AC – 07/07/2023
Item No. – 6.9 (N)

As Per NEP 2020

University of Mumbai

Title of the program

A- P.G. Diploma in Industrial Polymer Chemistry
B- M.Sc. (Industrial Polymer Chemistry) (Two Year) } **2023-24**
C-M.Sc. (Industrial Polymer Chemistry) (One Year) - **2027-28**

Syllabus for the
Semester – Sem I & II

Department of Chemistry (Autonomous)
in collaboration with
Indian Rubber Manufacturers Research Association, Thane

Ref: GR dated 16th May, 2023 for Credit Structure of PG

Preamble

1) Introduction

This program is designed to provide a comprehensive and in-depth understanding of the fascinating world of Industrial Polymer Chemistry. Through a rigorous academic curriculum and hands-on research experience, we aim to nurture the intellectual curiosity and scientific acumen of our students, preparing them for successful careers in various sectors of the chemical sciences. The M.Sc. (Industrial Polymer Chemistry) course is structured to equip students with a strong theoretical foundation, practical skills, and critical thinking abilities necessary to address the challenges and opportunities in the diverse fields of chemistry. Our esteemed faculty members are experts in their respective fields, with a passion for both teaching and research. They are committed to providing a nurturing learning environment, encouraging open discussions, and fostering collaborative research endeavors. Through their mentorship, students will have the opportunity to engage in cutting-edge research projects, pushing the boundaries of scientific knowledge and contributing to the advancement of the chemical sciences.

We envision our M.Sc. (Industrial Polymer Chemistry) postgraduates act as catalysts for positive change, equipped to drive innovation, shape industries, and address societal challenges through their expertise in chemistry. Whether your passion lies in research, industry, education, or beyond, our program aims to provide the knowledge and skills necessary to excel in your chosen path.

2) Aims and Objectives

The aims and objectives of M.Sc. (Industrial Polymer Chemistry) course are designed to provide students with a well-rounded and advanced education in the field of Analytical chemistry. These goals focus on equipping students with a deep understanding of chemical principles, fostering research and analytical skills, and preparing them for successful careers in various sectors of the chemical sciences.

The M.Sc. (Industrial Polymer Chemistry) course aims to produce skilled and knowledgeable professionals who can contribute to scientific research, industrial innovation, and the betterment of society through their expertise in Industrial polymer chemistry.

3) Learning Outcomes

The learning outcomes of an M.Sc. (Industrial Polymer Chemistry) course are designed to equip students with a comprehensive and advanced understanding of the field of chemistry. These learning outcomes reflect the knowledge, skills, and competencies that students are expected to gain upon successful completion of the program.

4) Any other point (if any) : The skills and knowledge acquired during this master's program will make the students well-equipped for diverse roles.

5) Credit Structure of the M.Sc. (Industrial Polymer Chemistry) (Sem I, II, III & IV) (Table as per परिशिष्ट-1 with sign of HOD and Dean)

R _____

Post Graduate Program: M.Sc. (Industrial Polymer Chemistry)

परिशिष्ट-1

[1)]

Year	Level	Sem	Major				RM	OJT/ FP	RP	Cum. Cr.	Degree
			Mandatory			Electives					
1	6.0	Sem I	3*4+ 2=14			4	4		-	22	PG Diploma (after 3 Years Degree)
			Physical Chemistry-I (112016150111)	TH	4	Analytical Chemistry-I (112016150511) **(OR)** Applied Industrial Chemistry-I (112016150512)	Research Methodology (112016150611)				
			Inorganic Chemistry-I (112016150211)	TH	4						
			Organic Chemistry-I (112016150311)	TH	4						
			Chemistry Practical-I (112016150411)	PR	2						
		Sem II	3*4+ 2=14			4	-	4 (11201625121 1)	-	22	
			Physical Chemistry-II (112016250711)	TH	4	Analytical Chemistry-II (112016251111) **(OR)** Applied Industrial Chemistry-II (112016251112)					
			Inorganic Chemistry-II (112016250811)	TH	4						
			Organic Chemistry-II (112016250911)	TH	4						
			Chemistry Practical-II (CHEM 510)/ 112016251011	PR	2						
Cum. Cr. For PG Diploma			28			8	4	4		44	
Exit Option: PG Diploma (44 credits) after Three Year UG Degree											

Year	Level	Sem (2yr)	Major				RM	OJT/FP	RP	Cum. Cr.	Degree
2	6.5	Sem III	3*4+ 2=14			4	-	-	(CHEM 686) 4	22	PG Degree after 3-yr UG or PG Degree after 4-yr UG
			Basics of Polymer, Rubber and Additives (CHEM 681)	TH	4	Biopolymers and Biocomposites (CHEM 68511) OR Advanced Topics in Rubber Chemistry-I (CHEM 68512)					
			Rheology and Processing Rubbers (CHEM 682)	TH	4						
			Testing of Rubber, allied materials and composites (CHEM 683)	TH	4						
			Industrial Polymer Chemistry Practical (CHEM 684)	PR	2						
		Sem IV	3*4=12			4	-	-	(CHEM 691) 6	22	
			Design and Development of Rubber Products (CHEM 687)	TH	4	Polymer Nano Composites (CHEM 69011) **(OR)** Advanced Topics in Rubber Chemistry-II (CHEM 69012)					
			Latex Science and Adhesives (CHEM 688)	TH	4						
			Tyre Science and Technology (CHEM 689)	TH	4						
Cum. Cr. For 1 Yr PG Degree			26			8			10	44	
Cum. Cr. For 2 Yr PG Degree			54			16	4	4	10	88	

Sign of HOD

Prof. Shivram S. Garje
Head of Department,
Department of Chemistry,
University of Mumbai

HEAD
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF MUMBAI

Sign of Dean,

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai

Syllabus for
M.Sc. (Industrial Polymer Chemistry)
(Sem. I & II)

Department of Chemistry
(Autonomous)
UNIVERSITY OF MUMBAI

Syllabus for M.Sc. (Industrial Polymer Chemistry)
Semester I and II

Under New Education Policy (NEP) 2020
(To be implemented from the academic year, 2023-2024)

PROGRAM OUTLINE 2023-2024

YEAR		COURSE CODE	COURSE TITLE	CREDITS
M.Sc. Sem-I	Mandatory Course-I	112016150111	Physical Chemistry-I	04
	Mandatory Course-II	112016150211	Inorganic Chemistry-I	04
	Mandatory Course-III	112016150311	Organic Chemistry-I	04
	Mandatory Course Practical	112016150411	Chemistry Practical-I	02
	Elective 1	112016150511	Analytical Chemistry-I	04
	Elective 2	112016150512	Applied Industrial Chemistry-I	04
	RM	112016150611	Research Methodology	04
M.Sc. Sem-II	Mandatory Course-I	112016250711	Physical Chemistry-II	04
	Mandatory Course-II	112016250811	Inorganic Chemistry-II	04
	Mandatory Course-III	112016250911	Organic Chemistry-II	04
	Mandatory Course Practical	112016251011	Chemistry Practical-II	02
	Elective 1	112016251111	Analytical Chemistry-II	04

	Elective 2	112016251112	Applied Industrial Chemistry-II	04
	OJT/FP	112016251211	Industrial Training/Field Project	04

PROGRAMME SPECIFIC OUTCOME (PSOs)

1. Gain knowledge of the advanced concepts in the branch of chemistry, identify and accomplish a solution to problems encountered in the field of research and analysis.

2. Apply the basic knowledge of chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the global standards.

3. Deduce qualitative and quantitative information of chemical compounds using advanced spectroscopic methods which can further be analysed using practical skills inculcated in them during the course.

4. Imbibe the attitude as well as aptitude of a scientific approach along with analytical reasoning with respect to the novel techniques actually implemented in the Industry.

5. Use the subject knowledge, communication and ICT skills to become an effective team leader/team member in the interdisciplinary fields.

6. Understand, Manage and contribute to solve basic societal issues and environmental concerns ethically based on principles of scientific knowledge gained.

7. Exhibit professional work ethics and norms of scientific development.

PROGRAM(s): M.Sc.-I	SEMESTER: I
Course: Paper-I	Course Code: (112016150111) Course Title:- Physical Chemistry-I

Teaching Scheme				Evaluation Scheme
Lectures (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks-50)	Semester End Examination (Marks- 50)
04	–	04	50	50

Learning Objectives:

1.To enable learners to have comprehensive knowledge and understanding of the advanced concepts in reaction kinetics, molecular dynamics and chemical thermodynamics.

2. To apply the basic knowledge of Physical chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.

3. Accomplish a solution to problems encountered in the field of research.

Course Outcomes:

1. The learners will apply the advanced thermodynamics, Maxwell equation and its applications to ideal gasses.
2. The learners evaluate the different theories of chemical kinetics and effect of temperature on reaction rates.
3. The learners will implement the applications of chemical thermodynamics to real gases, solutions, surfaces and their energetics.
4. The learners will understand the applications of operators and Schrodinger equation in the field of quantum Chemistry.
5. The learners will evaluate the resting membrane potential by using the concept of bio electrochemistry.
6. The learners will try to accomplish a solution to problems encountered in the field of research.

Semester – I

Paper -I

Course Code: 112016150111
PHYSICAL CHEMISTRY-I

Unit-I THERMODYNAMICS-I [15L]

State function, exact and inexact differentials, Internal energy, Enthalpy, Heat capacity, Relation between C_p and C_v, Limitations of first law of thermodynamics, Joule-Thomson experiment, Joule-Thomson coefficient, Joule-Thomson coefficient for real and an ideal gas, Inversion temperature

Absolute temperature, Spontaneous or irreversible process, Entropy, Thermodynamic equation of state, Maxwell relation, Helmholtz and Gibbs free energy, Third law of thermodynamics, Nernst heat theorem, Determination of absolute entropies, entropy changes in chemical reaction, residual entropy.

Unit-II FUNDAMENTAL ASPECTS OF QUANTUM CHEMISTRY (15L)

Introduction: Historical background, Old Vs New Quantum Theory, Heisenberg's Uncertainty Principle, The wave nature of matter

Fundamental Background: Postulates of Quantum Chemistry, Commutators of operators, Properties of Linear and Hermitian operators, Operators for the dynamic variables of a system such as position, linear momentum, angular momentum and total energy, Expectation Value,

Progressive and standing waves, Conditions on the wave function and its interpretation, Normalization and orthogonality, Separation of variables, Obtaining Schrödinger's time independent wave equation from Schrödinger's time dependent wave equation.

Application of Quantum Chemistry in Translation motion: Particle in one dimension box: Differential equation and its solution, Graphical representation of wavefunctions and probability densities, Normalization and orthogonality of wave functions. Even and Odd Functions.

Particle in a two- and three-dimensional box: Differential equation and its solution, Degeneracy, Energy level Diagram.

Unit-III PHASE RULE AND ITS APPLICATIONS [15L]

Recapitulation: - Phase rule, Phase diagrams and their classification, Lambda transition.

