Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Structure and Curriculum of Four Year Multidisciplinary Degree (Honors/Research) Programme with Multiple Entry and Exit option

Undergraduate Programme of Science & Technology

B.Sc. Chemistry Honors

Board of Studies

in

Chemistry

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

[PG I Year]

w.e.f. June, 2026

(In Accordance with NEP-2020)

Review Statement

The NEP Cell reviewed the Curriculum of **M.Sc. Chemistry** to be effective from the **Academic Year 2026-27.** It was found that, the structure is as per the NEP-2020 guidelines of Govt. of Maharashtra.

Date: 13/04/2026

Place: Latur

NEP CELL

Rajarshi Shahu Mahavidyalaya, Latur

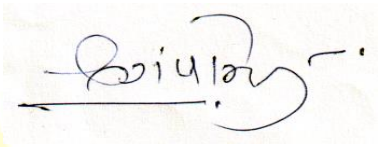
Empowered Autonomous Institution

CERTIFICATE

I hereby certify that the documents attached are the Bonafide copies of the Curriculum of **B.Sc. Chemistry Honors to** be effective from the **Academic Year 2026-27.**

Date: 11 / 04 / 2026

Place: Latur



Prof. Dhananjay Palke

Chairperson

Board of Studies in Chemistry

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Members of Board of Studies in the Subject Chemistry
Under the Faculty of Science and Technology

Sr. No.	Name	Designation	In position
1	**Prof. Dhananjay Palke** Head, Department of Chemistry, Rajarshi Shahu Mahavidyalaya (Autonomous), Latur	Chairperson	HoD
2	**Dr. Dashrath Munde,** Science College Nanded	Member	V.C. Nominee
3	**Dr. Bapurao Shingate,** Professor, Department of Chemistry, BAMU Chhatrapati Sambhaji Nagar	Member	Academic Council Nominee
4	**Dr. Dipak Dalal,** Professor & Director, KBC NMU, Jalgaon	Member	Academic Council Nominee
5	**Dr. Satish Mitragotri,** Walchand College, Solapur	Member	Expert from outside for Special Course
6	**Dr. Harichandra Parbat** Wilson College, Mumbai	Member	Expert from outside for Special Course
7	**Mr. Amol Bhadule,** Syngene International, Bengaluru	Member	Expert from Industry
8	**Dr. Vinod Jadhav** Aragen Life Sciences, Hyderabad	Member	P.G. Alumni
9	**Dr. K. I. Momin** Assistant Professor, Rajarshi Shahu Mahavidyalaya (Autonomous), Latur-413512	Member	Faculty Member
10	**Dr. K. C. Tayade** Assistant Professor, Rajarshi Shahu Mahavidyalaya (Autonomous), Latur-413512	Member	Faculty Member
11	**Mr. M. S. Sudewad** Assistant Professor, Rajarshi Shahu Mahavidyalaya (Autonomous), Latur-413512	Member	Faculty Member
12	**Mr. A. A. Bhandare** Assistant Professor,	Member	Faculty Member

Sr. No.	Name	Designation	In position
	Rajarshi Shahu Mahavidyalaya (Autonomous), Latur-413512		
13	**Mr. V. M. Dhumal** Assistant Professor, Rajarshi Shahu Mahavidyalaya (Autonomous), Latur-413512	Member	Faculty Member
14	**Ms. H. K. Sayyed** Assistant Professor, Rajarshi Shahu Mahavidyalaya (Autonomous), Latur-413512	Member	Faculty Member

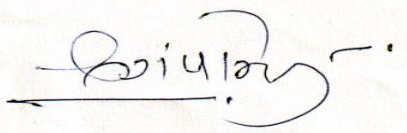
From the Desk of the Chairperson…

The Department of Chemistry was established in the academic year 1971-72. Need of Chemist, is at the forefront of the noteworthy growth in industries, the college took initiative in starting the B.Sc. Chemistry Program from 1971-72 at Undergraduate (B.Sc.) level. Now, this course is successfully flourishing the need of industries by availing Chemist with sound subject knowledge. Also, Post graduate Program in Chemistry started from Academic Year 2014-2015. From Academic Year 2023-24 we are implementing National Education Policy-2020 (NEP-2020) & Started B.Sc. (Honors/Research) Chemistry Programme to be effective from the same academic year. Department has well equipped laboratories with number of sophisticated instruments. In 2006-07, UGC recognized this department as a "Star Department" in the college and awarded CPE status.

The B.Sc. Chemistry Programme is designed to give sound knowledge and understanding of Chemistry to undergraduate students of the B.Sc. Degree course. The goal of the Programme is to make the study of Chemistry as stimulating, interesting, and relevant as possible. The curriculum is prepared with the aim of making the students capable of studying Chemistry in academic and industrial courses. Also, to expose the students to Chemistry and build up their interest in various fields of chemistry. The new and updated Curriculum is based on National Education Policy-2020 (NEP-2020) Guidelines which includes multiple entries & multiple Exit & interdisciplinary approach with vigor and depth. The curriculum is designed on the basis of Feedbacks & suggestion given by Various Stakeholders and by considering the syllabi of Competitive examination like, IIT-JAM, NET, SET, GATE examinations, UGC model curriculum, syllabi of different entrance examinations and syllabi of other Universities.

Our Vision to evolve as a world class dynamic center of higher education disseminating knowledge rigorously at affordable cost and to emerge as a premier centre that promotes technological competence and democratic values.

* "Pursuit of Excellence" in higher education to make our students globally competent.
* Enable students to develop as responsible citizens with human values.
* Provide value and need based education.
* Develop scientific attitude among students.



Prof. Dhananjay Palke
Chairperson
Board of Studies in Chemistry
Rajarshi Shahu Mahavidyalaya, Latur
(Autonomous)

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

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Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science & Technology

PG Skeleton in Accordance with NEP 2020 Structure for Two Year M.Sc. Chemistry

Year Level	Sem	MMC 24-28 (22-26) per Sem 46-56 for two years		Lab Course	RM	OJT/FP	RP	Cum. Cr	Marks	Degree
		Mandatory	**Elective**		RMC 4Cr	NA	NA	20Cr	Theory: 1Cr=25M Lab Course: 1Cr=50M	**PG Diploma (After 03 Year B.Sc. Degree)**
I 6.0	**I**	MMC I 3Cr MMC II 3Cr MMC III 3Cr	MEC I 3Cr	LC-I 1Cr LC-II 1Cr LC-III 1Cr LC-IV 1Cr						
	II	MMC IV 3Cr MMC V 3Cr MMC VI 3Cr	MEC II 3Cr	LC-V 1Cr LC-VI 1Cr LC-VII 1Cr LC-VIII 1Cr	NA	OJT-I 4Cr /FPI 4Cr	NA	20Cr	OJT/FP: 1Cr=25M	
	Total	**MMC 18Cr**	**MEC 06Cr**	**LC-8Cr**	**RMC 04Cr**	**OJT/FP 04Cr**	**NA**	**40Cr**		

Exit Option: PG Diploma with 40 Credits after 03 Year B.Sc. Degree

II 6.5	**III**	MMC VII 3Cr MMC VIII 3Cr MMC IX 3Cr	MEC III 3Cr	LC-IX 1Cr LC-X 1Cr LC-XI 1Cr LC-XII 1Cr	NA	NA	RP-I 4Cr	**20Cr**	RPI & RPII: 1Cr=25M	**PG Degree (After 03 Year UG Degree)**
	IV	MMC X 3Cr MMC XI 3Cr MMC XII 3Cr	MEC IV 3Cr	LC-XIII 1Cr LC-XIV 1Cr LC-XV 1Cr LC-XVI 1Cr	NA	NA	RP-II 6Cr	**22Cr**		
	Total	**MMC 18Cr**	**MEC 06Cr**	**LC-8Cr**	**NA**	**NA**	**RP 10 Cr**	**42Cr**		
Cum. Total of I & II Year		**MMC 36Cr**	**MEC 12Cr**	**LC-16Cr**	**RMC 04Cr**	**OJT/FP 04Cr**	**RP 10Cr**	**40+42 =82 Cr**		**82 Credits**
	Exit Option: Two Years 04 Sem. PG Degree with 82 Credits After 03 Year UG Degree									

Abbreviations:

1. **DSC : Discipline Specific Core (Major)**
2. **DSE : Discipline Specific Elective (Major)**
3. **DSM : Discipline Specific Minor**
4. **GE/OE : Generic/Open Elective**
5. **VSEC : Vocational Skill and Skill Enhancement Course**
6. **VSC : Vocational Skill Courses**
7. **SEC : Skill Enhancement Course**
8. **AEC : Ability**
9. **MIL : Modern Indian Languages**
10. **IKS : Indian Knowledge System**
11. **FSRCE : Fostering Social Responsibility & Community Engagement**
12. **VEC : Value Education Courses**
13. **OJT : On Job Training**
14. **FP : Field Projects**
15. **CEP : Community Engagement and Service**
16. **CC : Co-Curricular Courses**
17. **RP : Research Project/Dissertation**
18. **SES : Shahu Extension Services**

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Department of Chemistry

M.Sc. Chemistry Skeleton in Accordance with NEP-2020

Illustrative Credit Distribution Structure for Two Years/One Year PG (M.Sc.)

Year & Level	Semester	Course Code	Course Title	Credits	No. of Hrs.
I 6.0	I	601CHE1101 (MMC I)	Inorganic Chemistry - I	03	45
			Lab Course-I	01	30
		601CHE1102 (MMC II)	Organic Chemistry - II	03	45
			Lab Course-II	01	30
		601CHE1103 (MMCIII)	Physical Chemistry	03	45
			Lab Course-III	01	30
		601CHE1201 MEC-I (A) Or MEC-I(B)	Physical Methods in Chemistry OR Basic Concepts of Polymer Chemistry	03	45
			Lab Course-IV	01	30
		601CHE1301 (RMC)	Research Methodology Course	04	100
	Total Credits			**20**	
	II	601CHE2101 (MMC IV)	Inorganic Chemistry-II	03	45
			Lab Course-V	01	30
		601CHE2102 (MMCV)	Organic Chemistry-II	03	45
			Lab Course-VI	01	30
		601CHE2103 (MMC VI)	Physical Chemistry-II	03	45
			Lab Course-VII	01	30
		MEC-I (A) Or MEC-I(B)	Physical Methods in Chemistry-II OR Molecular Spectroscopy & Comp.Application	03	45
			Lab Course-VIII	01	30
		OJT-I/Field Project (FP) 601CHE2401	OJT/ Field Project	04	120
	Total Credits			**20**	
Total Credits (Semester I & II)				**40**	

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Name of the Programme: PG Chemistry

Programme Outcomes (POs) for M. Sc. Chemistry	
PO 1	**Advanced Chemical Knowledge** Develop in-depth understanding of core areas such as organic, inorganic, physical, and analytical chemistry, along with interdisciplinary concepts.
PO 2	**Scientific Attitude** Apply chemical principles and logical reasoning to analyze complex problems and propose scientifically sound solutions.
PO 3	**Environment & Sustainability Awareness** Understand environmental issues, green chemistry principles, and sustainable practices in chemical processes.
PO 4	**Personal and Professional Competence** Basic competence, systematic and coherent understanding of fundamental concepts in chemistry and related fields.
PO 5	**Entrepreneurial Competence:** An opportunity to contribute effectively in the laboratory, field, and professional environments and also to grab an employment. Competency to establish independent startup/innovation center etc.
PO 6	**Research Competence** Foster research and analytical skills in basic and applied research with the ability to undertake multidisciplinary and trans disciplinary research.
PO 7	**Ethics & Professional Responsibility** Demonstrate ethical practices in research, data handling, and professional conduct in chemical sciences.
PO 8	**Lifelong Learning** Recognize the need for continuous learning and adapt to emerging trends in chemistry and related fields.
PO 9	**Teamwork & Leadership** Work collaboratively in multidisciplinary teams and take leadership roles in scientific projects.

Programme Specific Outcomes (PSOs) for M. Sc. Chemistry	
PSO No.	After completion of this programme the students will be able to -
PSO 1	**Fundamental Knowledge of Chemistry** Demonstrate comprehensive understanding of core concepts, principles, and applications across analytical, inorganic, organic, and physical chemistry, including their interdisciplinary connections.
PSO 2	**Research and Analytical Skills** Design and perform experiments, carry out qualitative and quantitative analyses, interpret results, and utilize modern scientific methods in chemical research.
PSO 3	**Laboratory and Instrumentation Proficiency** Exhibit competence in laboratory techniques, adherence to safety protocols, chemical synthesis, and operation of advanced instruments such as spectroscopy, chromatography, and electrochemical systems.
PSO 4	**Problem Solving and Application** Apply chemical knowledge and appropriate methodologies to solve complex problems in chemistry and allied interdisciplinary areas like environmental, materials, and life sciences.
PSO 5	**Professional and Career Development** Develop the skills and competencies necessary for careers in academia, research, pharmaceuticals, chemical industries, environmental monitoring, and related sectors, as well as for higher education.
PSO 6	**Critical Thinking and Innovation** Integrate knowledge with critical thinking to become effective problem solvers, innovators, and responsible professionals contributing to scientific and societal advancement.

