SANT GADGE BABA AMRAVATI UNIVERSITY, AMRAVATI

Degree of Bachelor of Science

Chemistry

Semester III and IV

FACULTY: SCIENCE AND TECHNOLOGY

(Courses effective from Academic Year 2025-26)
Under NEP 2020

SYLLABUS

Credits, Workload, Examination, Evaluation and Assessment Scheme
Semester – III (Chemistry)

Subject	The Vertical	Course Code	Course Title	Credits	Workload	Theory/Practical				Theory/Pract (Total)	
						External		Internal			
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks
Chemistry	Major-T5	108211	**General Chemistry-3**	2	2	30	9	20	6	50	20
Chemistry	Major-T6	108212	**Inorganic Chemistry-1**	2	2	30	9	20	6	50	20
Chemistry	IKS-T	108213	**IKS in Chemistry**	2	2	30	9	20	6	50	20
Chemistry	Major-P	108214	**Chemistry Lab 6**	2	4	25	10	25	10	50	20
Chemistry	Minor-T	108215	**Minor Chemistry-1**	2	2	30	9	20	6	50	20
Chemistry	Minor-P	**108216**	**Minor Chemistry Lab 7**	2	4	25	10	25	10	50	20
Chemistry	GOEC-T	108217	**Chemistry for Competitive Examinations**	2	2	30	9	20	6	50	20
Chemistry	VSC-P	**108218**	**Chemistry Lab -8 (Preparation of Commercial products)**	2	4	-	-	50	20	50	20
Chemistry	FP/CES	**108219**	**Chemistry Lab 9 (FP/ CEP in Chemistry - I)**	2	4	-	-	50	20	50	20
Chemistry	CC		Separate SOP will be released	2	4	-	-	50	20	50	20

Credits, Workload, Examination, Evaluation and Assessment Scheme
Semester – IV (Chemistry)

Subject	The Vertical	Course Code	Course Title	Credits	Workload	Theory/Practical				Theory/Pract (Total)	
						External		Internal			
						Max. Marks	Min. Marks	Max. Marks	Min. Marks	Max. Marks	Min. Marks
Chemistry	Major-T9	108220	**Organic Chemistry-1**	2	2	30	9	20	6	50	20
Chemistry	Major-T10	108221	**Physical Chemistry-1**	2	2	30	9	20	6	50	20
Chemistry	Major-P	108222	**Chemistry Lab 10**	2	4	25	10	25	10	50	20
Chemistry	Minor-T	108223	**Minor Chemistry 2**	2	2	30	9	20	6	50	20
Chemistry	Minor-P	**108224**	**Minor Chemistry Lab 11**	2	4	25	10	25	10	50	20
Chemistry	GOEC-T	108225	**Chemistry for Sustainable Agriculture**	2	2	30	9	20	6	50	20
Chemistry	VSC-P	**108226**	**Chemistry Lab 12 (Synthesis and extraction of industrial products)**	2	4	-	-	50	20	50	20
Chemistry	SEC-P	**108227**	**Chemistry Lab 13 (Basic Cheminformatics)**	2	4	-	-	50	20	50	20
Chemistry	FP/CES	**108228**	**Chemistry Lab 14 (FP/ CEP in Chemistry - II)**	2	4	-	-	50	20	50	20
Chemistry	CC		Separate SOP will be released	2	4	-	-	50	20	50	20

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

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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	9	20	6	50	20	25	10	25	10	50	20
b	Minor		30	9	20	6	50	20	25	10	25	10	50	20
c	Generic/ Open Elective		30	9	20	6	50	20	--	--	--		--	--
d	VSC	Internal	--	--	--	--	--	--	--	--	50	20	50	20
	SEC	Internal	--	--	--	--	--	--	--	--	50	20	50	20
e	AEC (Eng. & One MIL Composite)	External & Internal	30	9	20	6	50	20	--	--	--	--	--	--
	IKS (Generic)	External & Internal	30	9	20	6	50	20	--	--	--	--	--	--
	VEC	External & Internal	30	9	20	6	50	20	--	--	--	--	--	--
F	FP/CEP	Internal	--	--	--	--	--	--	--	--	50	20	50	20
	Internship/ Apprenticeship		Assessment of these verticals shall be based on various activities/practices. It shall be evaluated by giving maximum marks of 50 per 2 Credit Course with separate activity weightages/levels. A detailed SOP for this assessment process is prescribed for Phase I and Phase II											
	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 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.