Two component Liquid systems:

Completely Miscible Liquid Systems: - Vapor pressure – composition diagrams, Temperature-Composition Diagram, fractional distillation of Zeotropic and Azeotropic mixtures.

Partially Miscible Liquid Systems: - Temperature Composition diagram, Critical solution temperature, influence of foreign substances (impurities) on CST.

Three component Liquid systems:

Type I-Formation of one pair of partially miscible liquids: Graphical representations, binodal curves, plait point, influence of temperature-System showing real critical solution temperature, System showing no real critical solution temperature.

Type II-Formation of two pairs of partially miscible liquids.

Type III-Formation of three pairs of partially miscible liquids

Influence of impurities on ternary system, Ternary Azeotropic mixtures, Preparation of absolute alcohol by azeotropic elimination of water.

Unit-IV CHEMICAL KINETICS [15L]

Accounting for the rate laws: simple reactions, temperature dependence of reaction rates, consecutive reactions,(rate determining step approximation and steady-state approximation), unimolecular reactions – Lindemann-Hinshelwood mechanism.

Kinetics of complex reactions - Chain reactions, polymerization reactions, explosions, photochemical reactions.

Fast reactions: Study of kinetics by flow methods, relaxation methods, flash photolysis, magnetic resonance method, shock tube method.

****Derivation not expected***

Note: Numerical and theoretical problems from each Unit- are expected.

References books:

1. Peter Atkins and Julio de Paula, *Atkin's Physical Chemistry*, 7th ed., 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 ed., John Wiley and Sons (Asia) Pte. Ltd., 2002.
4. Ira R. Levine, *Physical Chemistry*, 5th ed., Tata McGraw-Hill, New Delhi, 2002.
5. G. W. Castellan, *Physical Chemistry*, 3rd ed., Narosa Publishing House, New Delhi, 1983.
6. D. A. McQuarrie and J. D. Simon, *Physical Chemistry - a molecular approach*, Viva Books Private Limited, New Delhi, 1998.
7. S. Glasstone, Text Book of Physical Chemistry, 2nd ed., McMillan and Co. Ltd., London, 1962.
8. D. A. McQuarrie, *Quantum Chemistry*, Viva Books Private Limited, New Delhi, first Indian ed., 2003.
9. B. K. Sen, *Quantum Chemistry including spectroscopy*, Kalyani Publishers, 2003.
10. A. K. Chandra, *Introductory Quantum Chemistry*, Tata Mc Graw-Hill, 1994.
11. R. K. Prasad, *Quantum Chemistry*, 2nd ed., New Age International Publishers, 2000.
12. D. O. Hayward, *Quantum Mechanics for Chemists*, Royal Society for Chemists, 2002.
13. Sydney T. Bowden, *The phase rule and the phase reaction*, McMillan and Co. Ltd., London, 1938.
14. A. N. Cambell, Alexander Findlay, *The Phase Rule and its Applications*, Dover publications.
15. G. L. Agarwal, *Basics Chemical kinetics*, Tata Mcgraw Hill, New Delhi.
16. K. J. Laidler, *Chemical Kinetics*, 3rd ed., Pearson Education.
17. R. P. Rastogi, R. R. Mishra, *An Introduction to Chemical Thermodynamics*, Vikas Publishing House Pvt. Ltd.

List of Books for further reading:

1. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964.
2. W. G. Davis, *Introduction to Chemical Thermodynamics – A Non-Calculus Approach*, Saunders, Philadelphia, 1972.
3. I. M. Klotz and R. M. Rosenberg, *Chemical Thermodynamics*, 5th ed., John Wiley and Sons, Inc., 1994.
4. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.

5. Ira N. Levine, *Quantum Chemistry*, 5th ed., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
6. J. P. Lowe, *Quantum Chemistry*, 2nd ed., Academic Press, New York, 1993.
7. R. Anantharaman, *Fundamentals of Quantum Chemistry*, McMillan India Limited, 2001.
8. Mahendra R. Awode, *Quantum Chemistry*, S. Chand and Co. Ltd., New Delhi, 2002.

PROGRAM(s): M.Sc.-I	SEMESTER: I			
Course: Paper-II	Course Code: (112016150211) Course Title:- Inorganic Chemistry-I			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks-50)**	**Semester End Examination (Marks- 50)**
04	**–**	**04**	**50**	**50**

Learning Objectives:

1. To develop the ability to predict the feasibility and pathways of different chemical reactions.
2. To learn about the existence of various weak chemical forces and their effects on the physical properties of molecules.

Course outcomes:

1. The learner will gain an understanding of various mechanisms involved in inorganic chemical reaction.
2. The learner will acquire knowledge about the various aspects of organometallic compounds.
3. The learner will gain understanding of various weak intermolecular forces and wavefunction representation of different hybridization.
4. The learner will know the important fundamental concept of chemical reactivity of different entities.

Paper II

Course Code: 112016150211
INORGANIC CHEMISTRY-I

UNIT I: INORGANIC REACTION MECHANISMS [15 L]

(i) Rate of reactions, factors affecting the rate of reactions; techniques for the determination of rate of reactions. (Direct chemical analysis, spectrophotometric methods, polarimetric method, electrochemical and flow methods).

(ii) Mechanisms and factors affecting the ligand substitution reactions of (a) octahedral complexes with and without breaking of metal-ligand bond, stereochemistry of substitution reactions of octahedral complexes. (b) square planar complexes – trans-effect, its theories and applications and (c) tetrahedral complexes;

(iii) Redox reactions: inner and outer sphere mechanisms. Complimentary and non-complimentary reactions.

(iv) Isomerization and racemization reactions.

UNIT II : ORGANOMETALLIC CHEMISTRY [15 L]

(i) Recapitulation of classification of organometallic compounds, electron counting and eighteen electron rule.

(ii) Sixteen electron square planar complexes.

(iii) Synthesis, structure and bonding of the following organometallic compounds: (a) Alkyl and Aryl derivatives, (b) Carbenes and Carbynes, (c) Alkene complexes, (d) Alkyne complexes, (e) Allyl complexes, (f) Cyclopentadiene complexes and (g) Arene complexes (sandwich and half sandwich complexes).

UNIT III : CHEMICAL BONDING [15L]

(i) Hybridization: Derivation of wave functions for the following orbital hybridisation types: sp (BeH_2); sp^2 (BF_3); sp^3 (CH_4) considering only sigma bonding.

(ii) Molecular Orbital Theory (LCAO-MO approach) for Electron deficient and Electron rich species.

(iii) Weak intermolecular forces: Hydrogen bonding: concept, types, properties, and importance. Van der Waal's forces: ion-dipole, dipole-dipole, London forces.

(iv) Bent's Rule: Reactivity of molecules: e.g. chlorofluorides of phosphorous, fluoromethanes, etc.

UNIT IV: CHEMICAL REACTIVITY [15 L]

(i) Recapitulation of acidity of cations and basicity of anions. Hard soft acids and bases (HSAB) principle, Acid-base strength and softness and hardness.

(ii) Oxoanions, oxocations, Classification of oxoacids based on Pauling's rules, structural anomalies.

(iii) Classification of Lewis acids and bases based on Frontier Molecular orbital topology, Reactivity matrix of Lewis acids and bases; Group13-17 Lewis acids, superacids and bases. Heterogeneous acid base reactions.

(iv) Redox properties of the elements: Latimer diagram: Construction of the diagram, non-adjacent species and disproportionation. Frost Diagram: Construction and interpretation. Pourbaix diagram of Iron in natural water.

Reference books

Unit I

1. D. F. Shriver and P. W. Atkins, *Inorganic chemistry*, 3rd edition, Oxford University Press, 1999.
2. C. E. Housecroft and A. G. Sharpe, *Inorganic Chemistry*, Pearson Education Ltd. 2nd Edition, 2005.
3. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Ed., Wiley, 1967.
4. M. L. Tobe and J. Burgess, Inorganic Reaction Mechanism, Longman, 1999.
5. R. G. Wilkins, Kinetics and Mechanism of Reactions of Transition Metal Complexes,VCH, 2nd edition, 1991.

Unit II

1. R. C. Mehrotra and A. Singh, Organometallic Chemistry-A Unified Approach, 2nd Ed., New Age International Pvt. Ltd., 2000.
2. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 6th Ed., Oxford University Press, 2016.
3. P. Ghosh and M.S. Balakrishna, Introduction to Organometallic Chemistry,, Publisher National Programme on Technology Enhanced Learning (NPTEL)
4. J. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Ed., Harper Collins, 1993.

Unit III

1. J. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Ed., Harper Collins, 1993.
2. K. L. Kapoor, A textbook of Physical Chemistry, Volume 4, Mc Millan, 2001.
3. G. Miessler and D. Tarr, Inorganic Chemistry, 3rd Ed., Pearson Education, 2004.
4. B. W. Pfennig, Principles of Inorganic Chemistry, Wiley, 2015.

Unit IV

1. G. Wulfsberg, Inorganic Chemistry, Viva Books Pvt. Ltd., 2002.
2. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Ed., Oxford University Press, 2010.
3. B. W. Pfennig, Principles of Inorganic Chemistry, Wiley, 2015.
4. J. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Ed., Harper Collins, 1993.
5. http://www.meta-synthesis.com/webbook.html

PROGRAM(s): M.Sc.-I			SEMESTER: I
			Course Code: 112016150311 **Course Title:-Organic Chemistry-I**
Teaching Scheme			**Evaluation Scheme**
Lectures (Hours per week)	**Credit**	**Continuous Assessment (CA)** **(Marks- 50)**	**Semester End Examination** **(Marks- 50)**
04	**04**	**50**	**50**

Course Objectives:

1. To enable learners to have conceptual knowledge of organic chemistry to understand detail aspects of physical organic Chemistry.

2. To apply the basic knowledge of chiral chemistry to understand various Stereochemical aspects of Chemistry in detail.

3. To enable learners to understand mechanisms of name reactions and its applications in various pathways of reaction mechanisms.

4. To understand spectroscopic knowledge which provides solutions to problems encountered in structural elucidation of organic compounds.

Course Learning Outcomes.

After completing the course students will be able to:

1. predict the reactivity of organic compound from its structure.
2. understand different methods used for determination of Organic Reaction Mechanism
3. understand the fundamental concept in stereochemistry by applying various symmetry elements of organic molecule.
4. Acquire the knowledge of chirality by taking examples of symmetrical and unsymmetrical molecule.
5. Develop interest in stereochemistry by studying stereochemical features of different classes of organic compounds
2) 6. Understand Organic spectroscopy by problem solving approach for different class of organic compound.

Paper III

Course Code: 112016150311:
ORGANIC CHEMISTRY-I

Unit-I-PHYSICAL ORGANIC CHEMISTRY [15L]

1.1 Acidity-Basicity:

Different concepts and examples; factors affecting acidity and basicity. Electrophilicity and nucleophilicity. Ambident Electrophiles and Nucleophiles. Difference between nucleophilicity and basicity, electrophilicity and acidity.