Semester - I

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science & Technology

Department of Chemistry and Analytical Chemistry

PG I Sem I

Course Type: MMC-I

Course Title: Inorganic Chemistry-I

Course Code: 601CHE1101

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. To study inorganic reaction mechanisms, SN1 and SN2 reaction, inner and outer sphere electron transfer reactions.

LO 2. To understand the theories of Trans effect, Substitution reactions in square planar complexes.

LO 3. To know the Term symbols, microstates, Correlation diagram and Orgel diagram.

LO 4. To understand Organometallics & Solid state Chemistry.

Course Outcomes:

After completion of the course the students will be able to-

CO 1. Analyze inorganic reaction mechanisms, including inner-sphere and outer-sphere electron transfer reactions.

CO 2. Apply Trans effect rule in preparation of square planar complex.

CO 3. Calculate different term symbols, microstates of metal ions.

CO 4. Elucidate the structure and bonding in Organometallics & concept of Solid state Chemistry.

Unit No.	Title of Unit & Contents	Hrs.
I	**Inorganic Reaction Mechanism – I**	**12**
	1. Rate of reaction, factors affecting the rate of reactions. 2. Definition of stability constant, stepwise and overall formation constant. 3 Factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand. 4.Labile and inert complexes, VBT explanation of liability and inertness 5. Ligand substitution reactions, Acid hydrolysis, factors affecting the acid hydrolysis in octahedral complexes.	

Unit No.	Title of Unit & Contents	Hrs.
	6.SN1 reaction – Introduction, characteristics, explanation with example using energy profile diagram and mechanism (Dissociative mechanism). 7. SN2 reaction – Introduction, characteristics, explanation with example using energy profile diagram and mechanism (Associative mechanism. 8.SN^1CB reaction – Introduction, characteristics, explanation with example using mechanism.. 9. Redox reactions (Electron Transfer Reactions) – Introduction, explanation with example, Inner and outer sphere election transfer reactions with mechanism, characteristics, essential requisites, factors which favor the outer and Inner sphere electron transfer reactions.	
	Unit Outcomes: UO 1. Write different types of inorganic reactions and their mechanism. UO 2. Define Inert and Labile complex on the basis of VBT.	
II	**Inorganic Reaction Mechanism – II**	**11**
	1. Substitution reactions in square planar complexes. 2. Trans effect, Trans directing series 3. Theories of Trans effect – Polarization theory, Pi bonding theory, evidence in favor of trans effect theories, Defects of these theories 4. Application of trans effect in the synthesis of some square planar complexes with suitable example 5. Comparison of substitution in octahedral vs square planar complexes.	
	Unit Outcome: UO 1. Discuss the role of Trans effect in Substitution Reaction of Square planar Complexes. UO 2. Define theories of Trans effect.	
III	**Spectral properties of metal complexes**	**11**
	1. Introduction 2. Spectrochemical and nephlauxetic series 3. Charge transfer – classification, mechanism and interpretation with suitable example, Luminescence spectra 4. Term symbol, Rules for determining the ground state term symbol for dn configuration according to L-S coupling 5. Microstates – Calculation of number of microstates	

Unit No.	Title of Unit & Contents	Hrs.
	6. Correlation diagram of d1 and d9, d8 in octahedral and tetrahedral field 7. Orgel diagram of d1 to d9 configuration of an octahedral and tetrahedral environment 8. Tanabe – Sugano diagram of d2 and d3 configuration of an octahedral field 9. Racah parameter – calculation of Dq, β and B (Numericals).	
	Unit Outcomes: UO 1. Calculate the no. of Microstate for various configurations UO 2. Draw & explain Orgel diagram of d1 to d9 configuration of an octahedral and tetrahedral complexes	
IV	**Organometallics & Solid state Chemistry**	**11**
	A) Organometallics: 1. Introduction – stable electronic configuration, 18 – electron compound, electron count preference, electron counting by oxidation states and neutral method 2. Structure and bonding of ligands carbon monoxide, Cyclopentadiene, cycloheptatriene and carbine **B) Solid state Chemistry:** 1. Electronic structure of solids and band theory, Limiting radius ratio, coordination number and their relationship 2. Stoichiometric defects – Introduction, schottky defect, frenkel defects. 3. Non – stoichiometric defects – metal excess defect, F-centre Interstitial ions and electrons, metal deficiency defect. Positive absent, extra interstitial negative ions. 4.Semiconductors – Introduction, N and P types of semiconductors	
	Unit Outcomes: UO 1.Calculate 18 electron compounds. UO 2. Differentiate between Stoichiometric defects and Non – stoichiometric defects	

Learning Resources:

1. Advanced Inorganic Chemistry – Satyaprakash, G.D. Tuli, S.K. Basu, R.D. Madan – S. Chand Publication – 2009

2. Concise Inorganic Chemistry (5th Edition) – J. D. Lee – Wiley – 2008

3. Inorganic Chemistry (5th Edition) – Duward Shriver, P. W. Atkins – Oxford University Press – 2002

4. Advanced Inorganic Chemistry Gurudeep Raj, Chatwal Anand Goel Pub., 1974

5. Textbook of Inorganic Chemistry – Puri, Sharma, Kalia – Milestone Publications – 2013

6. Wilkinson and Cotton, Inorganic Chemistry, Wiley; Third edition

7. Inorganic Chemistry (3rd Edition) – Wilkinson, Cotton – Wiley – 1999

8. Concepts and Models of Inorganic Chemistry , Bodie Douglas and DarlMcdaniel Third Edition, Wiley, 1983.

9. Organometallic Chemistry – Ajay Kumar – Vishal Publishing Co. – 2010

10. Organometallic Chemistry: A Unified Approach – R. C. Mehrotra and A. Singh – International Publishers – 2000

Internal Examination Pattern :

CAT – I : Assignments

CAT – II ; PPT Presentation/ Online quiz

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	1	2	1	3	1	2	1	3	3	2	3	1	2
CO2	3	3	1	2	2	2	1	2	1	3	2	2	3	2	2
CO3	3	2	1	2	1	2	1	2	1	3	2	1	2	1	2
CO4	3	3	2	3	2	3	1	2	1	3	3	2	3	2	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science & Technology

Department of Chemistry and Analytical Chemistry

PG I Sem I

Course Type: MMC-I

Course Title: Lab. Course-I (Based on MMC-I)

Course Code: 601CHE1104

Credits: 01 **Max. Marks: 50** **Lectures:30 Hrs.**

Learning Objectives:

LO 1. To Acquire the skill of separation of binary and ternary mixture.

LO 2. To Learn about Estimation of binary and ternary mixture

LO 3. To perform volumetric and gravimetric analysis of Metal ions in binary and ternary mixture.

LO 4. To calculate concentrations and quantities of metal ions from experimental data.

Course Outcomes:

After completion of course the student will be able to-

CO 1. Apply volumetric and gravimetric techniques for the separation and estimation of metal ions from binary mixtures.

CO 2. Determine the amount of ions by volumetric and gravimetric methods of analysis in binary and ternary mixture solutions.

CO 3. Analyze experimental data, calculate the percentage of individual metal ions, and interpret results for complex mixtures.

CO 4. Design systematic procedures for separation and estimation of metal ions in complex mixtures.

I	Practical	30 Hrs
	1.Separation and estimation of metal ions from the following binary mixture solutions. one volumetrically and the other gravimetrically.(**Any five)** i) Copper – Nickel ii) Copper – Iron iii) Nickel – Zinc iv) Iron – Magnesium v) Copper – Barium vi) Iron – Aluminium 2. Separation and estimation of metal ions from the following ternary mixture solution by volumetrically and second gravimetrically. i) Copper Nickel – Zinc ii)Copper–Nickel– Magnesium iii) Iron – Nickel Zinc iv) Silver – Nickel – Magnesium v) Silver–copper–Zinc	

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	2	2	2	2	1	3	3	3	3	2	2
CO2	3	3	2	3	2	2	2	2	1	3	3	3	3	2	2
CO3	2	3	2	3	1	3	2	2	1	2	3	2	3	2	3
CO4	3	3	2	3	2	3	2	2	2	3	3	3	3	2	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science & Technology

Department of Chemistry and Analytical Chemistry

PG I Sem I

Course Type: MMC-II
Course Title: Organic Chemistry-I

Course Code: 601CHE1102

Credits:03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. To clarify the concepts and principles of organic chemistry, types of reagents , types of reactions, the Hammett equation ,concept of aromaticity etc.

LO 2. Enable students to outline mechanism of Nucleophilic and electrophilic substitution reaction

LO 3. To explain the Electrophilic and Nucleophilic addition reaction to carbon–carbon multiple bond and carbon–hetero atom multiple bond

LO 4. To confront students with E2, E1 and E1CB reaction mechanisms

Course Outcomes:

After completion of the course, the students will be able to-

CO 1. Explain and summarize the fundamental concepts of organic chemistry, including types of reagents, reaction mechanisms, the Hammett equation, and aromaticity.

CO 2. Apply and demonstrate mechanistic principles to interpret nucleophilic and electrophilic substitution reactions.

CO 3. Analyze and interpret the mechanisms of nucleophilic and electrophilic addition reactions by identifying intermediates and factors affecting reactivity.

CO 4. Evaluate and differentiate the mechanisms of E1, E2, and E1CB elimination reactions with respect to reaction conditions, intermediates, and kinetic/thermodynamic factors.

Unit No.	Title of Unit & Contents	Hrs.
I	**Fundamentals of Organic Chemistry**	**12**
	1. Types of reagent, Types of reactions, Kinetic and thermodynamic control, Hammond's postulate, Potential energy diagrams, Transition state and intermediates. The Hammett equation and linear free energy relationship, Substituents and reaction constants 2. Effect of structure on reactivity-Resonance/Mesomeric effect, Inductive effect, Field effect, Steric effect, Strength of acids and bases, quantitative treatment. 3. Delocalised chemical bonding: conjugation, Cross-conjugation, Hyperconjugation and Tautomerism 4. Generation, Structure and stability of reactive intermediates;-	

Unit No.	Title of Unit & Contents	Hrs.
	carbocation, carbanion, free radical, carbenes, nitrenes and arynes. 5. Introduction to Aromaticity: a) Alternant and Non-alternant hydrocarbons b) Annulenes , hetero annulenes, tropane, azulene, fulvene, and tropylium salts c) Concept of anti-aromaticity.	
	Unit Outcomes: UO 1.Clarify the concepts and principles of organic chemistry. UO 2. Identify the different intermediate form during reactions	
II	**Substitution Reactions:**	**11**
	1. Nucleophilic Substitution: **A. Aliphatic nucleophilic substitution:** a. The SN^2, SN^1, mixed SN^2 & SN^1 and SET mechanism, the neighbouring group participation by π & σ-bonds, Anchimeric assistance. b. Nucleophilic substitutions at an allylic, aliphatic and a vinylic carbon. c. Reactivity: Effects of substrate structure, attacking nucleophile, leaving group and reaction medium. **B. Aromatic nucleophilic substitution (ArSN):** a. $ArSN^1$, $ArSN^2$ and Benzyne mechanism. b. Reactivity: Effect of substrate, leaving group and attacking nucleophile. **2. Electrophilic Substitution:** A: Aliphatic Electrophilic Substitution. a. SE^2 and SE^1 mechanism. b. Electrophilic substitution accompanied by double bond shift. c. Effect of substrate, leaving group and the solvent polarity on the reactivity. B: **Aromatic Electrophilic Substitution:** a. Mechanism. b. Orientation:-deactivation and deactivation of aromatic ring c. Energy profile diagrams. The ortho/para ratio. Ipso attack,	
	Unit Outcome: UO 1. Describe mechanisms for Electrophilic and Nucleophilic substitution reaction UO 2. Predict the effect of nucleophile, leaving group, and solvent on relative rates.	

Unit No.	Title of Unit & Contents	Hrs.
III	**Addition Reactions:**	**11**
	A. Addition to Carbon–Carbon Multiple Bond 1. Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals. 2. Regioselectivity and chemoselectivity, orientation and reactivity. 3. Addition to cyclopropene ring. **B. Addition to Carbon–Hetero Multiple Bond** **(Carbonyl Compounds:** Aldeyhde, Ketone, and nitriles.) 1. Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds 2. Addition of Grignard's reagent, Organo-zinc and organo-Lithium reagent to carbonyl and unsaturated carbonyl compounds.	
	Unit Outcomes: UO 1. Explain the Electrophilic and Nucleophilic addition reaction to carbon–carbon multiple bond. UO 2.Explain the Electrophilic and Nucleophilic addition reaction to carbon–hetero atom multiple bond reactions	
IV	**Elimination Reaction:**	**10**
	1. The E2, E1 and E1CB mechanisms and their spectrum 2. Orientation of the double bond. 3. Reactivity: Effects of substrate structures, attacking base, the leaving group and the medium, Stereochemistry of double bond 4. Reaction of LTA with carboxylic Acid(Oxidative Decarboxylation) 5. Mechanism and orientation in pyrolytic elimination. 6. Name reactions: a) Cope Elimination of amine oxides to form alkenes and hydroxylamines. b) Chugaev Elimination to create alkenes, typically from alcohols. c) Hofmann Elimination to form the less substituted alkene. d) Corey-Fuchs Reaction for alkyne synthesis	
	Unit Outcomes: UO 1. Elaborate the mechanism of elimination reactions. UO 2. Predict the effect of structure & leaving groups.	