Sant Gadge Baba Amravati University, Amravati
FACULTY: Science and Technology
Teaching and Learning Scheme: for the Degree of Bachelor of Science (Chemistry)
(Three Years- Six Semesters Bachelor's Degree Programme)
SECOND YEAR: SEMESTER – III

Mode of Teaching	Vertical No.	The Vertical	Type of Course	Course Code	Course Name	Credits	Workload (Hrs/Wk)	Vertical Workload (Hrs/Week)
Classroom Teaching / Lab Work (Practical)/ Outdoor / Field	a	Major	Theory5	108211	**General Chemistry-3**	2	2	**10**
			Theory6	108212	**Inorganic Chemistry-1**	2	2	
			Theory	108213	**IKS in Chemistry**	2	2	
			Lab/ Practical-6	108214	**Chemistry Lab 6**	2	4	
	b	Minor	Theory7	108215	**Minor Chemistry-1**	2	2	**6**
			Lab/ Practical-7	**108216**	**Minor Chemistry Lab 7**	2	4	
	c	**Generic/ Open Elective**	**Theory 8**	108217	**Chemistry for Competitive Examinations**	**2**	**2**	**2**
	d	**VSC**	**Lab/ Practical-8**	**108218**	**Chemistry Lab -8 (Preparation of Commercial products)**	**2**	**4**	**4**
		SEC	-	-	-	-	-	
	e	AEC - English	Theory			1	1	**2**
		AEC – MIL	Theory			1	1	
		IKS- Generic	Theory	-	-	-	-	
		VEC	Theory					
	f	FP/CES	Project	**108219**	**Chemistry Lab 9 (FP/ CEP in Chemistry - I)**	**2**	**4**	**4**
		CC	**Outdoor**			**2**	**4**	**4**
		TOTAL				**22**	**32**	**32**

SECOND YEAR: SEMESTER – IV

Mode of Teaching	Vertical No.	The Vertical	Type of Course	Course Code	Course Name	Credits	Workload (Hrs/Wk)	Vertical Workload (Hrs/Week)
Classroom Teaching / Lab Work (Practical)/ Outdoor / Field	a	Major	Theory 9	108220	**Organic Chemistry-1**	2	2	**8**
			Theory10	108221	**Physical Chemistry-1**	2	2	
			Lab/ Practical-10	108222	**Chemistry Lab 10**	2	4	
	b	Minor	Theory 11	108223	**Minor Chemistry 2**	2	2	**6**
			Lab/ Practical-11	**108224**	**Minor Chemistry Lab 11**	2	4	
	c	GE/OE	**Theory 12**	108225	**Chemistry for Sustainable Agriculture**	**2**	**2**	**2**
	d	**VSC**	**Lab/ Practical-12**	**108226**	**Chemistry Lab 12 (Synthesis and extraction of industrial products)**	**2**	**4**	**8**
		SEC	**Lab/ Practical-13**	**108227**	**Chemistry Lab 13 (Basic Cheminformatics)**	**2**	**4**	
	e	AEC - English	Theory			1	1	**2**
		AEC – MIL	Theory			1	1	
		IKS- Generic	Theory					
		VEC	Theory					
	f	FP/CES	Project	**108228**	**Chemistry Lab 14 (FP/ CEP in Chemistry - II)**	**2**	**4**	**4**
		CC	**Outdoor**			**2**	**4**	**4**
		TOTAL				**22**	**34**	**34**

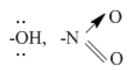
Course Category: **Major (Theory)**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	III	108211	General Chemistry-3	2	30	2 Hrs	30+20=50