1.2 Linear Free Energy Relationships:

Effect of structural factors on reactivity. Hammett equation, substituent and reaction constants. Through conjugative effects of substituents. Linear free energy relationships in the determination of reaction mechanism.

1.3 Arrhenius equation and its application to estimate Eact;

Hammond's postulate, principle of microscopic reversibility; Kinetic vs. thermodynamic control.

1.4 Influence of solvent polarity on reaction rates;

Solvent scales (Y-scale), solvatochromism (Z and ET scales); Ionic strengths and salt effect; Acid-base catalysis Bronsted catalysis equation.

Unit-II STEREOCHEMISTRY [15L]

2.1 Molecules with central chirality. Interconversion of projection formulae:

Molecules with central chirality. Tetrahedral geometry for molecules with asymmetric atom. Examples of chiral molecules with carbon, nitrogen, phosphorous, sulphur and silicon atoms in tetra-coordinated / tri-coordinatied states and their relative configurational stabilities. Racemization of nitrogen compounds through pyramidal inversion. Merits and demerits of different projection formulae and interconversion of the same.

2.2 Molecules with two or more chiral centres: Nomenclature for relative configuration for constitutionally unsymmetrical molecules; Erythro-threo and syn-anti. Stereochemistry of constitutionally symmetric molecules with odd and even number of chiral centres; the dissymmetric forms and meso forms. Concept of stereogenic, non-stereogenic, chirotopic, achirotopic and pseudoasymmetric centres. The examples of achirotopic but stereogenic centres and chirotopic but non-stereogenic centres. A lack of direct connection between chirotopicity and stereogenicity.

2.3 Axial and Planar chirality: Principles, stereochemical features, configurational descriptors of axial, planar chirality. Helicity as a sub-class of molecules with chiral axis. Stereochemical features and configurational descriptors of allenes, alkylidene

cycloalkanes, spiranes, biaryls (including binaphthyls), ansa compounds, cyclophanes and helicenes.

2.4 Concept of prochirality, homotopic, enantiotopic and diastereotopic ligands and faces. Criteria based on symmetry and substitution/addition. Notations of prochirality for all classes of molecules. Notation for molecules with pro-pseudosymmetric centres. Notations for molecules with presence of a chiral and a pro-chiral centres. Top-right mnemonic. Discrimination / recognition of stereo-heterotopic ligands and faces by chemical reagents/catalysts and NMR.

Unit-III METHODS OF C-C BOND FORMATION USING THE CARBONYL FUNCTON [15L]

3.1 Reactivity of carbonyl group, Enols and enolates- Regioselective kinetic and thermodynamic enolate formation using LDA. Different types of aldol condensations under acid and base catalysis

3.2 Generation of dianion derived from active methylene compounds and regioselective C-C bond formation on unstabilized site

3.3 Mechanism, stereochemistry and applications of the following reactions:Claisen, Darzen, Dieckman, Beckman, Knoevenagel, Mannich, Michael, Robinson Annulation and Stobbe.

3.4 Enamines as enolate equivalents. Metalloenamines, Synthesis of enamines and selected C-C bond formation.

Unit- IV SPECTROSCOPY [15L]

4.1 UV-Visible Spectroscopy: Recapitulation of basic concepts and sample handling. Woodward-Fieser rules for calculation of λ_{Max} of conjugated dienes, polyenes, enones and aromatic carbonyl compounds.

Problems based on Woodward-Fieser rules.

4.2 IR Spectroscopy: Recapitulation of basic concepts and sample handling. Group frequencies and their use in detection and identification of functional groups.

4.3 PMR Spectroscopy: Recapitulation of basic concepts and sample handling. Prediction of structure of organic compounds based on the use of chemical shift and J values.

4.4 Mass Spectrometry: Recapitulation of basic concepts and sample handling. Fragmentation Pattern of major classes of organic compounds, Retro-Diels Alder reaction, McLafferty rearrangement and ortho effect.

4.5 Structure determination of organic compounds involving individual or combined use of the above spectral techniques.

References Books:

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 and B, Plenum Press.
3. Stereochemistry: Conformation and mechamism, P.S. Kalsi, New Age International, New Delhi.
4. Stereochemistry of carbon compounds, E.L Eliel, S.H Wilen and L.N Manden, Wiley.
5. Stereochemistry of Organic Compounds- Principles and Applications, D. Nasipuri. New International Publishers Ltd.
6. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley.
7. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education.
8. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.

<table>
<tr><td colspan="3">PROGRAM(s): M.Sc.-I</td><td>SEMESTER: I</td></tr>
<tr><td colspan="3"></td><td>Course Code: 112016150511
Course Title:-Analytical Chemistry-I</td></tr>
<tr><td colspan="3">Teaching Scheme</td><td>Evaluation Scheme</td></tr>
<tr><td>Lectures (Hours per week)</td><td>Credit</td><td>Continuous Assessment (CA)
(Marks- 50)</td><td>Semester End Examination
(Marks- 50)</td></tr>
<tr><td>04</td><td>04</td><td>50</td><td>50</td></tr>
<tr><td colspan="4">Course Objectives:
1. To enable learners to have comprehensive knowledge, understanding of the various types of instruments.
2. To create, select and apply appropriate techniques, resources and modern technology in multidisciplinary environment.
3. A research oriented learning that develops analytical and integrative problem-solving approaches.
4. To get hands on various advance techniques with laboratory skills on preparation of various solutions, design of some reactions with its work up and isolation.
5. To enable learners to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.</td></tr>
<tr><td colspan="4">Course Learning Outcomes.
After completion of this Course, the learner will be able to:
1. Understand various terms used in analytical chemistry.
2. Students will be able to classify the analytical methods; select a method for analysis based on performance.
3. Learn the details of atomic absorption spectrometry and its applications to biological and environmental samples.
4. To learn the applications of UV-Visible spectroscopy for the quantitative determination of trace metals in food, blood and urine samples.
5. In AES, construction and working of plasma sources and their applications in geological, metallurgical, food, agricultural, environmental and biological samples.
6. In IR, the concept of Fourier Transform spectroscopy, various instrumentation like dispersive, non-dispersive and FT-types of instruments and their uses in the detection of CO and CO2 in the atmosphere.
7. Also the practical and theory needs to know to the students about the principle and working of Gas Chromatography and High Performance Liquid Chromatography techniques including discussion on carrier gas/liquid supply, sample introduction on-column and injection techniques; analytical columns; detectors, mode of separation and applications in various fields with examples.</td></tr>
</table>

Course Code: 112016150511
ANALYTICAL CHEMISTRY- I

Unit I: Fundamentals in Analytical Chemistry [15L]

1.1 Terms: Precision and Accuracy recapitulations and applications
Criteria for the selection of methods. Regression analysis with respect to applications in research, Chemometrics. [6L]

1.2 Concepts of optical methods: LASER as a source in optical methods, wavelength selectors and their functioning, effective bandwidth. [4L]

1.3 Concepts of Spectroscopy: Concept of Fourier Transform Spectroscopy, IR spectroscopy: Sample handling, instrumentation, advantages of FT-IR. [5L]

Unit II: Atomic and Molecular Spectroscopy: Instrumentation and Applications [15L]

2.1 Atomic Absorption Spectrometry: Recapitulation, Hydride generation technique for trace metal analysis, Cold Vapor technique for the determination of mercury, Importance of electro thermal analyzer in biological samples. [4L]

2.2 Atomic Emission Spectroscopy based on plasma sources, advantages of plasma sources. Applications including sample handling in geo-analysis, metallurgy, agriculture, food samples and environmental analysis. [5L]

2.3 Infrared Spectroscopy (Applications): Non-dispersive IR for detection of environmental gases. [2L]

2.4 UV-Visible Spectroscopy: Derivative and dual wavelength spectroscopy, molecular transitions, application to trace analysis (d-d transition and charge transfer), biological samples and simultaneous determination. [4L]

UNIT III: Separation methods [15L]

3.1 Solvent Extraction and Solid Phase Extraction: Recapitulation of basic concepts of solvent extraction and solid phase extraction. Liquid anion and cation exchangers. Mechanism of extraction. Crown ethers as extractants. Extraction equilibria of metal chelates. Factors favoring solvent extraction of metal chelates. Sorbents. [7L]

3.2 Chromatography: General classification of chromatographic methods. Efficiency, resolution, selectivity and separation capability. Broadening of chromatographic peak and van Deemter equation. Optimization of chromatographic conditions. Qualitative and Quantitative Analysis [8L]

UNIT IV: Column chromatography techniques [15L]

4.1 Gas Chromatography:

Recapitulation of concepts Principle of GLC and GSC; Instrumentation: carrier gas supply, sample introduction systems, packed & capillary columns; choice of detectors and comparative account of Recapitulation of TCD, FID, ECD & thermionic detector. Use of Temperature programming in separations [4L]

4.2 Applications of GC in environmental, pharmaceuticals, agrochemical, food, chemical analysis and forensic sciences. [3L]

4.3 High Performance Liquid Chromatography (HPLC): Principles of HPLC Types of liquid chromatography, Recapitulation of HPLC, Instrument for LC: mobile phase reservoir and solvent treatment systems, pumping systems, sample introduction systems, columns, Detectors: UV, RI, EC and diode array. [5L]

4.4 Applications of HPLC in environmental, pharmaceuticals, agrochemical, food, chemical analysis and forensic sciences. [3L]

References:

1. *Analysis*, 5th ed., Philadelphia: Saunders College Publishing, 1998.
2. D. A. Skoog, D. M. West, F. J. Holler and S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th ed., Philadelphia: Saunders College Publishing, 2004.
3. G. D. Christian, *Analytical Chemistry*, 6th ed., John Wiley and Sons, New York, 2003.
4. G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denney, *Vogel's Textbook of Quantitative Chemical Analysis*, 6th ed., ELBS, Longman Scientific & Technical, England, 2002.
5. H. H. Willard, L. L. Merrit, jr., J. A. Dean and F. A. Settle, Jr., *Instrumental Methods of Analysis*, 6th ed., CBS 1986.
6. R. D. Braun, *Introduction to Instrumental Analysis*, McGraw Hill, 1987.
7. G. H. Morrison and H. Freiser, *Solvent Extraction in Analytical Chemistry*, John Wiley & Sons, New York, 1966.
8. S. M. Khopkar, *Basic concept of Analytical Chemistry*, 3rd ed., Age International Publisher 2008.
9. T. Sekine and Y. Hasegawa, *Solvent Extraction chemistry*, Marcel Dekker, 1977.
10. P. G. Swell and B. Clarke, *Chromatographic Separations*, *Analytical Chemistry by open learning*, John Wiley & Sons, New York, 1987.
11. S. Sindsay, *High Performance Liquid Chromatography*, *Analytical Chemistry by open learning*, John Wiley & Sons, New York, 1987.
12. A. J. Bard and L. R. Faulkner, *Electrochemical Methods*, Wiley, New York, 1980
13. A. M. Bond, *Modern Polarographic Methods in Analytical Chemistry*, Marcel Dekker, New York, 1980.
14. L. C. Thomas and G. J. Chamberline, *Colorimetric Analytical Methods*, 9th ed., The Fintometer Ltd., Salisbury, England, 1980.
15. T. C. Morrili, R. m. Silverstein and G. C. Bassler, *Spectrometric Identification of Organic Compounds*, Wiley, 1981.
16. Vogel's Text Book of Quantitative Organic Analysis, 2th ed. ELBS.
17. R. A. Day, Jr. and A. L. Underwood, *Quantitative Analysis*, 6th ed., Prentice Hall of India Pvt. Ltd., New Delhi, 1993.
18. Jared L. Anderson, Alain Berthod, Veronica Pino, and Apryll M. Stalcup (ed),*Analytical Separation Science (Volume 1-5)*. WILEY-VCH 2015.
19. Jack Cazes (ed) *Ewing's Analytical Instrumentation Handbook,* 3rd edition, Marcel Dekker 2009.

