

Unit II

1. F. A. Cotton, Chemical Applications of Group Theory, 2ndEdition, Wiley Eastern Ltd., 1989.
2. H. H. Jaffe and M. Orchin, Symmetry in Chemistry, John Wiley & Sons, New York, 1996.
3. R. L. Carter, Molecular Symmetry and Group Theory, John Wiley & Sons, New York, 1998.
4. K. V. Reddy. Symmetry and Spectroscopy of Molecules, 2ndEdition, New Age International Publishers, New Delhi, 2009.
5. A. Salahuddin Kunju and G. Krishnan, Group Theory and its Applications in Chemistry, PHI Learning, 2012.
6. P. K. Bhattacharya, Group Theory and its Chemical Applications, Himalaya Publishing House. 2014.
7. S. Swarnalakshmi, T. Saroja and R. M. Ezhilarasi, A Simple Approach to Group Theory in Chemistry, Universities Press, 2008.

Unit III

1.A. K. De, Environmental Chemistry, 7th Ed., New Age International Publishers, 2007.
2. G. S. Sodhi, Fundamental Concepts of Environmental Chemistry, 3rd Ed., Narosa Publishing House, 2013.
3. S. S. Dara and D. D. Mishra, A Textbook of Enviromental Chemistry and Pollution Control, S. Chand & Company Ltd., 2012.
4. D. Banerjea, Coordination Chemistry, Tata Mc Graw Hill, 1993.
5. S. K. Banerji, Environmental Chemistry, 2nd Ed., Prentice-Hall of India, 2005.
6. R. A. Bailey, H. M. Clark, J. P. Ferris, S. Krause and R. L. Strong, Chemistry of Environment, 2nd Ed., Academic Press, 2005.
7. J. E. Girard, Principles of Environmental Chemistry, 2nd Ed., Jones and Bartlett publishers, 2011.
8. H. Kaur, Environmental Chemistry, Pragati Prakashan, 8th Ed., 2014.

CHEP452: Inorganic Chemistry Practical

Course Outcomes

1. To synthesize and characterize various metal complexes
2. To determine calcium and magnesium and iron in tablet by complexometric titration

Inorganic Preparations (Synthesis and Characterization)

1. Potassium trioxalatochromate (III)
2. Potassium dioxalato cuprate(II) dihydrate
3. Tetrammine monocarbanato Cobalt (III) Nitrate $[Co(NH_3)_4CO_3]NO_3$
4. Bis (ethylenediammine) Copper (II) Sulphate $[Cu(en)_2]SO_4$

A. Analysis of the following samples

1. Calcium tablet for its calcium content by complexometric titration.
2. Bleaching powder for its available chlorine content by iodometric method.
3. Iron tablet for its iron content colorimetry by 1,10-phenonthroline method.
4. Ion – exchange chromatography; Separation & estimation of (Zn^{+2}/ Cd^{+2}) & (Zn^{+2} / Mg^{+2}) in mixtures using Amberlite IRA 400 anion exchanger.

Instrumentation

1) Estimation of Copper using Iodometric method Potentiometrically.
2) Estimation of Fe^{+3} solution using Ce(IV) ions Potentiometrically

References:

1. I. Vogel, Quantitative Inorganic Analysis.
2. J. D. Woolins, Inorganic Experiments.
3. Palmer, Inorganic Preparations.
4. G. Raj, Advanced Practical Inorganic Chemistry.
5. J. E. House, Inorganic chemistry, Academic press, 2nd edition, (2013).
6. Bharat Bhusan, "Springer Handbook of Nanotechnology", springer, Newyork, 2007.
7. Vogel's textbook of quantitative analysis, 6th edition. – J. Mendham, R.C. Denney and all.
8. The Synthesis and Characterization of Inorganic Compounds by William L. Jolly

Paper III: Organic Chemistry (4 Credits)

Course Code: CHE453 (60 L)