Course Objectives:	1. Students will learn Fundamentals of organic chemistry and functional group approach for hydrocarbons. 2. To make the students proficient in thermodynamic principles and their mathematical formulations, preparing them for advanced studies in physical chemistry 3. To equip the students with a comprehensive understanding of colligative properties, enabling them to apply theoretical concepts and experimental techniques to real-world chemical systems.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Compare the reactivity of Hydrocarbons. 2. Explain the mechanisms of E1, E2, and E1cB reactions. 3. Rationalize for regioselectivity in addition and elimination reactions 4. Describe the structure of benzene and its stability 5. Write the mechanism of ArES reactions 6. Predict and rationalize the directive influence of a group in ArES. 7. Derive and apply Gibbs-Helmholtz equation, Gibbs-Duhem equation and Van't Hoff's reaction isotherm to real-world chemical processes 8. Define Colligative Properties and associated terms 9. Apply Thermodynamic Principles to Colligative Properties 10. Solve numerical related to Thermodynamics and Colligative properties.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	***Aliphatic Hydrocarbons:*** ***A) Alkanes****:* Formation of alkanes, Wurtz Reaction, Wurtz- Fittig ReactIions, Free radical substitutions: Halogenation - relative reactivity and selectivity. ***B) Alkenes:*** Formation of alkenes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), Reactions of alkenes: Oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-& 1,4-addition reactions in Dienes, Diels-alder reaction. Allylic and benzylic bromination. ***C) Alkynes:*** Preparation of alkynes: by Double Dehydrohalogenation of vicinal and germinal dihalides. Acidity of terminal alkynes. Reactions: Addition of halogens, hydrogen halides and hydration	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
Unit II	***A) Arenes:*** Introduction**,** derivatives of benzene and their nomenclature (mono, di and tri substituted benzenes). Structure of benzene: Kekules, Resonance Structures, and Molecular orbital picture. ***B)*** **Reactivity of benzene**: Mechanism of Electrophilic substitution reactions: Nitration, Sulphonation, Nuclear Halogenation and Friedel - Crafts reaction with mechanism, oxidation of side chain, reduction of benzene.	7 Hrs	7 Marks	

	Orientation Effect: Effects of substituent groups (o/p and meta directing groups), activating and deactivating groups. Directive influence of various groups (-OH, CH_3, - Cl, $-NO_2$) on the basis of modern electronic theory. ***C)*** **Polynuclear Hydrocarbons:** Definition and Classification **Naphthalene:** Haworth Synthesis. Resonance structure and Molecular orbital picture of Naphthalene. Orientation of Electrophilic Substitution in Naphthalene. **Chemical Reactions-** Electrophilic substitution reaction: Halogenation, Nitration, Sulphonation, Friedel-Crafts Alkylation, Friedel-Crafts Acylation, Chloro-methylation			relationships between different concepts. 7. **Inquiry-Based Learning:** Explore topics 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	**Thermodynamics:** Introduction, Important terms: Gibbs and Helmholtz free energy (Work function). Physical significance of Gibbs free energy and Helmholtz free energy, Derivation of variation of Gibbs free energy with temperature and Pressure, Derivation of variation Helmholtz free energy with temperature and volume, Change in free energy as a criterion of spontaneity and equilibrium, Derivation of Gibbs-Helmholtz equation and its applications, Nernst heat theorem, Statement of third law, Chemical potential or partial molar free energy, Derivation of Gibb's-Duhem equation, Derivation of Vant Hoff's reaction isotherm, Numerical.	8 Hrs	8 Marks	
Unit IV	**Colligative Properties of Dilute Solutions:** Introduction, Important terms: Colligative properties, Lowering of Vapor pressure, Relative lowering of vapor pressure, Elevation of boiling point, Depression of freezing point and Osmotic pressure. Importance and applications of colligative properties. Rault's law of relative lowering of vapor pressure. **Elevation of boiling point**: Thermodynamic derivation of the relationship between elevation of boiling point and the molar mass of non-volatile solute. Cottrell's method for the determination of elevation of boiling point and hence the molar mass of solute. **Depression of freezing point**: Thermodynamic derivation of the relationship between depression of freezing point and the molar mass of non-volatile solute. Rast's method for the determination of molar mass of solute. **Osmotic Pressure, and osmosis**: Determination of Molecular weight of solute by osmotic pressure. Isotonic solutions. **Abnormal behavior of solution:** Vant Hoff's factor 'i'. Determination of degrees of association and degree of dissociation from Van't Hoff's factor. Numericals.	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. 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 TWG Solomons, 8th edition, John Wiley 11. Organic Chemistry by R. K. Bansal			