Learning Resources:

1. Advanced Organic Chemistry: Reaction, Mechanism and Structure – Jerry March – John Wiley & Sons – 1968
2. Advanced Organic Chemistry – F. A. Carey and R. J. Sundberg – Plenum Press – 1977
3. A Guidebook to Mechanism in Organic Chemistry – Peter Sykes – Longman – 1961
4. Structure and Mechanism in Organic Chemistry – C. K. Ingold – Cornell University Press – 1953
5. Organic Chemistry – R. T. Morrison and R. N. Boyd – Prentice-Hall – 1959
6. Modern Organic Reactions – H. O. House – W. A. Benjamin – 1965
7. Principles of Organic Synthesis – R. O. C. Norman and J. M. Coxon – Blackie Academic & Professional – 1968

8. Reaction Mechanism in Organic Chemistry – S. M. Mukherji and S. P. Singh – Macmillan – 1976
9. Organic Chemistry (2nd Edition) – Jonathan Clayden, Nick Greeves and Stuart Warren – Oxford University Press – 2012
10. Organic Reaction Mechanism – Sanyal and Taneja – Tata McGraw-Hill – 1997
11. Organic Reaction Mechanism – V. K. Ahluwalia and Rakesh Parashar – Narosa Publishing House – 2002

Internal Examination Pattern:

CAT – I : Assignment

CAT – II: PPT Presentation /Seminar

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6
CO1	3	2	1	2	–	1	–	2	–	3	2	1	2	–	2
CO2	3	3	–	2	–	2	–	2	1	3	3	1	3	–	2
CO3	3	3	–	2	–	3	–	2	1	3	3	1	3	–	3
CO4	3	3	–	2	–	3	–	2	1	3	3	1	3	–	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science & Technology

Department of Chemistry and Analytical Chemistry

PG I Sem I

Course Type: MMC- II
Course Title: Lab Course –II (Based on MMC-II)
Course Code: 601CHE1105
Credits:01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. Understand the principles and procedures of basic laboratory techniques such as distillation and chromatographic methods (TLC and paper chromatography).
LO 2. Develop skills in qualitative analysis, including separation, purification, and identification of organic compounds in binary mixtures.
LO 3. Gain knowledge of synthetic organic reactions such as condensation, substitution, oxidation, and name reactions.
LO 4. Learn safe laboratory practices, proper handling of chemicals, and accurate documentation of experimental work.

Course Outcomes:

After completion of the course, the students will be able to-

CO 1. Perform and apply separation techniques such as simple distillation, thin layer chromatography, and paper chromatography.
CO 2. Analyze and identify components of binary organic mixtures through systematic qualitative analysis.
CO 3. Synthesize organic compounds using standard laboratory methods and named reactions with proper purification techniques.
CO 4. Demonstrate proficiency in laboratory skills, safety practices, and accurate reporting of experimental results.

Practical No.	Unit	
1	**I) Techniques** 1 Simple Distillation. 2 Thin layer Chromatography. 3 Paper Chromatography.	
2	**II) Qualitative Analysis:** Separation, purification, sample submission and identification of compounds of binary mixture (one solid and one liquid) by chemical method. (any fiv	

3.	**III) Preparations (One Stage) Any Five** 1. Preparation of Cinnamic acid by Perkin's reaction. 2. Aromatic electrophilic substitution. i.Synthesis of p-Nitroaniline ii.Synthesis of p- Bromoaniline 3. Aldol condensation – dibenzal acetone from Benzaldehyde. 4. Sandmeyer Reaction – P- Chlorotoulene from p- Toluidine. 5. Oxidation – adipic acid from Cyclohexanol by Chromic acid. 6. Cannizaro Reaction - 4-Chlorobenzaldehyde as substrate. Preparation of Salicylic acid from Phenol by Reimer-Tiemann reaction.	**IV)**

N.B.: Any Ten Practicals from above

Learning Resources:

1.Vogel's practical Organic Chemistry

2.Comprehensive practical Organic Chemistry – A. K. Ahluwalia and Renu Agrawal

3.Hand book of Organic Analysis – Qualitative and Quantitative – H. Clark and Adwar

Note:

1) Preparation should be carried out using 0.02 to 0.05 mol of the starting material.

2) Yield, M.P. and TLC of purified product should be recorded.

3) Sample of purified product and TLC plate should be submitted for inspection.

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6
CO1	2	3	2	3	2	2	2	2	2	2	3	3	2	2	2
CO2	3	3	2	3	1	3	2	2	1	3	3	3	3	2	2
CO3	3	3	2	3	2	3	2	2	2	3	3	3	3	2	3
CO4	2	2	3	3	2	2	3	2	2	2	2	3	2	3	2

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Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science & Technology

Department of Chemistry and Analytical Chemistry

PG I Sem I

Course Type: MMC-III
Course Title: Physical Chemistry
Course Code: 601CHE1103
Credits: 03 **Max. Marks: 75** **Lectures:45 Hrs.**

Learning Objectives:

LO 1. To understands the quantum Chemistry, Postulates of quantum mechanics, approximate methods.
LO 2. To study concepts of laws of thermodynamics – G, H, A, S etc, concept of activity & activity coefficients.
LO 3. To understand the concepts of Statistical Thermodynamics, Phase rule LO
LO 4. Ionic strength, Electrical double layer, Tafel equations etc.

Course Outcomes:

After completion of the course, the students will be able to---

CO 1. Apply the principles of quantum chemistry, including the postulates of quantum mechanics, the variation theorem, and perturbation theory to solve chemical problems.
CO 2. Explain the laws of thermodynamics and apply Raoult's law to calculate the vapor pressure of solutions.
CO 3. Analyze partition functions and utilize them to determine thermodynamic properties.
CO 4. Apply the phase rule and related terms to analyze three-component systems.

Unit No.	Title of Unit & Contents	Hrs.
I	**Unit - I Quantum Chemistry**	**15**
	1.The failure of Classical Mechanics, Origin of Quantum mechanics 2 The Postulates of quantum mechanics. 3 Schrodinger equations in Laplacian and Hamiltonian form. 4. Solutions of the Schrodinger equation for (derivations). a. Particle in one dimensional box b Particle in three dimensional box. c. Harmonic Oscillator d. Rigid rotator e. Hydrogen Atom 5. Orthogonality and Normalization of wave functions	

Unit No.	Title of Unit & Contents	Hrs.
	6. Operators and related theorems – Algebra of Operators, Commutator, linear operators, Hamiltonian operators, hermitian operators, Ladder operators. 7. Approximate Methods: a) Perturbation theory (first order and non degenrate) b)Variation Method Numerical Problems on – a. Particle in 1D – box, 3D-box (degeneracy) b. Orthogonality & Normalization c. Operators. Angular momentum-Eigen values and Eigen function	
	Unit Outcomes: UO 1. Distinguish between Classical mechanics & Quantum mechanics. UO 2 .Solve the Schrödinger equation for different model system.	
II	**Classical thermodynamics**	**10**
	1. Brief resume of concepts of laws of thermodynamics, Internal Energy, Enthalpy, Gibbs free energy and Entropy. 2. Partial molar properties – Partial Molar volume, partial molar heat content, partial molar free energy. (Chemical potential), significances, Gibbs-Duhem equation. 3. Concept of fugacity – determination from equation of state, Gibbs-Duhem – Margules equation. 4. Concept of activity & activity coefficient, any one method of determination. 5. Maxwell's thermodynamic relations. Ideal and non-ideal solutions (Raoults law), Excess functions for non-ideal solutions.	
	Unit Outcomes: UO 1. Apply partition function for determination of Thermodynamic Properties UO 2.Describe Partial Molar Properties & Roult's Law.	
III	**Statistical Thermodynamics and Phase Rule**	**13**
	3.1 Statistical Thermodynamics: 1. Introduction, Concept of distribution, thermodynamic probability,	

Unit No.	Title of Unit & Contents	Hrs.
	Ensemble and its types. 2. Partition functions – Translational, rotational, vibrational and electronic partition functions, calculation of thermodynamic properties in terms of partition functions, applications of partition functions. 3. Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics, Differences between them. **3.2 Phase Rule :** 1. Recapitulation of phase rule and terms involved in it. 2. Three component system: representation of ternary systems. 3. Partially miscible three liquid systems: System composed of three liquid components, one partially miscible pairs, two partially miscible and three partially miscible pairs. 4. System composed of two solid and a liquid components:- formation of eutectic systems, crystallization of pure components only, formation of binary compounds, one double salt formation	
	Unit Outcomes: UO1. Understand Partition functions, recapitulation of phase rule. UO2. Explains the basic definitions and terms in a phase diagram Defines phase, equilibrium, and component, degree of freedom and phase rule concepts.	
IV	**Electrochemistry**	**07**
	1. Ionic strength 2. Debye – Huckels limiting law, Numericals 3. Theoreis of Electrical double layer: Helmholtz, Gouy–Chapman & stern. 4. Debye–Falkenhagen effect & wien effect. 5. Over potential & its types. 6. Exchange current density, derivation of Butler–Volmer equation, Tafel equations & Tafel plot.	
	Unit Outcomes: UO 1.Solve the Problems on Ionic strength & Mean activity Coefficient. UO 2.Understand the Concept of Electrochemistry.	

Learning Resources:

1. Physical Chemistry – P. W. Atkins – ELBS -1978
2. Introduction to Quantum Chemistry – A. K. Chandra – Tata McGraw Hill – 1988

3. Quantum Chemistry – N. Levine – Prentice Hall of India Pvt. Ltd., New Delhi – 1994.
4. Introductory Quantum Chemistry (4th Edition) – A. K. Chandra – Tata McGraw-Hill Publishing Company Ltd., New Delhi – 1994.
5. Chemical Kinetics – K. J. Laidler – McGraw Hill
6. Kinetics and Mechanism of Chemical Transformations – J. Rajaraman and J. Kuriacose – Macmillan
7. Micelles: Theoretical and Applied Aspects – V. Moroi – Plenum Press
8. Modern Electrochemistry (Vol. I & II) – J. O'M. Bockris and A. K. N. Reddy – Plenum Press

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Internal Examination Pattern:

CAT – I: Open Book Test

CAT – II: Home Assignment

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PS O9	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6
CO1	3	2	1	3	1	2	1	2	1	3	2	1	2	1	2
CO2	3	2	2	3	1	2	1	2	1	3	2	1	2	1	2
CO3	3	3	1	3	1	3	1	2	1	3	3	2	3	1	3
CO4	3	2	2	3	1	2	1	2	1	3	2	1	3	1	2

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Rajarshi Shahu Mahavidyalaya, Latur

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Faculty of Science & Technology

Department of Chemistry and Analytical Chemistry

PG I Sem I

Course Type: MMC-III
Course Title: Physical Chemistry-III (Based on MMC-III)
Course Code:
Credits: 01 **Max. Marks: 50** **Lectures: 30Hrs.**

Learning Objectives:

LO 1. To determine the strength, concentrations, hydrolysis constant of solutions by Conductometer

LO 2. To determine pH, molar refractivity, freezing point by instrumental methods

LO 3. To Determine Atomic Refraction & Molar Refraction of various liquids

LO 4. To determine solubility, ionic strength, rate constant by non-instrumental methods

Course Outcomes:

After completion of the course, the students will be able to-

CO 1. Perform experiments using Conductometer, PH-meter, and refractometer.
CO 2. Determine solubility, ionic strength, rate constant by non-instrumental method.
CO 3. Determine Atomic Refraction & Molar Refraction of various liquids
CO 4. Determine solubility, ionic strength, rate constant by non-instrumental methods

I	Practical's	30 Hrs
	CONDUCTOMETER: 1. To estimate the concentrations of sulphuric acid, acetic acid and copper sulphate in given solution. 2. To determine solubility product and thermodynamic properties (ΔG, ΔH, ΔS) of sparingly soluble salts. 3. To determine the relative strength of chloroacetic acid and acetic acid. 4. To determine the hydrolysis constant of Aniline hydrochloride 5. To investigate basic hydrolysis of ethyl acetate at four different temperatures and to find out the energy of activation.	
	pH-METER : 1. To determine Hammet constant of given substituted benzoic acid. 2. To determine pH values of various mixtures of sodium acetate and acetic acid in aqueous solution and hence to find out dissociation constant of acid. To Determine pKa Values of Given organic Acids & Compare	

	REFRACTOMETER 1. To determine the molar refractivity of methyl acetate, ethyl acetate, n-hexane and carbon tetra chloride and to calculate refractive equivalence of C, H and Cl atom. 2. To study the variation of refractive index with composition of mixture of CCl_4 and ethyl acetate. 3. Determination of molecular radius of molecule of organic compound.	
	FREEZING POINT APPARATUS Determination of molecular weight of compound by freezing point method.	
	SECTION B (NON-INSTRUMENTAL) 1. To determine partial molar volume of ethanol and water mixture at given composition. 2. To determine solubility of benzoic acid at different temperature and hence to determine its heat of solution. 3. To determine effect of ionic strength on rate constant of reaction between potassium Persulphate & Potassium Iodide 4. To investigate the autocatalytic reaction between KMnO and oxalic acid and to find energy of activation. 5. To determine the rate constant of hydrolysis of methyl acetate catalyzed by HCl, per sulphate and potassium iodide. 6. To investigate the solubility of three component system and hence tie line on binodal curve.To study the variation of viscosity with composition of mixture of Ethanol-water, methanol-ethylidene chloride & Nitric acid-Chloroform. & determine whether there is compound formation between two liquids.	

