SANT GADGE BABA AMRAVATI UNIVERSITY, AMRAVATI

Degree of Bachelor of Science

Chemistry

Semester V and VI

FACULTY: SCIENCE AND TECHNOLOGY

(Courses effective from Academic Year 2026-27)
Under NEP 2020 (As per Uniform NEP Scheme)

SYLLABUS

Contents

TLE Scheme for THIRD YEAR: SEMESTER – V (Level 5.5)

Level	The Vertical	Course Code	Course Title	Credits	Workload	Theory/Practical Marks				Theory/Pract (Total) Marks	
						External		Internal			
						Max.	Min.	Max.	Min.	Max.	Min.
5.5	Major-T	108230	InorganicChemistry-2	2	2	30	9	20	6	50	20
5.5	Major-T	108231	Organic Chemistry-2	2	2	30	9	20	6	50	20
5.5	Major-T	108232	Physical chemistry 2	2	2	30	9	20	6	50	20
5.5	Major-P	108233	Chemistry Lab 15	2	4	25	10	25	10	50	20
5.5	Major-Elective T1	108234	Elective Chemistry-1 (Spectroscopy I)	2	2	30	9	20	6	50	20
5.5	Major-Elective P1	108235	Chemistry Lab 16 A (Elective Chemistry-1)	2	4	25	10	25	10	50	20
OR											
5.5	Major-Elective T2	108236	Elective Chemistry-2 (Spectroscopy II)	2	2	30	9	20	6	50	20
5.5	Major-Elective P2	108237	Chemistry Lab 16 B (Elective Chemistry-2)	2	4	25	10	25	10	50	20
OR											
5.5	Major-Elective T3	108238	Elective Chemistry-3 (Biomolecules)	2	2	30	9	20	6	50	20
5.5	Major-Elective P3	108239	Chemistry Lab 16 C (Elective Chemistry-3)	2	4	25	10	25	10	50	20
5.5	Minor-T	108240	Minor Chemistry-3	2	2	30	9	20	6	50	20
5.5	Minor-P	108241	Minor Chemistry Lab 17	2	4	25	10	25	10	50	20
5.5	VSC-P	108242	Chemistry Lab -18 (Oil and Milk Analysis)	2	4	-	-	50	20	50	20
5.5	SEC-P1	107243	Chemistry Lab 19 (ICT Tools in Chemistry)	2	4	-	-	50	20	50	20
5.5	FP/CEP	108244	Chemistry Lab 20 (FP/ CES in Chemistry - III)	2	4	-	-	50	20	50	20
5.5	Non Credit		Foundation of Artificial Intelligence	NC	2			30+20	9+6	50	20

Important:

- **VSC Should be Complementary to Major**
- **SEC must be selected from the Basket Provided by University, from the same Faculty/Discipline of the Major/Minor**
- As per Sant Gadge Baba Amravati University, Amravati Extra-Ordinary Notification No. No. 241/2025 Dated 24/12/2025 “Foundation of Artificial Intelligence” is the mandatory **Non Credit Course** compulsory course for all the UG students in fifth semester of all undergraduate programs of all faculties in Sant Gadge Baba Amravati University, Amravati to earn their degree
- NC is Non Credit Course
- Students must select **Any One** of the Major-Elective Courses (T1 to T3) with respective Practical Course in Semester V**.**

TLE Scheme for THIRD YEAR: SEMESTER – VI (Level 5.5)

Level	The Vertical	Course Code	Course Title	Credits	Workload	Theory/Practical Marks				Theory/Pract (Total) Marks	
						External		Internal			
						Max.	Min.	Max.	Min.	Max.	Min.
5.5	Major-T	108245	Inorganic Chemistry 3	2	2	30	9	20	6	50	20
5.5	Major-T	108246	Organic Chemistry 3	2	2	30	9	20	6	50	20
5.5	Major-T	108247	Physical Chemistry 3	2	2	30	9	20	6	50	20
5.5	Major-P	108248	Chemistry Lab 21	2	4	25	10	25	10	50	20
5.5	Major-Elective T1	108249	Elective Chemistry 4 (Organic Spectroscopy)	2	2	30	9	20	6	50	20
5.5	Major-Elective P1	108250	Chemistry Lab 22 A (Elective Chemistry 4)	2	4	25	10	25	10	50	20
OR											
5.5	Major-Elective T2	108251	Elective Chemistry 5 (Green Chemistry and Nanochemistry)	2	2	30	9	20	6	50	20
5.5	Major-Elective P2	108252	Chemistry Lab 22 B (Elective Chemistry 5)	2	4	25	10	25	10	50	20
OR											
5.5	Major-Elective T3	108253	Elective Chemistry 6 (Chemistry of Consumer and Industrial Products)	2	2	30	9	20	6	50	20
5.5	Major-Elective P3	108254	Chemistry Lab 22 C (Elective Chemistry 6)	2	4	25	10	25	10	50	20
5.5	Minor-T	108255	Minor Chemistry 4	2	2	30	9	20	6	50	20
5.5	Minor-P	108256	Minor Chemistry Lab 23	2	4	25	10	25	10	50	20
5.5	VSC-P	108257	Chemistry Lab 24 (Water and Soil Analysis)	2	4	-	-	50	20	50	20
5.5	Intern/Apprenticeship	108258	Chemistry Lab 25 (Internship / Apprenticeship)	4	8	-	-	50	20	50	20

Important:

- VSC Should be Complementary to Major has to be selected from the Basket Provided by University, from the same Faculty/Discipline of the Major/Minor
- **Students** must select **Any One** of the Major-Elective Courses (T1 to T3) with respective Practical Course in Semester VI**.**

Examination and Assessment Process:

i. The basic principle of the Credit framework is that Credits are a function of the successful completion of a program of study/ vocational education/ training and assessment. No Credit can be earned by the student unless the student is assessed for the achievement of the desired competencies and outcome of a program.

ii. Exit options are provided with Certificate, Diploma and Basic Bachelor's degrees to the students at the end of the second, fourth and sixth semesters of a Four Years Multidisciplinary Degree Programme. Students will receive a Bachelor's degree with Honors/ Research on successfully completing of all eight semesters of the UG Program either at a stretch or with opted exits and re-entries.

iii. For the smooth success of four-year degree programme with multiple entry and exit systems, the examination mode should be based on the combination of innovative trends in formative (informal and formal tests administered during the learning process) and summative (evaluation of students learning at the end of an instructional unit) examination modes in line with the UGC Report on 'Evaluation Reforms in Higher Educational Institutions (2019).

Examination, Evaluation and Assessment Scheme

The total marks for each Course shall be based on Continuous Assessment and Semester End Examination. Each theory course of Major, Minor, GE/OE, AEC, IKS, VEC as mentioned in **Teaching Learning Scheme** prepared by the Board of Studies shall be evaluated as per the scheme as mentioned in the following table

Examination, Evaluation and Assessment Scheme

Vertical No.	The Vertical	Mode of Examination, Evaluation & Assessment	Theory				Theory (Total)		Practical				Practical (Total)	
			External		Internal				External		Internal			
			Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks
A	Major	External & Internal	30/60	9/18	20/40	6/12	50/100	20/40	25/50	10/20	25/50	10/20	25/50	10/20
B	Minor		30/60	9/18	20/40	6/12	50/100	20/40	25/50	10/20	25/50	10/20	25/50	10/20
C	Generic/ Open Elective	Internal			50	20	50	20	--	--	50	20	50	20
D	VSC	Internal			50	20	50	20			50	20	50	20
	SEC	Internal	--	--	50	20	50	20			50	20	50	20
e	AEC (Eng. & One MIL Composite)	Internal			50	20	50	20						
	IKS (Generic)	Internal			50	20	50	20						
	VEC	Internal			50	20	50	20						
F	Internship/ Apprenticeship	Internal	Assessment of these verticals shall be based on various activities/practices. The evaluation/assessment shall be done by appointing external examiner by principal from Industry/Organisation/Academia. The mentor faculty shall be the internal examiner. It shall be evaluated by giving maximum 50 marks per 2 Credit Course with separate activity weightages/levels. A detailed SOP for this assessment process shall be prescribed separately.											
	FP/CEP													
	CC													

Continuous Assessment Tests (CAT)

For internal assessment, the Continuous Assessment Tests (CAT) shall be conducted as under-

i. Three CAT each of 8 / 10 Marks (Theory) as applicable and 10 Marks (Practical).

- First on completion of 25% Syllabus of the course or on completion of 25 teaching days,
- Second on completion of 50% Syllabus of the course or on completion of 50 teaching days,
- Third on completion of 75% Syllabus of the course or on completion of 75 teaching days.

ii. Each concurrent assessment (CAT-I, II & III) will be mapped to relevant Course

Learning Outcome.

iii. Total Performance in CAT (i.e.40 %) shall be based on the **best two out of three** in CAT examinations

iv. Internal assessment (CAT) shall be carried out by the respective course teacher by choosing variety of assessment tools/methods such as class test, record book, seminar, case study, field work, mini project work, quiz or any innovative method, which may be deemed to be appropriate for assessing the relevant course outcome.

Conduction of the Examination:

As per the scheme of teaching, learning, examination and evaluation, theory/practical examinations of Semester-I, II, III, IV, V, VI, VII and VIII shall be conducted by the University (except for Internal Examinations as applicable) at the end of each semester.

The theory/practical examinations of all the Semesters shall be held as per the following Schedule

Sr.No.	Name of the Examination	End Sem Examination	Supplementary Examination*
1	Semester-I, III, V and VII	Winter	Summer
2	Semester-II, IV, VI and VIII	Summer	Winter

*The University may evolve mechanism for conducting repeat end semester examination. Such repeat examinations shall have to be conducted within one month of the regular even semester examination and on demand examination.

1. The practical examination of all semesters shall be conducted by the University at the end of each semester. The HEI shall conduct the Practical examination of odd semesters as per the schedule announced by the University. **However, the appointment of the External and Internal Examiners shall be done by the Head or Principal of respective HEI to conduct external examination of the odd semester and the same should be communicated to the University before commencement of the practical examination.** The University shall conduct the external practical examination of all even semester by appointing external and internal examiners.
2. The examinations specified above shall be held twice in a year at such places and on such dates as may be prescribed by the University.
3. An applicant to an examination specified above, shall pursue a regular course of study in courses prescribed for the examination concerned for not less than one semester in a particular semester in a College/Institute/University department.
4. Provided that the student shall be eligible to appear for examination if -
   a. He/she complies with the provisions of the Ordinance pertaining to the Examination in general from time to time.
   b. He/she has prosecuted a regular course of study in a university department/college affiliated to the University.

c. He/she has in the opinion of the Principal shown satisfactory progress in his/her studies.

5. The provisions of Ordinance No. 6 and Ordinance No. 9 shall be *mutatis-mutandis* applicable to every collegiate/non-collegiate student.
6. The fees for each theory examination and practical examination conducted by the university shall be as prescribed by the University, from time to time.

Course Category: **Major (Theory)**

108230 Inorganic Chemistry-2

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108230**	**Inorganic Chemistry-2**	2	30	2 Hrs	30+20=50

Course Objectives:	1. To develop a comprehensive understanding of occurrence of elements in nature and their extractions, transition elements and their characteristics and coordination compounds 2. To develop fundamental understanding of formation of coordination compounds on the basis of different theories.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Learn the transition elements, their electronic configuration. 2. Write the general characteristics of transition elements 3. Appreciate the postulates of Werner's theory. 4. Classify double salt and coordination compounds 5. Know the meaning of the terms in coordination compounds 6. Learn the rules of IUPAC nomenclature of coordination compounds 7. Calculate EAN and to predict the magnetic properties of complexes. 8. Corelate the nature of metal-ligand bonding in coordination compound by VBT and predict their geometries. 9. Define different types of isomerism in coordination compounds. 10. Explain the terms minerals, ores, concentration of ores, roasting, calcinations, refining, etc. 11. Apply the basic principle of extraction of different metals on the basis of their occurrence and reactivity

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Chemistry of Elements of Transition Series**: Definition and general characteristics of transition elements; Comparative study of first transition series elements (3d) with reference to following properties: (i) Electronic configuration (ii) Atomic and ionic size (iii) Ionization energy (iv) Metallic nature (v) Oxidation states (vi) Magnetic properties (vii) Color of salts (viii) Catalytic properties and (ix) Complex formation behavior; Electronic configuration of 4d and 5d series elements; Comparison of 3d series elements with 4d and 5d series elements with respect to atomic size and oxidation states.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss
Unit II	**Coordination Chemistry-1** Addition compounds: double salts & complex salts; Important terms in coordination compounds: central metal ion, ligands, complex ion, coordination sphere, coordination number; Classification of ligands; Homoleptic and heteroleptic complexes; IUPAC nomenclature of coordination compounds; Werner's theory of coordination complexes with reference to cobaltammines and its experimental verification on the basis of molar conductance and precipitation; Sidgwick's electronic interpretation: EAN rule.	7 Hrs	7 Marks	
Unit III	**Coordination Chemistry-2 (VBT and Isomerism)** **A) Valence bond theory (VBT):** Steps involved in describing metal-ligand bonding	8 Hrs	8 Marks	

	in coordination compounds using VBT; Types of hybridization, geometries and magnetic properties to understand formation of complexes of 3d elements with coordination number 6 (Inner and outer orbital complexes) and 4 (Tetrahedral and square planar). Limitations of VBT. **B) Isomerism in coordination Compounds:** Structural or constitutional isomerism: ionization, linkage, coordination and hydrate; Stereoisomerism: Geometrical isomerism in square planar {type: Ma_2b_2, Ma_2bc &Mabcd} and in octahedral complexes {type: Ma_4b_2, $Ma_2b_2c_2$, Ma_3b_3 & Mabcdef}, Optical isomerism in octahedral complexes (type: cis-$Ma_2b_2c_2$, $M(AA)_3$ & $Ma_2(AA)_2$) and in tetrahedral complexes {type: Mabcd}			real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit IV	**Extraction of elements and General Principles of Metallurgy** Occurrence of metals; Principles involved in extraction of metals: Major methods of separating and extracting elements (mechanical separation, thermal decomposition, displacement of one metal by another, high temperature chemical reduction, reduction by another metal, electrolytic reduction); Factors influencing the choice of extraction process; Definitions of metallurgy, minerals, ores, gangue; examples of principal ores of Al, Fe, Cu and Zn; Meaning of terms hydrometallurgy, pyrometallurgy and electrometallurgy; General Principles or Steps in metallurgy: i) Processing of ore ii) Ore dressing: Physical methods (gravity separation, froth floatation & electromagnetic separation, Chemical method (leaching) iii) roasting & calcination iv) smelting v) refining of crude metals: Liquation, distillation, cupellation, Van-Arkel method & electrolytic refining)	7 Hrs	7 Marks	
References:	1. Principles of Inorganic Chemistry by Puri, Sharma and Kalia- S. Naginchand& Co., Delhi. 2. Inorganic Chemistry by A.K. De, Wiley East Ltd. 3. Selected Topics in Inorganic Chemistry by Malik, Tuli and Madan, S. Chand & Co. 4. Concise Inorganic Chemistry by J.D. Lee, ELBS. 5. Inorganic Chemistry by J.E. Huheey- and Kettle, Harper & Row. 6. Advanced Inorganic Chemistry, Vol-I, Satya Prakash, Madan, Tuli, Basu. 7. Advanced Practical Inorganic Chemistry by Gurdeep Raj, GoelPulishing House, Meerut. **Web resources:** 1. https://www.chemguide.co.uk/inorganic/transitionmenu.html 2. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Supplemental_Modules_and_Websites_(Inorganic_Chemistry)			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) What are transition elements? 2) Write the general electronic configuration of first transition series elements. 3) Define coordination compounds 4) Write IUPAC name of $[Co(NH_3)_4Cl_2]Cl$. 5) Write an example of ionization isomers in complexes. 6) Predict the geometry of $[Fe(H_2O)_6]^{2+}$ ion on the basis of VBT 7) Define Metallurgy			
	Answer in brief (At least 6) (3 Marks each) 1) Write the electronic configuration of first transition series elements 2) Discuss the variation of atomic radii in 3d elements. 3) What is EAN? Calculate the EAN of central metal ion in i) $[Cu(NH_3)_4]SO_4$ i) $K_4[Fe(CN)_6]$			

	4) Define i) Complex ion ii) Ligands iii) Homoleptic complexes 5) Distinguish between double salt and complex. 6) Explain the geometry of $[Co(NH_3)_6]^{3+}$ and $[CoF_6]^{3-}$ complex ions on the basis of VBT. 7) Define i) Hydrometallurgy ii) Pyrometallugy iii) Electrometallurgy
	Answer in Detail (At least 4) (6 Marks each) 1) Discuss the following properties of first transition series elements i) Oxidationa states ii) catalytic properties 2) Write the postulates of Werner's theory of coordination complexes. Give the experimental verification on the basis of molar conductance and precipitation 3) Write i) hybridization state of central metal ion, ii) geometry and iii) magnetic properties of each of the following a) $[Fe(H_2O)_6]^{3+}$ b) $[NiCl_4]^{2-}$ c) $[Co(en)_3]^{3+}$ and d) $[Ni(NH_3)_6]^{2+}$ 4) Explain the steps involved in metallurgical process
	MCQs for Internal Assessment (At least 4) 1) Which of the following elements shows maximum number of different oxidation states in its compounds? a) Ti b) V c) Cr d) Mn 2) Which of the following ions does not form coloured compounds? a) Fe^{2+} b) Ti^{3+} c) Zn^{2+} d) Cu^{2+} 3) The catalytic properties of transition metal ions are due to a) variable oxidation states b) surface area c) presence of one or more unpaired electrons d) all of these 4) The number of moles of AgCl formed, when 1 mole of $[Co(NH_3)_4Cl_2]Cl$ is treated with excess of $AgNO_3$ solution is a) 1 mole b) 1.5 moles c) 2 moles d) 3 mole 5) Coordination number and oxidation number of Cr in $K_3[Cr(C_2O_4)_3]$ are respectively a) 4 and +2 b) 6 and +3 c) 3 and +3 d) 3 and 0 6) $K_3[Al(C_2O_4)_3]$ is called .. a) Potassium alumino oxalate b) Potassiumtrioxalatoaluminate (III) c) Potassium aluminium (III) oxalate d) Potassium trioxalato aluminate (VI) 7) In which there is outer orbital hybridization? a) $[Zn(NH_3)_6]^{2+}$ b) $[Co(NH_3)_6]^{3+}$ c) $[Cr(NH_3)_6]^{3+}$ d) $[V(NH_3)_6]^{3+}$ 8) $[Co(NH_3)_4Cl_2]NO_2$ and $[Co(NH_3)_4ClNO_2]Cl$ exhibit which type of isomerism? [MP PMT 1993] a) Geometrical b) Optical c) Linkage d) Ionization 9) The sulphide ore of ZINC is concentrated by.. a) chemical method b) froth flotation method c) magnetic method d) gravity separation 10) Heating of ore in presence of excess of oxygen before its melting point is called.. a) roasting b) calcination c) smelting d) leaching

Course Category: **Major (Theory)**

108231 Organic Chemistry-2

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108231**	**Organic Chemistry-2**	2	30	2 Hrs	30+20=50

Course Objectives:	1. To provide fundamental understanding of the structure, preparation, properties, and reactions of carboxylic acids, esters, and nitrogen-containing organic compounds. 2. To introduce the chemistry of amino acids, peptides, and carbohydrates with emphasis on their structure, biological significance, and chemical behavior.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Explain the structure, preparation, properties, and reactions of carboxylic acids and esters, including mechanisms of esterification and hydrolysis. 2. Analyze the synthesis, reactivity, and applications of nitrogen-containing organic compounds such as nitro compounds, amines, and diazonium salts. 3. Describe the structure, stereochemistry, synthesis, and reactions of amino acids and peptides, and explain their biological and pharmaceutical importance. 4. Interpret the classification, structure, stereochemistry, and chemical behavior of carbohydrates including monosaccharides, disaccharides, and polysaccharides. 5. Apply mechanistic and structural concepts to predict the reactivity and interconversion of important organic compounds. 6. Correlate the chemical properties of biomolecules with their biological functions and industrial applications.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Carboxylic acids and Esters** A) **Carboxylic acids:** Structure and reactivity of carboxylic groups. Acidity of carboxylic acids, effects of substituents on acidic strength. **Oxalic acid:** Preparation from ethylene glycol and cyanogens, reactions with ethanol, ammonia, glycerol and action of heat. **Lactic acid:** Preparation from acetaldehyde and pyruvic acid, reaction with ethanol, PCl_5, action of heat, oxidation and reduction. **Benzoic acid**: Preparation from toluene, benzyl alcohol and benzamide, reactions with ethanol, PCl_5 and ammonia. **Salicylic acid:** Preparation by Reimer-Tiemann reaction. Reactions with CH_3COCl, CH_3OH and C_6H_5OH. **B) Ester**: Structure and nomenclature of esters, Preparation of ester by reaction of acetic acid, benzoyl chloride with ethanol; acetic anhydride with ethanol and salicylic acid; propanoic acid with diazomethane; silver acetate with methyl bromide. Reaction of methyl acetate with ammonia, PCl5, hydrolysis. Mechanism of esterification and hydrolysis (acidic and basic).	8 Hrs	8 Marks	**1. Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. 2. **Hands-On Models**: use of model 3. **Problem-Solving Sessions**: Organize regular problem-solving sessions. 4. Explore virtual labs and simulations to enhance understanding of the topic. 5. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. 6. Ask students to create concept maps that illustrate the relationships between different concepts. 7. **Inquiry-Based Learning:** Explore topics
Unit II	**Nitrogen containing compounds** **A) Aromatic nitro compounds:** Nitrobenzene: Resonance structure, synthesis from benzene, Reductions : i)	7 Hrs	7 Marks	

	in acidic medium, ii) In neutral medium, iii) In alkaline medium. **B) Amino Compounds:** Aniline: Basicity and effect of substituents. Preparation of aniline from nitrobenzene, reactions with acetyl chloride and benzoyl chloride, Br_2 (aq) and $Br_2(CS_2)$, carbylamine reaction, alkylation, Hoffmann's exhaustive methylation and its mechanism. C) **Diazo Compounds:** Preparation benzene diazonium chloride, Synthetic applications- Preparation of benzene, phenol, halobenzene, nitrobenzene, benzonitrile, coupling with phenol and aniline.			through questioning, investigation, and research. 8. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. 9. **Any other innovative pedagogy as applicable.**
Unit III	**Amino acids and Peptides :** **A) Amino Acids:** Structure & Classification, Chirality, D, L configuration. synthesis by Strecker and Gabriel phthalimide method, Zwitterion structure, Isoelectric point, reactions of amino acids with Ninhydrin, Sanger's Edman's reagent. **B) Peptides**: Classification and nomenclature, synthesis of peptides, structure determination of polypeptides by end group analysis, biological and pharmaceutical importance	8 Hrs	8 Marks	
Unit IV	**Carbohyadrates** Occurrence, classification and their biological importance. **Monosaccharides**: Constitution and absolute configuration of Glucose and Fructose, cyclic structure, Epimerization, conversion of glucose to fructose and vice-versa, Haworth projections and conformational structures. Structure of Ribose, 2-deoxyribose, Pyranose and Furanose, **Disaccharides –** Structure of Sucrose, maltose & Lactose. **Polysaccharides –** Structure and properties of starch & cellulose.	7 Hrs	7 Marks	
References:	1. Organic Chemistry Vol. I, II and III by Mukharjee, Singh and Kapoor- Wiley Eastern. 2. Organic Chemistry, Morrison, R. N. & Boyd, R. N. 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 3. Organic Chemistry Pine S. H., Fifth Edition, McGraw Hill, (2007) 4. Organic Chemistry F. A. Carey, Seventh Edition, Tata McGraw Hill (2008). 5. Organic Chemistry J. Clayden, N. Greeves, S. Warren, , 2nd Ed., (2012), Oxford Universitiy Press. 6. Advanced Organic Chemistry Part A: Structure and mechanism, F. A. Carey, R. J. Sundberg, Kluwer Academic Publisher, (2000). 7. Organic Chemistry by S.K. Ghosh. 8. Reaction Mechanism in Organic Chemistry by S.M. Mukharjee and S.P. Singh. 9. Stereochemistry and mechanism through solved problems by P.S. Kalsi. 10. Organic Chemistry by Solomons, 8th edition, John Wiley 11. Organic Chemistry by R. K. Bansal 12. Organic Chemistry by L.G. Wade. Prentice Hall. 13. Synthetic Organic Chemistry, by: G. R. Chatwal. 14. Modern Organic Chemistry by M. K. Jain and S. C. Sharma. 15. Organic Chemistry, Reactions, Rearrangements and Reagents, by: O. P. Agarwal. 16. A Text book of organic chemistry by Bahl and Bahl.			