	12. Physical Chemistry: Walter, J. Moore, 5th edn., New Delhi. 13. Physical Chemistry: G.M. Barrow, McGraw Hill, Indian Edn. 14. Principles of Physical Chemistry: Maron and Prutton. 15. Principles of Physical Chemistry: Puri, Sharma, and Pathania. 16. Physical Chemistry: P.W. Atkins, 6th Edn. 17. Physical Chemistry: Levine **Web resources:** 1. Introductory Organic Chemistry I- https://nptel.ac.in/courses/104106119 2. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Hydrocarbons/Arenes 3. https://nowgonggirlscollege.co.in/attendence/classnotes/files/1631169122.pdf 4. https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Basic_Principles_of_Organic_Chemistry_(Roberts_and_Caserio)/22%3A_Arenes_Electrophilic_Aromatic_Substitution/22.08%3A_Substitution_Reactions_of_Polynuclear_Aromatic_Hydrocarbons 5. https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Chemistry_-_The_Central_Science_(Brown_et_al.)/19%3A_Chemical_Thermodynamics 6. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/The_Live_Textbook_of_Physical_Chemistry_(Peverati)/14%3A_Properties_of_Solutions/14.02%3A_Colligative_Properties
Model Questions:	**Short Type (At least 8)** 1. Arrange the following in increasing order of boiling point. (i) n-pentane, (ii) isopentane and (iii) neopentane 2. Comment on Saytzeff rule 3. Comment on Hofmann elimination reaction 4. Define activating group. 5. Name the intermediate involved in ArES. 6. Which of the following groups are ortho-para directing and meta directing? -COOH, -CHO, $-CH_3$, $-NH_2$, -Cl, $-SO_3H$  7. Define Gibbs Free energy 8. Define boiling point 9. What is Vant Hoff's factor?
	Long Type (At least 4) 1. Explain the Formation of alkanes using Wurtz Reaction, Wurtz- Fittig Reactions, 2. Explain Mechanism of E_1, E_2 and E_1cB reactions with suitable example. 3. Explain the acidity of terminal hydrogen in alkyne. 4. What are ring activating and ring deactivation groups? Explain with suitable examples. 5. Discuss the mechanism of acetylation of benzene 6. How does benzene react with - i) H_2 in presence of nickel catalyst ii) Cl_2 in presence of halogen carrier iii) Conc. HNO_3 and Conc. H_2SO_4 iv) CH_3Cl in presence of anhydrous $AlCl_3$ 7. How will you obtain the following from benzene? i) Toluene ii) Acetophenone iii) Chlorobenzene iv) Nitrobenzene. 8. Derive Gibbs-Helmholtz equation. 9. Derive Gibb's-Duhem equation 10. Derive Vant Hoff's reaction isotherm
	MCQs for Internal Assessment (At least 8) 1. The addition of HBr on 2-butene in presence of peroxide follows (a) Electrophilic addition **(b) Free radical addition** (c) Nucleophilic addition (d) None of these 2. During debromination of meso-dibromobutane, the major compound formed is (a) n-butane (b) 1-butene (c) cis-2-butene **(d) trans-2-butene** 3. Toluene on reaction with Cl_2 in presence of $FeCl_3$ gives predominantly- a) Benzoyl chloride b) Benzyl chloride c) o- and p- chloro toluene d) m-chlorotoluene 4. Which of the following is o-p directing group? a) $-NH_2$ b) –CN c) –CHO d) $-NO_2$ 5. Chlorine substituent is_____. a) o,p- directing b) m-directing c) both (a) and (b) d) None of these 6. Benzene on reduction with sodium in liquid ammonia gives. a) Cyclohexane b) n-hexane c) 1, 4 cyclohexadiene d) 1, 4 hexadiene 7. Naphthalene preferably undergoes ArES at___position. a) 1 b)2 c)3 d)1 or 2 8. For a reaction to occur spontaneously a) $\Delta G < 0$ b) $\Delta G > 0$ c) $\Delta S < 0$ d) $\Delta H = 0$ 9. In association of solute, the Van't Hoff factor is __ a) 1 b) >1 c) <1 d) zero 10. In dissociation of solute, the Van't Hoff factor is __ a) 1 b) >1 c) <1 d) zero

Course Category: **Major (Theory)**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	III	108212	Inorganic Chemistry-1	2	30	2 Hrs	30+20=50