20. R. Kellner, J.M. Mermet, M. Oto, M. Valcarcel, H. M. Widmer (ed), *Analytical Chemistry: A modern Approach to Analytical Science 2nd edition.* WILEY-VCH 2004.
21. Solid phase Extraction- Principles, Techniques and Applications, N. J. K. Simpson, Marcel Dekker, New York, (2000).

Elective II

PROGRAM(s): M.Sc.-I			**SEMESTER: I**
			Course Code: 112016150512 **Course Title:-Applied Industrial Chemistry-I**
Teaching Scheme			**Evaluation Scheme**
Lectures (Hours per week)	**Credit**	**Continuous Assessment (CA)** **(Marks- 50)**	**Semester End Examination** **(Marks- 50)**
04	**04**	**50**	**50**

Course Objectives:

1. To enable learners to have comprehensive knowledge, understanding of the types of instruments with operations and automated methods of analysis.

2. To apply the basic knowledge of quality systems, quality audit and quality managements,.

3. To enable learners to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.

4. To provide solutions to problems encountered in the field of analysis and research.

Course Learning Outcomes.

After completing the course students will be able to:

1) predict the reactivity of organic compound from its structure.
2) understand different methods used for determination of Organic Reaction Mechanism
3) understand the fundamental concept in stereochemistry by applying various symmetry elements of organic molecule.
4) acquire the knowledge of chirality by taking examples of symmetrical and unsymmetrical molecule.
5) develop interest in stereochemistry by studying stereochemical features of different classes of organic compounds
6) identify the nomenclature of various stereochemical phenomena

Course Code: 112016150512
Applied Industrial Chemistry-I

Unit-I [15 L]

Perfumery Chemicals:

Essential oils and their application in cosmetic industries, synthetic preparation of eugenol, geraniol, phenyl ethanol, civetone, Yara-Yara, β-ionone, synthetic musk, musk ketone, ambrette, and xylene, phenylacetic acid and its' esters derivatives, benzyl acetate, Extraction process of naturally occurring perfumery like sandalwood oil, rose oil, and jasmine.

Unit-II [15 L]

Petrochemicals and Biofuels:

Petroleum refining, chemicals derived from ethylene, xylene, and naphthalene.

Types of biofuels (bioethanol, biodiesel), synthesis, properties, standard specification and uses of biofuels, Influence of biofuels on the environment and economy, modification of vegetable oils as biodiesel.

Unit-III [15L]

Paper, pulp, and Leather industry:

Introduction, types of pulping, types, and quality of paper, lignin and lignans, recycling. Introduction, constituents of animal skin, manufacture process, tanning: leather, vegetable, chrome; tanning effluents, pollution control.

Unit-IV [15 L]

Semiconductors in Electronic Industries

Introductions, applications of phosphorus, gallium, indium, germanium and arsenic and their composites in electronic industries, ferrite and magnetic materials, synthesis and characterizations of organic semiconductors, band gap engineering and its applications,.

Recommended Books

1. G. T. Austin, Shrieves Chemical Process Industries, Tata McGraw Hill publication, 2011.
2. M. G. Rao and M. Marshall, Dryden's Outline of Chemical Technology, East west press, 1997.
3. Shah and Pandey, Chemical Technology , Sangam Books Limited, 2000
4. K. R. Smith, Biofuels: Air Pollution and Health, East-West Center, Honolulu, USA, 1987.
5. G. M. Gübitz, M. Mittelbach, M. Trabi, biofuels and Industrial Products from Jatropha Curcas, 1997.
6. B. Billot and F. V. Wells, Perfumery Technology, 1981.
7. P. G .More, Comprehensive Industrial Chemistry, Pragati Prakashan 2018.
8. A. D. Covington, Tanning Chemistry: The Science of Leather, 2015.
9. P. Y. Yu and M. Cardona Fundamentals of Semiconductors: Physics and Materials Properties, 4th Edition, 2010, Springer
10. L. Alcacer, Electronic Structure of Organic Semiconductors: Polymers and Small Molecules, IOP Science and Morgan and Claypool Publishers, UK 2018.

PROGRAM(s): M.Sc.-I	**SEMESTER: I**			
Course: Practical	**Course Code: 112016150411** **Course Title:- Chemistry Practical-I**			
Teaching Scheme				**Evaluation Scheme**
Practical (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks-25)**	**Semester End Examination (Marks- 25)**
16	**NA**	**02**	**25**	**25**

Learning Objectives:

1. To Gain knowledge of the advanced concepts in pH metry, quantum mechanics, potentiometry and conductometry experiments.
2. To understand advance concept of thermodynamics and chemical kinetics in the chemical reactions.
3. To develop scientific temper and research based skills accomplish to encountered in the field of research.
4. The learners will characterize different coordination compounds with the help of conductivity measurements, electronic and magnetic measurements and spectroscopic measurements.
5. The learners will learn to open up different types of Alloys/Ores and carry out a Quantitative Analysis of the elements present in them.

Inorganic:

1. To gain ability to perform inorganic synthetic reactions.
2. To characterize synthesized compounds using different analytical methods.

Course Outcomes :

1. To usage of subject fundamentals-principles with practical knowledge to design experiments, analyze and interpret data so as to reach to proper conclusions.
2. Learner will train the handling of equipments like potentiometer, conductivity meter, colorimeter and spectrophotometer.
3. Learner will develop scientific temper and research based skills accomplish to encountered in the field of research.
4. Apply the knowledge of quantitative analysis for the determination of metals from ores/alloys.
5. Able to understand the analysis of various commercial inorganic compounds.

Inorganic Chemistry

1.The learner will learn to synthesize different coordination compounds.

2. The learner will gain knowledge and hands on experience of different analytical methods to characterize the synthesized coordination compounds.

Course Code: 112016150411
Chemistry Practical-I

Physical Chemistry Practical-I

Instrumental Experiments*:

Conductometry and Potentiometry

1. Titration of a mixture of trichloroacetic acid, monochloroacetic acid and acetic acid with sodium hydroxide conductometrically.
2. Verification of Ostwald's dilution law and determination of the dissociation constant of a weak monobasic acid conductometrically.
3. Study of the effect of substituent on dissociation constant of acetic acid conductometrically.
4. Determination of concentrations and amounts of iodide, bromide and chloride in the mixture by potentiometric titration with silver nitrate.
5. Determination of solubility product of silver chloride potentiometrically using a concentration cell.
6. Determination of the formula of the silver-ammonia complex by potentiometric method.
7. Determination of *pK* values of phosphoric acid by potentiometric titration with sodium hydroxide using a glass electrode.
8. Determination of acidic and basic dissociation constants of an amino acid and hence the iso-electric point of the acid.

(* Any four Physical Chemistry experiments to be performed from the above list)

Inorganic Chemistry Practical-I

Synthesis, Purification and Analysis of the following Inorganic Preparations:

1. Hexamminenickel(II) sulphate
2. Potassium dioxalatocuprate(II) dihydrate
3. Potassium trioxalato chromate (III) trihydrate
4. Potassium trioxalatoaluminate(III) trihydrate

Organic Chemistry Practical-I

Separation of Binary mixture by microanalytical technique

Separation of the binary mixtures using physical and chemical methods. Identification of one of the compounds and checking its purity by TLC. Preparation of the derivative of one of the compounds. The following types are expected: Solid-Solid mixtures. Compounds from the same or different chemical classes. The candidate is expected to carry out the separation of 4 mixtures.

Reference Books:

1. Elementary Practical Organic Chemistry Part-I small-scale preparations, A.L. Vogel (Longman)
2. Laboratory Manual of Organic Chemistry, B.B. Dey and M.V. Sitaram revised by T.R Govindachari (Allied Publishers Ltd.)

Analytical Chemistry Practical-I

Non-Instrumental Experiments*:

1. Calibration of a 10 mL pipette by weighing at room temperature and reporting the result with statistical data.
2. Determination of Manganese from pyrolusite by potassium permanganate method.
3. Estimation of vitamin C by titration with potassium bromate.
4. Determination of number of nitro group in organic compound by titanium method.
5. Separation and determination of Fe (III) and Mg (II) /Zn (II) using ethyl acetate /ether as a solvent.
6. Determination of exchange capacity of cation ion-exchnage resin.

(* Any four Analytical Chemistry experiments to be performed from the above list)

Research Methodology

<table>
<tr><td colspan="3">PROGRAM(s): M.Sc.-I</td><td>SEMESTER: I</td></tr>
<tr><td colspan="3"></td><td>Course Code: 112016150611

Course Title:- Research Methodology</td></tr>
<tr><td colspan="3">Teaching Scheme</td><td>Evaluation Scheme</td></tr>
<tr><td>Lectures (Hours per week)</td><td>Credit</td><td>Continuous Assessment (CA)
(Marks- 50)</td><td>Semester End Examination
(Marks- 50)</td></tr>
<tr><td>04</td><td>04</td><td>50</td><td>50</td></tr>
<tr><td colspan="4">Course Outcomes:
At the end of the Course,

1. To enable the student to be able to extract information from journals and digital resources.
2. Understanding tools to analyse the data, writing and presenting scientific papers.
3. Safe working procedure And ethical handling of chemicals.
4. Describe research, identification of research problems, and preparation of proposals.
5. Practice ethics in all the domains of research.
6. Analyze the results using mathematical and statistical tools.</td></tr>
<tr><td colspan="4">Course Learning Outcomes.
1. To create awareness and understanding the terms like intellectual property, patents, copyright,
industrial designs, trademarks, geographical indications etc.
2. To know trade secrets, IP infringement issues, economic value of intellectual property and study of various related international agreements.
3. To explore cheminformatics to facilitate molecular modeling and structure elucidations.
4. To apply the knowledge gained about various chemistry principles, techniques and tools in drug
designing, target identification and validation, lead finding and optimization..</td></tr>
</table>

Course Code: 112016150611
Research Methodology

Unit-I LITERATURE SURVEY **[15L]**

Print: **[5L]**

Primary, Secondary, Tertiary sources,

Journals:

Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, SubjectIndex, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital: **[5L]**

Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and commUnit-ites, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-Databases, ChemSpider, Science Direct, SciFinder, Scopus.