	17. A Text book of organic chemistry by P. L. Soni **Web resources:** 1. https://www.masterorganicchemistry.com/reaction-guide/ 2. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Carboxylic_Acids 3. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Esters 4. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Amines 5. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Organic_Chemistry_(OpenStax)/24%3A_Amines_and_Heterocycles 6. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Organic_Chemistry_(OpenStax)/26%3A_Biomolecules-_Amino_Acids_Peptides_and_Proteins 7. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Carbohydrates
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) Give the IUPAC name for the ester formed from acetic acid and ethanol. 2) Define the term 'Esterification'. 3) What is the action of heat on Lactic acid 4) What is the IUPAC name of the product obtained from the acetylation of aniline? 5) Why does the nitro group in nitrobenzene decrease the electron density of the benzene ring? 6) Identify the product formed when nitrobenzene is reduced in a strongly acidic medium. 7) Define the term 'Zwitterion'. 8) State the definition of the Isoelectric Point. 9) What is a 'Tripeptide'? 10) What are "Epimers"? Give one example. 11) What is "Mutarotation"? 12) What is a "Furanose" ring?
	Answer in brief (At least 6) (3 Marks each) 1) How is Lactic acid prepared from Pyruvic acid? 2) Explain the reaction of benzoic acid with ethanol and PCl5. 3) Write the Reimer-Tiemen reaction. 4) Explain the mechanism of the nitration of nitrobenzene. 5) Define Hoffmann's exhaustive methylation. What is the end product of this process? 6) What happens when aniline reacts with bromine in the presence of carbon disulphide. 7) Describe the Strecker synthesis of amino acids with the help of chemical equations. 8) Explain the classification of amino acids based on the nature of their side chains (Acidic, Basic, and Neutral) with one example each. 9) Explain the formation of a Zwitterion structure and how it affects the physical properties of amino acids 10) Differentiate between Pyranose and Furanose structures with suitable diagrams. 11) Explain the steps to convert D-Glucose into D-Fructose. 12) Draw and compare the structures of D-Ribose and 2-Deoxy-D-ribose. Mention their biological significance.
	Answer in Detail (At least 4) (6 Marks each) 1) Explain the reaction of oxalic acid with ethyl alcohol, ammonia and glycerol. 2) Explain acidic and basic hydrolysis of ester. 3) Discuss the reduction of nitrobenzene in detail under acidic, neutral, and alkaline conditions. 4) Explain the mechanism of Hoffmann's exhaustive methylation followed by Hoffmann elimination. 5) Discuss the complete mechanism of the Strecker synthesis and the Gabriel Phthalimide synthesis. 6) Describe in detail the Sanger Method (using DNFB) and the Edman Degradation method for N-terminal analysis of polypeptides. 7) Explain the detailed mechanism for the inter conversion of Glucose to Fructose and vice-versa. 8) Explain the Structure and properties of starch & cellulose.
	MCQs for Internal Assessment (At least 4) 1) Lactic acid contains which of the following functional groups? A) Only Carboxylic acid B) Carboxylic acid and Ketone C) Carboxylic acid and Hydroxyl D) Carboxylic acid and Aldehyde 2) Saponification is the:

A) Acidic hydrolysis of an ester B) Basic hydrolysis of an ester

C) Oxidation of an alcohol D) Dehydration of an acid

3) The reaction of Aniline with Benzoyl chloride is known as:

A) Friedel-Crafts reaction B) Schotten-Baumann reaction

C) Hoffmann reaction D) Perkin reaction

4) The Carbylamine reaction is performed by heating a primary amine with:

A) $CHCl_3$ and alcoholic KOH B) CCl_4 and alcoholic KOH

C) CHCl and alcoholic OH D) $CHCl_3$ and HCl

5) Which of the following amino acids is achiral?

A) Alanine B) Valine

C) Glycine D) Leucine

6) Which of the following is a basic amino acid?

A) Aspartic acid B) Lysine

C) Serine D) Phenylalanine

7) D-Glucose and D-Galactose are:

A) Anomers B) C-2 Epimers

C) C-4 Epimers D) Enantiomers

8) The number of chiral centers in the cyclic form of Glucose is:

A) 4 B) 5

C) 6 D) 3

9) Preparation of Benzoic acid from Benzamide involves:

A) Reduction B) Oxidation

C) Hydrolysis D) Hydrogenation

10) Nitrobenzene is also known as:

A) Oil of Wintergreen B) Oil of Mirbane

C) Oil of Vitriol D) Mustard Oil

11) A peptide bond is chemically an:

A) Ester linkage B) Ether linkage

C) Amide linkage D) Glycosidic linkage

12) Sucrose is composed of:

A) Glucose + Glucose B) Glucose + Galactose

C) Glucose + Fructose D) Fructose + Fructose

Course Category: **Major (Theory)**

108232 Physical chemistry 2

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108232**	**Physical chemistry 2**	2	30	2 Hrs	30+20=50

Course Objectives:	1. To understand the fundamental principles of quantum chemistry, chemical equilibrium, and phase equilibria. 2. To apply quantum mechanical and thermodynamic concepts to explain chemical systems and processes. 3. To develop analytical and numerical problem-solving skills in physical chemistry.
Course Outcomes:	After successful completion of the course, a student will be able to-. 1. Explain the limitations of classical mechanics and the development of quantum theory. 2. Describe photoelectric effect, Compton effect, and de Broglie matter waves. 3. Apply de Broglie equation and Heisenberg uncertainty principle to quantum systems. 4. Derive and interpret Schrödinger wave equation in one and three dimensions. 5. Explain the significance of wave functions and atomic orbitals. 6. Apply Schrödinger wave equation to simple systems such as particle in one-dimensional and three-dimensional boxes and interpret the physical significance of wave functions and atomic orbitals. 7. Analyze chemical equilibrium using the law of mass action, equilibrium constants, thermodynamic relationships, and Le-Chatelier's principle. 8. Explain phase equilibria using Gibbs phase rule and interpret phase diagrams of one-component and partially miscible liquid systems. 9. Solve numerical problems related to quantum chemistry, chemical equilibrium, and phase equilibria.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Quantum chemistry I** Limitations of classical mechanics. Planck's quantum theory (postulates only). Photoelectric effect - Experiments, observation and Einstein's explanation. Compton effect and its explanation. de Broglie hypothesis of matter waves. de Broglie's equation. Heisenberg's uncertainty principle. Numericals.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Any other innovative pedagogy as applicable.**
Unit II	**Quantum chemistry II** Classical wave equation, derivation of time independent Schrodinger's wave equation in one-dimension and its extension to a three-dimensional space. Well behaved wave function, physical significance of wave function (Born interpretation). Application of Schrodinger wave equation to a particle in one-dimensional box and its extension to a three-dimensional box. Concept of atomic orbital. Numericals.	7 Hrs	7 Marks	
Unit III	**Chemical equilibrium** Introduction. Characteristics of chemical equilibrium. Law of Mass Action, Law of Chemical equilibrium. Types of equilibrium constants and their units- Kc, Kp and Kx. Relation between Kp, Kc and Kx. Chemical potential or partial molar free energy, Derivation of Gibb's-Duhem equation, Thermodynamic derivation of law of chemical equilibrium. Derivation of Vant Hoff's reaction isotherm. Le-Chatelier's principle- Statement and effect of change of concentration, temperature and pressure on equilibrium.	8 Hrs	8 Marks	

	Clausius-Clapeyron equation (only qualitative statement).			
Unit IV	**Phase equilibria:** The Phase rule. Explanation of the terms: phase, component, degree of freedom. Calculation of number of components, phases and degrees of freedom in equilibrium systems. Phase diagram of one-component system- Water system and Sulphur system. Phase transition Partially miscible liquids - Phase diagram of phenol-water, triethyl amine - water and nicotine-water systems. Numericals.	7 Hrs	7 Marks	
References:	1) Principles of Physical Chemistry by B. R. Puri, L. R. Sharma & M. S. Pathania 2) Atkins' Physical Chemistry by Peter Atkins & Julio de Paula 3) Physical Chemistry by R. L. Madan 4) Physical Chemistry: A Molecular Approach by Donald A. McQuarrie & John D. Simon 5) Essentials of Physical Chemistry by B. S. Bahl, G. D. Tuli & Arun Bahl 6) Physical Chemistry: Quantum Chemistry And Spectroscopy by Peter W. Atkins and Julio de Paula **Web resources:** 3. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps?utm_source=chatgpt.com 4. https://ocw.mit.edu/search/?q=physical+chemistry&utm_source 5. hemcontent.com/2021/11/quantum-chemistry-handwritten-notes-pdf.html 6. https://www.physchem.info/en/lecture-notes/?utm_source 7. https://vergil.chemistry.gatech.edu/resources?utm_source 8. https://qchem1.qcdevs.org/?utm_source 9. https://mariovelo.com/physical-chemistry-quantum-mechanics?utm_			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1. State Planck's quantum theory. 2. What is photoelectric effect? 3. Define threshold frequency. 4. State Einstein's photoelectric equation. 5. What is Compton effect? 6. State de Broglie hypothesis. 7. State Heisenberg's uncertainty principle. 8. What is wave function? 9. Define well-behaved wave function. 10. What is a particle in a box? 11. Define chemical equilibrium. 12. State the law of mass action. 13. Define equilibrium constant. 14. Define phase. 15. What is a component in phase rule? 16. Define degree of freedom. 17. State Gibbs phase rule. 18. What is triple point? 19. Define eutectic point. 20. Define partially miscible liquids. 21. Give one example of a one-component system. 22. Name one system showing upper critical solution temperature (UCST).			

	Answer in brief (At least 6) (3 Marks each) 1. Explain the limitations of classical mechanics. 2. Explain Einstein's explanation of photoelectric effect. 3. Explain Compton effect with suitable illustration. 4. Derive de Broglie equation for matter waves. 5. Discuss the physical significance of wave function. 6. Write a short note on atomic orbitals. 7. State and explain the law of mass action. 8. Differentiate between Kc, Kp and Kx. 9. Derive the relation between Kp and Kc. 10. Derive Van't Hoff reaction isotherm. 11. Explain Le-Chatelier's principle with examples. 12. Discuss the effect of temperature on chemical equilibrium. 13. Discuss the effect of pressure on equilibrium. 14. Define phase, component and degree of freedom with examples. 15. Explain Gibbs phase rule. 16. Describe the phase diagram of water system.
	Answer in Detail (At least 4) (6 Marks each) 1. Explain the photoelectric effect and discuss Einstein's interpretation with experimental observations. 2. Explain de Broglie hypothesis of matter waves and derive de Broglie equation. 3. Derive the time-independent Schrödinger wave equation in one dimension and extend it to three dimensions. 4. Discuss the application of Schrödinger wave equation to a particle in one-dimensional box and derive the energy expression. 5. Explain different equilibrium constants (Kc, Kp and Kx) and derive the relationship among them. 6. Explain the concept of chemical potential and derive Gibbs–Duhem equation 7. State and explain Le-Chatelier's principle with suitable examples involving concentration, pressure and temperature changes. 8. Discuss the phase diagram of water system and explain its important features. 9. Explain the phase diagram of sulphur system and discuss the allotropy of sulphur. 10. Discuss the phase diagrams of partially miscible liquid systems such as phenol–water, triethylamine–water and nicotine–water systems.
	MCQs for Internal Assessment (At least 4) 1. According to de Broglie hypothesis, particles possess: A) Charge only B) Spin only C) Wave nature D) Magnetic nature **2.** The uncertainty principle was proposed by: A) Planck B) Einstein C) Schrödinger D) Heisenberg 3. The equilibrium constant Kp is related to: A) Concentration of reactants B) Partial pressures of gases C) Volume of reaction vessel D) Rate of reaction 4. The degree of freedom for water system at triple point is: A) 0 B) 1 C) 2 D) 3 5. The phenol–water system shows: A) Lower critical solution temperature only B) Upper critical solution temperature only C) Both upper and lower critical solution temperatures D) No critical solution temperature

Course Category: **Major Lab**

108233 Chemistry Lab 15

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108233**	**Chemistry Lab 15**	2	60	4 h	25+25= 50

Course Objectives:	1. To develop practical skills in the synthesis, purification, and characterization of coordination compounds and inorganic complexes in Inorganic Chemistry. 2. To provide hands-on training in qualitative organic analysis, separation techniques, and identification of components of binary organic mixtures.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1) Prepare and characterize various inorganic and coordination complexes using standard laboratory techniques. 2) Interpret the valence bond structure, magnetic behavior, and color of coordination compounds. 3) Perform spot tests and identify metal ions present in inorganic complexes. 4) Separate and identify components of binary organic mixtures using systematic qualitative analysis methods. 5) Apply recrystallization, filtration, extraction, and derivative preparation techniques for purification and identification of organic compounds. 6) Demonstrate safe laboratory practices, analytical skills, and accurate reporting of experimental observations and results.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	1. Writing balanced chemical equations for synthesis of coordination compounds. 2. Determination of oxidation state, coordination number, and geometry of complexes. 3. Prediction of magnetic properties and VB structures of coordination compounds. 4. Interpretation of color in transition metal complexes based on crystal field concepts. 5. Principles of separation techniques used in binary organic mixture analysis. 6. Selection of fixing reagents for separation of acidic, basic, and neutral organic compounds. 7. Flow chart preparation for systematic qualitative organic analysis.	• **Experiential Learning** Hands-on laboratory experiments for synthesis, separation, purification, and analysis of inorganic and organic compounds. • **Demonstration Method** Demonstration of complex preparation, spot tests, recrystallization, TLC, and melting point determination by instructor before student performance. • **Problem-Based Learning (PBL)** Students solve unknown mixture analysis and identification problems using systematic qualitative methods. • **Inquiry-Based Learning** Students select suitable fixing reagents, predict reaction outcomes, and interpret observations independently. • **Collaborative Learning** Group-based synthesis, analysis, and discussion activities to encourage teamwork and peer learning. • **Project-Based Learning** Mini-projects on coordination compounds, green synthesis, qualitative analysis schemes, or industrial applications of complexes. • **ICT-Enabled Teaching** Use of molecular visualization software, virtual laboratories, videos, and digital flowcharts for coordination chemistry and organic analysis. • **Flipped Classroom Approach** Students study theory, reaction
Inorganic Chemistry practical	**Inorganic Complex Preparations: (At least 5)** 1. Preparation of tetraamminecopper(II)sulphate. 2. Preparation of hexaamminenickel(II)chloride. 3. Preparation of Prussian blue 4. Preparation of potassiumtrisoxalato-aluminate(III). 5. Preparation of chrome alum. 6. Preparation of sodium thiosulphate and dithionite. 7. Preparation of cis and trans-bisoxalato diaqua chromate (III) ion. (Comment on VB structure, magnetic properties and color of 1, 2 and 3 complexes) **Preparation of following inorganic complexes and spot tests for metal ion: (At least 4)** 1. Preparation of Tris(acetylacetonato)iron(III): $[Fe(acac)_3]$ 2. Preparation of Hexaminecobalt(III) chloride: $[Co(NH_3)_6]Cl_3$ 3. Preparation of Sodium Hexanitritocobaltate(III): $Na_3[Co(NO_2)_6]$ 4. Preparation of Potassium trisoxalatoferrate(III): $K_3[Fe(C_2O_4)_3]$ 5. Preparation of Trsi(acetylacetonato)-manganese(III): $[Mn(acac)_3]$	

	6. Preparation of Tris(glycinato)nickelate(II): $[Ni(gly)_3]^-$ 7. Preparation of Potassium dioxalatocuprate (II): $[Cu(C_2O4)_2]^{2-}$	mechanisms, and analysis schemes before laboratory sessions for better practical engagement. • **Peer Teaching and Seminar Method** Student presentations on coordination compounds, spot tests, and qualitative analysis techniques. • **Reflective Learning** Maintenance of laboratory journals, error analysis, self-assessment, and interpretation of experimental results. • **Skill-Based Training** Emphasis on laboratory techniques, safe chemical handling, analytical calculations, and scientific report writing. **Any other innovative pedagogy as applicable.**
Organic Chemistry Practical	**Qualitative Organic Analysis (At least 6 mixture)** **Separation and Identification of One of the Components of a Binary Organic Mixture** (1.0 g mixture given) 1. Minimum Six mixtures to be completed by the students. 2. Components of the mixture should include water soluble and water insoluble acids (carboxylic acid), water insoluble phenols (2-naphthol, 1- naphthol), water insoluble bases (nitroanilines), water soluble (urea, thiourea) and water insoluble neutral compounds (anilides, amides, mDNB, hydrocarbons). 3. A sample of the mixture to be given to the student for detection of the chemical type of the mixture. 4. After correct determination of chemical type, the fixing reagent should be decided by the student for separation. 5. After separation into component A and component B, One component (decided by the mentor/examiner) is to be analyzed and identified.	
Suggested Group activity	**1. Coordination Complex Exhibition** Student groups prepare different inorganic complexes and present their: Structure, Color, Geometry, Magnetic properties, Applications **2. Binary Mixture Analysis Competition** **3. Flowchart Preparation Activity** **4. Model and Chart Presentation** **5. Mini Research Project** **6. Case Study Discussion**	
References	1. *Advanced Practical Inorganic Chemistry* – Gurdeep Raj, Goel Publishing. 2. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Inorganic Chemistry: Qualitative Analysis, University Press. 3. Vogel's Textbook of Quantitative Chemical Analysis – J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, Pearson. 4. Practical Chemistry (For B.Sc. I, II and III Year Students). By Pandey O.P. & Bajpai D.N. & Giri S., S.Chand 5. Morgan, E. D. "Vogel's textbook of practical organic chemistry. 5th edn.: By BS Furniss, AJ Hannaford, PWG Smith and AR Tatchell. Pp. 1514. Longman, Harlow. (1990): 148. 6. *Handbook of Organic Analysis: Qualitative and Quantitative* – H. T. Clarke, CBS Publishers. 7. Ahluwalia, V. K., and Renu Aggarwal. Comprehensive practical organic chemistry: preparation and quantitative analysis. Universities Press, 2001. 8. Sethi, Arun. *Systematic lab experiments in organic chemistry*. New Age International, 2006 9. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press. 10. Advanced practical Organic Chemistry: O P Agrawa **Web resources:** 1. MIT OpenCourseWare: https://ocw.mit.edu 2. Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry 3. ChemCollective Virtual Labs: http://chemcollective.org	
Model Questions:	**NA**	

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Inorganic Chem Practical) 10 Marks
- Exercise 2 (Organic Chem Practical) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **Major- Elective (Theory)**

108234 Elective Chemistry-1 (Spectroscopy-I)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108234**	**Elective Chemistry-1 (Spectroscopy-I)**	2	30	2 Hrs	30+20=50

Course Objectives:	To provide detailed understanding of the origin of electromagnetic radiation terms associated with it. The course aims to develop the ability to understand and apply the basic principles of spectroscopy, rotational spectroscopy, UV and IR spectroscopy for structure determination.
Course Outcomes:	After successful completion of the course, a student will be able to-. 1. Explain the origin and regions of electromagnetic radiation 2. Appreciate the factors governing the intensity of bands 3. Classify molecules as Microwave active/ inactive and IR active/inactive 4. State and apply Beer- Lambert law. 5. Predict and explain the type of transition in the molecule. 6. Predict approximate wavelength regions for different types of transitions. 7. Recognize the factors that complicate the interpretation of infrared spectra 8. Justify the peaks in ultra-violet spectrum. 9. Apply Woodward-Fieser rules for various compounds for calculating λ max

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Introduction to Spectroscopy:** Electromagnetic radiation, characteristics of electromagnetic radiation in terms of wavelength, wave number, frequency and energy of photon. Spectrum of electromagnetic radiation. Types of spectra - Emission and absorption spectra, atomic and molecular spectra, line and band spectra. Translational, vibrational, rotational and electronic motion. The degree of freedom in each motion. Energy level diagram of a molecule indicating electronic, vibrational and rotational transitions Franck-Condon principle, Stark effect, Zeeman effect.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge.
Unit II	**Rotational spectroscopy** Introduction, Condition for pure rotational spectrum (i.e. microwave active molecules), Derivation of expression for moment of inertia of a diatomic rigid rotor. Rotational energy levels of Diatomic Molecules, Selection rule for Microwave spectra. Derivation showing that Rotational Spectral Lines for diatomic molecules are equally spaced Isotope effect. Applications of microwave spectroscopy for the determination of moment of inertia and bond length in diatomic molecules. Problems.	7 Hrs	7 Marks	
Unit III	**UV-visible spectroscopy** Introduction, Instrumentation, Theory or Principle of Electronic Spectroscopy, Absorption Laws, Electronic Transitions, Important terms used in UV Spectroscopy- chromophore, auxochrome, bathochromic shift,	8 Hrs	8 Marks	

	hypsochromic shift, hyperchromic effect and hypochromic effect. Applications in the structure determination of dienes, Ultra-violet Absorption in unsaturated Carbonyl Compounds (aldehyde and Ketones), Ultraviolet visible Spectra of Aromatic Compounds. Problems			**Any other innovative pedagogy as applicable.**
Unit IV	**IR spectroscopy** Basic principles of IR spectroscopy. IR active and inactive molecules. Degree of Freedom. Calculation of vibrational degrees of freedom. Types of molecular vibrations- stretching and bending Hooke's law and factors affecting vibrational frequency. Functional group region (H-stretching, triple bond, double bond) and fingerprint region. IR spectra of simple organic molecules (alkanes, alkenes, alkynes, aromatic compounds, alcohols, amines and carbonyl compounds). Identification of simple organic compounds using IR spectral data. Distinction between the pair of compounds using IR spectra.	7 Hrs	7 Marks	
References:	1. Advanced Organic Chemistry Part-A &B by Carey, Francis A, Sundberg, Richard J 2. Advanced Organic Chemistry by Michael B. Smith, Jerry March. 3. Banwell.,(2017). Fundamentals of Molecular; Spectroscopy (IV Edition), McGraw-Hill Education (India) Pvt. Limited. 4. Sharma, Y. R. (2013). Elementary Organic Spectroscopy: Principles and Chemical. 5. Organic Structure From Spectra by L D Field, S Sternhell 6. P S Kalsi,(2016). Spectroscopy of Organic Compounds, 7th edition. Delhi: New age international publisher. 7. Robert M. Silverstein, Francis X. Webster, (1996).Spectrometric Identification of Organic Compounds, 6th Edition. New York: John Wiley & Sons. **Web resources:** https://onlinecourses.nptel.ac.in/noc21_cy09/unit?unit=24&lesson=30 https://onlinecourses.nptel.ac.in/noc21_cy09/unit?unit=100&lesson=102 https://onlinecourses.swayam2.ac.in/5231-online-refresher-course-in-chemistry-for-higher-education-faculty/unit?unit=75&lesson=77 https://onlinecourses.nptel.ac.in/noc21_cy09/unit?unit=41&lesson=46 https://onlinecourses.nptel.ac.in/noc21_cy09/unit?unit=57&lesson=60 https://onlinecourses.swayam2.ac.in/arp20_ap02/unit?unit=40&lesson=43 https://onlinecourses.swayam2.ac.in/arp20_ap02/unit?unit=40&lesson=44			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) Define Chromophores and auxochromes 2) Define Fluorescence and phosphorescence 3) What is selection rule for Rayleigh line In rotational Raman ? 4) What is the condition for a molecule to be microwave active? 5) Define Natural line width and Broadening-of spectral line 6) What is electronic spectroscopy?			
	Answer in brief (At least 6) (3 Marks each) 1) Discuss various types of electronic transitions giving one example of each 2) Discuss the Woodward-Fieser rules for calculating λmax in dienes. 3) Discuss Fluorescence and phosphorescence with diagram 4) Discuss the modes of vibration in IR 5) Derive the equation for Beer-Lambert Law 6) Discuss double bond region in IR			
	Answer in Detail (At least 4) (6 Marks each) 1. Explain why ethylene shows π→π* transitions at 180 nm while butadiene at 217 nm? 2. Calculate the energy associated with an ultraviolet radiation having wavelength 250 nm. Give the answer in kcal/rnole and also in kJ/mole. 3. Explain the Bathochromic and hypsochromic shifts with diagram 4. Explain the Franck-Condon principle			
	MCQs for Internal Assessment (At least 4)			

	1. The electron which do not involve in bonding between the atoms in molecule belongs to a) σ (b) π (c) n (d) π* 2.What is the number of vibrational degrees of freedom in $C_6H_5CH_3$? a) 39 b) 15 c)18 d) 4 3. Which of the following molecules will not show infrared spectrum? (a)HCl (b) H_2 (c) CH_4 (d) CO_2 4. Which of the following molecules show microwave activity? (a)SF6 (b) CH_3Cl (c) H_2 (d) CO_2

Course Category: **Major Elective Practical**

108235 Chemistry Lab 16 A (Elective Chemistry-1)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108235**	**Chemistry Lab 16 A (Elective Chemistry-1)**	2	60	4 h	25+25= 50