Course Objectives:	1. To develop a comprehensive understanding of bonding theories and are able to apply theoretical principles to analyze and predict molecular structures. 2. To develop the fundamental theoretical understanding of quantitative chemistry
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Describe Born-Haber's cycle. 2. Predict molecular geometries using hybridization 3. Predict shapes of molecules and ions using VSEPR theory 4. Explain core postulates of MO theory and apply the LCAO approximation to construct bonding and antibonding orbitals. 5. Construct and interpret MO energy level diagrams for diatomic molecules and calculate bond orders and predict magnetic properties. 6. Define the mole in terms of mass, volume, and number of particles. 7. Solve problems on concentrations (molarity, normality, molality, mole fraction). 8. Explain the requirements for standard solutions and primary standard substances. 9. Explain the terms like titrant, titrate, endpoint, equivalence point, and indicators in volumetric analysis.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Ionic bonding:** Definition of ionic bond, Factors affecting ionic bond formation (energetic of ionic bond formation ionization energy, electron affinity and lattice energy). Born-Haber's cycle to determine lattice energy. **Covalent bonding:** Directional nature of covalent bond. Valance Bond Theory (VBT), Limitations of VBT, Hybridization, Need of Hybridization, Types of hybridization to explain geometries of $BeCl_2$, BF_3, CH_4, $PC1_5$, SF_6 and IF_7.	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**
Unit II	**VSEPR Theory:** Postulates of Valence Shell Electron Pair Repulsion (VSEPR) theory. Prediction of shapes of following species: $BeCl_2$, BF_3, CH_4, NH_4^+, PCl_5, SF_6, IF_7, $SnCl_2$, NH_3, H_2O, PCl_3, SF_4, SF_2, ClF_3, BrF_5, CO_2, SO_2, XeF_6, XeF_4, & XeF_2. Limitations of VSEPR theory.	7 Hrs	7 Marks	
Unit III	**Molecular Orbital (MO) Theory**. Postulates of MO theory. LCAO approximation Method, Rules for LCAO for the formation of bonding and antibonding MOs. MO energy level diagram of homonuclear diatomic molecules namely H_2, He_2, N_2 and O_2, with bond order and magnetism. Stability sequence of species of O2 i.e. O_2, O_2^+, O_2^{2+}, O_2^- and O_2^{2-} on the basis of bond order. MO structure of CO (Coulson's structure) and NO.	8 Hrs	8 Marks	
Unit IV	**A) The mole concept** Definition of mole in terms of mass, volume and number of particles. Avogadro's law, Atomic mass, average atomic mass and Molar Mass, Terms to express concentrations of solutions namely- molarity, normality, molality, mole fraction (Simple numerical expected). **B] Volumetric Analysis:** Important terms: titrant, titrate, end point, equivalence point, indicator, etc.	7 Hrs	7 Marks	

	Requirements and advantages of volumetric analysis. Definition of standard solution, Primary standard substance and its requirements			**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, Goel Pulishing House, Meerut.

Web resources:

1. https://wou.edu/chemistry/courses/online-chemistry-textbooks/ch105-consumer-chemistry/chapter-3-ionic-covelent-bonding/
2. https://gchem.cm.utexas.edu/bonding/index.php
3. https://chem.libretexts.org/Courses/East_Tennessee_State_University/CHEM_3110%3A_Descriptive_Inorganic_Chemistry/03%3A_Bonding_Theories?
4. https://courses.lumenlearning.com/suny-mcc-introductorychemistry/chapter/formula-mass-and-mole-concept-from-che100/?
5. https://chemistry.coach/general-chemistry-1/
6. MIT OpenCourseWare: https://ocw.mit.edu
7. Royal Society of Chemistry (RSC): https://www.rsc.org/learn-chemistry

Model Questions:

Short Type (At least 8)

1. Define ionic bond
2. What is lattice energy?
3. Identify the hybridization of central atom in the following: $BeCl_2$, BF_3, CH_4, $PC1_5$, SF_6 and IF_7
4. Predict the of shapes of following species (any one): $BeCl_2$, BF_3, CH_4 , NH_4^+, PCl_5, SF_6, IF_7, $SnCl_2$, NH_3, H_2O, PCl_3, SF_4, SF_2, ClF_3, BrF_5, CO_2, SO_2, XeF_6, XeF_4, & XeF_2,
5. What is the bond order in (any one) O_2, O_2^+, O_2^{2+}, O_2^- and O_2^2
6. Sate Avogadro's law
7. What is standard solution?
8. Name any two primary standard acids.