NB:

1 Performance of eight experiments is expected
2 At least one experiment on each instrument should be perform.
3 Student should prepare the required solutions

Learning Resources:

4 Findlay's (1985): Practical Physical Chemistry, Revised and edited by B.P. Levitt 9 th edition, Longman, London.

5 Chatwal, G.R. and Anand,S.K (2000): Instrumental Methods of Chemical Analysis, Himalaya Publishing House, Delhi

6 Yadav, J. B (2005): Advanced Practical Physical Chemistry, 22nd edition, Goel publishing House, Krishna Prakashan Media Ltd.

7 Venkatesan, V,Veeraswamy, R and Kulandaivelu, A.R (1997): Basic Principles of Practical Chemistry", 2nd edition, Sultan Chand and Sons Publication, New Delhi.

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	1	3	2	2	2	2	2	3	3	3	2	2	2
CO2	3	3	2	3	2	3	2	2	1	3	3	2	3	2	3
CO3	3	2	1	3	1	2	1	2	1	3	2	2	2	1	2
CO4	3	3	2	3	2	3	2	2	2	3	3	3	3	2	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

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Department of Chemistry and Analytical Chemistry

PG I Sem I

Course Type: MEC-I (A)

Course Title: Physical Methods in Chemistry

Course Code: 601CHE1201

Credits: 033 **Max. Marks: 75** **Lectures: 45Hrs.**

Learning Objectives:

The objective of this course is to enable the learner to:

LO 1. Understand the theoretical and computational framework of chemometrics and basic concepts in analytical chemistry, enabling the application in chemical systems.

LO 2. Instill a rigorous approach to data integrity by teaching the application of significance tests, confidence intervals, and error propagation to ensure the scientific defensibility of data.

LO 3. Evaluate the theoretical and practical parameters of TLC, GC and HPLC to optimize the separation, identification, and quantification of components within a mixture.

LO 4. Confront with the integration of non-destructive & destructive methods within the regulatory framework of forensic science for the identification of controlled substances and trace evidence.

Course Outcomes:

On completion of this course, the learner will be able to:

CO 1. Construct and validate a multivariate calibration model to extract quantitative information from complex chemical mixtures.

CO 2. Evaluate experimental reliability by using statistical tests to quantify uncertainty, minimize errors, and validate the accuracy of analytical results.

CO 3. Optimize the separation and quantification of chemical mixtures by manipulating theoretical parameters like resolution, efficiency, and selectivity.

CO 4. Implement standardized analytical protocols and hyphenated techniques to provide scientific evidence of Forensic Analysis.

Unit No.	Title of Unit & Contents	Hrs.
I	**Basic Concepts of Analytical Chemistry and Chemometrics:**	12
	1.1 Basic Concepts of Analytical Chemistry i. The nature of analytical Chemistry, the role of analytical Chemistry, qualitative and quantitative analytical methods, ii. A typical quantitative analysis- sampling and treatment of samples, validation of a method. **1.2 Solution Concentrations & Chemometrics** i. Concentration of solution based on volume & mass unit. Mole concept and concentration unit. ii. Calculations of ppm, ppb, ppt and dilutions of solution, concept of milimole. iii. Stoichiometry of chemical reactions, concepts of kgmol, limiting and excess reactant, theoretical & practical yield. iv. Solubility & solubility equilibria, effect of the presence of the common ion. v. Calculation of pH of acids, bases & acidic – basic buffers vi. Numerical.	
	Unit Outcomes: On completion of this unit, the learner will be able to, UO 1. Apply Fundamental Analytical Principles and Concepts UO 2. Execute Stoichiometric and Chemometric Calculations.	
II	**Errors & Statistical treatment of Analytical Data**	12
	2.1 Errors: Determinant and Indeterminate errors, Accuracy and Precision, Significant Figures & Rounding Off. **2.2 Statistical Analysis:** Distribution of random errors, Average deviation & standard deviation, variance and confidence limit, significant figures & computation rules, least square methods (Q, t, χ^2, F tests).	
	Unit Outcomes: On completion of this unit, the learner will be able to, UO 1. Evaluate Analytical Quality through Error Analysis. UO 2. Apply Statistical Tests for Data Validation.	
III	**Separation Techniques :**	15

Unit No.	Title of Unit & Contents	Hrs.
	3.1 Basics of Chromatography Introduction, classification, basic principles, and theory of chromatographic techniques. **3.2 Chromatographic Techniques** **i. Thin Layer Chromatography:** Basic principle, experimental techniques, solvent system, plate development, detection of components, evaluation of chromatogram by different method, application of TLC. **ii. Gas Chromatography:** Introduction, Techniques-Column efficiency, plate theory, rate theory, Advantages, Gas chromatogram, Instrumentation, Applications. **iii. HPLC:** Introduction, principle, column efficiency in LC, mobile phase reservoirs, solvent treatment system, pumping system, sample introduction system, types of column, Detectors: EC and diode array detectors, fluorimetric detectors, applications of HPLC.	
	Unit Outcomes: On completion of this unit, the learner will be able to, UO 1. Analyze Chromatographic Principles and Separation Mechanisms UO2. Evaluate Instrumentation and Practical Applications	
IV	**Forensic Analysis**	**06**
	4.1 Overview: Concepts, Destructive and Nondestructive techniques, Data interpretation. **4.2 Blood Analysis:** Blood preservation and ageing effects, Analysis of blood components and exogenic substances, blood stain analysis. **4.3 DNA Profiling:** DNA and its polymorphism, DNA typing procedures-RFLP, PCR, MVR-PCR, Dot-blot, AMP-FLP, STR, other methods, paternity testing, applications.	
	Unit Outcomes: On completion of this unit, the learner will be able to, UO1. Evaluate Analytical Techniques for Biological Evidence. UO2. Implement DNA Profiling and Polymorphism Procedures	

Learning Resources:

1. Instrumental methods of chemical analysis (CBS) – H.H. Willard & L.L. Merritk, I.A. Dean.
2. Instrumental methods of Analysis – Chatval Anand.
3. Instrumental methods of chemical analysis – H. Kaur.
4. Fundamental Analytical Chemistry 8th edition – Skooq, west, holler, couch.
5. Analytical Chemistry 6th edition – L.D. Christain.
6. Computational Chemistry – A.C Noorris.

7. Computer for Chemistry – S.K. Pundir & Anshu Bansal.
8. Principal of Analytical Chemistry, Douglas & Koog, F.I. Holler & R.crouch 6th Edition, Thomson books / cole 2007.
9. H.P.L.C. Analytical Chemistry by open learning 2nd edition sundie lindsory Ed. John Willey & sons, New York 1993.
10. Instrumental Methods of Chemical Analysis – B.K. Sharma
11.Instrumental methods of Chemical Analysis – R.D. Braun.
12.Basic principles of spectroscopy – R Chang, Mc. Graw Hill.

Internal Examination Pattern:

CAT – I: Open Book Test

CAT – II: Home Assignment

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6
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CO2	3	3	2	3	1	3	3	2	1	3	3	2	3	2	3
CO3	3	3	2	3	2	3	2	2	1	3	3	3	3	2	3
CO4	3	3	2	3	2	3	3	2	2	3	3	3	3	3	3

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Department of Chemistry and Analytical Chemistry

PG I Sem I

Course Type: MEC-I (A)

Course Title: Lab. Course-IV (Based on MEC-I)

Course Code: 601CHE1203

Credits: 01 **Max. Marks: 50** **Lectures: 30Hrs.**

Learning Objectives:

The objective of this course is to enable the learner to:

LO 1. Identify and Validate: Execute standardized laboratory procedures to detect unknown ions, validate method reliability, and calculate the impact of chemical equilibria and stoichiometry on product yield.

LO 2. Evaluate Experimental Data: Perform repetitive measurements of physical constants and analyze experimental data to calculate absolute and relative errors, determining the degree of accuracy and precision.

LO 3. Implement Chromatographic Analysis: Operate chromatographic systems (e.g., HPLC, GC) to separate complex mixtures into individual components and determine separation efficiency using retention times and peak widths.

LO 4. Apply Statistical Analysis: Utilize manual statistical tools to identify outliers in experimental datasets and assess if differences between observed results are statistically significant.

Course Outcomes:

On completion of this course, the learner will be able to:

CO 1. Execute standard lab methods to identify unknown substances, execute stoichiometric calculations.

CO 2. Evaluate Accuracy, Precision and error.

CO 3. Develop chromatographic methods and their validate

CO 4. Apply statistical tools for data analysis.

No.	Practicals	Hrs
I	**Method Validation**	
1.	Determination of Iron in Pharmaceutical Tablets using a Colorimetric Method (1,10-phenanthroline) **Goal:** Recovery Studies by adding a known amount of standard iron to the sample (Spike Recovery) to validate the method's accuracy.	**3**
II	**Comparison of Qualitative vs. Quantitative Analysis**	
2.	Paper Chromatography to identify unknown metal ions (Qualitative) followed by a Titrimetric/Gravimetric estimation of one identified ion (Quantitative).	**3**

	(Mixture of $CuCl_2$, $NiCl_2$ and $FeCl_3$)	
	Goal: Insight about Qualitative vs. Quantitative Analysis.	
III	**Stoichiometry & Yield**	
3.	Synthesis and Yield Analysis of Aspirin or Benzil	**3**
	Goal: Synthesize a compound and identify the limiting reactant & Calculate the theoretical vs. practical yield and account for losses during the "treatment of samples" (recrystallization).	
IV	**Solubility & Common Ion Effect**	
4.	Determination of the Solubility Product (Ksp) of Calcium Sulphate (common ion $CaCl_2$).	**3**
	Goal: Check the effect of common ion on solubility	
V	**pH metry**	
5.	Determine the acid and basic dissociation constant of an amino acid (Glycine) and hence isoelectric point of an acid	**3**
	Goal: Understand pH and related concepts	
	Determination of pKa of weak acid using pH metry	
	Goal: Understand Henderson-Hesselbach Equation	
VI	**Errors, Accuracy, Precision**	
6.	**Comparative Titrimetry (Visual vs. Potentiometric)** Perform a standard acid-base titration using a visual indicator (Phenolphthalein) and repeat it using a pH meter (Potentiometric).	**3**
	Goal: Identify **Constant Errors** (like indicator blank) and **Indeterminate Errors** (visual judgment of color change). Compare the **Precision** (spread of results) between the two methods.	
7.	**The "Standard Addition" Method for Accuracy** Measure the concentration of a metal ion in an "unknown" sample. by spiking the sample with a known amount of standard solution.	**3**
	Goal: Calculate the percentage recovery. If recovery is not 100%, students must investigate Systematic (Determinate) Errors such as matrix interference	
VII	**Statistical Investigations**	
8.	Apply the **Dixon's Q-test** to statistically decide whether to retain or reject the suspected values in series of 5-7 titrations at a 95% confidence level.	**3**
	Goal: Learn application of statistical test	
9.	Determine Paracetamol in tablet conventional titration (redox titration with Ceric ammonium nitrate) and by potentiometric titration (redox titration using Pt and Calomel electrode) and compare the results of two method.	**6**
	Goal: 1. Use the **F-test** to see if the two methods have significantly different precision (variance). 2. Use the **Student's t-test** to determine if the means of the two methods are significantly different or if the difference is just due to random error.	
10.	Spectrophotometric Determination of Copper	**3**
	Goal: Use the Method of Least Squares to find the best-fit line ($y = mx + c$). Students must calculate the Correlation Coefficient (R^2) and the Standard Error of the Slope.	
VIII	**Chromatography**	

11.	Analysis of caffein by HPLC	**3**
	Goal: To quantify caffeine in samples using RP-HPLC	
12.	Separation and identification of organic compounds present in given mixture	**3**
	Goal: To get insight about separation of complex mixture by TLC	
13.	To separate and identify a mixture of metal cations (e.g., Cu^{2+}, Ni^{2+}, Co^{2+}, and Fe^{3+}) or halides using TLC and specific chromogenic reagents.	**3**
	Goal: To get insight about separation of complex mixture by TLC	

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6
CO1	3	3	1	3	2	2	2	2	1	3	3	2	3	2	2
CO2	3	3	2	3	1	3	3	2	1	3	3	2	3	2	3
CO3	3	3	2	3	2	3	2	2	2	3	3	3	3	2	3
CO4	3	3	2	3	2	3	2	2	1	3	3	2	3	2	3

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Department of Chemistry and Analytical Chemistry

PG I Sem I

Course Type: MEC I (B)

Course Title: Basic Concepts of Polymer Chemistry

Course Code: 601CHE1202

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. To recall and define basic concepts such as polymers, monomers, polymerization, and types of polymers.
LO 2. To explain the mechanisms and techniques of various polymerization processes.
LO 3. To calculate molecular weights and apply nomenclature rules to identify and name polymers.
LO 4. To Analyze the properties, manufacturing processes, and applications of commercial polymers and assess their suitability for different uses.