Information Technology and Library Resources: **[5L]**

The Internet and World Wide Web, Internet resources for chemistry, Finding and citing published information.

Unit-II DATA ANALYSIS **[15L]**

The Investigative Approch:

Making and recording Measurements, SI Unit-s and their use, Scientific methods and design of experiments.

Analysis and Presentation of data:

Descriptive statistics, Choosing and using statistical tests, Chemometrics, Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, *r* and its abuse, Basic aspects of multiple linear egression analysis.

Unit-III METHODS OF SCIENTIFIC RESEARCH & WRITING SCIENTIFIC PAPERS **[15L]**

Reporting practical and project work, Writing literature surveys and reviews, Organizing a poster display, Giving an oral presentation.

Writing scientific papers:

Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, Writing ethics, Avoiding plagiarism.

Unit IV: CHEMICAL SAFTEY & ETHICAL HANDLING OF CHEMICALS **[15L]**

Safe working procedure and protective environment, protective apparel, emergency procedure, and first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for

working with gases at pressures above or below atmospheric- safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

Reference books:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), *Practical skills in chemistry*, 2nd Ed., Prentice Hall, Harlow.
2. Hibbert, D. B., & Gooding, J. J., (2006), *Data analysis for chemistry*, Oxford University Press.
3. Topping, J., (1984), *Errors of observation and their treatment*, 4th Ed. Chapman Hll, London.
4. Harris, D. C., (2007), *Quantitaive chemical analysis*, 6th Ed., Freeman Chapters 3-5
5. Levie, R. de., (2001*), How to use Excel in analytical chemistry and in general scientific data analysis*, Cambridge Univ Press 487 pages.
6. Chemical safety matters-IUPAC-IPCS, Cambridge University Press, 1992.
7. OSU safet manual 1.01

SEMESTER: II

PROGRAM(s): M.Sc.-I	SEMESTER: II			
Course: Paper-I	Course Code: 112016250711 Course Title:- Physical Chemistry-II			
Teaching Scheme				Evaluation Scheme
Lectures (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	–	04	50	50

Learning Objectives:

1. To gain knowledge of the advanced concepts in quantum mechanics, applications of HMO theory, chemical kinetics and molecular dynamics.
2. To understand the advanced concepts in chemical thermodynamics and photochemistry.
3. To develop the skill to solve the problems encountered in the field of quantum and electrochemistry.

Course outcomes:-

1. To learn the concept of quantum chemistry and able to solve problems related to 1D box, 2D box, 3D box and to explain the role of operators in quantum chemistry.
2. To understand the use of Schrodinger wave equation in one and two electron systems along with applications of HMO.
3. To develop the skill to solve the problems based on chemical thermodynamics, molecular dynamics and quantum Chemistry.
4. To apply the concept of Jabolonski mechanism in photochemical reactions.
5. Learners will get knowledge of advanced chemical kinetics and molecular dynamics.

Semester II
Course code: 112016250711
PHYSICAL CHEMISTRY-II

Unit-I THERMODYNAMICS-II [15 L]

Partial molar quantities, chemical potential for ideal gas, gas mixtures, Gibbs free energy of mixing, entropy and volume of mixing, Gibbs Duhem equation, Variation of chemical potential with pressure and temperature.

Excess functions (Chemical potential, Gibbs free energy and enthalpy function), Equilibrium constant and its dependence on temperature and pressure.

Unit-II APPLIED ASPECTS OF QUANTUM CHEMISTRY [15]

Application of Quantum Chemistry in Vibrational motion:

The one-dimensional harmonic oscillator: Classical and Quantum mechanical treatment, Hermite polynomials**,** Wavefunctions, probability densities, and energy levels

Application of Quantum Chemistry in Rotational motion:

Spherical polar coordinates, Separation of variables, The rigid rotor: Legendre functions, energy levels and wave functions*****.

Application of Quantum Chemistry in Atomic system:

The hydrogen atom and hydrogen-like ions, Reduction of the two-particle problem to two one-particle problems, Solutions to R(r), $\Theta(\theta)$ and $\Phi(\phi)$ equations*****, Hydrogen-like orbitals, sketches of wave functions (ψ) and probability densities ($|\psi|^2$), polar plots of angular parts, orbital and spin angular momentum, spin orbitals.

Unit-III APPLICATIONS OF THERMODYNAMICS AND ELECTROCHEMISTRY [15L]

Experimental techniques for determination of thermodynamic quantities: Bomb Calorimeter, Coffee Cup Calorimeter, Differential Scanning Calorimeter.

Exergonic and endergonic reactions, Thermodynamics of ATP,

Debye-Hückel theory of strong electrolyte, ionic atmosphere, activity coefficients of electrolyte solutions- Debye-Hückel limiting law, extension to higher concentrations.

Electrolytic conductance and ion-ion interactions, Debye-Hückel-Onsager equation, validity of equation, Debye-Falkenhagen effect, Wien effect, weak electrolyte and Debye-Huckel theory.

Determination of thermodynamic functions of cell reaction.

Electrochemistry in water and effluent treatment.

Unit-IV MOLECULAR REACTION DYNAMICS [15L]

Collision theory, steric factor, activated complex theory, reaction coordinate and transition state, thermodynamic aspects, reaction between ions, salt effects, and dynamics of molecular collisions.

Homogeneous catalysis – enzyme catalysis, Michaelis-Menten mechanism, acid base catalysis.

Heterogeneous catalysis – Examples: hydrogenation, oxidation, cracking and forming.

****Derivation not expected***

Note: Numerical and theoretical problems from each Unit- are expected.

Reference books:

1. Peter Atkins and Julio de Paula, *Atkin's Physical Chemistry*, 7th ed., 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 ed., John Wiley and Sons (Asia) Pte. Ltd., 2002.
4. Ira R. Levine, *Physical Chemistry*, 5th ed., Tata McGraw-Hill, New Delhi, 2002.
5. G. W. Castellan, *Physical Chemistry*, 3rd ed., Narosa Publishing House, New Delhi, 1983.
6. D. A. McQuarrie and J. D. Simon, *Physical Chemistry - a molecular approach*, Viva Books Private Limited, New Delhi, 1998.
7. S. Glasstone, Text Book of Physical Chemistry, 2nd ed., McMillan and Co. Ltd., London, 1962.
8. Derek Pletcher, *Industrial Electrochemistry*, London New York.
9. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964.
10. Ira N. Levine, *Quantum Chemistry*, 5th ed., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
11. J. P. Lowe, *Quantum Chemistry*, 2nd ed., Academic Press, New York, 1993.
12. R. Anantharaman, *Fundamentals of Quantum Chemistry*, McMillan India Limited, 2001.
13. Mahendra R. Awode, *Quantum Chemistry*, S. Chand and Co. Ltd., New Delhi, 2002.
14. R. K. Prasad, *Quantum Chemistry*, 2nd ed., New Age International Publishers, 2000.
15. D. O. Hayward, *Quantum Mechanics for Chemists*, Royal Society for Chemists, 2002.
16. Samuel Glasstone,*An introduction to electrochemistry*,East West edition, New Delhi.
17. G. L. Agarwal, *Basics Chemical kinetics*, Tata Mcgraw Hill, New Delhi.
18. D. R. Crow, *Principles and Applications of Electrochemistry*, 4th edition, Blackie, London, 1994.
19. J.O'm. Bockris and A. K. N. Reddy, *Modern Electrochemistry*-Vol. 1 and 2, Plenum press, New York.
20. R. A. Robinson and R.H. Stokes, *Electrolyte Solutions*, 2nd Edition, Butterworths, London 1959.
21. R. P. Rastogi, R. R. Mishra, *An Introduction to Chemical Thermodynamics*, Vikas Publishing House Pvt. Ltd.
22. K. J. Laidler, *Chemical Kinetics*, 3rd ed., Pearson Education.

List of Books for further reading:

1. W. G. Davis, *Introduction to Chemical Thermodynamics – A Non-Calculus Approach*, Saunders, Philadelphia, 1972.
2. I. M. Klotz and R. M. Rosenberg, *Chemical Thermodynamics*, 5th ed., John Wiley and Sons, Inc., 1994.
3. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.

PROGRAM(s): M.Sc.-I	SEMESTER: II			
Mandatory Course -II	Course Code: 112016250811 Course title : Inorganic Chemistry-II			
Teaching Scheme				Evaluation Scheme
Lectures (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	–	04	50	50

Learning Objectives:

1. The course aims at generating awareness about the positive as well as negative aspects of inorganic chemicals on biophysical processes and our environment.
2. The course aims at developing theoretical approach to analyze symmetry, structure and physical properties of molecules.
3. The course aims to impart knowledge of basic concepts and recent advances in nano-sciences.

Course Outcomes:

1. The learner will gain understanding regarding the different crystal structures. They will also gain knowledge about the various aspects of nanoscience and nanotechnology.
2. The learner will be able to correlate the structure, symmetry and properties interrelationship of different molecules.
3. The learners will get awareness about the effect of toxic chemicals and radiations on our environment.
4. The learners will understand the role of different metallic compounds in various biological processes and applications.

Paper II

Course Code: 112016250811

INORGANIC CHEMISTRY-II

(Total lectures: 60, Credits: 4)

Unit I Solid State Chemistry and Nanomaterials 15 L

(A) Solid State Chemistry

(i) Recapitulation of basic solid state chemistry.

(ii) Structures of compounds of the type: AB [zinc sulfide (ZnS), nickel arsenide (NiAs)], AB_2 [fluorite (CaF_2), antifluorite (Na_2O), rutile (TiO_2) and layer structures viz., cadmium chloride ($CdCl_2$) and cadmium iodide, (CdI_2)].

(B) Nanomaterials

(i) Introduction to nanomaterials.

(ii) Preparative methods: Ball milling, Solvothermal, Sol-gel, Biological methods

(iii) Basic characterization techniques for nanomaterials.

(iv) Applications of nanomaterials.

Unit II Molecular Symmetry and Group theory 15 L

(i) Symmetry elements and symmetry operations, product of symmetry operations, Cartesian coordinate system and symmetry elements.

(ii) Symmetry classification of molecules: point groups, mathematical requirement for a point group, systematic assignment of point groups to molecules.

(iii) Identification of molecular point groups of molecules having low symmetry, high symmetry and special symmetry.

(iv) Descent in symmetry of molecules with substitution.

(v) Group multiplication tables, classes of symmetry operations. Matrix representation of symmetry elements and point groups.

(vi) Construction of C_{2v} character table.

(vii) Symmetry criteria for optical activity, Symmetry restrictions on dipole moment.

Unit III Environmental Chemistry 15 L

(i) Chemical Toxicology: MSDS, LD50, toxic chemicals in the environment, biochemical effects and speciation of toxic elements like arsenic, lead, mercury and cadmium; antidotes for the toxic elements. Biochemical effects of fluoride and pesticides.

(ii) Radiation pollution: Sources and biological implication of radioactive pollutants.

(iii) Non-conventional energy sources: Solar power, Wind power, Geothermal energy, Ocean thermal energy conversion (OTEC), Tidal power.