Long Type (At least 4)

1. Describe Born-Haber's cycle to determine lattice energy
2. Explain geometries of (any one) $BeCl_2$, BF_3, CH_4, $PC1_5$, SF_6 and IF_7 using concept of hybridization**.**
3. Predict of shapes of following species (any one): $BeCl_2$, BF_3, CH_4 , NH_4^+, PCl_5, SF_6, IF_7, $SnCl_2$, NH_3, H_2O, PCl_3, SF_4, SF_2, ClF_3, BrF_5, CO_2, SO_2, XeF_6, XeF_4, & XeF_2 using VSEPR theory
4. Explain MO energy level diagram of (any one) N_2, O_2, CO and calculate its bond order.
5. Calculate the normality of 0.1 M H_2SO_4
6. Calculate the mole fractions of H_3PO_4 and water in a solution of 14.5 g of H_3PO_4 in 125 g of water?

MCQs for Internal Assessment (At least 8)

1. The hybridization of P in $PC1_5$__
   a) sp3 b) sp3d c) sp3d2 d) sp2
2. The hybridization of S in SF_6 is___
   a) sp3 b) sp3d c) sp3d2 d) sp2
3. The hybridization of I in IF_7 is —
   a) sp3 b) sp3d3 c) sp3d2 d) sp2
4. According to VSEPR theory, the shape of NH_3 is__
   a) Tetrahedral b) pyramidal c) trigonal bipyramidal d) trigonal planar
5. According to VSEPR theory, the shape of SF_4 is _
   a) Tetrahedral b) pyramidal c) 'see-saw' shaped d) trigonal planar
6. According to VSEPR theory, the shape of SO_2, is__
   a) 'V' shaped b) pyramidal c) 'see-saw' shaped d) trigonal planar
7. According to VSEPR theory, the shape of XeF_4 is_
   a) Tetrahedral b) square planar c) 'see-saw' shaped d) trigonal planar
8. The mole is used in chemistry to represent ____of something
   a) 6.022×10^{23} b) 6.23×10^{23} c) 8.022×10^{23} d) 6.022×10^{32}

Course Category: **Major (Theory)**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	III	108213	Indian Knowledge System in Chemistry	2	30	2 Hrs.	30+20=50

Course Objectives:	To help the students to bridge the gap between ancient Indian chemical knowledge and modern scientific inquiry, providing them a holistic understanding of the subject.
Course Outcomes:	Upon completion of this course, students will be able to: 1. Explain the importance and scope of IKS in chemistry. 2. Describe the knowledge about the Indian scholars and their contribution to chemistry. 3. Analyze vedic metallurgical techniques and their impact on material sciences. 4. Explore the chemistry behind natural dyes and pigments used in historical contexts. 5. Describe different chemical processes used in ancient chemistry. 6. Rationalize the knowledge of plant used in Ayurveda and its chemical composition. 7. Compare various apparatus and different methods used in ancient and modern chemistry. 8. Evaluate the relevance of ancient chemical knowledge in contemporary scientific research.

Unit	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**A) Introduction to Indian Alchemy (Rasa Shastra)** Overview of alchemy in ancient India and its evolution: Vedic Chemistry and the terms used therein., Overview of Indian Chemistry in post Vedic period. CSIR National Chemical Laboratory: History and milestones. **B) Indian Scholar in Chemistry and Indian literature** Contributions of ancient and medieval Indians in the area of chemistry**:** Nagarjuna, Maharshi Kanada, Prafulla Chandra Ray, CNR Rao, Har Gobind Khorana, Govardhan Mehata, Shanti Swarup Bhatnagar and Venkataraman Ramakrishnan	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,
Unit II	A) Concepts of acid and bases in Indian chemistry from organic fruit, vegetable-based. acids, plant-ash-based bases to mineral acids of the medieval period. B) Chemistry of dyes, pigments, and other coloring materials used in paintings, fabrics, beads, and other day-to-day utilities since ancient times and their constant evolution through different periods of time.	7 Hrs	7 Marks	
Unit III	A) Vedic Metallurgy- Introduction, Sources of Vedic metallurgy (Rigveda, Yajurveda, Atharvaveda), Metal known to Vedic Indian (Copper, Iron, Lead, Zinc, Gold and Silver). B) Processing of gold, silver, copper, iron, tin, mercury, lead and zinc as mentioned in the Indian texts in the ancient and medieval period. Zinc distillation as	8 Hrs	8 Marks	