Course Outcomes:

On completion of this course, the student will be able to:

CO 1. Define polymers, monomers, and polymerization, and explain the classification of polymers based on source, structure, and thermal behavior.
CO 2. Describe and compare the mechanisms of different polymerization processes, including chain growth, step growth, ring-opening and advanced polymerization techniques.
CO 3. Calculate and interpret molecular weights (Mn, Mw, Mv, Mz), degree of polymerization, and explain the nomenclature of polymers based on IUPAC and structural conventions.
CO 4. Explain the manufacturing processes, properties, and applications of important commercial polymers such as polyethylene, polypropylene, PVC, polystyrene, PET, and nylon-6,6, and evaluate their suitability for various uses.

Unit No.	Title of Unit & Contents	Hrs.
I	**Unit I Basic Concepts and Classification of Polymers**	**10**
	Basic concepts - polymer, monomer and polymerization, functionality and reactivity, Classification of polymers based on - source, chemical nature, thermal response, ultimate form and branched/network structures, homopolymer and copolymer (types)	
	Unit Outcomes: UO 1. Define Polymers & Polymerization UO 2. Describe Different Types of Polymers	
II	**Mechanisms & Techniques of Polymerizations**	**15**
	Mechanisms of chain and step growth polymerizations, ring opening polymerisation, Miscellaneous polymerisations - electrochemical polymerisation, metathesis polymerisation, group transfer	

	polymerization Bulk polymerisation, solution polymerisation, suspension polymerisation, emulsion polymerisation, melt polycondensation, solution polycondensation, and interfacial polycondensation, solid and gas phase Polymerization	
	Unit Outcomes: UO 1. Discuss Different Techniques of Polymerization. UO 2. Describe Mechanism of Different Polymerization.	
III	**Molecular Weights and Nomenclature of Polymers**	**10**
	Degree of polymerisation, various average molecular weights (Mn, Mw, Mv and Mz) and molecular weight distribution (MWD),nomenclature of polymers based on - source, structure, IUPAC	
	Unit Outcomes: UO 1. Determination of Molecular Weight of polyper. UO 2. Nomenclature of polymers	
IV	**Commercial Polymers:**	**10**
	Manufacture, properties and applications of Polyethylene Polypropylene, polystyrene, polymethylmethacrylate, Polyvinylchloride, polybutadiene and polyacetals, PET, Nylon-6,6.	
	Unit Outcomes: UO 1. Describe Properties Polymer Defferent types of polymer. UO 2. Explain Manufacturing of Polypropylene, polystyrene, polymethyl methacrylate, etc.	

Learning Resources:

1. V. R. Gowarikar, N. V. Viswanathan and Jayadev Sreedhar, Polymer Science, New Age International (P) Limited, New Delhi, 1988.
2. M. P. Stevens, Polymer Chemistry an Introduction, 2nd Edition, Oxford University Press, New York, 1999.
3. J. R. Fried,Polymer Science and Technology, Eastern Economic Edition, Printice Hall of India, New Delhi, 2000.
4. C. E. Carraher Jr Introduction to Polymer Chemistry, Special Indian Edition, Taylor and Francis, New Delhi, First reprint, 2010.
5. P. Ghosh, Polymer Science and Technology, Plastics, Rubbers, Blends and Composites, , 3rd Edition, Tata McGraw Hill Education Private Ltd., New Delhi, 2011.
6. F. W. Billmayer, Text Book of Polymer ScienceJohn Wiley and Sons, New Delhi, 1984.
7. G. Odian, Principles of Polymerisation, 3rd Edition, Odian, John Wiley & Sons (Asia) Pvt. Ltd., Singapore, 2002.
8. P. Bahadur and N. V. Sastry, Principles of Polymer Science, 2nd Edition, Narosa Publishing House, New Delhi, 2012.

Internal Examination Pattern:

CAT – I: Assignments

CAT – II: Open Book Test

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6
CO1	3	2	2	3	1	1	1	2	1	3	2	1	2	1	2
CO2	3	3	2	3	1	2	1	2	1	3	2	1	3	1	2
CO3	3	3	1	3	1	2	1	2	1	3	3	1	3	1	3
CO4	3	3	3	3	2	2	2	2	1	3	2	2	3	3	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

Semester - II

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science & Technology

Department of Chemistry and Analytical Chemistry

PG I Sem II

Course Type: MMC-IV
Course Title: Inorganic Chemistry-II
Course Code: 601CHE2101
Credits: 03 **Max. Marks:75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. To understand the role of natural Metalloporphyrins.

LO 2. To understand the chemistry of P block elements.

LO 3. To evaluate magnetic behavior and Spectra of coordination compounds.

LO 4. To classify molecules into point groups using a systematic approach.

Course Outcomes:

After completion of the course, the students will be able to-

CO 1. Illustrate the role of metals in biological systems.

CO 2. Discuss the trends and reactivity of main group elements

CO 3. Interpret with inorganic Mossbauer and ESR Spectroscopy and their difference

CO 4. Apply symmetry and group theory concepts to classify molecules and predict physical properties.

Unit No.	Title of Unit & Contents	Hrs.
I	**Bio inorganic Chemistry**	**10**
	1.Biological importance of essential and Non-essential elements. 2. Na / K Pump. 3. Metalloporphyrins – structure of porphyrin molecule 4. Hemoglobin – structure, function of hemoglobin., Bhor effect 5 .Myoglobin – structure and function, Difference between hemoglobin and myoglobin 6.Chlorophyll – structure and function, photosynthesis PS-I and PS-II 7.Cytochrome –structure, its types & functions 8. Electron carrier protein in biological system: Iron-suphur protein – Rubredoxin, ferrodoxin.	
	Unit Outcomes: UO 1. Discuss biological importance of essential and Non-essential elements. UO 2. Define the role of Hemoglobin , Myoglobin, Chlorophyll and cytochrome	

Unit No.	Title of Unit & Contents	Hrs.
II	**Chemistry of Main group elements:**	**11**
	1 .Boron Group: Boron Hydrides, classification of boranes, preparation, structure and Bonding with reference to LUMO, HOMO, interconversion of lower and higher boranes, Metalloboranes, Carboranes 2. Carbon Group: C60 and its compounds (fullerenes), Intercalation compounds of Graphite, Graphene, Silicates 3. Nitrogen Group: Nitrogen activation, Oxidation states of nitrogen, phosphorus compounds 4. Oxygen Group: Oxyacids, and oxoanions of sulphur & nitrogen, comparison of strength of oxyacids 5.Halogen Group: Interhalogens, pseudohalogen, Synthesis, Structure, Properties and Application, Bonding	
	Unit Outcome: UO 1. Discuss the Chemistry of Main group elements. UO 2. Draw & explain allotropes of Carbon.	
III	**Magnetic Behavior and Spectroscopy of Complexes**	**11**
	A) Magnetic Properties of metal complexes: 1. Origin of magnetism, Types of magnetism, Curie Law, Curie-Weiss Law 2. Magnetic properties of complexes – paramagnetism, 1st and 2nd ordered Zeeman effect, Quenching of orbital angular momentum by ligand field. **B) Inorganic Spectroscopy** **1. IR Spectroscopy** Principle, Difference between IR and NMR Spectroscopy, IR spectra of some inorganic compounds **2. ESR Spectroscopy** Comparison between ESR and NMR spectroscopy types of substances with unpaired electron, theory of transition metal ion as ESR indicator ion. **3.Mossbauer Spectroscopy** Theory, Doppler Effect, Mossbauer spectra some inorganic compounds	
	Unit Outcomes: UO 1. Identify nature of magnetic property of metal complexes. UO 2. Apply principles of inorganic spectroscopy.	

Unit No.	Title of Unit & Contents	Hrs.
IV	**Molecular Symmetry and Group Theory**	**13**
	1..Symmetry criterion of optical activity, symmetry restrictions on dipole moment. A systematic procedure for symmetry classification of molecules. 2. Concepts of Groups, Sub-groups, Classes of Symmetry operations, Group Multiplication Tables. Abelian and non-Abelian point groups. 3. Representation of Groups: Matrix representation of symmetry operations, reducible and irreducible representations. The Great Orthogonality Theorem and its application in construction of character tables for point groups C2v, C3v and D2h, structure of character tables. 4. Applications of Group Theory. 5. Determination of symmetry species for translations and rotations. 6. Mulliken's notations for irreducible representations.	
	Unit Outcomes: UO 1. Predict the point groups of molecule UO 2. Apply group theory principles	

Learning Resources:

1. Inorganic Chemistry – by Shriver and Atkins (Ox ford)
2. Concise Inorganic Chemistry – by J.D. Lee (Chapman & Hall)
3. Inorganic Chemistry : Principle, Structure and reactivity by Huheey, Keiter Medhi (Pearson Education)
4. Inorganic – Chemistry by Catherine Housecraft.
5. Inorganic Chemistry by messler and tarr (pearson publishers)
6. Principle of Bio inorganic Chemistry: by S.J. Lippard and J.M. Berg.
7. Bioinorganic Chemistry : Inorganic elements in Chemistry of life by – W.Kaim and B. Schwederski.
8. Bioinorganic Chemistry by Robert Hay.
9. Bioinorganic Chemistry by Bertini, Gray, Lippard and Valentine.
10. Chemical Applications of Group Theory - F. Albert Cotton

Internal Examination Pattern:

CAT – I: Assignments

CAT – II: Numerical problems

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	3	3	1	2	2	2	1	3	2	1	3	2	2
CO2	3	3	2	3	1	2	1	2	1	3	2	1	3	1	2
CO3	3	3	1	3	1	3	2	2	1	3	3	3	3	2	3
CO4	3	3	1	3	1	3	1	2	1	3	3	2	3	1	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science & Technology

Department of Chemistry and Analytical Chemistry

PG I Sem II

Course Type: MMC-IV
Course Title: Lab. Course-V (Based on MMC-IV)
Course Code: 601CHE2104

Credits: 01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. To perform semi micro qualitative inorganic analysis of three acidic and three basic radicals

LO 2. To identify acidic and basic radicals, including rare earth metal ions, through qualitative analysis.

LO 3. To apply appropriate procedures for the synthesis of coordination compounds.

LO 4. To prepare different inorganic complexes.

Course Outcomes:

After completion of the course, the students will be able to-

CO 1. Identify different acidic and basic radicals by qualitative analysis a

CO 2. Demonstrate qualitative analysis techniques for identification of ions

CO 3. Construct coordination compounds using standard laboratory methods.

CO 4. Evaluate purity, stability, and characteristics of synthesized complexes

I	Practical	30 Hrs
	Semi micro qualitative inorganic analysis (**At least 08 mixtures**): 1 Three acidic and three basic radicals including one rare earth metal ions and acidic radicals. 2 **Synthesis of complex:** Potassium Trioxalato Ferrate, Potassium Trioxalato Aluminate, Dimethylglyoxime Nickel(II), Tris(acetyl acetonate)Manganese(III).	

Learning Resources:

1. **Vogel, A. I.** *A Textbook of Quantitative Chemical Analysis* Pearson Education India, 6th Edition, 2000.
2. **Vogel, A. I. (Revised by G. Svehla)** *Qualitative Inorganic Analysis* Pearson / Prentice Hall, 7th Edition, 1996.
3. **Mendham, J., Denney, R. C., Barnes, J. D., Thomas, M. J. K.** *Vogel's Textbook of Quantitative Chemical Analysis* Pearson Education India, 6th Edition.
4. **Svehla, G.** *Vogel's Qualitative Inorganic Analysis* Longman / Pearson, 7th Edition.

5. **Marr, G. & Rockett, B. W.** *Practical Inorganic Chemistry* Van Nostrand Reinhold, 1972.
6. **Pass, G. & Sutcliffe, H.** *Practical Inorganic Chemistry* Chapman & Hall, 2nd Edition, 1974.
7. **Greenwood, N. N. & Earnshaw, A.** *Chemistry of the Elements* Butterworth-Heinemann (Elsevier India reprint available).

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6
CO1	3	3	1	3	1	2	2	2	1	3	3	3	2	1	2
CO2	3	3	1	3	1	2	2	2	2	3	3	3	2	1	2
CO3	3	3	1	3	2	3	2	2	2	3	3	3	3	2	3
CO4	3	3	2	3	2	3	3	2	1	3	3	3	3	2	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science & Technology

Department of Chemistry and Analytical Chemistry

PG I Sem II

Course Type: MMC-V

Course Title: Organic Chemistry-II

Course Code: 601CHE2102

Credits: 03 **Max. Marks:75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. To introduce and explain oxidation and reduction reactions of hydrocarbons, alcohols, and carbonyl compounds.
LO 2. To develop understanding of polymerization mechanisms and their industrial applications.
LO 3. To clarify the concepts and classifications of pericyclic reactions.
LO 4. To provide insight into photochemical reactions and related fundamental concepts.