Course Objectives:	1. To develop practical skills in quantitative estimation of commercially important organic compounds using standard analytical methods. 2. To provide hands-on training in UV–Visible Spectroscopy and Infrared Spectroscopy for qualitative and quantitative analysis of organic compounds.	
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Perform quantitative estimation of organic compounds such as glucose, phenol, esters, vitamin C, aspirin, paracetamol, acetamide, and nitrogen using standard laboratory methods. 2. Apply Beer–Lambert law and UV–Visible spectroscopic techniques for concentration determination and spectral analysis of organic and inorganic compounds. 3. Interpret IR spectra for identification of functional groups, hydrogen bonding, aromatic/aliphatic compounds, and structural distinctions between organic molecules. 4. Analyze and compare spectral data to identify unknown compounds and correlate spectral features with molecular structure. 5. Demonstrate laboratory analytical skills, safe handling of instruments, data interpretation, and scientific reporting in spectroscopic and organic analytical experiments.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	1. Calculations involved in organic estimations. 2. Numerical problems based on wavelength, frequency, wave number, and photon energy calculations. 3. Problems based on Beer–Lambert law and determination of concentration using UV–Visible spectroscopy. 4. Identification of chromophores and auxochromes in organic compounds. 5. Calculation of vibrational degrees of freedom for linear and non-linear molecules. 6. Interpretation of IR spectra for identification of functional groups. 7. Distinction between aldehydes, ketones, alcohols, amines, and acids using IR spectra.	• **Experiential Learning** Hands-on laboratory training in organic estimations, UV–Visible spectroscopy, and IR spectral interpretation. • **Demonstration Method** Demonstration of spectrophotometer handling, sample preparation, calibration, and spectral recording before student experimentation. • **Problem-Based Learning (PBL)** Students solve unknown concentration and spectral interpretation problems using analytical and spectroscopic techniques. • **Inquiry-Based Learning**
Organic Estimations	**Organic Estimations (At least 4)** 1. Estimation of glucose by Fehling's method 2. Estimation of phenol by bromination method 3. Estimation of ester by hydrolysis method 4. Estimation of vitamin C in fruit juice/tablets 5. Estimation of aspirin/paracetamol in formulations 6. Estimation of acetamide. 7. Determination of equivalent weight of an organic acid 8. Estimation of Nitrogen by Kjeldahl's method	

Spectral interpretation	**UV-Visible spectroscopy** (Reference spectra may be obtained from literature) 1. Verification of Beer–Lambert law using potassium permanganate or potassium dichromate solution. 2. To determine the indicator constant of methyl red/ any suitable indicator 3. To estimate the Fe^{3+} ions by the thiocyanate method. 4. Estimation of copper using colorimetric/UV-visible method. 5. Determination of λmax of organic compounds such as benzaldehyde and anisole. 6. Determination of concentration of unknown solution using UV–Visible spectrophotometer. 7. Comparative UV spectra of 1,3-butadiene and 1,3,5-hexatriene. **IR Spectroscopy** (Reference spectra may be obtained from literature) 1. Identification of functional groups in alcohols, aldehydes, ketones, acids, esters, and amines using IR spectra. 2. Identification of hydrogen bonding using IR spectral shifts. 3. Determination of vibrational degrees of freedom for simple molecules. 4. Distinction between aldehydes and ketones (Benzaldehyde and Acetophenone) using IR spectra. 5. Identification of aromatic and aliphatic compounds using IR data. 6. Identification of hydrogen bonding in: Salicylic acid, o-Nitrophenol and p-Nitrophenol 7. Comparative study of IR spectra of primary, secondary and tertiary amines.	Students predict spectral behavior, identify functional groups, and interpret structural features from experimental data. • **Collaborative Learning** Group-based experimental work, spectral analysis, and comparative interpretation of compounds. • **ICT-Enabled Teaching** Use of online spectral databases, virtual spectroscopy tools, simulation software, and digital spectral libraries. • **Project-Based Learning** Mini-projects on pharmaceutical estimations, food analysis. • **Flipped Classroom Approach** Students study theory, spectra, and experimental procedures before laboratory sessions to improve practical engagement. • **Peer Learning and Seminar Method** Student presentations on UV, IR spectroscopy, and applications in pharmaceutical and industrial chemistry. • **Any other innovative pedagogy as applicable.**
Suggested Student Activities	1. Comparative Spectra Study 2. **Mini Project on Pharmaceutical Analysis** Estimation of vitamin C, aspirin, or paracetamol in commercial formulations and preparation of analytical reports. 3. **Preparation of Functional Group Charts** Students prepare charts correlating IR absorption frequencies with functional groups 4. **ICT-Based Spectral Analysis** Use of online spectral databases and software tools for interpretation of UV and IR spectra. 5. **Poster Presentation**	
References	1. Morgan, E. D. "Vogel's textbook of practical organic chemistry. 5th edn.: By BS Furniss, AJ Hannaford, PWG Smith and AR Tatchell. Pp. 1514. Longman, Harlow. (1990): 148. 2. *Handbook of Organic Analysis: Qualitative and Quantitative* – H. T. Clarke, CBS Publishers. 3. Practical Chemistry (For B.Sc. I, II and III Year Students). By Pandey O.P. & Bajpai D.N. & Giri S., S.Chand. 4. Ahluwalia, V. K., and Renu Aggarwal. Comprehensive practical organic chemistry: preparation and quantitative analysis. Universities Press, 2001. 5. Sethi, Arun. *Systematic lab experiments in organic chemistry*. New Age International, 2006 6. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC	

	Press. 7. Advanced practical Organic Chemistry: O P Agrawal 8. Sharma, Y. R. (2013). Elementary Organic Spectroscopy: Principles and Chemical. 9. Organic Structure From Spectra by L D Field, S Sternhell 10. P S Kalsi,(2016). Spectroscopy of Organic Compounds, 7th edition. Delhi: New age international publisher. 11. Robert M. Silverstein, Francis X. Webster, (1996).Spectrometric Identification of Organic Compounds, 6th Edition. New York: John Wiley & Sons. **Web resources:** https://nanohub.org/modelsimulate https://sdbs.db.aist.go.jp/SearchInformation.aspx https://avogadro.cc/ https://molview.org/
Model Questions:	**NA**

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Organic Estimation) 10 Marks
- Exercise 2 (Spectral interpretation) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **Major- Elective (Theory)**

108236 Elective Chemistry-2 (Spectroscopy-II)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108236**	**Elective Chemistry-2 (Spectroscopy-II)**	2	30	2 Hrs	30+20=50

Course Objectives:	The course aims to develop the ability to understand and apply the rotational, vibrational, Raman spectroscopy and X-ray diffraction for structural analysis
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Explain the origin and regions of electromagnetic radiation 2. Classify molecules as Microwave active/ inactive and IR active/inactive 3. Predict and explain the type of transition in the molecule 4. Determine the frequency, wavelength, wavenumber and energy change associated with an infrared transition. 5. Explain rotational, vibrational and Raman spectroscopy 6. Corelate the relationship between wavelength, interplanar spacing (d), and the diffraction angle. 7. Explain the principle and methods of X-ray diffraction for structural analysis

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Introduction to Spectroscopy:** Electromagnetic radiation, characteristics of electromagnetic radiation in terms of wavelength, wave number, frequency and energy of photon. Spectrum of electromagnetic radiation. Types of spectra - Emission and absorption spectra, atomic and molecular spectra, line and band spectra. Translational, vibrational, rotational and electronic motion. The degree of freedom in each motion. Energy level diagram of a molecule indicating electronic, vibrational and rotational transitions Franck-Condon principle, Stark effect, Zeeman effect.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit II	**Rotational spectroscopy** Introduction, Condition for pure rotational spectrum (i.e. microwave active molecules), Derivation of expression for moment of inertia of a diatomic rigid rotor. Rotational energy levels of Diatomic Molecules, Selection rule for Microwave spectra. Derivation showing that Rotational Spectral Lines for diatomic molecules are equally spaced Isotope effect. Applications of microwave spectroscopy for the determination of moment of inertia and bond length in diatomic molecules. Problems.	7 Hrs	7 Marks	
Unit III	**A) Vibrational or Infrared Spectroscopy:** Condition for molecule to be IR active, Vibrational energy levels of a simple harmonic oscillator, zero point energy. Selection rule for vibrational transitions, Relation between vibrational frequency and force constant. Problems. **Raman Spectroscopy:** Rayleigh scattering and Raman scattering.	8 Hrs	8 Marks	

	Discovery and significance of Raman effect. Stokes and anti-Stokes lines. Classical and quantum theories of Raman effects, Condition for exhibiting Raman spectrum (i.e. Raman active molecule), Pure rotational spectrum of diatomic molecule, vibrational Raman spectrum of a diatomic molecule. Pure vibrational and vibrational rotational Raman spectra, selection rules.			
Unit IV	• **X-ray diffraction :** X-ray diffraction: Interaction of x-ray with matter, scattering and diffraction. Brags method Debye-Sherrer method of X-ray structural analysis of crystals, index reflection, identification of unit cell from systematic absence in diffraction pattern structure of simple lattice and x-ray intensities structure factor, its relation to intensity of electron density procedure for x-ray structure analysis, Problems	7 Hrs	7 Marks	
References:	1. Banwell.,(2017). Fundamentals of Molecular Spectroscopy (IV Edition), McGraw-Hill Education (India) Pvt. Limited. 2. Sharma, Y. R. (2013). Elementary Organic Spectroscopy: Principles and Chemical. 3. Applications (Revised V Edition). New Delhi: S. Chand & Company Limited. 4. Principles of Physical Chemistry: Puri, Sharma, and Pathania. 5. Physical Chemistry: P.W. Atkins, 6th Edn. 6. Physical Chemistry: Levine 7. A Textbook of Physical Chemistry, Kapoor, K.L. (2019), Vol.7, 1st Edition, McGraw Hill Education **Web resources:** https://youtu.be/BU0DO7xaT0M https://onlinecourses.nptel.ac.in/noc21_cy09/unit?unit=100&lesson=102 https://onlinecourses.swayam2.ac.in/5231-online-refresher-course-in-chemistry-for-higher-education-faculty/unit?unit=75&lesson=77			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) What is Raman Effect? 2) What is rigid rotor? 3) What are microwave active molecules? 4) What is the selection rule for vibrational transitions? 5) Define the terms: unit cell and Bragg's law 6) What are Miller indices?			
	Answer in brief (At least 6) (3 Marks each) 1) What is the selection rule for Rotational spectra? 2) Discuss the conditions for molecule to be IR active 3) Differentiate between Coherent and incoherent scattering 4) Discuss the fundamental principle of X-ray diffraction 5) Differentiate between Absorption and Emission Spectra 6) What is the condition for a molecule to be microwave active? Explain with examples			
	Answer in Detail (At least 4) (6 Marks each) 1) Derive the relation between vibrational frequency and force constant 2) Outline the fundamental modes of Vibration of CO_2 and predict which of these modes will be IR active and which will be Raman active. 3) Derive the relation betweenmoment inertia and bondlength of a diatomic rigid rotator 4) Derive Bragg's equation.			
	MCQs for Internal Assessment (At least 4) 1. Which of the following molecules show microwave activity? (a) SF_6 (b) CH_3Cl (c) H_2 (d) CO_2 The radiant source of visible light is (a) Tungsten Filament lamp (b) Mercury lamp (c) Deuterium lamp (d) Hydrogen Discharge lamp 3. The best monochromtion is provided by (a) Grating (b) Filter (c) Prism (d) Human eye 4..Real deviation from Beer's law may arise from changes in a) Refraction index of analytical system b) Band pass of filters c) Shift in the position of chemical equilibrium d) Shift in the position of physical equilibrium			

Course Category: **Major Elective Lab**

108237 Chemistry Lab 16B (Elective Chemistry-2)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108237**	**Chemistry Lab 16B (Elective Chemistry-2)**	2	60	4 h	25+25= 50

Course Objectives:	1. To develop practical skills in quantitative estimation of commercially important organic compounds using standard analytical methods. 2. To provide hands-on training in interpretation and analysis of rotational, vibrational, Raman, and X-ray diffraction spectra in Spectroscopy. 3. To familiarize students with modern simulation software, spectral databases, and virtual laboratory platforms used in chemical analysis and structure determination.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Perform quantitative estimation of organic compounds such as glucose, phenol, esters, vitamin C, aspirin, acetamide, and nitrogen using standard laboratory procedures. 2. Analyze rotational, vibrational, Raman, and X-ray diffraction spectral data for determination of molecular and crystal structure parameters. 3. Calculate bond length, moment of inertia, force constant, lattice parameters, crystal density, and related spectroscopic quantities from spectral data. 4. Distinguish IR active and Raman active molecules and interpret molecular vibrations and electronic transitions. 5. Apply ICT-based tools, simulations, and spectral databases for visualization, analysis, and interpretation of spectroscopic data. 6. Demonstrate analytical thinking, problem-solving ability, and scientific reporting skills in spectroscopy and organic analytical experiments.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	• Numerical problems based on Planck's equation and photon energy. • Calculation of moment of inertia and bond length of diatomic molecules. • Problems based on rotational spectra and isotope effect. • Calculation of force constant from IR vibrational frequency. • Problems based on Raman shifts and selection rules. • Calculation of interplanar distance using Miller indices. • Numerical problems based on Bragg's equation and X-ray diffraction. • Indexing of diffraction peaks in cubic crystal systems**.**	• Experiential and hands-on laboratory learning • ICT-enabled teaching using virtual labs, PhET, and NanoHUB simulations • Problem-based and inquiry-based learning through spectral interpretation • Collaborative learning through group activities and discussions • Project-based learning using case studies and spectral analysis • Demonstration and peer-learning methods for instrument handling and data analysis • Outcome-based continuous assessment through practical performance, assignments, and viva voce Any other innovative pedagogy as applicable.
Organic Estimations	**Organic Estimations (At least 4)** 1. Estimation of glucose by Fehling's method 2. Estimation of phenol by bromination method 3. Estimation of ester by hydrolysis method 4. Estimation of vitamin C in fruit juice/tablets 5. Estimation of aspirin/paracetamol in formulations 6. Estimation of acetamide. 7. Determination of equivalent weight of an organic acid 8. Estimation of Nitrogen by Kjeldahl's method	
Spectral analysis	**Spectral analysis:** (Reference spectra may be obtained from literature) (at least 8) 1. Verification of relationship between wavelength, frequency, and wave number	

	2. Study of emission spectrum of hydrogen/mercury lamp 3. Identification of atomic and molecular spectra from spectral charts 4. Analysis of the given rotational spectrum of HCl(g) 5. Calculation of moment of inertia of diatomic molecules from microwave spectral data 6. Determination of bond length of diatomic molecules using rotational constants 7. Verification of equal spacing of rotational spectral lines 8. Study of isotope effect in rotational spectra using simulated data 9. Determination of force constant from vibrational frequency 10. Comparison of IR active and IR inactive molecules 11. Analysis of the given vibrational spectrum of CO2 12. Analysis of the given vibrational spectrum of H2O 13. Identification of Stokes and anti-Stokes lines from Raman spectra 14. Comparison of IR and Raman active molecules 15. Determination of lattice parameter from XRD data 16. Identification of simple cubic, BCC, and FCC structures from diffraction patterns 17. Analysis of crystal structure from X-ray diffraction spectra of any two compounds (Calculation d, lattice constant, crystal volume and density, and assigning planes to peaks using JCPDS data) **Simulation / ICT-Based Activities using PhET simulations/ NanoHUB Spectroscopy Tools/ Virtual Labs by IITs** 1. Simulation of rotational and vibrational spectra using online software 2. Molecular vibration visualization using virtual spectroscopy tools 3. Simulation of Raman scattering and IR absorption 4. Virtual XRD pattern analysis and indexing 5. Use of spectral databases for interpretation of IR and Raman spectra	
Suggested Skill-Based Activities	1. Spectral interpretation assignments 2. Group seminar on modern spectroscopic techniques 3. Comparison of IR and Raman spectroscopy applications 4. Mini-project on spectroscopy in pharmaceuticals/material science 5. Data analysis from published spectral data	
References	1. Morgan, E. D. "Vogel's textbook of practical organic chemistry. 5th edn.: By BS Furniss, AJ Hannaford, PWG Smith and AR Tatchell. Pp. 1514. Longman, Harlow. (1990): 148. 2. *Handbook of Organic Analysis: Qualitative and Quantitative* – H. T. Clarke, CBS Publishers. 3. Practical Chemistry (For B.Sc. I, II and III Year Students). By Pandey O.P. & Bajpai D.N. & Giri S., S.Chand.	

	4. Ahluwalia, V. K., and Renu Aggarwal. Comprehensive practical organic chemistry: preparation and quantitative analysis. Universities Press, 2001. 5. Sethi, Arun. *Systematic lab experiments in organic chemistry*. New Age International, 2006 6. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press. 7. Advanced practical Organic Chemistry: O P Agrawal 8. Sharma, Y. R. (2013). Elementary Organic Spectroscopy: Principles and Chemical. 9. Organic Structure From Spectra by L D Field, S Sternhell 10. P S Kalsi,(2016). Spectroscopy of Organic Compounds, 7th edition. Delhi: New age international publisher. 11. Robert M. Silverstein, Francis X. Webster, (1996).Spectrometric Identification of Organic Compounds, 6th Edition. New York: John Wiley & Sons. **Web resources:** https://nanohub.org/modelsimulate https://sdbs.db.aist.go.jp/SearchInformation.aspx https://avogadro.cc/ https://molview.org/ Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry ChemCollective Virtual Labs: http://chemcollective.org PhET Interactive Simulations (University of Colorado Boulder): https://phet.colorado.edu
Model Questions:	**NA**

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Organic Estimation) 10 Marks
- Exercise 2 (Spectral analysis) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Cat Course Category: **Major- Elective (Theory)**

108238 Elective Chemistry-3 (Biomolecules)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108238**	**Elective Chemistry-3 (Biomolecules)**	2	30	2 Hrs	30+20=50

Course Objectives:	To provide a comprehensive understanding of the structure, properties, biological functions, and significance of carbohydrates, lipids, vitamins, and nucleic acids in living systems.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Classify carbohydrates and lipids and explain their occurrence, structure, and biological importance. 2. Describe the constitution, stereochemistry, cyclic structures, Haworth projections, and conformations of important monosaccharides such as glucose and fructose. 3. Explain the structures and properties of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose). 4. Discuss the classification, structure, properties, and biological functions of fatty acids, triacylglycerols, and other lipids. 5. Explain the concepts of saponification, rancidity, iodine number, acid number, and saponification number and their significance in the analysis of fats and oils. 6. Relate the physicochemical properties of carbohydrates and lipids to their nutritional and biological functions in living organisms.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Carbohyadrates:** Occurrence, classification and their biological importance. **Monosaccharides**: Constitution and absolute configuration of Glucose and Fructose, cyclic structure, Epimerization, conversion of glucose to fructose and vice-versa, Haworth projections and conformational structures. Structure of Ribose, 2- deoxyribose, Pyranose and Furanose, **Disaccharides –** Structure of Sucrose, maltose & Lactose. **Polysaccharides –** Structure and properties of starch & cellulose.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:**
Unit II	**Lipids:** Classification and biological significance of lipids. Fatty acids, Triacylglycerols, Properties of Triacylglycerols (Saponification, Rancidity), Tests to check purity of fats and oils (Iodine number, Saponification number, , Acid number), Lipoproteins, steroids (Cholesterol, Ergosterol).	7 Hrs	7 Marks	
Unit III	**Vitamins:** Definition, Classification of Vitamins-Fat-soluble and Water-soluble.Individual Vitamin: Vitamin A, D, E, K, C, B1, B2, B6, B12, Biotin, Niacin, Folic acid, Pantothenic acid, (Chemistry, Functions, Sources, Deficiency symptoms)	8 Hrs	8 Marks	

Unit IV	**Nucleotides and Nucleic Acids:** Introduction to Nucleic Acids, Functions of nucleic acids, Chemistry of Nitrogenous Bases: Purines and pyrimidines, General Composition of Nucleic Acids: Nucleosides and nucleotides, Structure of DNA: Watson–Crick model, Chargaff's rule of DNA composition, RNA: Structure and function of major RNA species.	7 Hrs	7 Marks	Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
References:	1. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox, Macmillan Publishers, 4th Edition, 2005 2. Biochemistry, U. Satyanarayana, U. Chakrapani, Books and Allied (P) Ltd., 5th Edition, 2020. 3. Principles of Biochemistry, Donald Voet, Judith G. Voet, Charlotte W. Pratt, John Wiley & Sons, 3rd Edition, 2008. 4. Harper's Illustrated Biochemistry, Robert K. Murray et al., McGraw-Hill, 27th Edition, 2006. 5. Biochemistry, Jeremy M. Berg, John L. Tymoczko, Lubert Stryer, W. H. Freeman & Company, 7th Edition, 2012. 6. Fundamentals of Biochemistry, J. L. Jain, S. Jain, Nitin Jain, S. Chand Publishing, 7th Edition, 2016. 7. Organic Chemistry, R. T. Morrison, R. N. Boyd, Pearson Education, 7th Edition, 2010 **Web resources:** https://bio.libretexts.org/Bookshelves/Biochemistry https://med.libretexts.org/Bookshelves/Nutrition https://www.nature.com/scitable https://ocw.mit.edu			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1. What is an epimer? 2. Name the sugar present in DNA. 3. Which polysaccharide is the main structural component of plant cell walls? 4. What is rancidity of fats and oils? 5. What does the iodine number of an oil indicate? 6. Deficiency of which vitamin causes scurvy? 7. What is a nucleotide? 8. State Chargaff's rule of DNA composition.			
	Answer in brief (At least 6) (3 Marks each) 1. Explain the classification of carbohydrates with suitable examples. 2. Describe the cyclic structure of glucose and its Haworth projection. 3. Differentiate between starch and cellulose. 4. Explain the process of saponification of fats and oils. 5. Discuss the biological functions of cholesterol. 6. Classify vitamins into fat-soluble and water-soluble vitamins with examples. 7. Describe the structure and biological functions of Vitamin C. 8. Explain the Watson–Crick model of DNA and discuss its salient features.			
	Answer in Detail (At least 4) (6 Marks each) 1. Explain the constitution, absolute configuration, cyclic structure, Haworth projection, and conformational structure of glucose. 2. Describe the structure, properties, and biological significance of the following polysaccharides: i) Starch ii) Cellulose 3. Classify lipids and discuss the structure, properties, and biological importance of triacylglycerols, lipoproteins, and steroids. 4. Explain the concepts of saponification, rancidity, iodine number, saponification number, and acid number of fats and oils. 5. Classify vitamins and discuss the chemistry, functions, sources, and deficiency symptoms of Vitamins A, D, E, K, and C. 6. Describe the chemistry, biological functions, dietary sources, and deficiency diseases of the B-complex vitamins (B_1, B_2, B_6, B_{12}, biotin, niacin, folic acid, and pantothenic acid). 7. Discuss the structure and functions of nucleic acids. Explain the Watson–Crick model of DNA, Chargaff's rules, and the structure and functions of the major types of RNA..			