Course Outcomes

1. To understand the basic concept of molecular orbital theory, UV-Visible and IR spectroscopic techniques.
2. To predict the reaction mechanism of various rearrangement reactions
3. To illustrate various alkylating agents using carbanion intermediate
4. To understand and apply various spectroscopic techniques for predicting organic compounds

Unit-I

1.1. Introduction to Molecular Orbital Theory for Organic Chemistry: (7 L)

1.1.1. Molecular orbitals: Formation of σ-and π-MOs by using LCAO method. Formationof π MOs of ethylene, butadiene, 1, 3, 5-hexatriene, allyl cation, anion and radical. Concept of nodal planes and energies of π-MOs

1.1.2. Introduction to FMOs: HOMO and LUMO and significance of HOMO-LUMO gapin absorption spectra as well as chemical reactions. MOs of formaldehyde: The effect of electronegativity perturbation and orbital polarization in formaldehyde. HOMO and LUMO (π and π* orbitals) of formaldehyde. A brief description of MOs of nucleophiles and electrophiles. Concept of 'donor-acceptor' interactions in nucleophilic addition

reactions on formaldehyde. Connection of this HOMO-LUMO interaction with 'curved arrows' used in reaction mechanisms. The concept of hardness and softness and its application to electrophiles and nucleophiles. Examples of hard and soft nucleophiles/ electrophiles. Identification of hard and soft reactive sites on the basis of MOs.

1.1.3. Application of FMO concepts in (a) $S_N2$reaction, (b) Lewis acid base adducts (BF_3-NH_3 complex), (c) ethylene dimerization to butadiene, (d) Diels-Alder cycloaddition, (e) regioselective reaction of allyl cation with allyl anion (f) addition of hydride to formaldehyde.

1.2. Applications of UV and IR spectroscopy: (8 L)

1.2.1. Ultraviolet spectroscopy: Recapitulation, UV spectra of dienes, conjugated polyenes(cyclic and acyclic), carbonyl and unsaturated carbonyl compounds, substituted aromatic compounds. Factors affecting the position and intensity of UV bands – effect of conjugation, steric factor, pH, and solvent polarity. Calculation of absorption maxima for above classes of compounds by Woodward-Fieser rules (using Woodward-Fieser tables for values for substituents).

1.2.2. Infrared spectroscopy: Fundamental, overtone and combination bands, vibrationalcoupling, factors affecting vibrational frequency (atomic weight, conjugation, ring size, solvent and hydrogen bonding). Characteristic vibrational frequencies for alkanes, alkenes, alkynes, aromatics, alcohols, ethers, phenols, amines, nitriles and nitro compounds. Detailed study of vibrational frequencies of carbonyl compounds, aldehydes, ketones, esters, amides, acids, acid halides, anhydrides, lactones, lactams and conjugated carbonyl compounds.

Unit II

Reactions and Rearrangements: (15 L)

Mechanisms, stereochemistry (if applicable) and applications of the following:

2.1. Reactions: Baylis-Hilman reaction, McMurry Coupling, Nefreaction, Passerini reaction.

2.2. Concerted rearrangements: Hofmann, Curtius, Lossen, Schmidt, Wolff.

2.3. Cationic rearrangements: Tiffeneau-Demjanov, Pummerer, Dienone-phenol, Rupe,Wagner-Meerwein.

2.4. Anionic rearrangements: Brook, Neber, Von Richter, Wittig, Gabriel–Colman,.

Unit III

3.1. Alkylation of Nucleophilic Carbon Intermediates: (7 L)

3.1.1. Generation of carbanion, kinetic and thermodynamic enolate formation, Regioselectivity in enolate formation, alkylation of enolates.

3.1.2. Generation and alkylation of dianion, medium effects in the alkylation of enolates, oxygen versus carbon as the site of alkylation.