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Identify and explain various oxidizing and reducing agents and their applications in organic reactions.
CO 2. Illustrate and analyze mechanisms of different polymerization reactions and relate them to their applications.
CO 3. Explain and differentiate electrocyclic reactions, cycloaddition reactions, and sigmatropic rearrangements.
CO 4. Describe and apply principles of photochemistry, including photoreduction and Photo–Fries reactions

Unit No.	Title of Unit & Contents	Hrs.
I	**Oxidation and Reduction reactions**	**12**
	1. Oxidation 1.1 Oxidation of hydrocarbons 1.1.1 Alkanes 1.1.2 Aromatic hydrocarbons 1.1.3 Alkenes 1.2 Oxidation of alcohols 1.2.1 Oxidation via alkoxysulfonium salts 1.2.2 Other metal-based oxidants 1.2.3 Other non-metal-based oxidants 1.2.4 Oxidation to carboxylic acids or esters 1.3 Oxidation of ketones 1.3.1 Unsaturated ketones	

Unit No.	Title of Unit & Contents	Hrs.
	1.3.2 Hydroxy-ketones 2. Reduction 2.3 Reduction by hydride-transfer reagents 2.3.3 Derivatives of lithium aluminium hydride and sodium borohydride 2.3.4 Mixed lithium aluminium hydride–aluminium chloride reagents 2.3.5 Diisobutylaluminium hydride (DIBAL-H) 2.3.6 Sodium cyanoborohydride and sodium triacetoxyborohydride 2.4 Other methods of reduction 2.4.1 Enzyme catalysed 2.4.2 Wolff–Kishner reduction 2.4.3 Reductions with diimide 2.4.4 Reductions with trialkylsilanes	
	Unit Outcomes: UO 1. Identify oxidizing and reducing reagents in organic reactions UO 2. Write mechanism of oxidation and reduction reaction	
II	**Polymerization Reactions**	**13**
	Mechanisms of chain and step growth polymerizations, ring opening polymerisation, Miscellaneous polymerisations - electrochemical polymerisation, metathesis polymerisation, group transfer polymerization Bulk polymerisation, solution polymerisation, suspension polymerisation, emulsion polymerisation, melt polycondensation, solution polycondensation, and interfacial polycondensation, solid and gas phase Polymerization Manufacture, properties and applications of Polyethylene Polypropylene, polystyrene, polymethylmethacrylate, Polyvinylchloride, polybutadiene and polyacetals, PET, Nylon-6,6.	
	Unit Outcome: UO 1. Describe advanced and specialized polymerization methods UO 2. Analyze how reaction conditions and techniques influence polymer properties	
III	**Pericyclic Reactions**	**10**
	1. Molecular orbital symmetry. 2. Frontier orbitals of ethylene, 1,3-butadiene,1,3,5-haxatriene and allyl	

Unit No.	Title of Unit & Contents	Hrs.
	system. 3. Classification of pericyclic reactions. 4. Woodward Hoffmann correlation diagrams: FMO and PMO approach. **A. Electrocyclic Reactions:** 1 Conrotatory & disrotatory motions in ring opening and ring closing reactions 2 Ring opening and ring closing reactions of polyenes having 4n, 4n+2 electron systems. **B. Cycloaddition Reactions:** 1 [2+2] Cycloaddition reactions. 2 [4+2] Cycloaddition reactions 3 1,3-dipolar cycloadditions 4 Cheleotropic reactions **C. Sigmatropic rearrangements** 1 Suprafacial and antarafacial shifts of H. 2 Sigmatropic shifts involving carbon moieties, 3,3 and 5,5- Sigmatropic rearrangements. 3 Claisen, Cope and Aza–Cope rearrangement	
	Unit Outcomes: UO 1. Sketch Woodward Hoffmann correlation diagrams. UO 2. Explain the Cycloaddition and Sigmatropic Reactions	
IV	**Photochemical Reactions**	**10**
	1. Introduction to free radical reactions with mechanism 2. Principles – Photochemical theory. 3 Electronic excitation, singlet and triplet states. 4. Jablonski diagram, Energy transfer and quantum efficiency. 5. Photochemistry of carbonyl compound: Photoreduction Norrish type – I & II Paterno- Buchi reaction 1. Photochemistry of alpha, beta-unsaturated ketones.	

Unit No.	Title of Unit & Contents	Hrs.
	2. Photochemistry of olefins: cis – trans isomerism. Photo–Fries reaction of anilides, Barton reaction and nπ-pπ rearrangements.	
	Unit Outcomes: UO 1. Explain photochemical reactions UO 2. Familarize with photo reduction reactions, Photo –friesreactions	

Learning Resources:

1. Advanced Organic Chemistry-Reaction Mechanism and structure, Jerry March, John Wiley.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg , Plenum.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
4. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.
5. Organic Chemistry, R.T. Morrison Boyd, Prentice-Hall.
6. Modern Organic Reactions, H.O.House , Benjamin
7. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic and professional.
8. Pericyclic Reactions, S.M. Mukharji, Macmillan, India.
9. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P.Singh,Macmillan
10. Photochemistry and Pericyclic Reactions, Jagdamba Singh and Jaya Singh.
11. Modern Methods of Organic Synthesis, William Caruthers

Internal Examination Pattern:

CAT – I: Assignment

CAT – II: Poster Presentation

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6
CO1	3	3	2	3	1	2	1	2	1	3	2	1	3	1	2
CO2	3	3	2	3	2	3	1	2	1	3	3	1	3	2	3
CO3	3	3	1	3	1	3	1	2	1	3	3	1	3	1	3
CO4	3	3	2	3	2	3	1	2	1	3	3	1	3	2	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

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Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science & Technology

Department of Chemistry and Analytical Chemistry

PG I Sem II

Course Type: MMC-V
Course Title: Lab Course –VI (Based on MMC-V)
Course Code: 601CHE2105
Credits: 01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. To introduce and demonstrate essential laboratory techniques such as steam distillation, fractional distillation, and column chromatography.
LO 2. To develop skills in separation, purification, and identification of organic compounds from binary mixtures using physical methods.
LO 3. To train students in multi-step organic synthesis, including preparation and conversion of compounds.
LO 4. To enhance understanding of reaction processes and laboratory practices, including safe handling and proper sample submission.

Course Outcomes:

After successful completion of the practical course, students will be able to:

CO 1. Perform and demonstrate laboratory techniques such as distillation and chromatography effectively.
CO 2. Separate, purify, and identify components of binary mixtures using appropriate experimental methods.
CO 3. Carry out multi-step organic syntheses and obtain desired products with proper yield and purity.
CO 4. Apply analytical and observational skills to interpret results and follow good laboratory practices and safety measures.

Practical No.	Practical
1	**1. Demonstration:** a) Steam distillation b) Fractional distillation c) Column chromatography **2. Qualitative analysis:** Separation, Purification, Sample submission and Identification of compounds of binary mixture (Solids) by physical (Ether extraction) method (Any five)

2	**3. Preparations (double stage) (any five)** a) Phthalic acid ------ phthalic anhydride ----------anthranilic acid b) Acetophenone------ oxime ----------acetanilide c) Chlorobenzene-----2,4 –dinitro chlorobenzene----------2,4-dinitroaniline d) **Benzoin----- benzil ----------benzilic acid**

N.B.: Any Ten Practicals from above.

Note: 1) Preparation should be carried out using 0.02 to 0.05 mol of the starting material.

2)Yield, M.P. and TLC of purified product should be recorded.

3)Sample of purified product and TLC plate should be submitted for inspection.

Learning Resources:

1.Vogel›s practical Organic Chemistry.

2.Comprehensive practical Organic Chemistry – A. K. Ahluwalia and Renu Agrawal

3. Hand book of Organic Analysis – Qualitative and Quantitative – H. Clark and AdwardArnold.

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	3	2	3	2	2	2	2	2	2	3	3	2	2	2
CO2	3	3	2	3	1	3	2	2	1	3	3	3	3	2	2
CO3	3	3	2	3	2	3	2	2	2	3	3	3	3	2	3
CO4	2	3	3	3	2	2	3	2	2	2	3	3	2	3	3

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Faculty of Science & Technology

Department of Chemistry and Analytical Chemistry

PG I Sem II

Course Type: MMC-VI
Course Title: Physical Chemistry-II
Course Code: 601CHE2103

Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. To develop an understanding of chemical kinetics and reaction dynamics.
LO 2. To explain the concepts of surface tension and adsorption, including the Gibbs adsorption isotherm.
LO 3. To gain knowledge of micelles and macromolecules, including their properties and behavior.
LO 4. To understand the principles of molecular spectroscopy.

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Describe and analyze concepts of chemical kinetics and reaction dynamics, including ionic reactions and the steady-state approximation.
CO 2. Derive and apply adsorption isotherms such as Gibbs and BET isotherms to relevant systems.
CO 3. Explain and differentiate micelles, critical micelle concentration (CMC), macromolecules, and polymers.
CO 4. Apply principles of molecular spectroscopy to interpret spectral data and analyze molecular structure.

Unit No.	Title of Unit & Contents	Hrs.
I	**Unit - I Chemical Kinetics and reaction dynamics**	**12**
	1. Recapitulation – Zero, first, second, third, fourth, order rate equation, molecularity & order methods of determining order of reaction, fractional order reactions. 2 .Theories of reaction rates – collision theory , TST and Lindemann theory .(in detail) 3 .Oscillatory reactions (B-Z reaction). 4. Ionic reactions – Kinetic Salt effects. 5. Enzyme catalysis: - Michaelis – Menten mechanism, limiting rate, lineweaver-burk and Eadie plots. 6. Numaricals. Steady state approximation – Study of mechanism of reaction using Chemical kinetics, problems.	

Unit No.	Title of Unit & Contents	Hrs.
	8. Kinetics of free radical and condensation polymerization.	
	Unit Outcomes: UO 1. Understand the concept of Chemical Kinetics and reaction dynamics like ionicreactions. **UO 2.** Solve the Problems by using steady state approximation.	
II	**Surface Chemistry and Catalysis**	**10**
	1. Surface tension, capillary action, pressure difference across curved surfaces (Laplace equation). 2. Gibbs adsorption isotherm & BET adsorption isotherm, estimation of surface area from BET isotherm. 3. Kelvin equation for vapour pressure of droplets. Heat of adsorption, estimation of surface areas of solids from solution adsorption studies.	
	Unit Outcomes: UO 1. Explain concept of surface tension. UO 2.Derive Gibbs adsorption isotherm, BET adsorptionisotherm.	
III	**Micelles & Macromolecules**	**10**
	3.1 Micelles: 1 . Surface-active agents, classification. 2. Micelles, process of Micellisation, CMC, factors affecting CMC, thermodynamicsof micellisation, cleansing action of soap & detergent. **3.2 Macromolecules:** 1. Definition, examples . 2. Difference between polymers and macromolecules. 3. Types of polymers – electrically conducting, fire resistant, liquid crystal. 4. Stereochemistry of Polymer 5. Kinetics of polymerization 6. Molecular Mass ((*MN*, *Mw* & *Mz*) Determination of Molecular Mass by –Viscometry, Osmometry & Light Scattering Method. Numaricals.	
	Unit Outcomes: UO 1. Differentiate between polymers and macromolecules. UO 2. Calculate the molar mass of polymers .	
IV	**Molecular Spectroscopy**	**13**
	Microwave Spectroscopy Recapitulation, Isotope effect – Non rigid rotator – linear polyatomic	

Unit No.	Title of Unit & Contents	Hrs.
	molecules – symmetric top molecules – asymmetric top molecules – Microwave spectrometer – information derived from rotational spectra. **Infrared Spectroscopy:** Recapitulation, vibrations of polyatomic molecules – Rotation – vibration spectra of poly atomic molecules – interpretation of vibrational spectra – IR spectrophotometer – sample handling techniques – Fourier transform IR spectroscope – applications. **Raman Spectroscopy** Recapitulation, Hyper Raman effect – classical treatment of Raman effect – Experimental techniques for Hyper – Raman effect – stimulated Raman scattering – Inverse Raman scattering – CARS – PARS – SERS (basic ideas only). **Electronic spectroscopy**: Vibrational coarse structure – Vibrational analysis of band systems – Deslanders table – Progressions and sequences – Franck condon principle – Rotational fine Structure of electronic vibration spectra – the Fortrat parabola – Dissociation – Pre dissociation – photoelectron spectroscopy – Instrumentation – information from photoelectron spectra.	
	Unit Outcomes: Students will be able to **UO1. Explain and analyze the principles and instrumentation** of microwave, infrared, Raman, and electronic spectroscopy, including molecular rotations, vibrations, and electronic transitions. **UO2. Interpret different types of spectra** to extract structural and molecular information, including bond parameters, energy levels, and spectral transitions.	

Learning Resources:

1. Physical Chemistry -P.W. Atkins, ELBS.
2. Introduction to Quantum Chemistry -A.K.Chandra,Tata McGraw Hill.
3. Quantum Chemistry - Ira N.Levine, Prentice Hall.
4.Coulson's Valence -R. McWeeny ELBS.
5. Chemical Kinetics -K.J.Laidler, McGraw Hill.
6. Kinetics and Mechanism of Chemical Transformations -J.Rajaraman and J. Kuriacose, Macmillan.
7. Micelles, Theoretical and Applied Aspects - V.Moroi, Plenum
8. Modern Electrochemistry Vol.I & II, J.O.M. Bockris & A.K.N. Reddy, Plenum
9. Introduction to Polymer Science -

Wiley Eastern.