	MCQs for Internal Assessment (At least 4) 1. **Which of the following is a ketose sugar?** A) Glucose B) Ribose C) Fructose D) Galactose 2. **Which sugar is present in DNA?** A) Ribose B) Fructose C) Glucose D) 2-Deoxyribose 3. **Deficiency of Vitamin C causes:** A) Rickets B) Beriberi C) Scurvy D) Night blindness 4. **According to Chargaff's rule in DNA:** A) A = G and T = C B) A = T and G = C C) A = C and G = T D) A + G = T 5. **Which of the following is a purine base?** A) Cytosine B) Thymine C) Uracil D) Adenine

Course Category: **Major Elective Lab**

108239 Chemistry Lab 16C (Elective Chemistry-3)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108239**	**Chemistry Lab 16C (Elective Chemistry-3)**	2	60	4 h	25+25= 50

Course Objectives:	1. To develop practical skills in the identification, estimation, and analysis of biologically important molecules such as carbohydrates, lipids, proteins, vitamins, and nucleic acids. 2. To familiarize students with basic biochemical techniques and analytical methods used in food, pharmaceutical, and biological laboratories	
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Perform qualitative and quantitative analysis of carbohydrates, lipids, vitamins, proteins, and nucleic acids. 2. Apply biochemical tests for identification and characterization of biomolecules. 3. Determine important physicochemical properties of oils and biologically relevant compounds. 4. Demonstrate laboratory skills relevant to food, pharmaceutical, clinical, and biochemical industries. 5. Interpret experimental observations and prepare scientific laboratory reports.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	• Classification of carbohydrates and lipids. • Haworth structures of glucose and fructose. • Starch, cellulose, and glycogen. • Iodine number, saponification number, and acid number. • Classification and functions of vitamins. • Structure of nucleosides and nucleotides. • Watson–Crick model of DNA. • Differences between DNA and RNA.	• Experiential and hands-on laboratory learning • ICT-enabled teaching using virtual labs, PhET, and NanoHUB simulations • Problem-based and inquiry-based learning through spectral interpretation • Collaborative learning through group activities and discussions • Project-based learning using case studies and spectral analysis • Demonstration and peer-learning methods for instrument handling and data analysis • Outcome-based continuous assessment through practical performance, assignments, and viva voce Any other innovative pedagogy as applicable.
Organic Estimations	**Organic Estimations (At least 4)** 1. Estimation of glucose by Fehling's method 2. Estimation of phenol by bromination method 3. Estimation of ester by hydrolysis method 4. Estimation of vitamin C in fruit juice/tablets 5. Estimation of aspirin/paracetamol in formulations 6. Estimation of acetamide. 7. Determination of equivalent weight of an organic acid 8. Estimation of Nitrogen by Kjeldahl's method	
Biomolecules	**. Qualitative Analysis of Carbohydrates** . Molisch test . Benedict's test . Fehling's test . Iodine test . Seliwanoff's test . Distinction between reducing/non-reducing sugars **. Detection of Rancidity and Adulteration in Oils** . Rancidity test	

	. Comparative study of commercial edible oils . **Qualitative Analysis of Proteins and Amino Acids** . Biuret test . Xanthoproteic test . Ninhydrin test . **Isolation of DNA from Plant Material** . DNA isolation from onion/banana . Observation of DNA precipitation . **Identification of Biomolecules in Unknown Samples** Systematic identification of carbohydrate, protein, lipid, or vitamin-containing samples	
Suggested Skill-Based Activities	1. Comparative analysis of Vitamin C in local fruits. 2. Nutritional analysis of edible oils. 3. DNA isolation competition/project. 4. Survey and testing of commercial food products. 5. Preparation of biomolecule identification flowcharts.	
References	1. Sattanathan, Dr G., S. S. Padmapriya, and Balasubramanian Balamuralikrishnan. *Practical Manual of Biochemistry*. Skyfox Publishing Group, 2020. 2. Hassall, H. An introduction to practical biochemistry: By David T. Plummer. McGraw-Hill. (1972): 14-15. 3. Shanmugam, S., T. Sathish Kumar, and K. Panneer Selvam. *Laboratory handbook on biochemistry*. PHI Learning Pvt. Ltd., 2019. 4. Sadasivam, S. *Biochemical methods*. New age international, 1996. **Web resources:** https://bio.libretexts.org Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry ChemCollective Virtual Labs: http://chemcollective.org PhET Interactive Simulations (University of Colorado Boulder): https://phet.colorado.edu	
Model Questions:	**NA**	

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Organic Estimation) 10 Marks
- Exercise 2 (Biomolecules) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Category: **Minor (Theory)**

108240 Minor Chemistry-3

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108240**	**Minor Chemistry-3**	2	30	2 Hrs	30+20=50

Course Objectives:	1. To develop a comprehensive understanding of transition elements and their characteristics and to develop fundamental understanding of formation of coordination compounds. 2. To develop understanding of crystal structure, symmetry, solid-state properties, X-ray diffraction, and phase equilibria of one-component and partially miscible liquid systems.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Write the general characteristics of transition elements 2. Classify double salt and coordination compounds 3. Name the coordination compounds according to IUPAC. 4. Calculate EAN and to predict the magnetic properties of complexes 5. Analyze chemical equilibrium using the law of mass action, equilibrium constants, thermodynamic relationships, and Le-Chatelier's principle. 6. Explain phase equilibria using Gibbs phase rule and interpret phase diagrams of one-component and partially miscible liquid systems. 7. Explain symmetry elements and laws of crystallography. 8. Calculate Miller indices and interplanar distances in cubic systems. 9. Differentiate between S.C.C., B.C.C., and F.C.C. crystal structures. 10. Derive and apply Bragg's equation for X-ray diffraction

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit-I	**Chemistry of Elements of Transition Series**: Definition and general characteristics of transition elements; Comparative study of first transition series elements (3d) with reference to following properties: (i) Electronic configuration (ii) Atomic and ionic size (iii) Ionization energy (iv) Metallic nature (v) Oxidation states (vi) Magnetic properties (vii) Color of salts (viii) Catalytic properties and (ix) Complex formation behavior; Electronic configuration of 4d and 5d series elements; Comparison of 3d series elements with 4d and 5d series elements with respect to atomic size and oxidation states.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through
Unit-II	**Coordination Chemistry-1** Addition compounds: double salts & complex salts; Important terms in coordination compounds: central metal ion, ligands, complex ion, coordination sphere, coordination number; Classification of ligands; Homoleptic and heteroleptic complexes; IUPAC nomenclature of coordination compounds; Werner's theory of coordination complexes with reference to cobaltammines and its experimental verification on the basis of molar conductance and precipitation; Sidgwick's electronic interpretation: EAN rule.	7 Hrs	7 Marks	
Unit-III	• , **Crystaline/Solid state** Introduction, Symmetry in crystal, plane of symmetry, axis of symmetry and point of symmetry. Law of constancy of interfacial angles. Elements of symmetry in cubic crystals. Laws of symmetry. Law of rational indices, Weiss and Miller indices of a lattice planes, calculation of interplanar distance d(h,k,l) from Miller indices in a cubic system. Seven crystal systems and fourteen Bravais lattices, Bravais lattices of cubic system. Simple cubic system	8 Hrs	8 Marks	

	(S.C.C.), body centered cubic system (B.C.C.) and face centered cubic system (F.C.C.). Calculation of number of constituent units in S.C.C., B.C.C. and F.C.C. Derivation of Bragg's equation for X-ray diffraction, Numericals.			questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit-IV	**Phase equilibria:** The Phase rule. Explanation of the terms: phase, component, degree of freedom. Calculation of number of components, phases and degrees of freedom in equilibrium systems. Phase diagram of one-component system- Water system and Sulphur system. Phase transition Partially miscible liquids - Phase diagram of phenol-water, triethyl amine - water and nicotine-water systems. Numericals.	7 Hrs	7 Marks	

References

1. Principles of Inorganic Chemistry by Puri, Sharma and Kalia- S. Naginchand& Co., Delhi.
2. Inorganic Chemistry by A.K. De, Wiley East Ltd.
3. Selected Topics in Inorganic Chemistry by Malik, Tuli and Madan, S. Chand & Co.
4. Concise Inorganic Chemistry by J.D. Lee, ELBS.
5. Physical Chemistry: Walter, J. Moore, 5th edn., New Delhi.
6. Physical Chemistry: G.M. Barrow, McGraw Hill, Indian Edn.
7. Principles of Physical Chemistry: Maron and Prutton.
8. Principles of Physical Chemistry: Puri, Sharma, and Pathania.
9. Physical Chemistry: P.W. Atkins, 6th Edn.
10. Physical Chemistry: Levine

Web resource:

1. https://nptel.ac.in/courses/104106094?utm_source
2. https://www.physchem.info/en/lecture-notes/?utm_source
3. https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Online_Dictionary_of_Crystallography_(IUCr_Commission)/01%3A_Fundamental
4. https://serc.carleton.edu/research_education/geochemsheets/BraggsLaw.html

Model Questions:

Short Type (At least 6) (1 Marks each)

1) What are transition elements?
2) Write the general electronic configuration of first transition series elements.
3) Define coordination compounds.
4) Write IUPAC name of $[Co(NH_3)_4Cl_2]Cl$
5) Define plane of symmetry in crystals.
6) State Bragg's equation for X-ray diffraction.
7) What is meant by degree of freedom in phase rule?
8) Define partially miscible liquids.

Answer in brief (At least 6) (3 Marks each)

1. Write the electronic configuration of first transition series elements
2. Discuss the variation of atomic radii in 3d elements.
3. What is EAN? Calculate the EAN of central metal ion in i) $[Cu(NH_3)_4]SO_4$ i) $K_4[Fe(CN)_6]$
4. Define i) Complex ion ii) Ligands iii) Homoleptic complexes
5. Distinguish between double salts and complex compounds.
6. Explain the law of rational indices with suitable examples.
7. Explain Gibbs phase rule and define phase, component, and degree of freedom.
8. Discuss the phase diagram of phenol–water system.

Answer in Detail (At least 4) (6 Marks each)

1. Discuss the following properties of first transition series elements i) Oxidationa states ii) catalytic properties
2. Write the postulates of Werner's theory of coordination complexes. Give the experimental verification on the basis of molar conductance and precipitation
3. Explain the symmetry elements in crystals and discuss the seven crystal systems and fourteen Bravais lattices.
4. Derive Bragg's equation for X-ray diffraction and discuss its applications in crystal structure determination.
5. Explain the phase diagram of water system and discuss its important features and phase transitions.
6. Discuss the phase diagrams of partially miscible liquid systems such as phenol–water, triethylamine–water, and nicotine–water systems.

	MCQs for Internal Assessment (At least 4) 1. The number of Bravais lattices is: A) 7 B) 14 C) 21 D) 32 2. In a face-centered cubic (FCC) lattice, the number of constituent particles per unit cell is: A) 1 B) 2 C) 4 D) 6 3. Bragg's equation is represented as: A) PV = nRT B) $n\lambda = 2d \sin\theta$ C) $E = h\nu$ D) $\lambda = h/mv$ 4. The degree of freedom at the triple point of water system is: A) 0 B) 1 C) 2 D) 3 5. Phenol–water system exhibits: A) Lower critical solution temperature only B) Upper critical solution temperature only C) Both UCST and LCST D) No critical solution temperature

Course Category: **Minor Lab**

108241 Minor Chemistry Lab 17

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108241**	**Minor Chemistry Lab 17**	2	60	4 h	25+25= 50

Course Objectives:	1. To develop practical skills in volumetric analysis, inorganic complex preparation, and physicochemical measurements using standard laboratory techniques. 2. To provide hands-on training in redox titrations, coordination compound synthesis, conductometric analysis, phase equilibria, and partition studies in Physical Chemistry and Inorganic Chemistry.	
Course Outcomes:	At the end of this course students will be able to: 1. Perform redox volumetric estimations using potassium permanganate and potassium dichromate with suitable indicators. 2. Prepare and characterize inorganic coordination compounds and interpret their valence bond structure, magnetic properties, and color. 3. Determine molecular weight, partition coefficient, solubility, heat of solution, and consolute temperature using physicochemical methods. 4. Apply conductometric techniques for acid-base titrations, determination of dissociation constants, and solubility product measurements. 5. Analyze experimental data, perform calculations accurately, and interpret physicochemical and analytical results scientifically. 6. Demonstrate laboratory skills, safe handling of chemicals and instruments, and proper scientific reporting practices.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	• Balancing redox equations using ion–electron method and Calculation of equivalent weight of $KMnO_4$ and $K_2Cr_2O_7$. • Principles and applications of internal and external indicators in redox titrations. • Determination of oxidation state, coordination number, and geometry of coordination compounds. • Prediction of magnetic properties and VB structures of inorganic complexes. • Construction and interpretation of phase diagrams of partially miscible liquids. • Calculation of partition coefficient using Nernst distribution law. • Graph plotting and interpretation in conductometric titrations.	1. Experiential and hands-on laboratory learning 2. Demonstration-based teaching for titrations, conductometry, and complex preparation 3. Problem-based learning through analytical calculations and data interpretation 4. Inquiry-based learning for experimental observations and result analysis 5. Collaborative learning through group experiments and discussions 6. ICT-enabled teaching using
Inorganic Chemistry practical	**Volumetric estimations: (At least 2)** 1. Estimation of oxalic acid using standardized KMnO4 as an intermediate solution. 2. Estimation of Fe(II) (FAS) using standardized KMnO4 as an intermediate solution. 3. Estimation of Fe(II) (FAS) with K2Cr2O7 using internal (diphenylamine, anthranilic acid) or external indicator potassium ferricyanide.	

	4. Determination of equivalent weight of oxidizing agent $KMnO_4$ or $K_2Cr_2O_7$ by titration with standard Fe(II) (FAS) solution **Inorganic Complex Preparations: (At least 4)** 1. Preparation of tetraamminecopper(II)sulphate. 2. Preparation of hexaamminenickel(II)chloride. 3. Preparation of Prussian blue 4. Preparation of potassiumtrioxalate aluminate(III). 5. Preparation of chrome alum. 6. Preparation of sodium thiosulphate and dithionite. 7. Preparation of cis and trnas-bisoxalato diaqua chromate (III) ion. • (Comment on VB structure, magnetic properties and color of 1, 2 and 3 complexes)	virtual labs and simulation tools 7. Project-based learning through mini-projects and case studies 8. Peer learning and seminar presentations on coordination chemistry and physicochemical analysis 9. Outcome-based continuous assessment through laboratory performance, assignments, viva voce, and reports
Physical Chemistry Practical	**(At least 6 experiments)** 1. To determine the molecular weight of nonvolatile solute by Rast's method 2. To construct phase diagram of phenol-water system and to determine consolute temperature for the system 3. To determine partition coefficient of benzoic acid between toluene and water 4. To determine partition coefficient of iodine between CCl4/Kerosene and water. 5. To determine solubility of benzoic acid at different temperature and heat of solution 6. To determine the cell constant of a conductivity cell. 7. To find out the strength of HCl solution by titrating against standard NaOH solution conductometrically. 8. To find out the strength of acetic acid solution by titrating against standard NaOH solution conductometrically. 9. To find out the strength of HCl and acetic acid in mixture of both by titrating against standard NaOH solution conductometrically. 10. To determine the dissociation constant of weak acid (acetic acid) conductometrically. 11. To determine the solubility and solubility product of a sparingly soluble salt conductometrically.	
Suggested Student Activities	• Coordination Compound Exhibition • Phase Diagram Plotting Activity • Conductometric Data Analysis • Mini Project on Coordination Chemistry • ICT-Based Simulation Activities	
References	Advanced Practical Inorganic Chemistry – Gurdeep Raj, Goel Publishing. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Inorganic Chemistry: Qualitative Analysis, University Press. Vogel's Textbook of Quantitative Chemical Analysis – J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, Pearson. Practical Chemistry (For B.Sc. I, II and III Year Students). By Pandey O.P. & Bajpai D.N. & Giri S., S.Chand. Vogel, Arthur Israel, and John Bassett. "Vogel's textbook of quantitative inorganic analysis: including elementary instrumental analysis." (1978). Advanced Physical Chemistry Experiments: J N Gurtu and Amit Gurtu (Pragati Prakashan) Experimental Physical Chemistry: V D Athawale and Parul Mathur (New Age Int. Publishers) Advanced Practical Physical Chemistry: J B Yadav Experiments in Chemistry: D V Jahagirdar). Advanced Physical Chemistry Experiments: J N Gurtu and Amit Gurtu (Pragati Prakashan) . **Web resources:** https://vlab.amrita.edu/?sub=2 https://chemcollective.org/vlabs https://chem.libretexts.org/ Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry	
Model Questions:	**NA**	

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Inorganic Chem Practical) 10 Marks
- Exercise 2 (Physical Chem Practical) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **Vocational Skill Course VSC**

108242 Chemistry Lab- 18 (Oil and Milk Analysis)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108242**	**Chemistry Lab- 18 (Oil and Milk Analysis)**	2	60	4 Hrs	50

Course Objectives:	To develop practical skills in estimation and quality analysis of edible oils, oil seeds, and milk using standard analytical techniques relevant to food, pharmaceutical, and chemical industries.	
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Perform physicochemical analysis of oil seeds and edible oils using standard analytical methods. 2. Determine important quality parameters of oils such as acid value, iodine value, peroxide value, saponification value, and ester value. 3. Analyze milk samples for physicochemical properties including pH, acidity, fat content, total solids, and SNF. 4. Detect adulteration and assess quality and purity of edible oils and milk samples. 5. Apply laboratory analytical and quality control techniques relevant to food, dairy, and edible oil industries.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	1. Calculations involved in volumetric and gravimetric estimations. 2. Interpretation of analytical data and report writing. 3. Calculation of acid value, iodine value, peroxide value, and saponification value of oils. 4. Error analysis and precautions in analytical experiments.	By combining hands-on experiments, discussions, and real-world applications, students will gain a comprehensive understanding of chemistry lab practices. A few suggested pedagogies are: • Students should be given suitable **pre- and post-lab** assignments and explanation revising the theoretical aspects of laboratory experiments prior to and after the conduct of each experiment. • **Hands-On Laboratory Sessions:** Provide regular hands-on laboratory sessions where students can directly apply theoretical knowledge to practical experiments. • **Demonstrations and Simulations:** Use virtual
Analysis of Oil and Milk	**Analysis of Oil Seeds and Oil** 1. Determination of moisture content in oil seed 2. Estimation of oil content from oil seed by solvent extraction 3. Determination of ash contents in oil seed 4. Determination of acid value of an oil sample 5. Determination of saponification value of an oil sample 6. Determination of iodine value of an oil sample 7. Determination of peroxide value of an oil sample 8. Determination of ester value of an oil sample 9. Determination of specific gravity and refractive index of an oil sample 10. Detection of rancidity of an oil sample **Analysis of milk:** 1. Determination of pH and acidity of milk 2. Determination of specific gravity using lactometer 3. Estimation of fat content in milk	

	4. Determination of total solids and solids-not-fat (SNF) Detection of adulterants in milk: Water, Starch, Urea, Detergent, Formalin	simulations for certain experiments to enhance accessibility and understanding
Suggested Group Activities	1. Comparative analysis of commercial oil and milk samples 2. Detection of food adulteration survey 3. Preparation of analytical reports and presentations 4. Industrial visit to dairy/oil processing laboratory	
Group Discussion or Seminar	• Career opportunities in food, dairy, and analytical laboratories. • Food adulteration and public health issues. • Nutritional importance of edible oils and milk products. • Detection and prevention of adulteration in commercial products. • Quality standards of edible oils and dairy products (FSSAI/BIS). • Consumer awareness regarding food quality and safety.	
References	1. Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3rdEd. ELBS (1964) 2. Vogel's textbook of quantitative chemical analysis, Sixth Ed. Mendham, Denny, Barnes 3. Nielsen, S. Suzanne, ed. "Food analysis." (2010). 4. Nielsen, S. Suzanne. "Introduction to food analysis." In *Nielsen's food analysis*, pp. 3-14. Cham: Springer International Publishing, 2024. **Web resources:** 1. http://elibrary.mukuba.edu.zm:8080/jspui/bitstream/123456789/144/1/Food%20Analysis%20Laboratory%20Manual.pdf 2. https://www.academia.edu/download/54933601/S._Suzanne_Nielsen_auth.__S._Suzanne_Nielsen_eds._Food_Analysis.pdf#page=15	
Model Questions:	**NA**	

Distribution of Marks and the scheme of (VSC) Practical Examination is as follows:

Section I: Continuous Internal Assessment

- Continuous Assessment Tests (CAT) (At least three tests) * 15 Marks
- Submission of duly certified practical record 10 Marks

Total 25 Marks

Section II: End Semester Examination (Internal only)

- Exercise 1 20 Marks
- Viva-Voce (internal) 05 Marks

Total 25 Marks

Total (Section I And II) 50 Marks

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Course Category: **Skill Enhancement Course SEC**

108243 Chemistry Lab- 19 (ICT Tools in Chemistry))

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108243**	**Chemistry Lab- 19 (ICT Tools in Chemistry)**	2	60	4 Hrs	50

Course Objectives:	1. To introduce Information and Communication Technology (ICT) tools used in teaching, learning, research, and data analysis in Chemistry. 2. To develop practical skills in chemical structure drawing, molecular visualization, spectral interpretation, data handling, and virtual laboratory applications. 3. To familiarize students with digital resources, simulation tools, and online databases used in modern chemical sciences.	
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Use ICT tools for chemical structure drawing, molecular visualization, and scientific communication. 2. Retrieve and interpret chemical and spectral data using online databases and software tools. 3. Apply virtual laboratory simulations and digital platforms for understanding chemical concepts and experiments. 4. Perform basic chemical data analysis, graph plotting, and preparation of scientific reports and presentations. 5. Utilize chemoinformatics resources and ICT-enabled platforms in chemistry learning and research.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	**A. Scientific Documentation** Introduction to scientific documentation, digital report preparation, spreadsheet applications, data handling, graph plotting, and scientific presentations using MS Office and Google Workspace tools. **B. Data Visualization and Reporting** Introduction to scientific data visualization, graph preparation, interpretation of experimental data, and preparation of reports on chemistry e-resources and digital platforms. **C. Chemical Databases and Scientific Literature** Introduction to chemical databases, scientific journals, publishers, online literature searching, research and review articles, citation methods, and scientific summarization techniques. **D. Academic and Professional Networking** Introduction to academic networking platforms such as Google Scholar, ResearchGate, and LinkedIn for literature searching, citation tracking, scientific communication, and professional development. **E. Basic Chemoinformatics and Molecular Visualization** Introduction to chemoinformatics, molecular representation, resonance effects, stereochemistry, molecular visualization, conformational analysis, geometry optimization, and physicochemical property analysis using computational chemistry tools and online databases.	To enhance conceptual understanding and digital competency in chemistry, the following pedagogical approaches will be incorporated: • **Experiential Learning:** Hands-on training in scientific documentation, molecular visualization, chemical structure drawing, and computational chemistry tools. • **Inquiry-Based Learning:** Activities involving interpretation of molecular structures, resonance effects, conformational analysis, and physicochemical properties. • **Collaborative Learning:** Group-based assignments, presentations, database searching, and scientific discussions to promote teamwork and communication skills. • **Technology-Enhanced Learning:** Use of
Exercise/ Experiments	**(At least 12) (Any suitable software other than the software mentioned can be used)** **A. Scientific Documentation** 1. Preparation of a scientific document (2–3 pages) containing: Text, Images, Hyperlinks using MS Word or Google Docs. 2. Preparation of a spreadsheet containing: Experimental data, Calculations, Tables, Graphs, Hyperlinks using MS Excel or Google Sheets. 3. Preparation of a scientific presentation (8–10 slides) containing: Text, Images, Graphs, Video embedding, Hyperlinks using MS PowerPoint or Google Slides. **B. Data Visualization and Reporting** 1. Preparation and interpretation of scientific graphs using software tools. a) Plot graphs using experimental data. b) Prepare a report containing: Graph title, Axis labels,	

	Captions, Interpretation 2. Preparation of a report on chemistry e-resources. The report should contain: Name of e-resource, Website link, Applications and uses **C. Chemical Databases and Scientific Literature** 1. Study of ChemSpider database for searching, retrieving, and downloading chemical structure and molecular information. 2. Study of chemistry journals and scientific publishers by preparing a document containing journal names, publishers, subject areas, and website links. 3. Study and analysis of research and review articles in chemistry through identification of article components (Title, Authors and affiliations, Abstract, Materials and Methods, Results and Discussion, Conclusion) and preparation of article summary. **D. Academic and Professional Networking (Activity based only)** 1. Study of Google Scholar for scientific literature searching, citation tracking, and academic profile management. 2. Study of ResearchGate as a platform for scientific networking, publication sharing, and academic collaboration. 3. Study of LinkedIn for academic communication, professional networking, and career development in chemistry. **E. Basic Chemoinformatics and Molecular Visualization** 1. Illustration of resonance structures showing the directive influence of activating and deactivating groups on aromatic rings using curly arrows and preparation of scientific documents using MS Word or MS PowerPoint. *(Examples: –OH, –CH_3, –Cl, –NO_2 groups)* 2. Visualization and comparison of structural, geometrical, and optical isomers using MolView or KingDraw. *(Examples: n-Butane & isobutane, cis/trans-2-butene, D- and L-lactic acid)* 3. Study of the three-dimensional structure and molecular properties of paracetamol using PubChem molecular visualization tools. 4. Study and analysis of molecular geometry, polarity, dipole moment, hydrogen bonding, and physicochemical properties of molecules using PubChem/ Discovery Studio Visualizer or related molecular visualization tools.	ICT tools, chemoinformatics software, online databases, molecular visualization platforms, and virtual chemistry resources. • **Project-Based Learning:** Preparation of scientific reports, presentations, article summaries, and chemistry-related digital content. • **Research-Oriented Learning:** Exposure to scientific literature, academic networking platforms, citation tracking, and modern computational chemistry techniques. • **Assessment through Reflective Learning:** Evaluation through practical performance, digital assignments, seminars, report writing, presentations, and viva voce.
Activities	Suggested list of activities (may be extended according to the wisdom of the instructor): 1. Preparation of a scientific PowerPoint presentation using molecular drawing and visualization software and submission of soft copy to the instructor. 2. Preparation of a report on chemistry e-resources, scientific databases, and academic networking platforms including their applications in chemical sciences. 3. Preparation and presentation of a seminar on chemoinformatics and molecular visualization topics using digital tools and scientific software. 4. Students shall prepare a short educational video on any chemistry-related topic using screen recording software such as OBS Studio or similar tools, upload the video to YouTube or another digital platform, and submit the video link to the instructor	
References	**References:** 1. Kalsi, P. S. Stereochemistry, Conformation and Mechanism (8th ed.). New Age International Publishers, 2015. 2. Clayden, J., Greeves, N., & Warren, S. Organic Chemistry (2nd ed.). Oxford University Press, 2012. 3. Vogel, A. I. Vogel's Textbook of Practical Organic Chemistry (5th ed.). Pearson Education, 1989. 4. Gasteiger, J., & Engel, T. *Chemoinformatics: A Textbook*. Wiley-VCH, 2003. **Web source:** 1. https://sourceforge.net/projects/openbabel 2. https://jmol.sourceforge.net/ 3. Jmol Application - 3D chemical structure viewer By Prof Kannan Moudgalya, https://onlinecourses.swayam2.ac.in/aic20_sp63/preview 4. https://discover.3ds.com/discovery-studio-visualizer 5. https://pubchem.ncbi.nlm.nih.gov.com	