	mentioned in Rasārṇava and Rasaratnasamukāyā. C) Metallurgical processes (smelting, alloying, Forging, Casting), Application of Vedic Metallurgy.			investigation, and research. **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit IV	**Introduction to traditional Indian System of medicine** Definition of Ayurvedic Drugs, Classification of Ayurvedic Drugs, Plant parts used in Ayurveda, Good Agricultural Practices, Methods of extraction, purification and formulation processes. Chemical procedures- Distillation, sublimation, alloying, purifying substances as described in Indian scriptures (Ancient apparatus and methods of chemical processes). Unique Traditional Practices in Ayurveda and Applied Traditional Knowledge, traditional guideline & regulations.	7 Hrs	7 Marks	
References:	1. R.M. Pujari, Pradeep Kolhe, N. R. Kumar, 'Pride of India: A Glimpse into India's Scientific Heritage', Samskrita Bharati Publication. 2. 'Indian Contribution to science', compiled by Vijnana Bharati. 3. A Concise History of Science in India, ed. D M Bose, S N Sen and B V Subbarayappa; INSA; 2009 4. Science and Technology in Medieval India - A Bibliography of Source Materials in Sanskrit, Arabic and Persian by A Rahman, M A Alvi, S A Khan Ghori and K V Samba Murthy; 1982. 5. Science and Technological Exchanges between India and Soviet Central Asia (Medieval Period), ed B V Subbarayappa;1985 6. Scientific and Technical Education in India, 1781-1900 by S N Sen; 1991 7. History of Technology in India, Vol. I, ed. A K Bag (1997); Vol III, ed. K V Mital (2001); Vol-II by Harbans Mukhia (2012). 8. AcharyaPrafulla Chandra Ray, A History of Hindu Chemistry, 1902, republ., Shaibya Prakashan Bibhag, centenary edition, Kolkata, 2002 9. R. Balasubramaniam, Delhi Iron Pillar: New Insights, Indian Institute of Advance Study, Shimla & Aryan Books International, New Delhi, 2002 10. R. Balasubramaniam, Marvels of Indian Iron through the Ages, Rupa& Infinity Foundation, New Delhi, 2008. 11. Mahadevan, B., Bhat, V. R., & Nagendra, P. R. N. (2022). *Introduction to Indian Knowledge System: Concepts and Applications*. PHI Learning Pvt. Ltd. 12. Kapoor, K., & Singh, A. (2021). *Indian Knowledge Systems* (Vols. I & II). Indian Institute of Advanced Study. 13. Frawley, D., & Ranade, S. (2001). *Ayurveda, Nature's Medicine*. Lotus Press. 14. Dharmapal. (1971). *Indian Science and Technology in the Eighteenth Century*. Other India Press. **Web resources:** 1. Vedic Chemistry: https://www.puranavedas.com/vedic-chemistry/ 2. Indian Alchemy as a yogic practices: https://youtu.be/ozuT0Az9_Lk 3. Savrikar, S. S., & Ravishankar, B. (2011). Introduction to 'Rasashaastra' the Iatrochemistry of Ayurveda. *African journal of traditional, complementary, and alternative medicines: AJTCAM*, *8*(5 Suppl), 66–82. https://doi.org/10.4314/ajtcam.v8i5S.1 https://artsandculture.google.com/story/rasashala-ancient-indian-alchemical-lab-national-council-of-science-museums/VAVBaP1RF0y-KQ?hl=en 4. CSIR NCL:https://www.ncl-india.org/files/AboutNCL/HistoryMilestones/Default.aspx.			
Model Questions:	**Short Type (At least 8)** 1. What is the significance of Vedic chemistry in the evolution of Indian alchemy? 2. How did Nagarjuna influence the development of Indian chemistry? 3. How did Prafulla Chandra Ray contribute to inorganic chemistry? 4. Explain the role of Ayurveda in shaping early chemical practices in India. 5. How were plant ashes utilized to produce alkaline substances in early Indian chemistry? 6. How was lime (calcium hydroxide) used as a base in ancient India?			