10.Advanced physical chemistry – J.N. Gurtu & A. Gurtu, A Pragati.

Internal Examination Pattern:

CAT – I: Assignment

CAT – II Numerical Problems

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	1	3	1	3	1	2	1	3	3	1	3	1	3
CO2	3	3	2	3	1	3	1	2	1	3	3	1	3	1	3
CO3	3	2	2	3	2	2	1	2	1	3	2	1	3	2	2
CO4	3	3	2	3	1	3	2	2	1	3	3	2	3	2	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

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Department of Chemistry and Analytical Chemistry

PG I Sem II

Course Type: MMC-VI
Course Title: Lab. Course-VII (Based on MMC-VI)
Course Code: 601CHE2106
Credits: 01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. To introduce and develop understanding of instrumental techniques such as conductometry, colorimetry, potentiometry, and polarimetry.

LO 2. To build practical skills in quantitative analysis, including determination of equilibrium constants, pKa values, and concentration of analytes.

LO 3. To understand physicochemical properties such as surface tension, viscosity, and distribution laws through experimental methods.

LO 4. To enhance analytical and problem-solving skills in interpreting experimental data and reaction kinetics.

Course Outcomes:

After successful completion of the practical course, students will be able to:

CO 1. Operate and apply instrumental techniques (conductometer, colorimeter, potentiometer, polarimeter) for quantitative chemical analysis.

CO 2. Determine physicochemical parameters such as CMC, equilibrium constants, pKa values, and concentrations using appropriate experimental methods.

CO 3. Analyze and interpret experimental data related to surface tension, viscosity, reaction kinetics, and distribution laws.

CO 4. Demonstrate laboratory competence, including accurate measurement, data handling, and adherence to safety and good laboratory practices.

Practical No.	Practical	30
1	**Section-A: (Instrumental)** **Conductometer**: 1. To determine critical micelle concentration of sodium lauryl sulphate in aqueous solution. **Colorimeter :** **1.** To determine equilibrium quotient for formation of mono thiocyanate iron (III) complex. 2. To determine Indicator constant of an indicator. 3. To determine concentration of Cu (II) iron in given solution titrating with EDTA solution. **Potentiometer :** **1.** To determine PK_1, PK_2 values of Phosphoric acid. 2. To determine strength of strong acid and weak acid in given mixture.	

	3. To determine the oxidation state of metal ion by method of concentration. 4. Cell without transference. **Polarimeter :** **1.** To determine the relative strength of two acids. 2. To determine the percentage of two optically active substance (d-glucose and d-tartaric acid) in the mixture.	
	Section B (Non-instrumental) 1.To determine molecular weight of high polymer by viscosity measurement. 2. To study the effect of surfactant on surface tension of water by using Stalagmometer. 3. To determine surface tension of methyl acetate, ethyl acetate and chloroform andhence to calculate atomic parachors of C, H, Cl. 4. To determine order of reaction of given reaction kinetics by fractional change method. 5. To study distribution of benzoic acid between benzene and water at room temperature and hence show that benzoic acid dimerises in benzene.	

Learning Resources:

1. Findlay's (1985): Practical Physical Chemistry, Revised and edited by B.P. Levitt 9 th edition, Longman, London.

2. Chatwal, G.R. and Anand,S.K (2000): Instrumental Methods of Chemical Analysis, Himalaya Publishing House, Delhi.

3. Yadav, J. B (2005): Advanced Practical Physical Chemistry, 22 ndedition, Goel publishing House, Krishna Prakashan Media Ltd.Media Ltd.

4.Venkatesan, V,Veeraswamy, R and Kulandaivelu, A.R (1997): Basic Principles of Practical Chemistry", 2nd edition, Sultan Chand and Sons Publication, New Delhi.

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6
CO1	3	3	2	3	2	2	2	2	2	3	3	3	2	2	2
CO2	3	3	2	3	1	3	2	2	1	3	3	3	3	2	3
CO3	3	3	2	3	1	3	2	2	1	3	3	2	3	2	3
CO4	2	3	3	3	2	2	3	2	2	2	3	3	2	3	2

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science & Technology

Department of Chemistry and Analytical Chemistry

PG I Sem II

Chemistry Course Type: MEC-II (A)
Course Title: Physical Methods in Chemistry-II
Course Code: 601CHE2201
Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

The objective of this course is to enable the learner to:

LO 1. Understand the fundamental principles of electron transfer kinetics and the application of current-voltage relationships in quantitative electrochemical analysis.

LO 2. Comprehend the kinetic and thermodynamic variables of chromatography, focusing on the manipulation of the mobile and stationary phases to achieve peak capacity and resolution.

LO 3. Confront with the techniques of TGA, DTA, and DSC for studying the physical and chemical changes in materials as a function of controlled temperature.

LO 4. Understand theoretical framework of X-ray interactions with matter, focusing on crystal structure determination via diffraction and elemental analysis via fluorescence.

Course Outcomes:

On completion of this course, the learner will be able to:

CO 1. Differentiate between reversible and irreversible redox systems by interpreting polarographic waves and cyclic voltammograms to calculate analyte concentrations.

CO 2. Apply the principles of atomic spectroscopy to accurately quantify trace metals in environmental or industrial samples while correcting for chemical interferences.

CO 3. Determine the thermal stability, decomposition patterns, and phase transition temperatures of materials by analyzing TG, DTA, and DSC thermograms.

CO 4. Identify the crystalline phases and lattice parameters of unknown solid samples using Bragg's Law and X-ray diffraction patterns

Sr. No.	Unit	Hrs
I	**Electroanalytical Techniques**	**12**
	1.1 Polarography: Fundamental principle of voltammetric analysis and electrode system for voltammetric analysis; Fundamental principle of Polarographic analysis and electrode system for polarographic analysis; Principle of Polarographic Analysis; Working Electrode in Polarographic Analysis; Dropping mercury electrode (DME); Construction and working Dropping mercury electrode (DME);Advantages of DME; Disadvantages of DME; Apparatus for polarographic analysis; Instrumentation of Polarography; Electrode system for polarographic cell containing analyte; System for removal of dissolve oxygen; Working of Polarography; Qualitative and Quantitative Analysis by polarogram; Factors Affecting the Nature of the Polarographic Wave; Residual current; Migration current; Condenser or non-faradic current; Diffusion or faradic current; Half wave potential; Applications of Polarography: Qualitative	

Sr. No.	Unit	Hrs
	analysis/Identification of the electroactive species; Quantitative analysis by Ilkovic equation; Simultaneous determination of cations in the mixture; Polarographic titration; Classification of Voltammetric Methods. **1.2 Cyclic Voltammetry:** **a. Hydrodynamic Voltametry:** Hydrodynamic voltametry and applications of hydrodynamic voltammetry. **b. Cyclic Voltametry:** Principle of cyclic Voltammetry, cyclic voltamogram of K3[Fe(CN)6] **c. Stripping Voltammetry:** Stripping voltammetry, Principle, Electrode System, Anodic Stripping Voltametry and Cathodic Stripping Voltammetry, adsorptive striping voltammetry and their applications, problems	
	Unit Outcomes: On completion of this unit, the learner will be able to, UO 1. Calculate the concentration of an unknown analyte by measuring the diffusion current (id) and applying the Ilkovicequation under controlled experimental conditions. UO 2. Characterize the redox properties of a chemical system by analyzing Cyclic Voltammetry data to identify peak potentials (Epc, Epa) and assess the degree of electrochemical reversibility	
II	**Spectroscopic Techniques**	**12**
	2.1 AAS (Atomic absorption Spectroscopy) Introduction, principle of AAS, absorption of radiant energy by atoms, classification of atomic spectroscopic methods, measurement of atomic absorption, instrumentation, atomic absorption spectrophotometer, detection limit, interferences in AAS applications, some typical determination, difference between AAS & FES, advantages & disadvantages of AAS **2.2 Flame photometry (Flame Emission Spectroscopy)** Principle, flames & flame temperature, excitation profiles & chemical reaction in flames, spectra of metal in flame, instrumentation, evaluation methods in flame photometry, factors affecting intensity of emitted radiation, interferences in flame photometry, background correction methods, applications, flame emission experiments, limitations numerical, applications.	
	Unit Outcomes: On completion of this unit, the learner will be able to, UO1. Differentiate between the physical processes of ground-state atomic absorption and excited-state atomic emission to determine the most sensitive method for a specific alkali or transition metal analyte. UO2. Select and configure instrumental components, such as the appropriate Hollow Cathode Lamp (HCL) and oxidant-fuel mixture, to minimize chemical and spectral interferences during quantitative analysis.	
III	**Thermal Methods**	**15**

Sr. No.	Unit	Hrs
	3.1 Thermogravimetric analysis (TGA): Introduction, Thermoanalytical methods, Thermogravimetric analysis, instrumentation, modern thermobalances, interfacing TGA to FTIR or MS for EGA, DTGA, factors affecting TGA, simultaneous TGDTA-MS analysis, Applications of TGA. 3.2 Differential thermal analysis (DTA) Introduction, theory, differential scanning calorimetry, instrumentation for DTA, heat flux DSC, simultaneous DTA & TGA curves, factors affecting DTA. 3.3 Differential Scanning Calorimetry (DSC): Factors Affecting, Applications	
	Unit Outcomes: On completion of this unit, the learner will be able to, UO1. Quantify the moisture content, volatile components, and thermal stability of a sample by interpreting mass-loss steps in a Thermogravimetric (TG) curve. UO2. Identify physical transitions such as melting points, glass transition temperatures (Tg), and crystallization events by analyzing the peaks in DTA & DSC.	
IV	**X-Ray Methods**	**06 Hours**
	4.1 X-ray diffraction (XRD): Bragg condition, Millers indices, Laue method, Powder XRD Bragg method, Debye–Scherrer method of X-ray structural analysis of crystals, index reflections, identification of unit cells from systematic absences in the diffraction pattern, structure of simple lattices and X-ray intensities, structure factor and its relation to intensity of electron density. **4.2 X-ray Fluorescence (XRF):** Principle, Instrumentation, Applications	
	Unit Outcomes: On completion of this unit, the learner will be able to, **UO1**. Determine the crystal structure and lattice parameters of solid materials by applying Bragg's Law to analyze diffraction peak positions and intensities. **UO2.** Perform qualitative and quantitative elemental identification of unknown samples by measuring the energy and intensity of characteristic X-rays emitted during X-ray Fluorescence.	

Learning Resources:

1. 'Analytical Chemistry: A Modern Approach to Analytical Science', Ed. by R. Kellner, J. M. Mermet, O. Otto, M. Valcarcel, H. M. Widmer, Second Ed. Wiley –VCH
2. 'Cyclic Voltammetry', Simultaneous Analysis and Reaction Mechanism, David K Gosser, VCH, 1994. sons, New York 1993.
3. 'Introduction to Instrumental Analysis' by R. D. Braun, Pharmamed Press.
4. 'Instrumental Methods of Analysis', 6th Ed., H. H. Willard. L. L. Merritt, J. A. Dean, and F. A. Settle, Jr., CBS Publishing Company
5. Instrumental Methods of Chemical Analysis, H. Kaur, Pragati Prakashan, 2012. 'Textbook of Quantitative Chemical Analysis', Jeffery G. H., Bassett J., Mendham J., Denney R.C., 5th edition., ELBS London.
6. Instrumental Methods of Chemical Analysis, Dr. G.R. Chatwal, Sham Anand, Himalaya Publishing House, 2011.

7. ‘Principles of Instrumental Analysis’, 6th Ed., Skoog, Holler and Crouch, Brooks/Cole, Thomson Learning.

Internal Examination Pattern :

CAT – I: Assignments

CAT – II; PPT Presentation/ Online quiz

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6
CO1	3	3	2	3	1	3	2	2	1	3	3	3	3	2	3
CO2	3	3	3	3	2	3	2	2	1	3	3	3	3	3	3
CO3	3	3	2	3	1	3	2	2	1	3	3	3	3	2	3
CO4	3	3	2	3	1	3	2	2	1	3	3	3	3	2	3

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Faculty of Science & Technology

Department of Chemistry and Analytical Chemistry

PG I Sem II

Course Type: MEC-II (A)
Course Title: Lab. Course-VIII (Based on MEC-II)
Course Code: 601CHE2203
Credits: 01 **Max. Marks: 50** **Lectures: 30 Hrs.**

Learning Objectives:

LO 1. Develop proficiency in the three-electrode cell setup and the optimization of electrochemical parameters to resolve overlapping redox waves.
LO 2. Expertise the technique of serial dilution and instrumental optimization (flame alignment and wavelength selection) for trace elemental analysis.
LO 3. Gain technical competence in micro-balance handling and the interpretation of thermal signatures in complex material matrices.
LO 4. Develop skills in powder sample preparation (achieving uniform particle size) and the use of software for peak fitting and phase matching.