	6. https://molview.org.com 7. https://www.chemspider.com 8. https://scholar.google.com 9. https://www.researchgate.net.com 10. https://www.linkedin.com 11. https://chemaxon.com/products/marvin?utm_source=chatgpt.com
Model questions	NA

Distribution of Marks and the scheme of (SEC) Practical Examination is as follows:

Section I: Continuous Internal Assessment

- Continuous Assessment Tests (CAT) (At least three tests) * 15 Marks
- Submission of duly certified practical record 10 Marks

Total 25 Marks

Section II: End Semester Examination (Internal only)

- Exercise 1 20 Marks
- Viva-Voce (internal) 05 Marks

Total 25 Marks

Total (Section I And II) 50 Marks

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Course Category: **FP/CES**

108244 Chemistry Lab- 20 (FP/ CES in Chemistry - III)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V	**108244**	**Chemistry Lab- 20 (FP/ CES in Chemistry - III)**	2	60	--	50

Course Objectives:	The intended objectives are: • To develop an appreciation of rural culture, lifestyle and wisdom amongst students. • To learn about the status of various agricultural and development programmes. • To understand the causes of distress and poverty faced by vulnerable households and explore solutions for the same. • To apply classroom knowledge of courses to field realities and thereby improve the quality of learning.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Gain an understanding of rural life, Indian culture and ethos and social realities 2. Develop a sense of empathy and bonds of mutuality with the local community 3. Appreciate significant contributions of local communities to Indian society and Economy 4. Learn to value the local knowledge and wisdom of the community 5. Identify opportunities for contributing to community's socio-economic improvements

Guidelines/ SoP for FP/CEP

For understanding key principles of CE, forms of CE, operational guidelines and implementation strategy please refer https://www.ugc.gov.in/pdfnews/4187860_Revised-Final-Guidelines.pdf

As per NEP 2020, students of B Sc. III of Semester V need to perform a Field Project (FP) for TWO (2) credits i.e. 50 Marks. The guidelines regarding the field project are as follows:

1) The total time allocation for the student to carry out field project is 60 hours.
2) Students should participate in field-based projects under the supervision of faculty.
3) Assignment of project topics to individual students or groups of students (max 4 students in one group) and one faculty member from the department will act as Guide for the student or group of students.
4) For a SURVEY based project related questionnaire (15 or more questions) should be prepared.
5) The departmental coordinator/guide should check the questions and finalize the questionnaire. The question that may create unnecessary complications should be avoided. The questions should be qualitative as well as quantitative.
6) If the project is related to work that does not involve survey work, then the questionnaire part can be replaced accordingly (e.g. Sample collection/Data collection/ Experimental base etc).
7) The student should compile all the relevant data and carry out its analysis.
8) A project report should be written individually in the standard format (2 Copies): Index, Introduction, Materials, Methods, Result, Conclusion/output, References (Numeric citation type) etc.
9) The project report should be of minimum 6 pages (excluding Title page, Certificate, Index, Acknowledgement etc.). Submit the project report with the Guide's signature to the department.
10) The oral /poster presentation for all the projects should be arranged in the department. To evaluate the project, examiner should be appointed by HoD.
11) The total project work including preparation of questionnaire to presentation should be evaluated for 2 credits (50 Marks).

Some suggested forms of FP/ CEP are:

1. **Linking learning with community service:** For example, students of chemistry can conduct water and soil testing in local areas and share the results with the local community.
2. **Linking research with community knowledge:** Community-based Participatory Research (CBPR) approaches are gaining recognition in this regard. For example, students of chemistry can undertake research in partnership with the community on solid and liquid waste disposal.
3. **Knowledge sharing and knowledge mobilization:** These can take the forms of enumerations, surveys, awareness camps and campaigns, training, learning manuals/films, maps, study reports, public hearings, policy briefs, cleanliness and hygiene teachings, legal aid clinics, etc. For example, students can undertake a 'swachhta survekshana' and/or nutrition survey for mothers and children, and educate them about hygiene and nutrition.
4. **Social innovations by students:** The students can be encouraged to initiate learning projects with a social impact and supported by HEIs. Incubation of such social innovation projects by students can also have meaningful links to existing curriculum and courses.

A few suggested (not exclusive) areas which not only provide practical applications of chemistry concepts but also foster collaboration, education, and sustainable practices within the community. are:

1. Understanding the chemical footprints of household products such as toothpaste, haircare, facecare food products etc
2. Enhance science literacy among school students through interactive chemistry demonstrations.
3. Managing organic waste to composting and improve soil health.
4. Explore the extraction and application of natural dyes as alternatives to synthetic dyes.
5. Identify and mitigate lead exposure risks in the community.
6. Implement a community-wide recycling initiative focusing on chemical waste and recyclable materials.
7. Introduce and demonstrate the principles of renewable energy sources, such as biofuels or solar energy.
8. Assess local air quality and raise awareness about pollution sources and mitigation strategies.
9. Educate community members on the safe use, storage, and disposal of household chemicals.
10. Assist local farmers in understanding soil nutrient content and composition to optimize crop production.
11. Evaluate local water sources for contaminants such as heavy metals, nitrates, and pH levels.

References	1. https://www.ugc.gov.in/pdfnews/4187860_Revised-Final-Guidelines.pdf 2. https://en.wikipedia.org/wiki/OU_Citizen_Science_Soil_Collection_Program 3. https://www.immerse.education/study-tips/100-ideas-for-research-projects-in-chemistry/ 4. https://pubs.rsc.org/en/content/articlelanding/2021/rp/d0rp00374c 5. https://www.acs.org/education/student-communities/activities.html 6. https://www.nettercenter.upenn.edu/academically-based-community-service-chemistry-outreach
Model Questions:	**NA**

Distribution of Marks and the scheme of FP/CEP Examination is as follows:

- Students' performance 20 Marks
- Submission of duly certified FP/CEP report 20 Marks
- Presentation (PPT or Poster) 10 Marks

Total **50 Marks**

Course Category: **Non-Credit**

Foundation of Artificial Intelligence

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	V		**Foundation of Artificial Intelligence**	Non credit	30	2 Hrs	30+20=50

Introduction :

The National Education Policy (NEP) 2020 emphasizes the integration of Artificial Intelligence (AI) across all undergraduate levels and disciplines to foster digital literacy and problem-solving skills. 'It can enhance the employability of the youth and prepare professionals in cutting-edge areas.'(pg. 46, R.D Kulkarni Report)

The Foundations of Artificial Intelligence course offers an overview of the key concepts, structures, applications, and ethical aspects of AI. It helps learners understand how intelligent systems work and shape modern life. The course covers AI's definition, evolution, types, and practical uses, along with its basic architectures like rule-based systems, machine learning, and neural networks. Learners will explore AI's role in education, healthcare, and commerce while reflecting on ethical and social concerns such as privacy, bias, and automation. In line with NEP 2020, it fosters digital literacy and responsible AI awareness for all disciplines.

A) Objective

i) Introduce all undergraduate students of all the faculties to the basic concepts, uses, and importance of AI.

ii) Enable learners to understand AI's principles, applications, limitations, and effectively use AI tools.

iii) Encourage students to recognize AI's role in enhancing life and engage with its social and ethical implications.

B) Outcomes

i) Understand the fundamental concepts, types, and evolution of Artificial Intelligence.

ii) Apply basic AI techniques and tools to real-world problems across different domains.

iv) Evaluate the social, ethical, and professional implications of AI in everyday life.

C) Implementation of Syllabus, Scheme of Examination and Teaching.

1) Curriculum, Teaching and Examination Scheme Given in Appendix A

2) This course given in Appendix A shall be compulsory course in **fifth semester** of all undergraduate programs of all faculties in Sant Gadge Baba Amravati University, Amravati.

2) Medium of instruction, paper setting and writing of Answer paper shall be in English, Marathi and Hindi.

3) Question paper shall be set and valuated by the College/ Department.

4) Duration of external examination shall be of 2 hours and paper shall be of 30 marks.

5) Internal 20 marks shall be distributed, 5 to attendance, 15 marks to assignment/class test/viva voce/presentation.

6) Distribution of 30 external marks shall be based on 4 units, 15 marks to short and 15 marks to long answer type questions.

7) It shall be obligatory on part of the college/department to conduct examination on prescribed date by the university and submit the candidate wise information as follows on university portal on due date after valuation answer books.

Grade A -- mark secured 30 to 50,

Grade B -- 25 to 29,

Grade C -- 20 to 24,

FAIL 19 and below

8) The final Grade shall be determined by the combined performance in internal and external assessments. A student must secure a minimum of 30% in the internal assessment, 30% in the external assessment, and at least 40% overall to pass. Failure to meet any of these criteria will result in a grade of "Fail."

9) In case of failure, student need to appeared in backlog examination by paying prescribed fees.

10) Valuated answer book shall be kept in college custody for one academic year and random verification may be done by the University if required.

11) Result of final year of respective degree shall not be declared of an examination unless secured any of the grades out of A to C in Foundation of Artificial intelligence.
12) Grade secured by an examinee in examination of said course shall be shown on fifth and last semester marksheet.
13) The candidates shall have to pay Rs 150 /- in 5th semester to the college to meet out the expenses by the college on teaching of course, question paper setting and printing, paper valuation, providing answer sheet, and filling grade on University portal. In case of failure student need to pay Rs 20 /- for conduction of examination. There shall not have any facility of revaluation of answer book.
14) For teaching of the subject person having PG degree in any faculty with second class shall be considered eligible, provided priority shall be given to Ph.D., NET, SET, regular teacher.

15) **Format of question paper**
Distribution of 30 external marks shall be based on 4 units, 15 marks to short and 15 marks to long answer type questions with internal choice.
1a) Long or short answer questions based on unit number 1 having 8 marks

Or
1b) Long or short answer questions based on unit number 1 having 8 marks
2a) Long or short answer questions based on unit number 2 having 7 marks

Or
2b) Long or short answer questions based on unit number 2 having 7 marks
3a) Long or short answer questions based on unit number 3 having 8 marks

Or
3b) Long or short answer questions based on unit number 3 having 7 marks
4a) Long or short answer questions based on unit number 4 having 8 marks

Or
4b) Long or short answer questions based on unit number 4 having 8 marks

Program:				**Semester:**	**V**	
Course:	**Foundation of Artificial Intelligence**			**Code:**		
Teaching Scheme				**Evaluation Scheme**		
Level	**Lecture**	**Hours**	**Credit**	**Internal**	**External**	**Total**
5.5	2	2	2	20	30	50
Methods of Internal Assessment: 15 Marks to Class Tests, /Assignments/ Viva voce/ Presentation & 5 Marks to Attendance						
Course Objectives: To introduce AI concepts in a simple, real-life way with focus on understanding applications, ethics, and future opportunities.						
Course Outcomes: After completion of the course, the students will be able to:						

CO	**Course Outcomes**	**BT Level**
CO-1	Explain the basic concepts, history, and types of AI with real-life examples.	L1 – Knowledge, L2 – Understanding
CO-2	Describe AI structures and architectures using simple real-world analogies.	L2 – Understanding, L3 – Application
CO-3	Identify and analyze applications of AI in the area of arts, commerce, humanities, and daily life.	L3 – Application, L4 – Analysis
CO-4	Evaluate ethical, social issues and predict future opportunities of AI in their own fields.	L4 – Analysis, L5 – Evaluation

Unit 1: Introduction to Artificial Intelligence (8 Hours)

Definition of AI: What is Intelligence? Natural vs. Artificial, Simple definition of AI; History & Evolution of AI: From early computers to modern AI; Types of AI: Narrow AI vs. General AI vs. Super AI; AI in Everyday Life: Google Maps, E-commerce suggestions, Chatbots, Social Media feeds; Key Components: Data, Algorithms, Computing Power

Unit 2: AI Structures, Architectures & Techniques (7 Hours)

Basic Structure of an AI System; AI Architectures (Simplified): Rule Based System, Machine Learning, Neural Networks; Key Concepts: Knowledge Representation (using symbols, facts), Search & Problem Solving (maze example, finding shortest route), Natural Language Understanding (Google Translate, chatbots)

Unit 3: Applications of AI in Society (7 Hours)

AI in Different Fields: Education (Personalized learning apps, plagiarism checkers), Healthcare (Disease prediction, medical chatbots), Commerce (Fraud detection in banking, stock market predictions, customer support), Daily Life (Smart home devices, language translation, travel assistants); AI & Decision Making: Hiring, Loan Approval, Court Decisions; Advantages of AI, Limitations of AI

Unit 4: Ethical, Social & Future Aspects of AI (8 Hours)

Ethical Concerns in AI: Privacy issues (CCTV, online data), Bias & Fairness (AI preferring certain groups), Job Displacement (automation replacing humans); Responsible AI: Transparency, Accountability, Human oversight; Future Trends in AI: Self-driving cars, AI in governance, creative industries; AI and You (Career Perspective): Opportunities in Digital Marketing, Content Creation, Business Analytics, HR Tech, Creative Industries (non-programming roles)

Textbook:

Melanie Mitchell – *Artificial Intelligence: A Guide for Thinking Humans*

Reference Books:

1. Boden, Margaret A., *Artificial Intelligence*: A Very Short Introduction
2. Elaine Rich – *Artificial Intelligence* (3rd Edition)
3. Godbole, Achyut, *Artificial Intelligence* (आर्टिफिशियल इंटेलजन्स), Bookganga Publication.
4. Kulkarni, Dr Anand, आर्टिफिशियल इंटेलजन्सच्या वाटेवर, Sakal Media Pvt. Ltd.
5. Stuart Russell – *Human Compatible* (2019)
6. Thorpe, Josh, *AI for Students: Creative Hacks for Academic Success*, Promplty Books

Course Category: **Major (Theory)**

108245 Inorganic Chemistry 3

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108245**	**Inorganic Chemistry 3**	2	30	2 Hrs	30+20=50

Course Objectives:	1. To develop a fundamental understanding of inner transition elements and their characteristics properties. 2. To develop comprehensive understanding of formation of coordination compounds on the basis of CFT and electronic spectra. 3. To know the organo-metallic compounds and the role of metal ions in biological processes.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Describe the general properties of f-block elements 2. Compare lanthanoids and actinoids with respect to electronic configuration, oxidation state and chemical behaviour. 3. Explain the nature of metal-ligand bonding in coordination compound by CFT 4. Calculate CFSE of complexes. 5. Describe various factors affecting CFSE 6. Explain the electronic transitions occurs in coordination compounds 7. Distinguish between complex and chelate. 8. Explain the organometallic compounds and the nature of metal carbon bonds in them. 10. Identify the essential and trace elements in biological processes. 11. Realize the role of haemoglobin and myoglobin in human body.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Inner Transition(f-block) Elements:** Definition and properties of f-block elements (Lanthanoids and Actinoids); Lanthanoids: comparative study w.r.t (i) electronic configuration (ii) variation in atomic and ionic radii, lanthanoids contraction-definition and cause, effect of lanthanoids contraction on basicity of their oxides and hydroxides (iii) oxidation states (iv) magnetic properties (v) color of salts (vi) complex formation behavior; Occurrence of lanthanoids; Actinides-Electronic configuration and oxidation states. Comparison of lanthanides and actinides.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply
Unit II	**Coordination Chemistry-3 (CFT)** Postulates of CFT; Crystal field splitting in octahedral, distorted octahedral, square planar and tetrahedral complexes; concept of CFSE, high spin and low spin octahedral complexes on the basis of Δ_o and pairing energy, distribution of electrons in t_{2g} and e_g orbitals in high spin and low spin octahedral complexes; Factor affecting magnitude of crystal field splitting in octahedral complexes. Spectrochemical series.	7 Hrs	7 Marks	
Unit III	**A) Electronic Spectra of Transition Metal Complexes: [5]** Introduction to electronic spectra, selection rules for d-d transitions, spectroscopic terms: determination of ground term symbols for d^1 to d^{10}, Orgel diagram for d^1 and d^9 states, electronic spectrum of $[Ti(H_2O)_6]^{3+}$ complex ion. **B) Chelates: [3]** Definition, classification and applications of chelates in analytical chemistry. Stability of chelate with special reference to chelate effect.	8 Hrs	8 Marks	

Unit IV	**A) Organometallic Chemistry : [4]** Definition and classification of organometallic compounds; Metal carbonyls: definition and classification, Structure and bonding in $Ni(CO)_4$, $Fe(CO)_5$, $Cr(CO)_6$; Nature and evidences of metal-carbon bond in metal carbonyls. **b) Bio-inorganic Chemistry: [3]** Essential and trace elements in biological processes. Biological role of Na^+, K^+, Ca^{2+} and Mg^{2+} ions. Metalloporphyrins-Haemoglobin and Myoglobin and their role in oxygen transport.	7 Hrs	7 Marks	theoretical knowledge. **Any other innovative pedagogy as applicable.**
References:	1. Principles of Inorganic Chemistry by Puri, Sharma and Kalia- S. Naginchand& Co., Delhi. 2. Inorganic Chemistry by A.K. De, Wiley East Ltd. 3. Selected Topics in Inorganic Chemistry by Malik, Tuli and Madan, S. Chand & Co. 4. Concise Inorganic Chemistry by J.D. Lee, ELBS. 5. Inorganic Chemistry by J.E. Huheey- and Kettle, Harper & Row. 6. Advanced Inorganic Chemistry, Vol-I, Satya Prakash, Madan, Tuli, Basu. 7. Advanced Practical Inorganic Chemistry by Gurdeep Raj, GoelPulishing House, Meerut. **Web resources:** 1. MIT OpenCourseWare: https://ocw.mit.edu 2. Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) Define Lanthanoid contraction. 2) What is the position of 4d series elements in the periodic table? 3) Write general electronic configuration of f-block elements. 4) What is spectro-chemical series? 5) Give the relationship between Δ_o and Δ_t. 6) Define chelate. 7) What are organometallic compounds? 8) Calculate the EAN of Ni in $[Ni(CO)_4]$			
	Answer in brief (At least 6) (3 Marks each) 1) Explain the basicity of oxides and hydroxides of lanthanoids. 2) Write any three postulates of CFT. 3) Draw crystal field splitting diagram for octahedral geometry and tetrahedral geometry 4) Explain the selection rules of electronic transitions in complexes 5) Discuss the electronic spectrum of $[Ti(H_2O)_6]^{3+}$ ion. 6) Explain the role of hemoglobin and myoglobin in oxygen transport. 7) Discuss structure and bonding in $[Cr(CO)_6]$ on the basis of VBT. 8) What is chelate effect? Explain the stability of chelate with respect to chelate effect.			
	Answer in Detail (At least 4) (6 Marks each) 1) Write the similarities and difference between lanthanoids and actinoids. 2) Discuss the factors affecting crystal field stabilization energy. 3) Explain the crystal field splitting in square planar geometry. 4) Draw an explain Orgel diagram for d^1 and d^9 octahedral as well as tetrahedral geometry. 5) Give the classification of chelates of bidentate and tridentate ligands. 6) Explain the role of sodium and magnesium ions in biological processes along with their deficiency and toxic effect. 7) What are metal carbonyls? Explain the nature of metal carbon bond in metal carbonyls with at least two evidences.			
	MCQs for Internal Assessment (At least 4) 1) Lanthanide contraction can be observed in a) At b) Gd c) Ac d) Lw 2) Which of the following is most basic oxide? a) Ce_2O_3 b) Pr_2O_3 c) La_2O_3 d) Er_2O_3 3) Among the lanthanoids, the radioactive element is/are… a) all lanthanoids b) only Pr c) only Pr and Pm d) only Pm 4) In which of the following series all the elements are radioactive. a) s-block elements b) p-block elements c) Lanthanoids d) Actinoids 5) According to CFT, the electronic configuration of $[Co(CN)_6]^{3-}$ ion is a) $(t_{2g})^3 (e_g)^2$ b) $(t_{2g})^4 (e_g)^2$ c) $(t_{2g})^6 (e_g)^1$ d) $(t_{2g})^6 (e_g)^0$ 6) On the basis of CFT predict the number of electrons in c) $[Cr(NH_3)_6]^{3+}$ a) 1 b) 2 c) 3 d) 0			

	7) Which of the following is low spin complex? a) $[Fe(H_2O)_6]^{2+}$ b) $[Co(NH_3)_6]^{3+}$ c) $[Cr(NH_3)_6]^{3+}$ d) $[V(NH_3)_6]^{3+}$ 8) The term letter used for the resultant azimuthal quantum numbers, L=2 is a) S b) P c) D d) F 9) The ground term symbol for Fe^{2+} ion is. a) ^2D b) ^2F c) ^5D d) ^5F 10) The chelates are stable complexes due to a) formation of heterocyclic ring between metal and ligand b) ligands stabilize the oxidation state of central metal ion c) monodentate ligands are present in coordination sphere d) highest solubility in solvent. 11) Which of the followings is not an organometallic compound? a) Nickel tetracarboyl b) Methyl magnesium bromide c) Ethyl lithium d) sodium acetate 12) The metal ion present in heamoglobin is a) Mg^{2+} b) Fe^{2+} c) Fe^{3+} d) Co^{2+}

Course Category: **Major (Theory)**

108246 Organic Chemistry-3

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108246**	**Organic Chemistry-3**	2	30	2 Hrs	30+20=50

Course Objectives:	To provide fundamental understanding of organometallic compounds, heterocyclic compounds, drugs, dyes, and polymers with emphasis on their synthesis, properties, and applications
Course Outcomes:	After successful completion of the course, a student will be able to- 1) Explain the synthesis, properties, and synthetic applications of organometallic compounds such as Grignard reagents and organolithium compounds. 2) Describe the structure, basicity, and electrophilic/nucleophilic substitution reactions of important heterocyclic compounds such as pyrrole and pyridine. 3) Discuss the synthesis, classification, and applications of important drugs and dyes used in pharmaceutical and industrial chemistry. 4) Explain the classification, polymerization mechanisms, structure, properties, and applications of important synthetic polymers. 5) Apply mechanistic and structural concepts to predict the reactivity and practical applications of organic, heterocyclic, and polymeric compounds

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Organometallic Chemistry:** **Grignard reagent**: Methyl magnesium bromide- Synthesis from methyl bromide, Synthetic applications: Electrophilic substitution reactions, formation of alkanes, alkenes, higher alkynes and other organometallic compounds, Nucleophilic substitution reactions- Reaction with aldehydes and ketones, ethylene oxide, acetyl chloride, methyl cyanide and CO_2. **Methyl lithium**- Synthesis and reaction with water, formaldehyde, acetaldehyde, acetone, ethylene oxide and CO_2.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between
Unit II	**Heterocyclic Chemistry** Nomenclature, Pyrrole: Synthesis from acetylene, succinimide and furan, Basicity, Electrophilic substitution reactions (orientation) – nitration, sulphonation, acetylation and halogenation, Molecular orbital structure. Pyridine: Synthesis from acetylene and pentamethylene diamine hydrochloride, Basicity, Electrophilic substitution reactions (orientation) – nitration, sulphonation,	7 Hrs	7 Marks	

	nucleophilic substitution reactions (orientation)- with $NaNH_2$, C_6H_5Li and KOH.			different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit III	**Drugs and Dyes** **A) Drugs:** Analgesic and antipyretics: Synthesis and uses of phenylbutazone. Sulpha drugs: Synthesis and uses of sulphanilamide and sulphadiazine. Antimalarials: Synthesis of chloroquine from 4,7 dichloroquinoline and its uses. **B) Dyes :** Classification on the basis of structure and mode of application, Preparation and uses of Methyl orange, Crystal violet, Phenolphthalein , Alizarin and Indigo.	8 Hrs	8 Marks	
Unit IV	**Polymers:** Introduction and history of polymeric materials: Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers. Polymerization reactions – addition and condensation, mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Preparation, structure, properties and applications of the following polymers: polyolefins (polyethylene, polypropylene), polystyrene, polyvinyl chloride, polyvinyl acetate, polyacrylamide, fluoro polymers (Teflon).	7 Hrs	7 Marks	
References:	1. Organic Chemistry Vol. I, II and III by Mukharjee, Singh and Kapoor- Wiley Eastern. 2. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 3. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007) 4. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008). 5. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford Universitiy Press. 6. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher, (2000). 7. Synthetic Organic Chemistry, by: G. R. Chatwal. 8. Modern Organic Chemistry by M. K. Jain and S. C. Sharma. 9. Organic Chemistry, Reactions, Rearrangements and Reagents, by: O. P. Agarwal. 10. Organic Chemistry by L.G. Wade. Prentice Hall. 11. A Text book of organic chemistry by Bahl and Bahl. 12. A Text book of organic chemistry by P. L. Soni. 13. Heterocyclic Chemistry by Raj K. Bansal, New Age International 14. Heterocyclic Chemistry by J. A. Joule and K. Mills, Blackwell Science **Web resources:** 1. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Organic_Chemistry_(OpenStax)/24%3A_Amines_and_Heterocycles 2. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Polymers 3. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Map%3A_Organic_Chemistry_(Bruice)/11%3A_Organometallic_Compounds 4. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Map%3A_Organic_Chemistry_(Bruice)/31%3A_The_Organic_Chemistry_of_Drugs-_Discovery_and_Design 5. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Map%3A_Organic_Chemistry_(Bruice)/21%3A_More_About_Amines_(Heterocylic_Compounds)			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) Write the chemical equation for the synthesis of Methyl magnesium bromide from methyl bromide. 2) Name the gas evolved when Methyl lithium reacts with water. 3) Identify the product of the reaction between Methyl lithium and ethylene oxide after hydrolysis.			