Unit IV Bioinorganic Chemistry 15 L

(i) Biological oxygen carriers: myoglobin, hemoglobin, Hill equation, Bohr effect and their implications, hemerythrene and hemocyanine.

(ii) Reactions of dioxygen in biological system with examples of peroxidase, monooxygenase, superoxide dismutase and oxidase reactions. Biochemical effect of cyanide.

(iii) Nitrogen fixation: Nitrogenase, Hydrogenases.

(iv) Metal ion transport and storage: transferrin and Ferritin.

(v) Metal ions in medicines: Introduction to metallodrugs, cis-platin and related compounds.

Reference books

Unit I

1. A. R. West, Solid State Chemistry and Its Applications, John Wiley & Sons, 1987.
2. C. N. R. Rao and G. Gopalkrishnan, New Directions in solid state chemistry, 2nd Ed., Cambridge University Press, 1997.
3. Lesley E. Smart and Elaine A. Moore, Solid State Chemistry – An introduction, 3rd Ed., Taylor and Francis, 2005.
4. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone, 2014.
5. S. K. Kulkarni, Nanotechnology-Principles and Practices, Capital Publishing Co., 2007.
6. G. Cao, Nanostructures and Nanomaterials- Synthesis, Properties and Applications, Imperial college Press, 2004.
7. C. N. R. Rao, A. Muller and A. K. Cheetham, The Chemistry of Nanomaterials-Synthesis, Properties and Applications, Volume-I, Wiley VCH, 2004.

Unit II

1. K.V.Reddy, Symmetry and Spectroscopy of Molecules, 2nd Ed., New Age International Publishers2009.
2. R. L. Carter, Molecular Symmetry and Group Theory, John Wiley & Sons, 1998.
3. A.S. Kunju and G. Krishnan, Group Theory and its Applications in Chemistry, PHI-Learning, 2010.
4. F. A. Cotton, Chemical Applications of Group Theory, 2nd Ed., Wiley Eastern Ltd., 1989.

Unit III

1. A. K. De, Environmental Chemistry, 7th Ed., New Age International Publishers, 2007.
2. J. E. Girard, Principles of Environmental Chemistry, 2nd Ed., Jones and Bartlett publishers, 2011.
3. H. Kaur, Environmental Chemistry, Pragati Prakashan, 8th Ed., 2014.

Unit IV

1. I. Bertini, H.B.Gray, S. J. Lippard and J.S. Valentine, Bioinorganic Chemistry, 1st Indian Ed., Viva Books, 1998.
2. D. Banerjea, Coordination Chemistry, Tata Mc Graw Hill, 1993.
3. G. N. Mukherjee and A. Das, Elements of Bioinorganic Chemistry, Dhuri&Sons, 1988.

General Inorganic Chemistry Reference books

1. D. Banerjea, Coordination Chemistry, Tata McGraw Hill, 1993.
2. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Ed., Oxford University Press, 2010.
3. R. Gopalan and V. Ramlingam, Concise Coordination chemistry, Vikas Publishing house Pvt Ltd., 2001

4. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, 5th Ed., Wiley Interscience, 2009.
5. G. O. Spessard and G. L.Miessler, Organometallic Chemistry, Prentice-Hall, 1977.
6. K. F. Purcell and J. C. Klotz, Inorganic Chemistry, Saunders, 1977.
7. B. Douglas, D. H. McDaniel and J. J. Alexander, Concepts and Models of Inorganic Chemistry, 2nd Ed., John Wiley & Sons, 1983.
8. G. Miessler and D. Tarr, Inorganic Chemistry, 3rd Ed., Pearson Education, 2004.
9. R. L. Madan and G. D. Tuli, Inorganic Chemistry, 5th Ed., S. Chand, 2012.
10. J. D. Lee, Concise Inorganic Chemistry, 5th Ed., Wiley, 2012.
11. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone, 2014.
12. G. Raj, A. Bhagi and V. Jain, Group Theory and Symmetry in Chemistry, 3rd Ed., Krishna Prakashan, 2010.
13. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Ed., Oxford University Press, 2010.
14. R. S. Drago, Physical Methods in Inorganic Chemistry, Affiliated East-West Press Pvt. Ltd., 2014.
15. G. S. Sodhi, Fundamental Concepts of Environmental Chemistry, 3rd Ed., Narosa Publishing House, 2013.
16. S. S. Dara and D. D. Mishra, A Textbook of Enviromental Chemistry and Pollution Control, S. Chand & Company Ltd., 2012.
17. S. K. Banerji, Environmental Chemistry, 2nd Ed., Prentice-Hall of India, 2005.
18. R. A. Bailey, H. M. Clark, J. P. Ferris, S. Krause and R. L. Strong, Chemistry of Environment, 2nd Ed., Academic Press, 2005.
19. R. W. Hay, Bioinorganic Chemistry, Ellis Harwood, 1984.
20. J. A. Cowan, Inorganic Biochemistry-An introduction, VCH Publication, 1993.
21. S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry, University Science Publications, Mill Valley, Caligronic, 1994.
22. P. J. Durrant and B. Durrant, Introduction to Advanced Inorganic Chemistry, Oxford University Press, 1967.
23. R. L. Dekock and H.B.Gray, Chemical Structure and Bonding, The Benjamin Cummings Publishing Company, 1989.
24. R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., 2001.
25. C. M. Day and J. Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 1985.
26. J. N. Murrell, S. F. A. Kettle and J. M. Tedder, The Chemical Bond, Wiley, 1978.
27. G. A. Jeffrey, An Introduction to Hydrogen Bonding, Oxford University Press, Inc., 1997.
28. W. W. Porterfield, Inorganic Chemistry-A Unified Approach, 2nd Ed., Academic Press, 1993.
29. L. V. Azaroff, Introduction to solids, Tata McGraw Hill Book Co, 1977.
30. H. V. Keer, Principles of Solid State, Wiley Eastern Ltd., 1993.

PROGRAM(s): M.Sc.-I			SEMESTER: II
			Course Code: 112016250911 **Course Title:-Organic Chemistry-II**
Teaching Scheme			**Evaluation Scheme**
Lectures (Hours per week)	**Credit**	**Continuous Assessment (CA) (Marks-50)**	**Semester End Examination (Marks- 50)**
04	**04**	**50**	**50**

Course Objectives:

1. To gain knowledge of aromaticity and understand Nomenclature system and various other concepts related to aromaticity

2. To understand various rules of reaction mechanism and various new concepts of elimination and substitution reactions.

3. To introduce new aspects of reaction mechanism and stereo chemical behaviors of reaction mechanism.

4. To study various organic reagents and its applications in synthetic organic Chemistry.

Course outcomes: -

After completing the course students will be able to:

1) Recognize the type of mechanism & intermediates involved in the given organic reaction and to prove mechanism for the reaction.
2) Identify the ways to modify aliphatic and aromatic compounds via Nucleophilic and Electrophilic substitution reactions.
3) Predict the mechanism and stereochemistry of important organic reactions.
4) Understand and write the mechanism of rearrangement reactions with stereochemistry and its applications.
5) Understand the HOMO-LUMO concept and it significance in organic chemistry.
6) To understand and recognize use of reagents in various functional group modifications.

Semester II

Course Code: 112016250911

ORGANIC CHEMISTRY-II

UNIT- I: PHYSICAL ORGANIC CHEMISTRY AND AROMATICITY [15L]

1.1 Idea about molecular orbitals, application to Hydrogen molecule, ethylene molecule and carbonyl group, **a qualitative approach**. Empirical idea about magnitude of coefficients in molecular orbitals. Discussion on unequal sizes of coefficients in 1,3-butadiene. Relative energies of FMOs of hard/soft electrophiles and nucleophiles. Identification of hard / soft electrophilic centres in allylcation and hard / soft nucleophilic centres in allyl anion. Ambident nucleophiles and ambident electrophiles.

1.2 Structural, thermodynamic and magnetic criteria for aromaticity. Shielding deshielding effects in NMR due to ring current, DRE, REPE, London diamagnetism, diamagnetic exaltation.

1.3 Huckel's (4n+2) pi electron rule and idea about closed shell configuration. Frost-Musulin diagram.

1.4 Concept about Aromatic, antiaromatic and Homoaromatic compounds. Aromaticity of benzenoid systems, annulenes, five-membered and six-membered heterocyclic compounds with one hetero atom, metallocenes, azulenes, tropyliumcation and conjugated monocyclic molecules with exocyclic double bond.

Unit-II: ELIMINATION AND NUCLEOPHILIC SUBSTITUTION REACTIONS [15L]

2.1 Types of elimination reactions, $E_1$and E_2 mechanisms

2.2 Orientation of elimination reactions: Saytzeff and Hoffmann rules. E_2 - reactions of vinyl halide, E_1cB mechanism. Nomenclature for relative configuration for consstitutuionally unsymmetrical molecules; Erythro-threo and syn-anti. Stereochemistry of constitutionally symmetric molecules with odd and even number of chiral centres; the dissymmetric forms and meso forms. Concept of stereogenic, non-stereogenic, chirotopic, achirotopic and pseudoasymmetric centres. The examples of achirotopic but stereogenic centres and chirotopic but non-stereogenic centres. A lack of direct connection between chirotopicity and stereogenicity.

2.3 Pyrrolytic elimination: Chugaev reaction, Cope reaction, Hoffmann's and Pyrrolysis of acetates.

2.4 Aliphatic nucleophilic substitution at sp^3 carbon: S_N1, S_N2, S_Ni, S_NcA reactions. Ion pair in S_N1, reactions, Stereochemistry of all the above reactions, Factors affecting these reactions: substrate nucleophilicity, solvent, steric effect, hard-soft interaction, leaving group.

2.5 Nucleophilic substitution reactions at sp^2 (vinylic) carbon.

2.6 Aromatic nucleophilic substitution reaction: S_NAr, S_N^1, Benzynemechanism, ipso, cine and tele substitutions, vicarious substitution.

Unit-III: REACTIONS AND REARRANGEMENTS [15L]

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

Arndt-Eistert reaction, Baylis-Hilman reaction, McMurry Coupling, Mitsunobu reaction and Mukiyama esterification, Woodward Prevost Hydroxylation.

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

Cope rearrangement, Claisen rearrangement, Dienone-Phenol rearrangement, Favroskii rearrangement, Fries rearrangement and Tiffeneau-Demjanov rearrangement.

3.3 Ester hydrolysis (all 8 mechanisms of acid and base catalyzed hydrolysis)

Unit-IV: OXIDATION-REDUCTION [15L]

4.1 Preparation of reagents (wherever applicable), mechanism and applications of the following:

Epoxidation: Baeyer-Villiger Oxidation and Oppenauer Oxidation. Oxidations using Osmium Tetroxide, Lead Tetraacetate, Periodic acid, Selenium dioxide, PCC and PDC.

4.2 Dehydrogenation with DDQ and TCQ, and Ozonolysis

4.3 Preparation of reagents (wherever applicable), mechanism and applications of the following: Wolf-Kishner reduction, Clemmensen reduction, Meerwein-Pondorff-Verley reduction, Birch reduction, Reductions with $NaBH_4$, $LiAlH_4$ and DIBAL.