3.1.3. Alkylation of aldehydes, ketones, esters, amides and nitriles.

3.1.4. Nitrogen analogs of enols and enolates- Enamines and Imines anions, alkylation of enamines and imines.

3.1.5. Alkylation of carbon nucleophiles by conjugate addition (Michael reaction).

3.2. Reaction of carbon nucleophiles with carbonyl groups: (8 L)

3.2.1. Mechanism of Acid and base catalyzed Aldol condensation, Mixed Aldol condensation with aromatic aldehydes, regiochemistry in mixed reactions of aliphatic aldehydes and ketones, intramolecular Aldol reaction and Robinson annulation.

3.2.2. Addition reactions with amines and iminium ions; Mannich reaction.

3.2.3. Amine catalyzed condensation reaction: Knoevenagel reaction.

Unit-IV

NMR spectroscopy and Mass spectrometry (15 L)

4.1. Proton magnetic resonance spectroscopy: Principle, Chemical shift, Factorsaffecting chemical shift (Electronegativity, H-bonding, Anisotropy effects). Chemical and magnetic equivalence, Chemical shift values and correlation for protons bonded to carbon and other nuclei as in alcohols, phenols, enols, carboxylic acids, amines, amides. Spin-spin coupling, Coupling constant (J), Factors affecting J, geminal, vicinal and long range coupling (allylic and aromatic). First order spectra, Karplus equation.

4.2. ^{13}C NMR spectroscopy: Theory and comparison with proton NMR, proton coupledand decoupled spectra, off-resonance decoupling. Factors influencing carbon shifts, correlation of chemical shifts of aliphatic, olefin, alkyne, aromatic and carbonyl carbons.

4.3. Mass spectrometry:. Introduction to Mass spectra, Fragmentation pattern in various classes of organic compounds (including compounds containing hetero atoms), McLafferty rearrangement, Retro-Diels-Alder reaction, ortho effect.

4.4. Structure determination involving individual or combined use of the above spectral techniques.

References:

1. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A, page no. 713-769, and B, Plenum Press.
3. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley.
4. Organic Chemistry, R.T. Morrison, R.N. Boyd and S.K. Bhattacharjee, Pearson Publication (7^{th} Edition)
5. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education.
6. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.
7. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press.
8. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press.
9. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes.
10. Advanced Organic Chemistry: Reactions and Mechanisms, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education.
11. Mechanism in Organic Chemistry, Peter Sykes, 6^{th}

Organic Chemistry Practical (2 credit)
Course Code: CHEP453

Course Outcomes

1. To enhance the separation techniques for organic compounds
2. To understand solubility of organic compound in different solvents

3. Determination of type and functional group of the organic compound

Separation of Binary mixture using micro-scale technique

1. Separation of binary mixture using physical and chemical methods.

2. Characterization of one of the components with the help of chemical analysis and confirmation of the structure with the help of derivative preparation and its physical constant.

3. Purification and determination of mass and physical constant of the second component.

The following types are expected:

(i) Water soluble/water insoluble solid and water insoluble solid,

(ii) Non-volatile liquid-Non-volatile liquid (chemical separation)

(iii) Water-insoluble solid-Non-volatile liquid.

Minimum three mixtures from each type and a total of ten mixtures are expected.

Reference:

6. Systematic Qualitative organic analysis, H. Middleton (Orient Longman)
7. A Handbook of Organic Analysis, H.T. Clark (Orient Longman)
8. Systematic Identification of organic compounds, R.L. Shriner (John Wiley, New York)
9. Practical Organic Chemistry by Mann and Saunders.
10. Advance Practical Organic Chemistry, N.K. Vishnoi, Vikas Publication

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CHE454A :CHROMATOGRAPHY AND SPECTROSCOPIC TECHNIQUES

Course Outcomes

1. To study different cinematographic techniques.
2. To study instrumentation of Gas Chromatography
3. To study Applications of HPLC