	4) Draw the structure & name the product formed when Pyridine reacts with $NaNH_2$. 5) Draw the structure of Pyrrole and number the ring positions according to IUPAC nomenclature. 6) Which is the reagent used to convert Furan into Pyrrole. 7) Define the term 'Antipyretic' and give one example. 8) Write the structure of Crystal Violet dyes. 9) Name and draw the structure of heterocyclic ring present in Sulphadiazine 10) Define the term 'Degree of Polymerization. 11) Give the IUPAC name for the polymer commonly known as PVC. 12) Define a 'Copolymer'.
	Answer in brief (At least 6) (3 Marks each) 1) Explain the reaction of methyl magnesium bromide with aldehyde and ketone. 2) How will you prepare alkane and alkene from Grignard reagent? 3) Describe the reaction of CH_3Li with CO_2. Compare this with the reaction of CH_3MgBr with CO_2. 4) Describe the synthesis of Pyrrole from Succinimide. 5) Explain the synthesis of Pyridine from Acetylene and Hydrogen Cyanide. 6) Explain Molecular orbital structure of Pyrolle. 7) Explain the synthesis of Sulphanilamide starting from Acetanilide. 8) Write the preparation of Methyl Orange. 9) Explain the synthesis of Phenylbutazone. 10) Explain the difference between 'Natural', 'Synthetic', and 'Semi-synthetic' polymers with one example each. 11) Describe the preparation and two major industrial applications of Polystyrene. 12) Describe the synthesis of polyvinyl acetate (PVAc) and its common use in adhesives and emulsions
	Answer in Detail (At least 4) (6 Marks each) 1) Discuss the reaction of Methyl lithium with water, formaldehyde, and ethylene oxide. 2) Discuss the reaction of Methyl magnesium bromide with acetaldehyde, acetone and acetyl chloride. 3) Explain the synthesis of pyridine from acetylene and pentamethylene diamine hydrochloride. 4) Explain the synthesis of pyrrole from acetylene and furan. 5) Explain the synthesis and uses of phenylbutazone and chloroquine. 6) Describe the synthesis, properties, and uses of Alizarin and Indigo. 7) Explain the synthesis of Teflon (PTFE) and its applications 8) Explain the synthesis, chemical properties, and applications of Polyvinyl Chloride (PVC) and Polyacrylamide.
	MCQs for Internal Assessment (At least 4) 1) Methyl magnesium bromide reacts with ethyl alcohol to give: A) Ethane B) Methane C) Propane D) Ethyl methyl ethe 2) Organolithium reagents are typically prepared in: A) Water B) Ethanol C) Non-polar solvents like Hexane or Ether D) Concentrated H_2SO_4 3) Methyl lithium reacts with formaldehyde to give: A) Methanol B) Ethanol C) Propanol D) Ethanoic acid 4) Pyrrole is a _____ base than Pyridine. A) Stronger B) Weaker C) Equal D) None of the above 5) In the MO structure of Pyrrole, the number of \pi electrons contributed by Nitrogen is: A) 0 B) 1 C) 2 D) 6 6) Reaction of Pyridine with KOH at 300^0 C produces**:** A) 2-Hydroxypyridine B) 3-Hydroxypyridine C) Pyridine N-oxide D) Benzene 7) Sulphanilamide is synthesized starting from: A) Benzene B) Aniline C) Acetanilide D) Phenol 8) Phenylbutazone is primarily used to treat: A) Malaria B) Bacterial infections C) Rheumatoid arthritis and inflammation D) Tuberculosis 9) Alizarin is an example of an: A) Azo dye B) Anthraquinone dye C) Nitro dye D) Phthalein dye 10) Which of the following is a step-growth polymer? A) Polyethylene B) Polyvinyl Chloride

	C) Nylon-6,6 D) Polypropylene 11) Bakelite is an example of a: A) Thermoplastic polymer B) Thermosetting polymer C) Elastomer D) Fiber 12) Which of the following is a natural polymer? A) Buna-S B) Starch C) PVC D) Terylene

Course Category: **Major (Theory)**

108247 Physical Chemistry-3

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108247**	**Physical Chemistry-3**	2	30	2 Hrs	30+20=50

Course Objectives:	1. To understand crystal structure, symmetry elements, and X-ray diffraction methods in solid-state chemistry. 2. To study electrode systems, EMF, potentiometric and pH metric methods, 3. To understand principles and applications of nuclear chemistry and nuclear reactions.			
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Explain crystal systems, Bravais lattices, and Miller indices. 2. Apply Bragg's equation for crystal structure determination. 3. Understand different electrodes and potentiometric titrations. 4. Determine pH using various electrochemical methods. 5. Explain principles and applications of electroanalytical techniques. 6. Differentiate between nuclear and chemical reactions. 7. Explain nuclear fission, fusion, and nuclear models. 8. Apply numerical methods in solid-state chemistry, electrochemistry, and nuclear chemistry.			
Unit System	**Contents**	**Workload Allotted**	**Weightage of Marks Allotted**	**Incorporation of Pedagogies**
Unit I	• **Crystalline/Solid state:** Introduction, Symmetry in crystal, plane of symmetry, axis of symmetry and point of symmetry. Law of constancy of interfacial angles. Elements of symmetry in cubic crystals. Laws of symmetry. Law of rational indices, Weiss and Miller indices of a lattice planes, calculation of interplanar distance d(h,k,l) from Miller indices in a cubic system. Seven crystal systems and fourteen Bravais lattices, Bravais lattices of cubic system. Simple cubic system (S.C.C.), body centered cubic system (B.C.C.) and face centered cubic system (F.C.C.). Calculation of number of constituent units in S.C.C., B.C.C. and F.C.C. Ratio of interplanar distances for 100, 110 and 111 lattice plane in S.C.C., B.C.C. and F.C.C. (No geometrical derivation). Derivation of Bragg's equation for X-ray diffraction, Bragg's X-ray spectrometer method for the determination of crystal structure of NaCl and KCl. Anomalous behaviour of KCl towards X-ray. Numericals	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:**
Unit II	• **Electrochemistry II** **Introduction**: Electrochemical cells and electrolytic cells and their differences. **Electrode Reactions and Electrode Potentials**: Oxidation and reduction reactions at electrodes Electrode potential, representation and sign convention. **Types of electrodes**: Gas-metal ion. Metal-metal ion, metal-insoluble salt-anion electrode and redox electrodes **Representation and Working of Electrochemical Cells:** Cell notation, Construction and working of electrochemical cells, EMF of a cell **Nernst Equation:** Derivation of EMF of electrochemical cell electrode potential, Applications of Nernst equation. Numericals	7 Hrs	7 Marks	

	Reference electrode: Construction and working of Standard Hydrogen Electrode and Calomel electrode **Electrochemical Series:** Electrochemical series and its significance (Prediction of spontaneity using EMF data). **Concentration cells –** Introduction and types of concentration cells. Determination of emf concentration cell without transfer. Numericals			Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit III	**Potentiometry and pH-Metry** A) Principle of Potentiometric titration. Study of acid-base, redox and precipitation titration (Interpretation of potentiometric titration curve). Advantages of potentiometric titrations. B) Definition of pH and pKa. Determination of pH of a solution using hydrogen, quinhydrone and glass electrodes. Advantage and disadvantage of these electrodes. pH-metric titrations. Determination of pka of a weak acid by pH-metric measurement. C) Buffer solution- Types of Buffer solution and mechanism of buffer action. Henderson-Hasselbalch equation for pH of a buffer solution.	8 Hrs	8 Marks	
Unit IV	• **Nuclear Chemistry** A) Introduction, Shell model of a nucleus - Assumptions, evidences for existence of magic numbers, advantages and limitations. Liquid drop model of a nucleus - Assumptions, similarities between nucleus and liquid drop, advantages and limitations, explanation of nuclear fission reaction on the basis of liquid drop model. Nuclear force and its explanation on the basis of Meson theory. B) Characteristics of nuclear reaction, difference between nuclear and chemical reactions. Calculation of Q value of a nuclear reaction. Characteristics of nuclear fission reaction, fission yield. Fission reaction as an alternative source of energy. Nuclear fusion reaction - Characteristic of a nuclear fusion reaction. Thermonuclear reactions as a source of energy of sun and other stars. Fusion reactions as a potential future source of energy. C) Applications of radio isotopes in industry, agriculture, medicines and bio-sciences with two examples each. Numericals.	7 Hrs	7 Marks	
References:	1. Physical Chemistry: Walter, J. Moore, 5th edn., New Delhi. 2. Physical Chemistry: G.M. Barrow, McGraw Hill, Indian Edn. 3. Principles of Physical Chemistry: Maron and Prutton. 4. Principles of Physical Chemistry: Puri, Sharma, and Pathania. 5. Physical Chemistry: P.W. Atkins, 6th Edn. 6. Physical Chemistry: Levine 7. Essential of Physical Chemistry: Bahl and Tuli 8. A Textbook of Physical Chemistry: K.L. Kapoor 9. Solid State Chemistry and its Applications by Anthony R. West 10. Elements of X-ray Diffraction by B. D. Cullity 11. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma & M. S. Pathania 12. Advanced Physical Chemistry by Gurdeep Raj 13. Nuclear Chemistry by Satya Prakash 14. Essentials of Nuclear Chemistry by H. J. Arnikar **Web resources:** 1. https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Chemistry_-_The_Central_Science_(Brown_et_al.) 2. https://ocw.mit.edu/courses/3-091sc-introduction-to-solid-state-chemistry-fall-			

	2010/?utm_source 3. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry?utm_source
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1. Define Miller indices. 2. State Bragg's equation. 3. Define pH. 4. What is a glass electrode? 5. Define potentiometry. 6. Define nuclear fission. 7. What is meant by magic numbers?
	Answer in brief (At least 6) (3 Marks each) 1. Explain the law of rational indices. 2. Differentiate between S.C.C., B.C.C., and F.C.C. structures. 3. Explain the principle of potentiometric titration. 4. Describe the construction of calomel electrode. 5. Discuss the applications of potentiometry. 6. Explain the liquid drop model of nucleus. 7. Differentiate between nuclear and chemical reactions.
	Answer in Detail (At least 4) (6 Marks each) 1. Explain seven crystal systems and fourteen Bravais lattices. 2. Derive Bragg's equation and discuss determination of crystal structure of NaCl and KCl. 3. Discuss pH-metric titrations and determination of pKa of weak acid. 4. Explain concentration cells and determination of EMF of concentration cell without transference. 5. What is buffer solution? Explain the mechanism of buffer action.. Derive Henderson equation. 6. Explain shell model and liquid drop model of nucleus with advantages and limitations.
	MCQs for Internal Assessment (At least 4) 1) Miller indices are used to represent: a) Crystal defects b) Lattice planes c) Atomic masses d) Symmetry elements 2. Bragg's equation is related to: a) Conductivity b) X-ray diffraction c) Radioactivity d) Photoelectric effect 3. The standard hydrogen electrode is used as: a) Indicator electrode b) Reference electrode c) Metal electrode d) Ion-selective electrode 4. The pH of a neutral solution is: a) 0 b) 7 c) 14 d) 1

Course Category: **Major Lab**

108248 Chemistry Lab 21

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108248**	**Chemistry Lab 21**	2	60	4 h	25+25= 50

Course Objectives:	To develop practical skills in gravimetric, volumetric, complexometric, potentiometric, and pH-metric analytical techniques in Analytical Chemistry and Physical Chemistry.	
Course Outcomes:	At the end of this course students will be able to: 1. Perform gravimetric and volumetric estimations using standard analytical procedures and appropriate indicators. 2. Apply complexometric titration techniques for estimation of metal ions in different samples such as water, milk powder, fungicides, and talcum powder. 3. Determine partition coefficient, consolute temperature, solubility, heat of solution, and related physicochemical parameters experimentally. 4. Perform potentiometric and pH-metric titrations for determination of concentration, pKa, redox potential, and dissociation constants. 5. Analyze experimental data, construct graphs, perform calculations accurately, and interpret physicochemical and analytical results scientifically. 6. Demonstrate laboratory skills, safe handling of instruments and chemicals, and proper scientific documentation and reporting practices.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	1. Principles and steps involved in gravimetric analysis. 2. Calculations of molarity, normality, and EDTA equivalence in complexometric titrations. 3. Selection and role of indicators in EDTA titrations (EBT, murexide, etc.). 4. Construction and interpretation of phase diagrams of partially miscible liquids. 5. Application of Nernst distribution law in partition coefficient experiments.	By combining hands-on experiments, discussions, and real-world applications, students will gain a comprehensive understanding of chemistry lab practices. A few suggested pedagogies are: 1. Experiential and hands-on laboratory learning 2. Demonstration-based teaching for gravimetric, volumetric, potentiometric, and pH-metric techniques 3. Problem-based learning through analytical calculations and data interpretation 4. Inquiry-based learning for experimental observations and result analysis 5. Collaborative learning through group experiments and discussions 6. ICT-enabled teaching using virtual labs, simulations, and graphing software 7. Project-based learning through sample analysis and mini-projects 8. Peer learning and seminar presentations on analytical and physical chemistry concepts 9. Outcome-based continuous
Inorganic Chemistry practical	**Gravimetric Analysis (at least One)** 1. Estimation of Ba2+ as BaSO4 2. Estimation of Fe3+ as Fe2O3 3. Estimation of Ni2+ as Ni-DMG. **Volumetric Estimations: (at least 5)** 1. Estimation of Zn(II) by complexometric titration. 2. To determine the strength of unknown calcium salt solution by complexometric titration. 3. Analysis of Talcum powder 4. Analysis of Iodine from Iodized salt. 5. Analysis of Calcium from milk powder/ limestone 6. Analysis of Cu from Cu-Fungicide. 7. Estimation of calcium and magnesium in water separately by complexometric titration 8. Estimation of nickel ions using EDTA 9. Estimation of cobalt ions by EDTA titration	
Physical Chemistry Practical	**Physical Chemistry Practical (at least 6)** 1. To construct phase diagram of phenol-water system and to determine consolute temperature for the system 2. To determine partition coefficient of benzoic acid between toluene and water 3. To determine partition coefficient of iodine between CCl4/Kerosene and water. 4. To determine solubility of benzoic acid at different temperature and heat of solution 5. To determine strength of given HCl solution potentiometrically. 6. pH metric titration of strong acid against strong base by pH measurement and hence determine the concentration and strength of strong acid. 7. To determine redox potential of Fe^{+2}/Fe^{+3} system potentiometrically	

	8. To determine the pKa value of a given monobasic weak acid by potentiometric titration. 9. To determine the acid and base dissociation constant of an amino acid and hence the isoelectric point of an acid pH metrically 10. To determine the dissociation constant of oxalic acid by pH-metric titration with strong base	assessment through practical performance, assignments, viva voce, and laboratory reports
References	1. Practical Chemistry (for B.Sc. I, II and III year students) – O P Pandey, D. N. Bajpaiand S. Giri (S Chand and company Ltd) 2. *Advanced Practical Inorganic Chemistry* – Gurdeep Raj, Goel Publishing. 3. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Inorganic Chemistry: Qualitative Analysis, University Press. 4. Vogel's Textbook of Quantitative Chemical Analysis – J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, Pearson. 5. Practical Chemistry (For B.Sc. I, II and III Year Students). By Pandey O.P. & Bajpai D.N. & Giri S., S.Chand. 6. Vogel, Arthur Israel, and John Bassett. "Vogel's textbook of quantitative inorganic analysis: including elementary instrumental analysis." (1978). 7. Advanced Physical Chemistry Experiments: J N Gurtu and Amit Gurtu (Pragati Prakashan) 8. Experimental Physical Chemistry: V D Athawale and Parul Mathur (New Age Int. Publishers) 9. Advanced Practical Physical Chemistry: J B Yadav 10. Experiments in Chemistry: D V Jahagirdar **Web resources:** 11. https://vlab.amrita.edu/?sub=2 12. https://chemcollective.org/vlabs 13. https://chem.libretexts.org/ 14. MIT OpenCourseWare: https://ocw.mit.edu 15. Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry	
Model Questions:	**NA**	

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Inorganic Chem Practical) 10 Marks
- Exercise 2 (Physical Chem Practical) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **Major- Elective (Theory)**

108249 Elective Chemistry-4 (Organic Spectroscopy)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108249**	**Elective Chemistry-4 (Organic Spectroscopy)**	2	30	2 Hrs	30+20=50

Course Objectives:	The course aims to develop the ability to apply the basic terms involved in NMR for structure determination and Interpret spectra to identify functional groups, chemical shifts, coupling patterns, and fragmentation patterns.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Classify the nuclei according to their spin quantum numbers. 2. Define the terms involved in NMR and Mass spectroscopy. 3. Explain the shielding mechanism of chemical shift measurement and anisotropy effects. 4. Explain the factors affecting chemical shift of proton. 5. Interpret spectra to identify functional groups, chemical shifts, coupling patterns, and fragmentation patterns. 6. Explain methods for estimation of carbon and nitrogen in organic compounds 7. Determine empirical and molecular formulae using elemental analysis data 8. Interpret combined spectral data to deduce structures of organic compounds. 9. Solve unknown spectral problems systematically using analytical data.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**NMR Spectroscopy I** Introduction, Spin quantum number of some common nuclei, The NMR phenomenon. Nuclear Transition, Experimental Method,. Number of PMR Signals: Equivalent and Non-equivalent protons, Shielding and Deshielding and Chemical shift, Measurement of Chemical shift: TMS as reference, NMR Scale, Factors Affecting chemical Shift, Numericals	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply
Unit II	**NMR Spectroscopy II** Peak Area and Proton Counting. Splitting of Signal- Spin Spin splitting, Coupling constant (J), Karplus curve variation of coupling constant with dihedral angle. Explanation of PMR Spectra of Simple Molecules. Deuterium exchange. Identification of simple organic compounds using NMR spectral data. Distinction between the pair of compounds using NMR spectra.	7 Hrs	7 Marks	
Unit III	**Mass Spectrom**etry Basic principles of mass spectrometry, Components of a mass spectrometer, Ionization process and mass-to-charge ratio (m/z). Molecular ion peak, base peak, Isotope abundance and isotopic patterns (Cl and Br), Nitrogen rule, Metastable ions. Fragmentation processes- homolysis, heterolysis and hemi heterolysis. Retro Diels–Alder rearrangement, McLafferty rearrangement. Mass spectral fragmentation of organic compounds (Alkanes, Alcohols,	8 Hrs	8 Marks	

	Carbonyl compounds, Aromatic compounds, Amines) Interpretation of simple mass spectra.			theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit IV	**Elemental Analysis and Structure Elucidation using spectral data** • Quantitative elemental analysis: Estimation of carbon and hydrogen, Estimation of nitrogen by Kjeldahl method. • Empirical and molecular formula determination • Degree of unsaturation (DBE calculations) • Problems based on joint application of elemental analysis, chemical reactions, UV, IR, PMR, and Mass spectroscopic techniques.	7 Hrs	7 Marks	
References:	1. Advanced Organic Chemistry Part-A &B by Carey, Francis A, Sundberg, Richard J 2. Advanced Organic Chemistry by Michael B. Smith, Jerry March. 3. Banwell.,(2017). Fundamentals of Molecular; Spectroscopy (IV Edition), McGraw-Hill Education (India) Pvt. Limited. 4. Sharma, Y. R. (2013). Elementary Organic Spectroscopy: Principles and Chemical. 5. Organic Structure From Spectra by L D Field, S Sternhell 6. P S Kalsi,(2016). Spectroscopy of Organic Compounds, 7th edition. Delhi: New age international publisher. 7. Robert M. Silverstein, Francis X. Webster, (1996).Spectrometric Identification of Organic Compounds, 6th Edition. New York: John Wiley & Sons. **Web resources:** Nuclear Magnetic Resonance Spectroscopy: https://onlinecourses.swayam2.ac.in/arp20_ap02/unit?unit=40&lesson=43 https://onlinecourses.swayam2.ac.in/arp20_ap02/unit?unit=40&lesson=44 https://storage.googleapis.com/swayam1-pub-data/stomhrdproddoc01.blob.core.windows.net/wcsourcepre/300831_636831504535573071.mp4 https://onlinecourses.swayam2.ac.in/5231-online-refresher-course-in-chemistry-for-higher-education-faculty/unit?unit=69&lesson=73 https://onlinecourses.swayam2.ac.in/5231-online-refresher-course-in-chemistry-for-higher-education-faculty/unit?unit=75&lesson=76 Mass Spectrometry: https://onlinecourses.swayam2.ac.in/arp20_ap02/unit?unit=65&lesson=68 https://onlinecourses.swayam2.ac.in/arp20_ap02/unit?unit=65&lesson=69			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) What is chemical shift in NMR? 2) Define molecular ion and molecular in peak 3) What is Coupling constant (J)? 4) What is Nitrogen rule in Mass spectrometry 5) What are the scales used to measure the chemical shift in NMR? 6) What are general fragmentation modes in Mass spectrometry			
	Answer in brief (At least 6) (3 Marks each) 1) What do you mean by molecular ion peak and base peak? 2) Why TMS is used as reference in NMR Spectroscopy? 3) Predict the signal pattern of the CH_3 protons in the NMR spectra of CH_3CHBr_2 and $CH3CH_2Br$ 4) Hydrocarbon with molecular formula C_7H_{12} exhibits peak at m/z 96,54 Assign the structure. 5) Explain Kjeldahl's method for estimation nitrogen. 6) Why deuterated solvents are used in NMR spectroscopy?			
	Answer in Detail (At least 4) (6 Marks each) 1) Explain the shielding and deshielding with suitable examples. 2) Discuss the factors affecting chemical shift 3) Discuss the Mclaffertty rearrangement with example in mass spectrometry 4) In the 1-H NMR spectrum recorded at 293 K, an organic compound A having molecular formula is (C3H7NO), exhibited signals at 8 7.8 (1H, s), 2.8 (3H, s) and 2.6 (3H, s). The compound A is? 5) A compound of MF $C_5H_{12}O$ gave following spectral data: IR: 3400 (cm-1); 1H-NMR: 0.95 (d, 6H), 1.8-1.9 (m, 3H), 2.70 (s, 1H), 3.9 (t, 2H). Peak at 2.70 disappears on shacking with D2O. Find out structure of the compound. 6) Explain the following spectral data systematically and deduce the structure of an organic molecule containing C, H and O: UV: Amax 278 and 319 nm.			