4.4 Homogeneous reductions: Wilkinson's catalysts and related systems.

References Books:

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 and B, Plenum Press.
3. Stereochemistry: Conformation and mechamism, P.S. Kalsi, New Age International, New Delhi.
4. Stereochemistry of carbon compounds, E.L Eliel, S.H Wilen and L.N Manden, Wiley.
5. Stereochemistry of Organic Compounds- Principles and Applications, D. Nasipuri. New International Publishers Ltd.
6. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley.
7. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education.
8. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.

9. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press.
10. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press.
11. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes.
12. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education.
13. Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, Thomson Brooks.
14. Spectrometric Identification of Organic Compounds, R. Silverstein, G.C Bassler and T.C. Morrill, John Wiley and Sons.
15. Organic Spectroscopy, William Kemp, W.H. Freeman & Company.
16. Organic Spectroscopy-Principles and Applications-Jagmohan, Narosa Publication.
17. Organic Spectroscopy, V.R. Dani, Tata McGraw Hill Publishing Co.
18. Spectroscopy of Organic Compounds, P.S. Kalsi, New Age International Ltd.
19. Mechanism in Organic Chemistry, Peter sykes, 6th edition onwards.
20. Physical Organic Chemistry, Neil Isaacs
21. Modern Physical Organic Chemistry, Eric V. Anslyn and Dennis A. Dougherty
22. Stereochemistry: A Three-Dimensional Insight by Anil V. Karnik and Mohammed Hasan.

PROGRAM(s): M.Sc.-I	SEMESTER: II			
Course:	Course Code: 112016251011 Course Title:- Chemistry Practical-II			
Teaching Scheme				Evaluation Scheme
Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks-25)	Semester End Examination (Marks- 25)
16	–	02	25	25

Learning Objectives:
Physical Chemistry

1.To gain knowledge of the advanced concepts in pH metry, quantum mechanics, potentiometry and conductometry experiments.
2.To develop scientific temper and research based skills accomplish to encountered in the field of research.

Inorganic Chemistry

3. To gain ability to analyze different samples of ores and alloys.
To learn different analytical methods for composition analysis.

Course Outcomes:-

Physical Chemistry

1.To use the concept of quantum chemistry to interpret the shape and information about the orbitals like 1s, 2pz and 3dz2.

2. To apply the subject fundamentals-principles with practical knowledge to design experiments, analyze and interpret data so as to reach to proper conclusions

3. Learner will train to handle the sophisticated instrument like digital potentiometer, conductivity meter, spectrophotometer.

Inorganic Chemistry
1.The learner will learn to analyze the composition of different ores and alloys.
2. The learner will gain knowledge and hands on experience of different analytical methods used in the estimation of metals.

Course Code: 112016251011

CHEMISTRY PRACTICAL-II

Physical Chemistry Practicals-II

Non-Instrumental Experiments*:

Thermodynamics, Phase Rule and Reaction Kinetics:

1. Determination of heat of solution of benzoic acid by solubility measurements.
2. Determination of heat of solution of salicylic acid by solubility measurements.
3. Study of three-component system: Water-Acetic acid-Chloroform.
4. Study of three-component system: Water–Toluene-Acetic acid.
5. Study of variation of solubility of calcium sulphate with ionic strength and hence determine the thermodynamic solubility product. (Complexometric titration with EDTA)
6. Determination of equilibrium constant of the reaction $KI + I_2 \rightleftharpoons KI_3$ by distribution method.
7. Investigation of the reaction between acetone and iodine.

(* Any four Physical Chemistry experiments to be performed from the above list)

Inorganic Chemistry Practical-II

Analysis of Complex Materials:

1. Lime Stone Ore: Loss on ignition; Ca by EDTA method.
2. Solder Alloy: Sn gravimetrically by oxide method; Pb by EDTA method.
3. Cu-Ni Alloy: Cu by iodometric method; Ni gravimetrically by DMG method.
4. Devarda's Alloy: Cu by EDTA method, Al gravimetrically by oxine method.

Reference books for practicals

1. A. I. Vogel, Vogel's Text Book of Quantitative Inorganic Analysis, 6th Ed., Pearson Education, 2000.
2. J. D. Woolins, Inorganic Experiments, Wiley-VCH Verlag GmbH and Co., 2003.
3. W. G. Palmer, Experiments in Inorganic Chemistry, Cambridge University Press, 1954.
4. G. Raj, Advanced Practical Inorganic Chemistry,
5. G. Brauer, Handbook of Preparative Inorganic Chemistry, Vol. 1 and 2, Academic Press, 1967.
6. G. Marr and B. W. Rockette, Practical Inorganic Chemistry, Van Nostrnad Reinhond, 1972.
7. G. Pass and H. Sutcliffe, Practical Inorganic Chemistry, 2nd Ed., Chapman and Hall, 1985.

Organic Chemistry Practical-II

Separation of Binary mixture by microanalytical technique

Separation of the binary mixtures using physical and chemical methods. Identification of one of the compounds and checking its purity by TLC. Preparation of the derivative of one of the compounds. The following types are expected: (i)

Non-volatile liquidNon-volatile liquid (ii) Water-soluble/insoluble solid-Non-volatile liquid with compounds from the same or different chemical classes. The candidate is expected to carry out the separation of 4 mixtures.

Reference Books:

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)

Analytical Chemistry Practical-II

Instrumental Experiments*:

1. Non aqueous titration: Determination of sodium benzoate / glycine by using perchloric acid in glacial acetic acid by potentiometry using glass-calomel system.
2. Determination of glucose by Folin-Wu method.
3. Determination of nitrite in a water sample by colorimetric method.
4. Determination of chromium and manganese by simultaneous spectrophotometry (to be replaced).
5. Determination of silica by Molybdenum Blue method.
6. Flame Photometric determination of Li /Na/K by standard addition method.

(* Any four Analytical Chemistry experiments to be performed from the above list)

PROGRAM(s): M.Sc.-I			SEMESTER: II
			Course Code: 112016251111 **Course Title:-Analytical Chemistry-II**
Teaching Scheme			**Evaluation Scheme**
Lectures (Hours per week)	**Credit**	**Continuous Assessment (CA) (Marks-50)**	**Semester End Examination (Marks- 50)**
04	**04**	**50**	**50**

Course Objectives:

1. To gain knowledge about electroanalytical techniques and applications of sensing electrodes.
2. To understand basic instrumentation of NMR and Mass techniques.
3. To principle, construction, working and applications of XRF, XRA and XRD techniques.
4. To apply the surface analytical techniques for system.
5. To learn about the automations in chemical analysis and process analytical techniques with some hyphenated techniques.

Course outcomes: -

After completion of this Course, the learner will be

1. able to learn the tool for quantitative analysis of analytes using solid state, precipitate and liquid-liquid membrane, enzyme and gas sensing electrodes with applications.
2. able to know the basic concepts of modern voltammetric techniques with electrochemical properties of compounds and systems and also the theory of thermodynamics and kinetics of electrochemistry.
3. The advantages and disadvantages of voltammetric techniques like DPP, CV and Stripping voltammetry of analysis.
4. Students are expected to learn the basic concepts and instrumentation of ^{1}H, ^{13}C, ^{19}F, and ^{31}P NMR and Mass Spectrometry.
5. Also the applications of such analytical techniques in various fields like pharma, medical, academia and research.
6. Able to learn about the basic concept of XRA, XRF and XRD techniques and its applications in the various fields.

7. Able to understand the the automation processes in analytical instrumentation and some hyphenated techniques in detail like GC-MS and LC-MS.

Course Code: 112016251111
ANALYTICAL CHEMISTRY-II

Unit-I ELECTROANALYTICAL CHEMISTRY[15L]

1.1 Ion selective potentiometry: Basic concept, solid state, precipitate and liquid-liquid membrane, enzyme and gas sensing electrodes with applications. **[8L]**

1.2 Introduction to modern voltammetric techniques viz., Differential pulse polarography, Cyclic voltammetry and Stripping (cathodic & anodic) voltammetry. **[7L]**

Unit-II SPECTROSCOPIC METHODS [15L]

1.1 **Magnetic resonance spectroscopy**:
Basic principles, instrumentation and sample handling, Quantitative applications of proton NMR, Introduction to Carbon–13, Phosphorous-31 and Fluorine-19 with applications. **[8L]**

1.2 **Mass spectrometry**:
Recapitulation, instrumentation; ion sources for molecular studies; EICI, FI, ESI, APCI, FAB & MALDI sources. Mass analyzers: quadrupole, time of flight and ion trap, Applications. [**7L]**

Unit-III MISCELLANEOUS TECHNIQUES [15L]

3.1 **X-ray Techniques:**

Principles, instrument components and applications of X-ray fluorescence, absorption and diffraction methods. [**10L]**

3.2 Introduction to surface analytical techniques: ESCA **[5L]**

Unit-IV: AUTOMATION IN CHEMICAL ANALYSIS AND Process Analytical Techniques [15L]

4.1 An overview of automated instruments and instrumentation, process control analysis; Types of automatic analytical systems: Flow injection analysis, automatic organic elemental analyzers, Gas monitoring equipment. **[8L]**

4.2 Process Analytical Techniques **[4L]**

4.3 Introduction to hyphenated techniques: GC-MS and LC-MS **[3L]**

Reference books:

1. D. A. Skoog, F. J. Holler, and T. A. Nieman, *Principles of Instrumental Analysis*, 5th ed., Philadelphia: Saunders College Publishing, 1998.
2. D. A. Skoog, D. M. West, F. J. Holler and S. R. Crouch, *Fundamentals of Analytical Chemistry*, 8th ed., Philadelphia: Saunders College Publishing, 2004.
3. G. D. Christian, *Analytical Chemistry*, 6th ed., John Wiley and Sons, New York, 2003.
4. G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denney, *Vogel's Textbook of Quantitative Chemical Analysis*, 6th ed., ELBS, Longman Scientific & Technical, England, 2002.
5. H. H. Willard, L. L. Merrit, jr., J. A. Dean and F. A. Settle, Jr., *Instrumental Methods of Analysis*, 6th ed., CBS 1986.
6. R. D. Braun, *Introduction to Instrumental Analysis*, McGraw Hill, 1987.
7. G. H. Morrison and H. Freiser, *Solvent Extraction in Analytical Chemistry*, John Wiley & Sons, New York, 1966.
8. S. M. Khopkar, *Basic concept of Analytical Chemistry*, 3rd ed., Age International Publisher 2008.
9. T. Sekine and Y. Hasegawa, *Solvent Extraction chemistry*, Marcel Dekker, 1977.