Course Outcomes:

On completion of this course, the learner will be able to:

CO 1. Configure a three-electrode voltammetric cell and manipulate scan rates and supporting electrolyte concentrations to resolve individual peaks from a mixture of overlapping electroactive species.
CO 2. Execute precise serial dilutions to create sub-ppm standard ranges and calibrate the flame photometer or AAS by aligning the burner head and lamp intensity for maximum absorbance sensitivity.
CO 3. Demonstrate mastery in loading micro-gram samples into specialized crucibles and analyze resulting thermograms to quantify weight loss percentages and enthalpy changes in multi-component materials.
CO 4. Prepare uniform powder samples to eliminate preferred orientation effects and utilize diffraction software to perform peak fitting and identify unknown crystalline phases via JCPDS database matching.

Note: A minimum of 10 practicals must be conducted.

No.	Practicals	Hrs
I	**Cyclic Voltammetry**	
1.	Study of cyclic voltammogram of $K_3[Fe(CN)_6]$	**3**
	Goal: Evaluate the electrochemical reversibility and diffusion kinetics of the redox couple using a three-electrode system.	
	Preparation of graphite electrode from pencil or cell	**3**
	Goal: Creation of electrode	
II	**Atomic Emission Spectroscopy**	
2.	Flame photometric analysis of water /soil sample for Na+ by calibration curve method (give regression analysis for both curves)	**3**

No.	Practicals	Hrs
	Flame photometric analysis of water /soil sample for K^+ by calibration curve method (give regression analysis for both curves)	
	Determination of Ca in egg shell by flame photometry	
	Goal: Quantify the concentration of alkali & alkaline metal ions in environmental samples using the principle of Flame Photometry.	
III	**Atomic Absorption Spectroscopy**	
3.	Determination of Copper in the Given Sample by AAS	**3**
	Determination of Zinc in the Given Sample by AAS	
	Goal: Quantify the concentration of transition metal ions in given samples using the principle of AAS.	
IV	**Thermal Methods of Analysis**	
4.	To determine the TGA curve of CaCO3	**3**
	To determine the curie point of the given alloy sample	
	Goal: Analyse the results of thermal methods of analysis	
V	**X-ray Diffraction**	
5.	To study the XRD spectra of NaCl.	**3**
	Goal: Analyze XRD data	
VI	**Conductometry**	
6.	Analyze vanillin in the vanilla extract by conductometry	**3**
	Determination of the strength of strong acid and weak acid from mixture solution conductometrically	
	Analysis of aspirin by conductometric method.	
	Goal: To understand the principle of conductometric analysis	
VII	**Potentiometry**	
7.	Determination of the concentration of halides in the halide mixture	**3**
	Goal: To understand the principle of potentiometric analysis	

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
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CO2	3	3	3	3	2	3	2	2	1	3	3	3	3	3	3
CO3	3	3	2	3	1	3	2	2	1	3	3	3	3	2	3
CO4	3	3	2	3	2	3	2	2	2	3	3	3	3	2	3

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Faculty of Science & Technology

Department of Chemistry and Analytical Chemistry

PG I Sem II

Chemistry Course Type: MEC-II (B)
Course Title: Fundamentals of Spectroscopy & Computer Application -II
Course Code: 601CHE2201
Credits: 03 **Max. Marks: 75** **Lectures: 45 Hrs.**

Learning Objectives:

LO 1. To gain the knowledge regarding the Basic Concepts in Molecular Spectroscopy

LO 2. To familiarize students with, Infrared & Microwave Spectroscopy's

LO 3. To acquaint students with knowledge of Electronic & Raman Spectroscopy

LO 4. To train the students about brief application of computer in chemistry

Course Outcomes:

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

CO 1. Explain the fundamental principles and concepts of molecular spectroscopy.
CO 2. Apply the principles of infrared and microwave spectroscopy for chemical analysis.
CO 3. Analyze and solve numerical and conceptual problems related to electronic and Raman spectroscopy.
CO 4. Utilize computational tools and software to solve chemistry-related problems.

Unit No.	Title of Unit & Contents	Hrs.
I	**Basic Principles of Spectroscopy**	**5**
	1. Characterization of electromagnetic radiation, quantization of energy. 2. Regions of the spectrum, interaction of radiation with molecular systems & types of molecular energies. 3. Factors affecting width and intensity of spectral lines, selection rule, general discussion on various molecular excitation processes	
	Unit Outcomes: **CO 1:** Explain the fundamental principles of electromagnetic radiation, including quantization of energy, spectral regions, and types of molecular energies. **CO 2:** Describe the interaction of radiation with molecular systems, including molecular excitation processes, selection rules, and factors affecting spectral line width and intensity.	
II	**Microwave spectroscopy & Infrared spectroscopy**	**15**
	1. Microwave spectroscopy Classification of molecules according to their moment of inertia, rigid	

	rotor model, effect of isotopic substitution on the transition frequencies, stark effect, non-rigid rotor, selection rules, mechanism of interaction, spectra of symmetric and asymmetric top molecules, applications of microwave spectroscopy. **2. Infrared spectroscopy** Review of linear harmonic oscillator, vibrational energies of diatomic molecules, zero point energy, force constant and band strengths, anharmonicity, morse potential energy diagram, vibration-rotation spectroscopy, PQR branches, Breakdown of oppenheimer approximation, vibrations of polyatomic molecules, selection rules, normal modes of vibrations, overtones, hot bands, finger- print region, functional group identification.	
	Unit Outcomes: UO 1: Explain the principles of microwave spectroscopy, including molecular classification based on moment of inertia, rigid and non-rigid rotor models, selection rules, spectral characteristics of different molecular types, and their applications. UO 2: Describe the fundamentals of infrared spectroscopy, including vibrational behavior of molecules, vibration–rotation spectra, selection rules, normal modes of vibration, and interpretation of IR spectra for functional group identification.	
IV	**Raman Spectroscopy & electronic spectroscopy**	**15**
	1. Raman Spectroscopy Classical and quantum theory, Raman effect, Stokes and antistokes lines, pure rotational, vibrational and rotation-vibration Raman spectra, selection rules, mutual exclusion principles, structure determination of di-, tri- and tetra-atomic molecules from Raman and IR spectra, effect of polarization of light. **2. Electronic spectroscopy** Atomic transitions, spin orbit interaction, atom in uniform magnetic field, many electron atoms, spectra of alkali/alkaline earth atoms, molecular electronic transition, vibrational coarse structure, intensity/selection rule, Frank-Condon Principles, ground and first excited electronic states of diatomic molecule, dissociation energy and dissociation products, rotational fine structure, Fortrat diagram, predissociation	
	Unit Outcomes **UO 1:** Explain the principles of Raman spectroscopy, including classical and quantum theory, Raman effect, Stokes and anti-Stokes lines, selection rules, mutual exclusion principle, and its application in molecular structure determination. **UO 2:** Describe the fundamentals of electronic spectroscopy, including atomic and molecular transitions, selection rules, Franck–Condon principle, vibrational and rotational fine structure, and interpretation of spectra for molecular properties and dissociation behavior.	

IV	Computer Application	10
	1 Overview of computer, operating system and programming languages. 2 Introduction to chemometric and cheminformatic methods and applications in solving chemical problems. 3 Application of ChemDraw & Chemsketch . 4 Fragment code, linear notation, SMILES and connection table 5 Chemical structure databases. Molecular similarity and structural searching.	
	Unit Outcomes **UO 1:** Explain the fundamentals of computers, operating systems, programming concepts, and chemometric/cheminformatics methods used in solving chemical problems. **UO 2:** Apply cheminformatics tools and techniques, including ChemDraw/ChemSketch, chemical structure representation (SMILES, connection tables), databases, and molecular similarity for structural analysis and searching.	

Learning Resources

1. **Banwell, C. N. & McCash, E. M.** *Fundamentals of Molecular Spectroscopy* Tata McGraw-Hill, 4th Edition, 1994.
2. **Hollas, J. M.** *Modern Spectroscopy* Wiley India, 4th Edition, 2004.
3. **Barrow, G. M.** *Introduction to Molecular Spectroscopy* McGraw-Hill, 1962.
4. **Pavia, D. L., Lampman, G. M., Kriz, G. S., Vyvyan, J. A.** *Introduction to Spectroscopy* Cengage Learning India, 5th Edition, 2015.
5. **Silverstein, R. M., Webster, F. X., Kiemle, D. J.** *Spectrometric Identification of Organic Compounds* Wiley India, 8th Edition, 2014.
6. **Atkins, P. & de Paula, J.** *Physical Chemistry* (Spectroscopy chapters) Oxford University Press India, Latest Edition.
7. **Bernath, P. F.** *Spectra of Atoms and Molecules* Oxford University Press, 3rd Edition, 2015.
8. **Herzberg, G.** *Molecular Spectra and Molecular Structure* (Vol. I: Spectra of Diatomic Molecules) Krieger Publishing / CBS Publishers (India reprints available).

Internal Examination Pattern :

CAT – I: Assignments

CAT – II; PPT Presentation/ Online quiz

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PS O1	PS O2	PS O3	PS O4	PS O5	PS O6
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CO2	3	3	2	3	2	2	1	2	1	3	3	2	3	2	2
CO3	3	3	1	3	1	3	1	2	1	3	3	2	3	1	3
CO4	2	3	2	3	2	3	1	3	2	2	3	3	3	2	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

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Extra Credit Activities

Sr. No.	Course Title	Credits	Hours T/P
1	MOOCs	Min. of 02 credits	Min. of 30 Hrs.
2	Certificate Courses	Min. of 02 credits	Min. of 30 Hrs.
3	IIT Spoken English Courses	Min. of 02 credits	Min. of 30 Hrs.

Guidelines:

Extra -academic activities

1. All extra credits claimed under this heading will require sufficient academic input/ contribution from the students concerned.
2. Maximum 04 extra credits in each academic year will be allotted.
3. These extra academic activity credits will not be considered for calculation of SGPA/CGPA but will be indicated on the grade card.

Additional Credits for Online Courses:

1. Courses only from SWAYAM and NPTEL platform are eligible for claiming credits.
2. Students should get the consent from the concerned subject Teacher/Mentor/Vice Principal and Principal prior to starting of the course.
3. Students who complete such online courses for additional credits will be examined/verified by the concerned mentor/internal faculty member before awarding credits.
4. Credit allotted to the course by SWAYAM and NPTEL platform will be considered as it is.

Additional Credits for Other Academic Activities:

1. One credit for presentation and publication of paper in International/National/State level seminars/workshops.
2. One credit for measurable research work undertaken and field trips amounting to 30 hours of recorded work.
3. One credit for creating models in sponsored exhibitions/other exhibits, which are approved by the concerned department.
4. One credit for any voluntary social service/Nation building exercise which is in collaboration with the outreach center, equivalent to 30 hours
5. All these credits must be approved by the College Committee.

Additional Credits for Certificate Courses:

1. Students can get additional credits (number of credits will depend on the course duration) from certificate courses offered by the college.
2. The student must successfully complete the course. These credits must be approved by the Course Coordinators.
3. Students who undertake summer projects/ internships/ training in institutions of repute through a national selection process, will get 2 credits for each such activity. This must be done under the supervision of the concerned faculty/mentor.

Note:

1. The respective documents should be submitted within 10 days after completion of Semester End Examination.
2. No credits can be granted for organizing or for serving as office bearers/ volunteers for Inter-Class / Associations / Sports / Social Service activities.
3. The office bearers and volunteers may be given a letter of appreciation by the respective staff coordinators. Besides, no credits can be claimed for any services/ activities conducted or attended within the college.
4. All claims for the credits by the students should be made and approved by the mentor in the same academic year of completing the activity.
5. Any grievances of denial/rejection of credits should be addressed to Additional Credits Coordinator in the same academic year.
6. Students having a shortage of additional credits at the end of the third year can meet the Additional Credits Coordinator, who will provide the right advice on the activities that can help them earn credits required for graduation.

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Examination Framework

Theory:

40% Continuous Assessment Tests (CATs) and 60% Semester End Examination (SEE)

Practical:

50% Continuous Assessment Tests (CATs) and 50% Semester End Examination (SEE)

Course	Marks	CAT & Mid Term Theory				CAT Practical		Best Scored CAT & Mid Term	SEE	Total
1	2	3				4		5	6	5 + 6
		Att.	CAT I	Mid Term	CAT II	Att.	CAT			
DSC/DSE/ GE/OE/Minor	100	10	10	20	10	-	-	40	60	100
DSC	75	05	10	15	10	-	-	30	45	75
Lab Course/AIPC/ OJT/FP/SEC (Science & Technology)	50	-	-	-	-	05	20	-	25	50
VSC/SEC/ AEC/VEC/CC	50	05	05	10	05	-	-	20	30	50

Note:

1. All Internal Exams are compulsory
2. Out of 02 CATs best score will be considered
3. Mid Term Exam will be conducted by the Exam Section
4. Mid Term Exam is of Objective nature (MCQ)
5. Semester End Exam is of descriptive in nature (Long & Short Answer)
6. CAT Practical (20 Marks): Lab Journal (Record Book) 10 Marks, Overall Performance 10 Marks