	IR: Significant absorption bands at 3070-3010, 2970-2860, 1685, 1605, 1580 and 1450 cm-1• PMR: 82.1 (3H, *s)* and 7.5 (5H, *m).* Be NMR: *8* 198 and 137 (two singlets), 134, 129 and 128 (three doublets) and 26 (one quartet). MS: *mle* 120 (W), 105, 77, 51 and 43.
	MCQs for Internal Assessment (At least 4) 1.Which of the following combinations of peaks appears in the 1H NMR spectrum of diethyl ether $CH_3CH_2OCH_2CH_3$? A) a triplet and a quartet B) a. triplet and a singlet C) a quartet and a sextet D)a triplet and a doublet 2. Equivalent protons in a molecules will have (a) Same environment (b) Same shielding effect (c) Same chemical shift (d) All of the above 3. Mass spectrometers are used to determine which of the following? (a) Composition in sample (b) Relative mass of atoms (c) Concentration of elements in sample (d) Properties of sample 4. In Kjeldahl's method, nitrogen present in an organic compound is converted into: A) NO_2 B) NH_3 C) N_2 D) HNO_3 **5.** The absorption band around 1700 cm^{-1} in IR spectroscopy generally indicates: A) O–H group B) N–H group C) C=O group D) C=C group

Course Category: **Major Elective Lab**

108250 Chemistry Lab 22A (Elective Chemistry 4)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108250**	**Chemistry Lab 22A (Elective Chemistry 4)**	2	60	4 h	25+25= 50

Course Objectives:	1. To provide hands-on training in reaction mechanisms, stoichiometric calculations, and preparation of important organic compounds and derivatives. 2. To enhance understanding of spectral interpretation using UV, IR, NMR, mass spectra, and elemental analysis for structure elucidation of organic molecules.	
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Perform synthesis, purification, and characterization of organic compounds using standard laboratory methods. 2. Apply TLC, melting point determination, and recrystallization techniques for assessment of purity and compound identification. 3. Explain mechanisms of important organic reactions such as acetylation, benzoylation, bromination, nitration, and aldol condensation. 4. Interpret PMR spectra, assign chemical shifts and multiplicity, and analyze spin-spin coupling patterns. 5. Identify molecular ion peaks, isotopic patterns, and fragmentation pathways in mass spectra. 6. Determine empirical and molecular formulae, calculate degree of unsaturation, and interpret combined UV, IR, NMR, and mass spectral data for structure elucidation of organic compounds.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	1. Interpretation of TLC results and calculation of Rf values. 2. Mechanism of acetylation, benzoylation, bromination, nitration, and aldol condensation reactions. 3. Stoichiometric calculations in organic preparations 4. Assignment of PMR signals, multiplicity, and chemical shift values in simple organic compounds. 5. Problems based on spin-spin splitting and coupling constants. 6. Identification of molecular ion peak, base peak, Fragmentation pattern and isotopic peaks in mass spectra. 7. Determination of empirical and molecular formula from elemental analysis data.and calculation of	1. Experiential and hands-on laboratory learning 2. Demonstration-based teaching for organic synthesis, TLC, recrystallization, and spectral interpretation 3. Problem-based learning through reaction mechanism and spectral analysis exercises 4. Inquiry-based learning for identification and

	degree of unsaturation (DBE) for organic molecules. 8. Combined spectral interpretation problems involving UV, IR, NMR, and mass spectra.	structure elucidation of organic compounds 5. ICT-enabled teaching using spectral databases, molecular visualization tools, and virtual labs 6. Collaborative learning through group experiments, discussions, and peer learning 7. Project-based learning through mini-projects on organic synthesis and spectral characterization 8. Flipped classroom approach for pre-lab study of reactions and spectra 9. Outcome-based continuous assessment through laboratory performance, assignments, viva voce, and reports **10. Any other innovative pedagogy as applicable.**
Organic Preparations	**Organic Preparations** (Collected solid samples may be used for recrystallization, melting point and TLC) **(At least 6 preparations)** 1. Acetylation of one of the following compounds: amines (aniline, o-, m-, p-toluidines and o-, m-, p-anisidine) (Using conventional method) 2. Benzoylation of one of the amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) 3. Iodoform from ethanol or acetone 4. P-nitroacetanilide from acetanilide 5. P-bromoacetanilide from acetanilide 6. 2,4,6-tribromophenol from phenol 7. Preparation of methyl orange 8. Preparation methyl red 9. Benzoic acid from toluene 10. Aniline from nitrobenzene 11. Hydrolysis of benzamide 12. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde. 13. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid). 14. Aldol condensation with either conventional or green method.	
Spectral Interpretation	**NMR Spectroscopy** (Reference spectra may be obtained from literature) 1. Identification of equivalent and non-equivalent protons in given molecules. (p-Xylene, ethylbenzene and Acetophenone) 2. Determination of chemical shift values using standard PMR spectra (Chloroform, Acetaldehyde, Benzaldehyde and Anisole) 3. Interpretation of splitting patterns and coupling constants. (Ethyl bromide Isopropyl alcohol, Ethyl acetate) 4. Proton counting using integrated peak areas**.** **(**Acetone, Toluene, Acetic acid) 5. Identification of simple compounds using PMR spectral data. 6. Distinction between structural isomers using ^{1}H NMR spectra**.** (o-Xylene, m-Xylene, p-Xylene and 1-propanol and 2-propanol) 7. Interpretation of ^{1}H NMR spectra of simple aliphatic organic compounds. 8. Interpretation of ^{1}H NMR spectra of simple aromatic organic compounds **Mass Spectroscopy** (Reference spectra may be obtained from literature) 1. Identification of molecular ion peak and base peak in: Toluene, Acetophenone, Cyclohexanone 2. Study of isotopic patterns in: Chlorobenzene and Bromobenzene	

	3. Fragmentation pattern studies of: Ethanol, Acetone, Acetophenone and Aniline 4. Identification of McLafferty rearrangement in: 2-Hexanone , Butanone , Hexanoic acid ester 5. Nitrogen rule and molecular formula determination using: Aniline, m-dinitrobenzene and Benzamide 6. Mass spectral analysis of aromatic compounds: Toluene, Ethylbenzene and Cumene **Combined Spectral Interpretation / Structure Elucidation (At least 6)** (References from standard spectroscopy books may also be taken for such purpose for enhancing students understanding and skill) 1. Determination of empirical and molecular formula of: Acetanilide, Aspirin etc. 2. Degree of unsaturation calculations for: Benzene, Cyclohexene and Acetophenone 3. Structural elucidation of simple organic compounds by elemental analysis, UV, IR NMR and Mass spectroscopy (Sample spectra may be provided for simple organic compounds like Ethanol, Aniline, Phenol, acetic acid, other simple aldehydes, carboxylic acid, etc.).	
Suggested Student Activities	• **Organic Synthesis Demonstration Activity:** Students perform and present synthesis of selected organic compounds highlighting reaction mechanism and yield calculation. • **TLC Analysis Activity:** Comparative TLC study of synthesized compounds and calculation of Rf values for purity assessment. • **Spectral Interpretation Workshop:** Group-based interpretation of UV, IR, NMR, and mass spectra of simple organic compounds. • **Reaction Mechanism Chart Preparation:** :Preparation of flowcharts/mechanistic pathways for acetylation, benzoylation, nitration, bromination, and aldol condensation reactions. • **Mini Project on Organic Compound Characterization:** Synthesis, purification, and spectral characterization of an assigned organic compound. • **Structure Elucidation Competition:** Identification of unknown compounds using combined spectral and elemental analysis data. • **Poster Presentation** • **ICT-Based Learning Activity**: Use of spectral databases, ChemDraw, MolView, or virtual spectroscopy tools for molecular visualization and spectral assignment.	
References	1. Morgan, E. D. "Vogel's textbook of practical organic chemistry. 5th edn.: By BS Furniss, AJ Hannaford, PWG Smith and AR Tatchell. Pp. 1514. Longman, Harlow. (1990): 148. 2. Handbook of Organic Analysis: Qualitative and Quantitative – H. T. Clarke, CBS Publishers. 3. Practical Chemistry (For B.Sc. I, II and III Year Students). By Pandey O.P. & Bajpai D.N. & Giri S., S.Chand. 4. Ahluwalia, V. K., and Renu Aggarwal. Comprehensive practical organic chemistry: preparation and quantitative analysis. Universities Press, 2001. 5. Sethi, Arun. Systematic lab experiments in organic chemistry. New Age International, 2006 6. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press. 7. Advanced practical Organic Chemistry: O P Agrawal 8. Spectrometric Identification of Organic Compounds, Robert M. Silverstein, FrancisX. Webster, David J. Kiemle, John Wiley & Sons, 7th Edition, 2005 9. Green Chemistry Experiments: A Monograph, R. K. Sharma, Indu Tucker Sidhwani, M. K. Chaudhuri, I. K. International Pvt. Ltd., 1st Edition, 2009 10. Sharma, Rakesh K., Indu Tucker Sidhwani, and Mihir K. Chaudhuri. *Green Chemistry Experiments: A Monograph*. IK International Pvt Ltd, 2012. Web resources: https://nanohub.org/modelsimulate	

	https://sdbs.db.aist.go.jp/SearchInformation.aspx https://avogadro.cc/ https://molview.org/ Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry ChemCollective Virtual Labs: http://chemcollective.org PhET Interactive Simulations (University of Colorado Boulder): https://phet.colorado.edu
Model Questions:	**NA**

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Organic Preparations) 10 Marks
- Exercise 2 (Spectral Interpretation) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **Major- Elective (Theory)**

108251 Elective Chemistry-5 (Green Chemistry and Nanochemistry)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108251**	**Elective Chemistry-5 (Green Chemistry and Nanochemistry)**	2	30	2 Hrs	30+20=50

Course Objectives:	To introduce the principles of Green Chemistry and Nanochemistry with emphasis on sustainable chemical processes, green technologies, and unique properties of nanomaterials.
Course Outcomes:	After successful completion of the course, a student will be able to-. 1. Explain the principles and importance of Green Chemistry and sustainable chemical processes. 2. Apply the Twelve Principles of Green Chemistry to minimize waste, hazards, and energy consumption in chemical processes. 3. Describe green synthesis methods, renewable resources, safer solvents, and catalytic approaches used in sustainable chemistry. 4. Explain the fundamental concepts, classification, and unique properties of nanomaterials in Nanochemistry. 5. Differentiate between bulk materials and nanoscale materials based on their physicochemical properties and applications.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Introduction to Green Chemistry** • Definition, scope, and importance of green chemistry • Need for sustainable chemical processes • Difference between environmental chemistry and green chemistry • Concept of sustainability and circular economy	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Any other innovative pedagogy as applicable.**
Unit II	**Twelve Principles of Green Chemistry I** • Prevention of waste • Atom economy: Atom economy calculations in some reactions. • Less hazardous chemical synthesis • Designing safer chemicals with examples • Safer solvents and auxiliaries • Energy efficiency: Energy-efficient techniques: microwave and ultrasound-assisted synthesis	7 Hrs	7 Marks	
Unit III	**Twelve Principles of Green Chemistry II** • Use of renewable feedstocks • Reduce derivatives and protecting groups • Catalysis: Examples of Catalysts in green synthesis • Design for degradation: Biodegradable materials and polymers • Real-time analysis for pollution prevention • Inherently safer chemistry for accident prevention	8 Hrs	8 Marks	
Unit IV	**Introduction to Nano chemistry** • Definition and scope of Nano chemistry. • Historical development of nanoscience and nanotechnology. Size scale and classification of nanomaterials. • Unique properties of nanomaterials: • Surface area effects, Quantum confinement, • Optical, electrical, and magnetic	7 Hrs	7 Marks	

	properties • Difference between bulk and nanoscale materials			
References:	1. 1.Ahluwalia, V.K., Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers (2005). 2. Anastas, P.T. & Warner, J.K, *Green Chemistry- Theory and Practical*, Oxford University Press (1998). 3. Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001). 4. Cann, M.C.and Connely, M.E. *Real-World cases in Green Chemistry*, ACS (2000). 5. Ryan, M.A. and Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, (2002). 6. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, Second Edition,2010 7. Poole, C.P. & Owens, F.J. *Introduction to Nanotechnology* John Wiley 2003 8. Chattopadhyay, Kalyan K., and A. N. Banerjee. *Introduction to nanoscience and nanotechnology*. PHI Learning Pvt. Ltd., 2009. 9. Rao, C N R, Achim Müller, and A K. Cheetham, eds. *The chemistry of nanomaterials: synthesis, properties and applications*. John Wiley & Sons, 2006. **Web resources:** 1. https://www.epa.gov/greenchemistry/basics-green-chemistry 2. https://chemicals.gov.in/green-chemistry 3. https://www.acs.org/green-chemistry-sustainability/principles/12-principles-of-green-chemistry.html 4. https://sc.uobaghdad.edu.iq/wp-content/uploads/sites/64/mainfiles/lectures/chem/NANOCH1.pdf			
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1. Define Green Chemistry. 2. Define circular economy. 3. What is atom economy? 4. State the principle of waste prevention in green chemistry. 5. What are safer solvents? 6. Define biodegradable polymers. 7. Name two energy-efficient techniques used in green synthesis. 8. Define Nanochemistry. 9. What is the size range of nanomaterials? 10. What is quantum confinement effect?			
	Answer in brief (At least 6) (3 Marks each) 1. Discuss the concept of sustainability and circular economy. 2. Explain the principle of atom economy with suitable examples. 3. Write a short note on safer solvents and auxiliaries. 4. Discuss microwave-assisted synthesis as an energy-efficient green technique. 5. Explain the importance of biodegradable materials and polymers. 6. Define Nanochemistry and discuss its scope. 7. Discuss the classification of nanomaterials based on size and dimensions. 8. Explain surface area effects in nanomaterials. 9. Write a short note on quantum confinement effect. 10. Discuss the optical, electrical, and magnetic properties of nanomaterials. 11. Differentiate between bulk materials and nanoscale materials			
	Answer in Detail (At least 4) (6 Marks each) 1. Explain the Twelve Principles of Green Chemistry and discuss their significance in sustainable chemical processes. 2. Discuss atom economy, safer solvents, renewable feedstocks, and catalysis as important tools of green chemistry with suitable examples. 3. Explain energy-efficient green synthesis techniques such as microwave-assisted and ultrasound-assisted synthesis and discuss their advantages over conventional methods. 4. Define Nanochemistry and discuss the classification, unique properties, and applications of nanomaterials. 5. □ Explain the surface area effect and quantum confinement effect in nanomaterials and discuss how nanoscale materials differ from bulk materials in their optical, electrical, and magnetic properties.			
	MCQs for Internal Assessment (At least 4) 1. The term "Green Chemistry" mainly focuses on: A) Increasing reaction rate B) Reducing environmental hazards			

	C) Producing colored compounds D) Increasing yield only 2. Atom economy was introduced by: A) Arrhenius B) Paul Anastas C) Rutherford D) Bohr 3. Which of the following is considered a green solvent? A) Benzene B) Carbon tetrachloride C) Water D) Chloroform 4. Nanomaterials generally possess dimensions in the range of: A) 1–100 nm B) 100–1000 nm C) 1–10 µm D) 10–100 µm 5. Quantum confinement effect is mainly observed in: A) Bulk materials B) Macroscopic crystals C) Nanomaterials D) Solutions only

Course Category: **Major Elective Lab**

108252 Chemistry Lab 22B (Elective Chemistry 5)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108252**	**Chemistry Lab 22B (Elective Chemistry 5)**	2	60	4 h	25+25= 50

Course Objectives :	1. To provide thorough knowledge of the green chemistry principles, and new remediation technologies for the cleaning up of hazardous substances. 2. To develop basic skills to be able to design, develop and run chemical processes in a sustainable way	
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Design and develop materials/ processes that reduce the use and generation of hazardous substances in industry. 2. Describe how injudicious use of chemicals can have an adverse/potentially damaging effect on humans and the environment. 3. Propose ideas for innovative approaches to environmental and societal challenges. 4. Critically analyse the existing traditional chemical pathways/processes and creatively think about bringing environmentally benign reformations in these protocols. 5. Convert biomass into valuable chemicals through green technologies.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	• Definition and Importance of green chemistry. • Introduction to the prevention of waste/ by products and waste/ pollution prevention hierarchy. • Provide the scheme for the traditional as well as green method for the synthesis of ibuprofen and ask students to compare the amount and hazards of waste generated in both the processes.	• Atom economy calculations of reactions • Comparative study of conventional vs green synthesis • Literature review on green industrial processes • Seminar on one principle of green chemistry
Green Chemistry Experiments	1. Use of molecular model kit to stimulate the reaction Green Methods in Chemistry to investigate how the atom economy can illustrate Green Chemistry. For eg. Preparation of propene by two methods can be studied (I) Hoffman elimination (II) Dehydration of propanol (https://www.acs.org/content/dam/acsorg/greenchemistry/education/resources/cleaning-up-with-atom-economy.pdf 2. Preparation of biodiesel from waste cooking oil and characterization 3. Nitration of salicylic acid using green method 4. Preparation of dibenzalacetone by cross aldol condensation reaction using base catalysed green method 5. Acetylation of primary aromatic amine using the green method 6. Manganese (III) acetylacetonate using green method in water 7. Benzil- Benzilic acid rearrangement in solid State under solvent-free Condition 8. Mechanochemical solvent free, solid–solid synthesis of azomethine using p- toluidine and o-vanillin/p-vanillin 9. Photoreduction of benzophenone to benzopinacol in the presence of sunlight 10. Rearrangement of diazoamino benzene to p-aminoazo benzene using K10 montmorillonite clay 11. Synthesis of Benzimidazole by green method 12. Synthesis of 1,4 – dihydropyridine by green method 13. Preparation of nanoparticles of using plant extracts.	

Group Activities	1. Green synthesis project using household or natural materials 2. Preparation and comparative study of nanoparticles using different plant extracts 3. Poster presentation on green chemistry principles 4. Mini-project on waste minimization in chemistry laboratories 5. Demonstration of green laboratory techniques 6. Seminar on the topics (suggested): i. Applications of nanotechnology in medicine and environment ii. Bhopal Gas Tragedy and safer route to carbaryl synthesis iii. Flixiborough accident and safer route to cyclohexanol iv. Use of Surfactants for SC-CO2 for precision cleaning and dry cleaning of garments replacing PERC. v. A brief study of Green Chemistry Challenge Awards (Introduction, award categories and study about five last recent awards) vi. Healthier Fats and oils by Green Chemistry: Enzymatic Interesterification for production of No Trans-Fats and Oils	
References	1. Anastas, P.T., Warner, J.C. (2014), Green Chemistry, Theory and Practice, Oxford University Press. 2. Alhuwalia, V.K.; Kidwai, M.R. (2012), New Trends in Green chemistry, Kluwer Academic Publishers, Springer 3. Kirchoff, M., Ryan, M.A. (2002), Greener approaches to undergraduate chemistry experiment, American Chemical Society, Washington DC. 4. Sharma, R.K., Sidhwani, I.T., Chaudhari, M.K. (2013), Green Chemistry Experiments: A monograph, I.K. International Publishing House Pvt Ltd. New Delhi. 5. Pavia, D.L., Lamponam, G.H., Kriz, G.S.W. (2006), Introduction to organic Laboratory Technique- A Microscale approach, 4th Edition, Brooks-Cole Laboratory Series for Organic chemistry. **Web resources:** 1. MIT OpenCourseWare: https://ocw.mit.edu 2. Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry 3. ChemCollective Virtual Labs: http://chemcollective.org 4. NPTEL (IIT Online Courses): https://nptel.ac.in/courses/104 5. LibreTexts Chemistry: https://chem.libretexts.org 6. PhET Interactive Simulations (University of Colorado Boulder): https://phet.colorado.edu	
Model Questions:	**NA**	

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Green Chem Practical) 10 Marks
- Exercise 2 (Group activity) Presentation 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **Major- Elective (Theory)**

108253 Elective Chemistry-6 (Chemistry of Consumer and Industrial Products)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108253**	**Elective Chemistry-6 (Chemistry of Consumer and Industrial Products)**	2	30	2 Hrs	30+20=50

Course Objectives:	To introduce students to the chemistry, manufacture, quality control, and applications of food products, soaps, detergents, and petrochemicals used in everyday life and industry.
Course Outcomes:	After successful completion of the course, a student will be able to-. 1. Explain the composition, nutritional value, preservation, and quality aspects of food products. 2. Identify common food adulterants and discuss food quality control and safety measures. 3. Describe the chemistry, manufacture, properties, and applications of soaps and detergents. 4. Explain petroleum refining, petrochemical products, and their industrial applications. 5. Evaluate environmental issues and sustainability concerns associated with food, detergent, and petrochemical industries.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Food Chemistry:** Composition of food: • Carbohydrates • Proteins • Fats and oils Nutritional importance of food constituents • Food additives: • Preservatives • Sweeteners • Colouring agents • Flavouring agents Food spoilage and preservation methods	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-On Models**: use of model **Problem-Solving Sessions**: Organize regular problem-solving sessions. Explore virtual labs and simulations to enhance understanding of the topic. **Flip-Class:** Assign readings or video lectures as homework and use class time for interactive discussions. Ask students to create concept maps that illustrate the relationships between different concepts. **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. **Any other innovative pedagogy as applicable.**
Unit II	**Food Quality and Analysis** Food adulteration: • Milk • Edible oils • Honey • Spices Detection of common food adulterants Food quality control Food packaging and labeling Food safety standards and regulations	7 Hrs	7 Marks	
Unit III	**Soap and Detergent** **Soaps: -**Introduction, Manufacture of soaps by i) Kettle's process, ii) Hydrolyser process, cleansing action of soap. **Synthetic Detergents:** Introduction, Synthetic detergent classification, i) Anionic detergent, ii) Cationic detergents, iii) Non-ionic detergents. Synthetic detergent versus soaps, Soft versus Hard detergents	8 Hrs	8 Marks	
Unit IV	**Petrochemical Products** Petroleum: Composition and classification Fractional distillation of crude oil Petrochemical feedstocks Manufacture and applications of: • LPG • Petrol • Diesel	7 Hrs	7 Marks	

	• Kerosene Petrochemical products: • Ethylene • Propylene • Benzene			
References :	1. Srilakshmi, B. *Food science*. New Age International, 2003. 2. Sharma, B. K. *Industrial chemistry*. Krishna Prakashan Media, 1991. 3. Austin, George T. "Shreve's chemical process industries." (1984): 136-138. 4. Sukumar Maiti*, Introduction to Petrochemicals*, Oxford & Ibh, 2002 **Web resources:** **https://www.fssai.gov.in** **https://www.nin.res.in** **https://www.fao.org** **https://www.iocl.com**			
Model Questions:	**Short Type (At least 6) (1 Marks each)** **1.** What is saponification? **2.** Name the main constituent of natural fats and oils. **3.** What is a food preservative? Give one example. **4.** What is food adulteration? **5.** Name the process used for refining crude petroleum. **6.** Which petrochemical is commonly used for the manufacture of polyethylene? **7.** What is a biodegradable detergent? **8.** Name one synthetic detergent used in household cleaning products.			
	Answer in brief (At least 6) (3 Marks each) **1.** Explain the composition and nutritional importance of carbohydrates, proteins, and fats in food. **2.** Describe the causes of food spoilage and the methods used for food preservation. **3.** Discuss the role of food additives in food processing with suitable examples. **4.** Explain common food adulterants found in milk, edible oils, and spices and their effects on health. **5.** Describe the chemistry of saponification and the manufacture of soaps. **6.** Differentiate between soaps and synthetic detergents. **7.** Explain the fractional distillation of crude petroleum and its products. **8.** Discuss the applications and environmental impact of petrochemical products and polymers.			
	Answer in Detail (At least 4) (6 Marks each) 1. Discuss the composition of food and explain the nutritional significance of carbohydrates, proteins, fats, vitamins, and minerals. 2. Describe the causes of food spoilage and explain various methods of food preservation used in the food industry. 3. What are food additives? Discuss the types, functions, and applications of preservatives, sweeteners, colouring agents, and flavouring agents. 4. Explain food adulteration and discuss common adulterants in milk, edible oils, honey, and spices along with their detection methods. 5. Describe the chemistry of fats and oils. Explain the process of saponification and the manufacture of soaps. 6. Classify detergents and discuss the preparation, properties, applications, and environmental impact of synthetic detergents. 7. Discuss the composition of petroleum and explain the fractional distillation of crude oil with a neat flow diagram.			
	MCQs for Internal Assessment (At least 4) 1. The major constituents of soaps are: A) Alcohols B) Esters C) Sodium or potassium salts of fatty acids D) Hydrocarbons 2. Which of the following is commonly used as a food preservative? A) Sodium benzoate B) Glucose C) Urea D) Ethanol 3. The process used to separate petroleum into different fractions is called: A) Cracking B) Polymerization C) Fractional distillation D) Hydrogenation 4. Adulteration of milk with water mainly reduces its: A) Acidity B) Density C) Nutritional value D) Colour			

Course Category: **Major Elective Lab**

108254 Chemistry Lab 22C (Elective Chemistry 6)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108254**	**Chemistry Lab 22C (Elective Chemistry 6)**	2	60	4 h	25+25= 50

Course Objectives:	3. To provide thorough knowledge of the green chemistry principles, and new remediation technologies for the cleaning up of hazardous substances. 4. To develop basic skills to be able to design, develop and run chemical processes in a sustainable way	
Course Outcomes:	Upon successful completion of this course, students will be able to:	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	• Definition and Importance of green chemistry. • Introduction to the prevention of waste/ by products and waste/ pollution prevention hierarchy. • Provide the scheme for the traditional as well as green method for the synthesis of ibuprofen and ask students to compare the amount and hazards of waste generated in both the processes.	• Hands-on laboratory learning • Demonstration-based experiments • Industry-oriented practical training • Group projects and sample analysis • Case-study-based learning • Continuous assessment through reports, viva, and practical performance
Food and Oil analysis	1. Determination of moisture content in food samples. 2. Estimation of Vitamin C in fruit juice. 3. Detection of adulterants in milk (water, starch, urea, detergent). 4. Detection of adulterants in edible oils. 5. Detection of adulterants in honey, turmeric, chili powder, and black pepper. 6. Determination of acidity in fruit juices or beverages. 7. Determination of acid value of edible oils. 8. Determination of saponification value of oils. 9. Determination of iodine value of oils. 10. Determination of peroxide value of oils. 11. Determination of specific gravity of oils. 12. Detection of rancidity in fats and oils.	
Soap, Detergent and Petrochemical Analysis	1. Preparation of soap by saponification. 2. Determination of total alkali content in soap. 3. Determination of moisture content in soap. 4. Comparison of cleansing efficiency of different detergents. 5. Determination of foaming capacity of soaps and detergents. 6. Study of hard water effect on soaps and detergents. 7. Determination of density/specific gravity of petroleum products. 8. Determination of viscosity of lubricating oil. 9. Determination of flash point of petroleum products (demonstration). 10. Determination of cloud point and pour point of lubricating oils (demonstration). 11. Comparative study of petrol, diesel, kerosene, and lubricating oils. 12. Determination of refractive index of petroleum products.	
Suggested Student Activities	• Market survey of food adulteration. • Comparative study of commercial edible oils. • Comparative evaluation of detergent brands. • Analysis of nutritional labels on packaged foods. • Preparation of herbal soap formulations. • Mini-project on quality control of consumer products.	
References	1. Bailey's Industrial Oil and Fat Products, 6th Edition, Wiley, 2005. 2. The Analysis of Fats and Oils, Springer. 3. The Chemical Analysis of Foods, 8th Edition, Churchill Livingstone. 4. Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, Pearson Education. 5. Shreve's Chemical Process Industries, 5th Edition, McGraw-Hill, 1984. **Web resources:**	

	1. https://fssai.gov.in/upload/uploadfiles/files/Manual_Food_Additives_25_05_2016(1).pdf 2. https://www.iocl.com 3. https://www.iocl.com 4. LibreTexts Chemistry: https://chem.libretexts.org
Model Questions:	**NA**

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40%) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (**Food and Oil analysis**) 10 Marks
- Exercise 2 (**Soap, Detergent and Petrochemical Analysis**) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category**: Minor (Theory)**

108255 Minor Chemistry-4

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108255**	**Minor Chemistry-4**	2	30	2 Hrs	30+20=50

Course Objectives:	1. To develop fundamental comprehensive understanding of formation of coordination compounds on the basis of VBT and CFT. 2. To provide fundamental understanding of the structure, preparation, properties, and reactions of carboxylic acids, esters, and nitrogen-containing organic compounds
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Understand the nature of metal-ligand bonding in coordination compound by VBT and predict their geometries. 2. Define different types of isomerism in coordination compounds. 3. Explain the nature of metal-ligand bonding in coordination compound by CFT 4. Calculate CFSE of complexes and describe various factors affecting CFSE 5. Explain the structure, preparation, properties, and reactions of carboxylic acids and esters, including mechanisms of esterification and hydrolysis 6. Analyze the synthesis, reactivity, and applications of nitrogen-containing organic compounds such as nitrogen containing compounds.