Unit I 2

I Chromatographic Techniques (15)

a) Recapitulation of basic concepts in chromatography: Classification of chromatographic methods, requirements of an ideal detector, types of detectors in LC and GC, comparative account of detectors with reference to their applications (LC and GC respectively), qualitative and quantitative analysis.[2 L]

b) Concept of plate and rate theories in chromatography: efficiency, resolution, selectivity and separation capability. Van Deemter equation and broadening of chromatographic peaks. Optimization of chromatographic conditions.[5 L]

c) Gas Chromatography: Instrumentation of GC with special reference to sample injection systems – split/splitless, column types, solid/ liquid stationary phases, column switching techniques, temperature programming, Thermionic and mass spectrometric detector, Applications. [3 L]

d) High Performance Liquid Chromatography (HPLC): Normal phase and reversed phase with special reference to types of commercially available columns (Use of C8 and C18 columns). Diode array type and fluorescence detector, Applications of HPLC. Chiral and ion chromatography. [5 L]

II Spectroscopic Methods (15)

a) X-ray spectroscopy: principle, instrumentation andapplications of X-ray fluorescence, absorptionand diffraction spectroscopy. (4L)

b) Mass spectrometry: recapitulation, instrumentation, ion sources for molecular studies, electron impact, field ionization, field desorption, chemical ionization and fast atom bombardment, Electro spray ionization (ESI) and Matrix-assisted desorption-ionization (MALDI) sources. Mass analyzers: Quadrupole, time of flight, ion trap, Magnetic Sector and Hybrid. Applications.

III Surface Analytical Techniques & Atomic Spectroscopy (15)

a) Surface Analytical Techniques: Introduction, Principle, Instrumentation and Applications of: Scanning Electron Microscopy (SEM), Scanning Tunneling Microscopy (STM) Transmission Electron Microscopy (TEM)

b) Electron Spectroscopy: principles,instrumentation and applications of the followingESCA (XPS), AUGER and UPS.

c) Atomic Spectroscopy: Advantages and Limitations of AAS, Atomic Spectroscopy based on plasma sources Introduction, Principle, Instrumentation andApplications.

References:

1. Principles of Instrumental Analysis - Skoog, Holler and Nieman, 5th Edition.
2. Analytical Chemistry Principles – John H Kennedy, 2nd edition, Saunders College Publishing1990.
3. Modern Analytical Chemistry David Harvey; McGraw Hill Higher education publishers, 2000.
4. Vogel's Text book of quantitative chemical analysis, 6th edition, Pearson Education Limited,2007.
5. Electrochemical Methods Fundamentals and Applications, Allen J Bard and Larry R Faulkner,John Wiley and Sons, 1980.
6. Instrumental Methods of Analysis Willard, Merrit, Dean and Settle, 7thedition,

CBS publishers.
7. Analytical chemistry by Garry D Christian,6th edition, John Wiley & Sons.
8. R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill Publisher.
9. Fundamentals of Analytical Chemistry, By Douglas A. Skoog, Donald M. West, F. JamesHoller, Stanley R. Crouch, 9th Edition, 2004.

CHEP454A: CHROMATOGRAPHY AND SPECTROSCOPIC TECHNIQUES

Practical

Course Outcomes

1. To determine amount of metal ions in given sample spectrophotometrically
2. To determine the percentage purity of a sample
3. To Evaluate amount of metals in given mixture of two by simultaneous spectrphotometry.
4. To evaluate percentage composition of two acids in mixture by conductometric titration.
5. To apply standard addition method for estimation of potassium in fertilizer by flame photometry

	Analytical Chemistry	**Credits**
1	. To determine percentage purity of sodium carbonate in washing soda pH metrically.	**2**
2.	To determine amount of Ti(III) and Fe(II) in a mixture by titration with Ce(IV) potentiometrically.	
3.	To determine the percentage purity of a sample (glycine/sodium benzoate/primary amine) by titrationwith perchloric acid in a non aqueous medium using glass calomel system potentiometrically.	
4.	To determine the amount of nitrite present in the given water sample colorimetrically.	
5.	To determine the amount of Fe(II) and Fe(III) in a mixture using 1,10-phenanthroline spectrophotometrically.	
6.	Simultaneous determination of Cr(VI) and Mn(VII) in a mixture spectrophotometrically.	
7.	To determine the percentage composition of HCl and H_2SO_4 on weight basis in a mixture of two by conductometric titration with NaOH and $BaCl_2$.	
8.	To determine amount of potassium in the given sampleof fertilizers using flame photometer by standard addition method.	