10. P. G. Swell and B. Clarke, *Chromatographic Separations, Analytical Chemistry by open learning*, John Wiley & Sons, New York, 1987.
11. S. Sindsay, *High Performance Liquid Chromatography, Analytical Chemistry by open learning*, John Wiley & Sons, New York, 1987.
12. A. J. Bard and L. R. Faulkner, *Electrochemical Methods*, Wiley, New York, 1980
13. A. M. Bond, *Modern Polarographic Methods in Analytical Chemistry*, Marcel Dekker, New York, 1980.
14. L. C. Thomas and G. J. Chamberline, *Colorimetric Analytical Methods*, 9th ed., The Fintometer Ltd., Salisbury, England, 1980.
15. T. C. Morrili, R. m. Silverstein and G. C. Bassler, *Spectrometric Identification of Organic Compounds*, Wiley, 1981.
16. Vogel's Text Book of Quantitative Organic Analysis, 2th ed. ELBS.
17. R. A. Day, Jr. and A. L. Underwood, *Quantitative Analysis*, 6th ed., Prentice Hall of India Pvt. Ltd., New Delhi, 1993.
18. Jared L. Anderson, Alain Berthod, Veronica Pino, and Apryll M. Stalcup (ed),*Analytical Separation Science (Volume 1-5)*. WILEY-VCH 2015.
19. Jack Cazes (ed) *Ewing's Analytical Instrumentation Handbook,* 3rd edition, Marcel Dekker 2009.
20. R. Kellner, J.M. Mermet, M. Oto, M. Valcarcel, H. M. Widmer (ed), *Analytical Chemistry: A modern Approach to Analytical Science 2nd edition.* WILEY-VCH 2004.

PROGRAM(s): M.Sc.-I			SEMESTER: II
			Course Code: 112016251112 **Course Title:-Applied Industrial Chemistry-II**
Teaching Scheme			**Evaluation Scheme**
Lectures (Hours per week)	**Credit**	**Continuous Assessment (CA)** **(Marks- 50)**	**Semester End Examination** **(Marks- 50)**
04	**04**	**50**	**50**

Course Objectives:

1. To enable learners to have comprehensive knowledge, understanding of the types of instruments with operations and automated methods of analysis.

2. To apply the basic knowledge of quality systems, quality audit and quality managements,.

3. To enable learners to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.

4. To provide solutions to problems encountered in the field of analysis and research.

Course Learning Outcomes.

After completing the course students will be able to:

2) predict the reactivity of organic compound from its structure.
7) understand different methods used for determination of Organic Reaction Mechanism
8) understand the fundamental concept in stereochemistry by applying various symmetry elements of organic molecule.
9) acquire the knowledge of chirality by taking examples of symmetrical and unsymmetrical molecule.
10) develop interest in stereochemistry by studying stereochemical features of different classes of organic compounds
11) identify the nomenclature of various stereochemical phenomena

Course Code: 112016251112
Applied Industrial Chemistry-II

Unit-I [15L]

Sugar industry-based chemicals and Industrial gases:

Introduction, manufacturing process of sugar, manufacture processes, properties and uses of oxalic acid, citric acid, ethanol, furfural from sugar by product. Introduction, application of hydrogen, nitrogen, oxygen, carbon dioxide, and liquefied gases.

Unit-II [15 L]

Agrochemicals:

i). Pesticides: history, invention, development, definition, and importance. Classification: General, based on the mode of action, according to target species and chemical nature. Formulations: conventional and advanced types, uses, and current trends. Pesticide residues, toxicity, warning symbols, safety with pesticides, first aid and antidotes.

ii). Fertilizers**:** Introduction, Manufacture, and uses of nitrogenous, phosphatic and potassic fertilizers, compound fertilizers, Mixed fertilizers: method of preparation and formulation.

iii). Fluid fertilizers: Introduction, manufacturing of nitrogenous and mixed fluids.

Unit-III [15 L]

Corrosion and Protective Coating:

Introduction dry and wet corrosion(mechanism), galvanic corrosion passivity, pitting corrosion, intergranular corrosion, waterline corrosion, stress corrosion, galvanic series, factors affecting corrosion, and corrosion control.

Introduction to metallic and electroplating, electroplating methods, chemical conversion coating, organic coating, paints, formulation of paints, varnishes, enamels, lacquers, emulsion paints, and special paints.

Unit-IV [15 L]

Lubricant and Adhesives:

Introduction, classification of lubricants, liquid, semisolid and solid lubricants, synthesis, properties, and application of lubricants. Introduction to adhesives, classification, adhesive action, physical and chemical factors affecting adhesives action, and bonding processes.

Recommended Books

1. R. W. Thomos and P. Farago, Industrial chemistry, 1973
2. P. G . More, Comprehensive Industrial Chemistry, Pragati Prakashan 2018.
3. S. K. Handa, Principles of pesticide chemistry, Agrobios (India); 2012.
4. A. Knowles, New developments in crop protection product formulation.T and F Informa UK Ltd. 2005.
5. D.S.Hill, Agricultural insect pests of the tropics and their control. CUP Archive; 1983.
6. S. B.Chattopadhyay, Principles and procedures of plant protection, Oxford & IBH Publishing Company, Pvt. Limited; 1991.
7. Ó. López, J. Fernandez-Bolanos, Green trends in insect control, Royal Society of Chemistry; 2011.
8. U. S. Sree Ramulu, Chemistry of Insecticides and Fungicides, Oxford and IBM Pub., 1979
9. P. S. Magee, G. K. Kohn, J. J. Menn, Pesticides Synthesis through Rational Approaches, American Chemical Society, 1979.
10. M. G. Rao and M. Marshall, Dryden's Outline of Chemical Technology, East west press, 1997.
11. K. S. Yawalkar, J. P. Agrawal, S. Bokde, Manures and Fertilizers, 1967.
12. D. A. Palgrave, Fluid Fertilizers, 1993.
13. G. H. Collings, Commercial Fertilizers, 2002.

14. P.C. Jain, Engineering chemistry, Dhanpat Rai publishing company private Ltd, New Delhi, 16th edition, 2014.
15. S. S. Dara and S. S. Umare, A textbook of Engineering Chemistry, S. Chand& Company Ltd, New Delhi, 20th Edition, 2013.

Course: On Job Training/ Field Projects

Course Code: 112016251211

PROGRAM(s): M.Sc-I		**SEMESTER: II**			
Course: On Job Training/ Field Projects		**Course Code: 112016251211**			
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks-50)**	**Semester End Examination (Marks- 50)**
NA	**08**	**–**	**04**	**50**	**50**

Learning Objectives:

1) To provide students the opportunity to test their interest in a particular career before permanent commitments are made.
2) To develop skills in the application of theory to practical work situations. To develop skills and techniques directly applicable to their careers.

Course Outcomes:

At the end of the Course,

1) Understand the Organizational Structure of a company.
2) Develop work habits and attitudes necessary for job success (technical competence, professional attitude, organization skills etc.)
3) Develop written communication and technical report writing skills.

Proposed Examination Pattern
Theory Examination Pattern:
A. Internal Assessment- 50%- 50 Marks per paper

Sr.No.	Evaluation Type	Marks
1	Written Objective/Short Answer Examination	25
2	Assignment/ Case study/ field visit report/ presentation/ project	25
	Total	50

External Examination- 50%-

Paper Pattern:

Question	Options	Marks
Q.1	2 out of 4	10
Q.2	2 out of 4	10
Q.3	2 out of 4	10
Q.4	2 out of 4	10
Q.5	4 out of 4	10
	TOTAL	**50**

Semester End Practical Examination:

Particulars	Continuous assessment (CA)	Semester end external examination
Laboratory work	15	15
Viva	05	05
Journal	**05**	**05**
Total	**25**	**25**

PRACTICAL BOOK/JOURNAL

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

Letter Grades and Grade Points

Semester GPA/ Program CGPA/Semester	% Marks	Letter Grade Result
9.00-10.00	90.0-100.0	O (Outstanding)
8.00≤9.00	80.0≤90.0	A+ (Excellent)
7.00≤8.00	70.0≤80.0	A (Very Good)
6.00≤7.00	60.0≤70.0	B+ (Good)
5.50≤6.00	55.0≤60.0	B (Above Average)
5.00≤5.50	50.0≤55.0	C (Average)
4.00≤5.00	40.0≤50.0	P (Pass)
Below 4.00		F (Fail)
Ab (Absent)		Absent

Team for Creation of Syllabus

Name	College Name	Sign
Dr. Suresh D. Pawar	Department of Chemistry, University of Mumbai	
Dr. Vishwanath R. Patil	Department of Chemistry, University of Mumbai	
Dr. Ramcnadra G. Thorat	Department of Chemistry, University of Mumbai	
Dr. Ramesh M. Kamble	Department of Chemistry, University of Mumbai	
Dr. Rupesh Rohan	IRMRA, Thane	
Dr. Bharat Kapgate	IRMRA, Thane	

Sign of HOD

Prof. Shivram S. Garje
Head of Department,
Department of Chemistry,
University of Mumbai

HEAD
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF MUMBAI

Sign of Dean,

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai

Appendix B

Justification for M.Sc. (Industrial Polymer Chemistry)

1.	The necessity for starting the course:	M.Sc. (Industrial Polymer Chemistry) course is necessary for those who seek to deepen their knowledge, specialize in a particular area, and pursue advanced careers in research, industry, academia, or other chemistry-related fields. It offers numerous opportunities for personal and professional growth, enabling you to make a positive impact on the world through scientific exploration and discovery.
2.	Whether the UGC has recommended the course:	Yes
3.	Whether all the courses have commenced from the academic year 2023-24	The course has already commenced from the academic year from 2016 and in the academic year 2022-23 it is restructured under NEP 2020
4.	The courses started by the University are self-financed, whether adequate number of eligible permanent faculties are available?:	This course is a self-financed collaborative course with IRMRA Thane. Currently, twelve permanent faculty members are working in the department out of 26 sanctioned faculty positions. The second year (semesters III and IV) is run by scientist / Faculty members from IRMRA, Thane at their campus
5.	To give details regarding the duration of the Course and is it possible to compress the course?:	The duration of the program is two years (4 semesters). It is not possible to compress the course. Under NEP 2020 students have option of exit at the end of the first year with PG Diploma in Industrial Polymer Chemistry.
6.	The intake capacity of each course and no. of admissions given in the current academic year:	The intake capacity of the program is 15. Number of admission for the academic year 2022-23 is 15.
7.	Opportunities of Employability / Employment available after undertaking these courses:	M.Sc. (Industrial Polymer Chemistry) students have a wide range of employment opportunities across various sectors. The skills and knowledge acquired during their master's program make them well-equipped for diverse roles. Some of the common areas where M.Sc. (Industrial Polymer Chemistry) students can find employment include; Research and Development (R&D), Pharmaceutical Industry, Chemical

		Manufacturing, Environmental and Analytical Chemistry, Quality Assurance and Control, Materials Science and Nanotechnology, Teaching and Academia, Healthcare and Clinical Research etc. The key to employability for M.Sc. (Industrial Polymer Chemistry) students is to build a strong resume through internships, research projects, and networking. Additionally, staying updated with the latest advancements in the field and continuously improving their skills can enhance their competitiveness in the job market.

Sign of HOD

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HEAD
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF MUMBAI

Sign of Dean,

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