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Coordination Chemistry-2** **A) Valence bond theory (VBT):** Steps involved in describing metal-ligand bonding in coordination compounds using VBT; Types of hybridization, geometries and magnetic properties to understand formation of complexes of 3d elements with coordination number 6 (Inner and outer orbital complexes) and 4 (Tetrahedral and square planar). Limitations of VBT. **B) Isomerism in coordination Compounds:** Structural or constitutional isomerism: ionization, linkage, coordination and hydrate; Stereoisomerism: Geometrical isomerism in square planar {type: Ma_2b_2, Ma_2bc &Mabcd} and in octahedral complexes {type: Ma_4b_2, $Ma_2b_2c_2$, Ma_3b_3 & Mabcdef}, Optical isomerism in octahedral complexes {type: cis-$Ma_2b_2c_2$, $M(AA)_3$ & $Ma_2(AA)_2$)} and in tetrahedral complexes {type: Mabcd}	8 Hrs	8 Marks	To enhance conceptual understanding and practical skills, a **blended teaching methodology** is employed, integrating the following strategies: **1. Conceptual & Visual Learning** • **Concept Mapping & Digital Simulations** (PhET, ChemSketch) for bonding, reaction mechanisms, and isomerism. • **3D Molecular Models & Interactive Discussions** for stereochemistry and hybridization. **2. Inquiry-Based & Experimental Learning** • **Hands-on Lab Work & Virtual Labs** for volumetric analysis, calorimetry, and synthesis. • **Problem-Solving & Data Analysis** for numerical applications (molarity, bond order,
Unit II	**Coordination Chemistry-3:** Postulates of CFT; Crystal field splitting in octahedral, distorted octahedral, square planar and tetrahedral complexes; concept of CFSE, high spin and low spin octahedral complexes on the basis of Δ_o and pairing energy, distribution of electrons in t_{2g} and e_g orbitals in high spin and low spin octahedral complexes; Factor affecting magnitude of crystal field splitting in octahedral complexes. Spectro-chemical series.	7 Hrs	7 Marks	
Unit III	**Carboxylyllic acids and Esters** **Carboxylic acids:** Structure and reactivity of carboxylic groups. Acidity of carboxylic acids, effects of substituents on acidic strength.	8 Hrs	8 Marks	

	Oxalic acid: Preparation from ethylene glycol and cyanogens, reactions with ethanol, ammonia, glycerol and action of heat. **Lactic acid:** Preparation from acetaldehyde and pyruvic acid, reaction with ethanol, PCl_5, action of heat, oxidation and reduction. **Benzoic acid**: Preparation from toluene, benzyl alcohol and benzamide, reactions with ethanol, PCl_5 and ammonia. **Salicylic acid:** Preparation by Reimer-Tiemann reaction. Reactions with CH_3COCl, CH_3OH and C_6H_5OH. **B) Ester**: Structure and nomenclature of esters, Preparation of ester by reaction of acetic acid, benzoyl chloride with ethanol; acetic anhydride with ethanol and salicylic acid; propanoic acid with diazomethane; silver acetate with methyl bromide. Reaction of methyl acetate with ammonia, PCl5, hydrolysis. Mechanism of esterification and hydrolysis (acidic and basic)..			thermodynamics). **3. Digital & Flipped Learning** • **Pre-Class Video Lectures & Online Quizzes** for self-paced learning. • **Gamification & Case Studies** to relate theory to real-world applications. **4. Application & Research-Based Learning** • **Case-Based & Interdisciplinary Approach** connecting chemistry with industrial and environmental applications. • **Mini-Projects & Literature Reviews** to encourage analytical thinking.
Unit IV	**Nitrogen containing compounds** **A) Aromatic nitro compounds:** Nitrobenzene: Resonance structure, synthesis from benzene, Reductions: i) in acidic medium, ii) In neutral medium, iii) In alkaline medium. **B) Amino Compounds:** Aniline: Basicity and effect of substituents. Preparation of aniline from nitrobenzene, reactions with acetyl chloride and benzoyl chloride, Br_2 (aq) and $Br_2(CS_2)$, carbylamine reaction, alkylation, Hoffmann's exhaustive methylation and its mechanism. **Diazo Compounds:** Preparation benzene diazonium chloride, Synthetic applications- Preparation of benzene, phenol, halobenzene, nitrobenzene, benzonitrile, coupling with phenol and aniline.	7 Hrs	7 Marks	This **integrated approach** fosters **engagement, critical thinking, and practical competence**, ensuring a **dynamic and research-oriented** chemistry learning experience.
References:	1. Principles of Inorganic Chemistry by Puri, Sharma and Kalia- S. Naginchand & Co., Delhi. 2. Inorganic Chemistry by A.K. De, Wiley East Ltd. 3. Selected Topics in Inorganic Chemistry by Malik, Tuli and Madan, S. Chand & Co. 4. Concise Inorganic Chemistry by J.D. Lee, ELBS. 5. Inorganic Chemistry by J.E. Huheey- and Kettle, Harper & Row. 6. Advanced Inorganic Chemistry, Vol-I, Satya Prakash, Madan, Tuli, Basu. 7. Advanced Practical Inorganic Chemistry by Gurdeep Raj, Goel Pulishing House, Meerut. 8. Organic Chemistry Vol. I, II and III by Mukharjee, Singh and Kapoor- Wiley Eastern. 9. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 10. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007) 11. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008). 12. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford Universitiy Press. 13. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism,			

	Kluwer Academic Publisher, (2000). 14. Organic Chemistry by S.K. Ghosh. 15. Reaction Mechanism in Organic Chemistry by S.M. Mukharjee and S.P. Singh. 16. Organic Chemistry by TWG Solomons, 8th edition, John Wiley 17. Organic Chemistry by R. K. Bansal **Web resources:** 1. https://www.masterorganicchemistry.com/reaction-guide/ 2. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Carboxylic_Acids 3. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Esters 4. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Amines
Model Questions:	**Short Type (At least 6) (1 Marks each)** 1) Write an example of ionization isomers in complexes. 2) Predict the geometry of $[Fe(H_2O)_6]^{2+}$ ion on the basis of VBT 3) Give the relationship between Δ_o and Δ_t. 4) Give the IUPAC name for the ester formed from acetic acid and ethanol. 5) Define the term 'Esterification'. 6) What is the action of heat on Lactic acid 7) What is the IUPAC name of the product obtained from the acetylation of aniline? 8) Why does the nitro group in nitrobenzene decrease the electron density of the benzene ring?
	Answer in brief (At least 6) (3 Marks each) 1) Write any three postulates of CFT. 2) Draw crystal field splitting diagram for octahedral geometry and tetrahedral geometry. 3) How is Lactic acid prepared from Pyruvic acid? 4) Explain the reaction of benzoic acid with ethanol and PCl5. 5) Write the Reimer-Tiemen reaction. 6) Explain the mechanism of the nitration of nitrobenzene. 7) Define Hoffmann's exhaustive methylation. What is the end product of this process? 8) What happens when aniline reacts with bromine in the presence of carbon disulphide.
	Answer in Detail (At least 4) (6 Marks each) 1) Discuss the factors affecting crystal field stabilization energy. 2) Explain the crystal field splitting in square planar geometry 3) Explain the reaction of oxalic acid with ethyl alcohol, ammonia and glycerol. 4) Explain acidic and basic hydrolysis of ester. 5) Discuss the reduction of nitrobenzene in detail under acidic, neutral, and alkaline conditions. 6) Explain the mechanism of Hoffmann's exhaustive methylation followed by Hoffmann elimination.
	MCQs for Internal Assessment (At least 4) 1. In which there is outer orbital hybridization? a) $[Zn(NH_3)_6]^{2+}$ b) $[Co(NH_3)_6]^{3+}$ c) $[Cr(NH_3)_6]^{3+}$ d) $[V(NH_3)_6]^{2.}$ $[Co(NH_3)_4Cl_2]NO_2$ and $[Co(NH_3)_4ClNO_2]Cl$ exhibit which type of isomerism? [MP PMT 1993] a) Geometrical b) Optical c) Linkage d) Ionization 3. Lactic acid contains which of the following functional groups? A) Only Carboxylic acid B) Carboxylic acid and Ketone C) Carboxylic acid and Hydroxyl D) Carboxylic acid and Aldehyde 4. Saponification is the: A) Acidic hydrolysis of an ester B) Basic hydrolysis of an ester C) Oxidation of an alcohol D) Dehydration of an acid 5. The reaction of Aniline with Benzoyl chloride is known as: A) Friedel-Crafts reaction B) Schotten-Baumann reaction C) Hoffmann reaction D) Perkin reaction 6. The Carbylamine reaction is performed by heating a primary amine with: A) $CHCl_3$ and alcoholic KOH B) CCl_4 and alcoholic KOH C) CHCl and alcoholic OH D) $CHCl_3$ and HCl

Course Category**: Minor Lab**

108256 Minor Chemistry Lab- 23

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108256**	**Minor Chemistry Lab- 23**	2	60	4 h	25+25= 50

Course Objectives:	1. To develop practical skills in gravimetric, volumetric, and complexometric analytical techniques for quantitative estimation of inorganic substances. 2. To provide hands-on training in qualitative analysis and identification of organic compounds containing mono- and bifunctional groups.
Course Outcomes:	1. Perform gravimetric and volumetric estimations using standard analytical procedures and appropriate indicators. 2. Apply complexometric titration techniques for estimation of metal ions in water, milk powder, fungicides, talcum powder, and other samples. 3. Carry out systematic qualitative analysis and identification of unknown organic compounds containing different functional groups. 4. Interpret preliminary tests, solubility behavior, and functional group reactions for characterization of organic compounds. 5. Analyze experimental data, perform analytical calculations accurately, and report results scientifically. 6. Demonstrate laboratory skills, safe handling of chemicals and instruments, and proper scientific documentation practices.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	1. Principles and steps involved in gravimetric analysis. 2. Concepts of precipitation, digestion, filtration, ignition, and weighing in gravimetry. 3. Selection and role of indicators in EDTA titrations (EBT, murexide, etc.). 4. Principles and applications of complexometric titrations in industrial and environmental analysis. 5. Classification and identification of organic compounds based on solubility behavior.	• Experiential and hands-on laboratory learning • Demonstration-based teaching for gravimetric, volumetric, and qualitative organic analysis techniques • Problem-based learning through analytical calculations and compound identification exercises • Inquiry-based learning for interpretation of observations and selection of suitable analytical procedures • Collaborative learning through group experiments and discussions • ICT-enabled teaching using virtual labs, digital flowcharts, and molecular visualization tools • Project-based learning through sample analysis and mini-projects • Peer learning and seminar presentations on analytical and organic chemistry methods • Outcome-based continuous assessment through laboratory performance, viva voce, assignments, and reports
Inorganic Experiments	**Gravimetric Analysis (at least One)** 1. Estimation of Ba2+ as BaSO4 2. Estimation of Fe3+ as Fe2O3 3. Estimation of Ni2+ as Ni-DMG. **Volumetric Estimations: (at least 5)** 1. Estimation of Zn(II) by complexometric titration. 2. To determine the strength of unknown calcium salt solution by complexometric titration. 3. Analysis of Talcum powder 4. Analysis of Iodine from Iodized salt. 5. Analysis of Calcium from milk powder/ limestone 6. Analysis of Cu from Cu-Fungicide. 7. Estimation of calcium and magnesium in water separately by complexometric titration 8. Estimation of nickel ions using EDTA 9. Estimation of cobalt ions by EDTA titration	
Organic Experiments	**Organic Qualitative analysis (at least 8)** Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc.	

Suggested Student Activities	• **Complexometric Titration Workshop:** Group activity on estimation of calcium, magnesium, zinc, nickel, and cobalt using EDTA titration methods. • **Organic Compound Identification Activity:**Students perform systematic qualitative analysis of unknown organic compounds and prepare identification flowcharts. • **Preparation of Functional Group Charts:**Groups prepare charts summarizing characteristic tests for carbohydrates, nitro compounds, amines, amides, aryl halides, and bifunctional compounds. • **Poster Presentation**

References	1. Vogel's Textbook of Practical Organic Chemistry, 5th Edition by B. S. Furniss, A. J. Hannaford, Peter W. G. Smith, A. R. Tatchell; Pearson. 2. Organic Chemistry: Laboratory Manual by R. K. Bansal, New Age International Publisher 3. Advanced Practical Organic Chemistry by N. K. Vishnoi, Vikas Publishing House 4. Practical Organic Chemistry by Mann & Saunders, Pearson 5. Practical Chemistry (for B.Sc. I, II and III year students) – O P Pandey, D. N. Bajpai and S. Giri (S Chand and company Ltd 6. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press. 7. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press. 8. Advanced practical Organic Chemistry: O P Agrawal **Web resources:** 1. **Royal Society of Chemistry (www.rsc.org/learn-chemistry) –** Free chemistry resources and lab techniques. 2. Organic Syntheses (www.orgsyn.org) – Peer-reviewed procedures for organic compound synthesis. 3. MIT OpenCourseWare: https://ocw.mit.edu 4. https://vlab.amrita.edu/?sub=2 5. https://chemcollective.org/vlabs
Model Questions:	**NA**

Distribution of Marks and the scheme of Practical Examination is as follows:

Section 1: Internal Assessment

- Active participation in activities 10 Marks
- Continuous Assessment Tests (CAT) (At least three tests) * 10 Marks
- Submission of duly certified practical record 05 Marks

Total **25 Marks**

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Section 2: External Assessment

- Exercise 1 (Inorganic Chem Practical) 10 Marks
- Exercise 2 (Organic Chem Practical) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **Vocational Skill Course VSC**

108257 Chemistry Lab- 24 (Water and Soil Analysis)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108257**	**Chemistry Lab- 24 (Water and Soil Analysis)**	2	60	4 Hrs	50

Course Objectives:	To develop practical skills in sampling, analysis, and quality assessment of water and soil using standard chemical methods for environmental and agricultural applications
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Perform sampling and preservation of water and soil samples using standard procedures. 2. Analyze important physicochemical parameters of water and soil. 3. Interpret analytical data for assessment of water quality and soil fertility. 4. Apply laboratory analytical skills in environmental monitoring and agricultural testing.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	1. Sampling and preservation of water samples 2. Collection and preparation of soil samples 3. Preparation of standard solutions.	To enhance student engagement and learning outcomes, the following pedagogical approaches will be incorporated: • **Experiential Learning (Hands-on Laboratory Work)** • **Inquiry-Based Learning** • **Collaborative Learning** a. Facilitate group-based experimental work to enhance teamwork and problem-solving skills. b. Conduct peer discussions on challenges and improvements in experimental procedures. • **Case-Based and Problem-Solving Approach** • **Assessment through Reflective Learning** a. Encourage students to maintain lab journals for recording observations and interpretations. b. Conduct oral presentations and report writing to develop scientific communication skills. • **Environmental Awareness Campaign** a. Students prepare posters/models on water pollution, soil degradation, and sustainable agriculture. b. Conduct awareness sessions within campus or nearby schools/villages.
Water Analysis	1. Determination of pH of water samples 2. Estimation of hardness of water by complexometric titration 3. Measurement of salinity of water samples 4. Estimation of total alkalinity of water samples (CO32-, HCO3-) using double titration method 5. Estimation of chloride content 6. Estimation of calcium in the given water sample 7. Determination of dissolved oxygen (DO) 8. Estimation of chemical oxygen demand (COD) / biological oxygen demand (BOD) 9. Measurement of Turbidity 10. Measurement of TDS in water samples	
Soil Analysis	1. Determination of soil pH 2. Determination of soil moisture content 3. Estimation of organic carbon in soil 4. Determination of available nitrogen in soil 5. Estimation of phosphate content 6. Estimation of potassium in soil 7. Measurement of Electrical conductivity of soil	
Suggested Group Activities	**1. Water Quality Survey Project** i. Students collect water samples from different sources (tap water, river, pond, borewell, etc.). ii. Analyze parameters such as pH, hardness, alkalinity, and chloride content. iii. Compare results with standard permissible limits and prepare a report **2. Soil Fertility Mapping** i. Groups collect soil samples from agricultural fields or gardens. ii. Analyze pH, moisture, organic carbon, and nutrient content. **iii.** Prepare a comparative soil fertility chart and suggest suitable crops/fertilizers	

References	5. Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3rdEd. ELBS (1964) 6. Vogel's textbook of quantitative chemical analysis, Sixth Ed. Mendham, Denny, Barnes, 7. Thomas, Pearson education Girard J, Principles of Environmental Chemistry, Jones Bartlett Learning, 20142. 8. Glasson, J., Therivel, R., Chadwick, A. 1994. Introduction to Environmental ImpactAssessment. London, Research Press, UK. 9. H.S. Peavy, D.R. Rowe & G. Tchobanoglous, "Environmental Engineering". McGraw HillInternational Edition.4. Jacob D. J, Introduction to Atmospheric Chemistry, Princeton, 200 10. Essential Oils: Extraction Methods and Applications by by Inamuddin, Tariq Altalhi, Jorddy Neves Cruz, Wiley-Scrivener **Web resources:** 1. **Royal Society of Chemistry (www.rsc.org/learn-chemistry) –** Free chemistry resources and lab techniques.
Model Questions:	**NA**

Distribution of Marks and the scheme of (VSC) Practical Examination is as follows:

Section I: Continuous Internal Assessment

- Continuous Assessment Tests (CAT) (At least three tests) * 15 Marks
- Submission of duly certified practical record 10 Marks

Total 25 Marks

Section II: End Semester Examination (Internal only)

- Exercise 1 20 Marks
- Viva-Voce (internal) 05 Marks

Total 25 Marks

Total (Section I And II) 50 Marks

*Note: Total Performance in CAT (i.e. 40 %) shall be based on the best two out of three in CAT examinations

Course Category: **Internship / Apprenticeship/ OJT**

108258 Internship / Apprenticeship/ OJT (On the Job Training)

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.5	VI	**108258**	**Internship / Apprenticeship/ OJT (On the Job Training)**	4	80	--	100

Course Objectives:	1. To provide hands-on training in chemistry-related industries, laboratories, and research organizations. 2. To expose students to industrial practices, instrumentation, quality control, and safety 2. procedures. 3. To enhance problem-solving, teamwork, communication, and technical skills. 4. To create awareness regarding entrepreneurship and employment opportunities in chemistry.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Apply theoretical chemistry concepts in practical and industrial environments. 2. Operate and understand basic analytical instruments and laboratory techniques. 3. Demonstrate professional ethics, laboratory safety, and teamwork. 4. Analyze chemical processes, observations, and experimental data effectively. 5. Prepare technical reports and communicate scientific findings professionally. 6. Explore employability and entrepreneurship skills in chemistry-related sectors.

Guidelines/ SoP for Internship / Apprenticeship/ OJT

For understanding key principles of Intrnship/Apprentiship/OJT operational guidelines and implementation strategy please refer

1. https://www.ugc.gov.in/pdfnews/2051511_Internship-Research-Internship-Guidelines.pdf
2. https://www.sgbau.ac.in/pdf/1092Internship%20Policy.pdf

As per NEP 2020, students of B Sc. III need to undertake Internship / Apprenticeship/ OJT for FOUR (4) credits i.e. 100 Marks.

The guidelines for Internship / Apprenticeship/ OJT are as follows:

2. **Credit: 04**
3. **Duration: 120 Hrs**
4. **Internship Period**: Ideally, the internship should be completed during the summer break between the second and third year. Students who are unable to complete the internship during this period must ensure its completion by the end of the VI semester, either in a part-time manner during Semester V, or during the Diwali break, or winter break or through an alternative arrangement subject to prior approval by the parent institution (University School/College).
5. **Internship Categories:**
   i. **Internship for enhancing the employability:** Employability is a set of skills and attributes developed through a range of experiences at workshops and workplaces.
   ii. **Internship for developing the research aptitude:** Research internship aims at providing hands-on training to work on research tools, techniques, methodologies, equipment, policy framework and various other aspects in pursuing quality research.
6. **Implementation and assessment**: For implementation and assessment of this vertical a separate SoP or relevant document that shall be provided by the University will be applicable.
7. These can be implemented through:
   1. Industries
   2. Research labs
   3. Government testing laboratories
   4. Colleges/departments
   5. MSMEs and startups
   6. Online/virtual internships with report and viva evaluation

Some suggested forms of Internship / Apprenticeship/ OJT are:

Laboratory and Analytical Training:

1. Water quality testing laboratory internship
2. Soil and fertilizer analysis training
3. Food and dairy testing laboratory apprenticeship
4. Edible oil analysis and quality control training
5. Pharmaceutical quality control laboratory training

6. Clinical pathology and diagnostic laboratory exposure
7. Environmental monitoring and pollution analysis internship
8. Industrial analytical chemistry laboratory training

Chemical Industry-Based OJT

1. Internship in chemical manufacturing units
2. Paint, dye, pigment, and polymer industry training
3. Soap, detergent, and cosmetic industry apprenticeship
4. Agrochemical and pesticide formulation training
5. Distillery, sugar, or fermentation industry exposure
6. Cement, ceramic, or glass industry laboratory training
7. Electroplating and metal finishing industry training

Research and Academic Exposure

1. Internship in university or research laboratories or premier institutes like IITs/IISERs etc.
2. Spectroscopy and instrumentation laboratory training
3. Computational chemistry or chemoinformatics training
4. Nanochemistry and material characterization exposure
5. Scientific documentation and laboratory management training

Entrepreneurship and Skill-Based OJT

1. Small-scale chemical product preparation: Oil, Soap, Sanitizer, Phenyl, Detergent, Herbal products etc.
2. Food preservation and quality analysis training
3. Entrepreneurship in chemical products and formulations
4. Laboratory chemical preparation and packaging training

References	https://www.ugc.gov.in/pdfnews/2051511_Internship-Research-Internship-Guidelines.pdf https://www.sgbau.ac.in/pdf/1092Internship%20Policy.pdf
Model Questions:	**NA**