Reference:

G H Jeffery, J Bassett, J Mendhem, R C Denney, Vogel's Textbook Of Quantitative Chemical Analysis, 3rd Edition, Longman Scientific & Technical,1989

CHE454B: ENVIRONMENTAL ANALYTICAL CHEMISTRY 2 Credit

Course Outcomes

1. To study sources, consequences and remedies for prevention of soil pollution and radioactive pollution.
2. To study detection and monitoring techniques of radioactive pollutants and methods of safe disposal of radioactive waste.
3. To study sources of water pollution, types of water pollutants and parameters of water analysis.
4. To understand the health effects of various heavy metals and different instrumental techniques analysis of heavy metals.
5. To study water pollution laws and standards

Unit

Unit I	**Soil and Radio Active pollution** Segments of atmosphere Soil pollution: Definition; Sources; Man made and natural-Agricultural, Domestic, Industries, Mining Causes, Consequences and remedies for prevention. Radioactive Pollution: Sources of pollutants; effect of vegetation and health. Detection and monitoring of radioactive pollutants. Methods of safe disposal of radioactive waste.	**(15)**
Unit II	**Water Pollution:** Origin of waste water, types of water pollutants and their effects; sources of water pollution; domestic, industrial and agricultural soil has source of pollution. Objectives of analysis. Parameters of analysis; colour, turbidity, total solids, conductivity, acidity, alkalinity and hardness, chloride, sulphate, fluoride, silica, phosphate and different forms of nitrogen.	**(15)**
Unit III	**Heavy Metal Pollution:** Public health significance of cadmium, chromium, copper, lead, zinc, manganese, mercury and arsenic. General survey in instrumental techniques for the analysis of heavy metals in aquatic systems; pesticides as water pollutants and their analysis; water pollution laws and standards	**(15)**

REFERENCES

1. Standard Methods for Chemical Analysis, A.J Welcher (Part-B), Robort E Kiegor Publishing Co., USA, 1975.
2. Environmental Chemistry, S.E Manahar, Willard Graut Press, London, 1983.
3. Environmental Chemistry, A.K De, Wiley Eastern Publishers.
4. Environmental Chemistry, B.K Sharma, Himalaya Publishing House.
5. Environmental Chemistry, C. Baird & W.H Freeman.

CHEP454B Practical

Course Outcomes

6. To determine amount of metal ions in given sample spectrophotometrically
7. To determine the percentage purity of a sample
8. To Evaluate amount of metals in given mixture of two by simultaneous spectrphotometry.
9. To evaluate percentage composition of two acids in mixture by conductometric titration.
10. To apply standard addition method for estimation of potassium in fertilizer by flame photometry

	Analytical Chemistry	**Credits**
1.	To determine percentage purity of sodium carbonate in washing soda pH metrically.	**2**
2.	To determine amount of Ti(III) and Fe(II) in a mixture by titration with Ce(IV) potentiometrically.	
3.	To determine the percentage purity of a sample (glycine/sodium benzoate/primary amine) by titrationwith perchloric acid in a non aqueous medium using glass calomel system potentiometrically.	
4.	To determine the amount of nitrite present in the given water sample colorimetrically.	
5.	To determine the amount of Fe(II) and Fe(III) in a mixture using 1,10-phenanthroline spectrophotometrically.	
6.	Simultaneous determination of Cr(VI) and Mn(VII) in a mixture spectrophotometrically.	
7.	To determine the percentage composition of HCl and H_2SO_4 on weight basis in a mixture of two by conductometric titration with NaOH and $BaCl_2$.	
8.	To determine amount of potassium in the given sampleof fertilizers using flame photometer by standard addition method.	

Reference:

G H Jeffery, J Bassett, J Mendhem, R C Denney, Vogel's Textbook Of Quantitative Chemical Analysis, 3rd Edition, Longman Scientific & Technical,1989