	7. What are the key differences between organic and mineral pigments used in Indian paintings? 8. How did ancient Indian artisans ensure the durability of their pigments on paintings and fabrics? 9. How was gold processed in ancient India according to Vedic texts? 10. What were the primary applications of lead in Vedic metallurgy? 11. What role did mercury play in alchemical processes in medieval India? 12. What were the key metallurgical techniques used for iron processing in ancient India? 13. What is the definition of Ayurvedic drugs? 14. What is the significance of purification in Ayurvedic formulations? 15. What is the role of distillation in Ayurvedic medicine preparation? 16. What are some purification techniques described in Indian scriptures? 17. What are the key principles of formulation in Ayurveda? 18. How do traditional guidelines ensure the efficacy of Ayurvedic medicines? 19. How are Ayurvedic drugs classified? 20. Name three plant parts commonly used in Ayurveda.
	Long Type (At least 4) 1. Explain how modern Indian scientists like CNR Rao and Venkatraman Ramakrishnan have contributed to global chemistry. 2. What are the key contributions of Indian chemists to global scientific advancements? 3. Describe the evolution of Indian chemistry from the Vedic period to the post-Vedic period. 4. Explain the role of plant ash in the production of bases and its applications in ancient Indian industries. 5. Describe the chemistry behind natural dye extraction and how Indian artisans perfected the dyeing process over centuries. 6. Discuss the significance of indigo dye in Indian history and its chemical composition. 7. Discuss the contributions of Rigveda, Yajurveda, and Atharvaveda in shaping early Indian metallurgy. 8. Describe the role of gold and silver in ancient Indian economy and craftsmanship 9. Explain the role of Rasārṇava and Rasaratnasamukāyā in documenting metallurgical advancements. 10. Discuss the importance of Good Agricultural Practices (GAP) in Ayurveda for ensuring medicinal plant quality. 11. Analyze the role of distillation, sublimation, and alloying in the Ayurvedic system of medicine. 12. Discuss the significance of applied traditional knowledge in the evolution of Indian medicine.
	Multiple Choice Questions (MCQ): (At least 8) 1. Which ancient Indian text extensively discusses Rasa Shastra? a) Charaka Samhita b) Sushruta Samhita c) Rasaratnakara d) Arthashastra 2. Who among the following is known as the "Father of Indian Chemistry"? a) Prafulla Chandra Ray b) Nagarjuna c) CNR Rao d) Har Gobind Khorana 3. Maharshi Kanada is known for proposing which of the following concepts in chemistry? a) Atomic theory b) The periodic table c) The structure of DNA d) Thermodynamics 4. Which Indian scientist is known for his pioneering work in solid-state and materials chemistry? a) CNR Rao b) Prafulla Chandra Ray c) Har Gobind Khorana d) Govardhan Mehta 5. Which of the following natural substances was traditionally used as a source of acid in ancient Indian chemistry? a) Tamarind b) Turmeric c) Ashwagandha d) Sandalwood

	6. Which mineral acid was commonly prepared and used in medieval Indian alchemy? a) Nitric acid b) Sulfuric acid c) Hydrochloric acid d) All of the above 7. Which of the following traditional Indian substances is **not** acidic? a) Lemon juice b) Tamarind extract c) Turmeric paste d) Amla juice 8. The blue dye extracted from Indigofera tinctoria is chemically classified as: a) A flavonoid b) A carotenoid c) An organic nitrogen compound d) A polysaccharide 9. What was the primary source of black ink in ancient Indian manuscripts? a) Charcoal and gum b) Indigo extract c) Hematite powder d) Copper sulfate 10. The Rasaratnasamukāyā and Rasārṇava texts provide detailed knowledge about the distillation of which metal? a) Copper b) Iron c) Zinc d) Gold 11. The lost-wax casting technique (used for making metal sculptures) was widely practiced in: a) Vedic period b) Harappan civilization c) Medieval India d) Modern India 12. Which alloy, widely used in ancient Indian metallurgy, is a mixture of copper and tin? a) Brass b) Bronze c) Pewter d) Bell metal

Course Category: **Major Lab**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	III	108214	Chemistry Lab 6	2	60	4 h	25+25= 50

Course Objectives:	1. To develop a strong conceptual understanding of fundamental principles in Inorganic and Physical Chemistry through hands-on experimental work. 2. To enhance analytical and problem-solving skills by applying theoretical knowledge to laboratory-based tasks, including synthesis, titration, calorimetry, and cryoscopic measurements.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. **Predict Molecular Structures & Bonding** – Visualize and predict molecular geometries using VSEPR theory and molecular orbital concepts. 2. **Analyze Buffer Systems** – Prepare buffer solutions and compare theoretical vs. experimental pH values. 3. **Apply Stoichiometry in Quantitative Analysis** – Utilize the mole concept and volumetric analysis for determining unknown concentrations in chemical mixtures. 4. **Perform Redox Titrations** – Accurately determine iron (Fe^{2+}) and oxalate concentrations using standard solutions of $KMnO_4$ and $K_2Cr_2O_7$. 5. **Synthesize and Characterize Inorganic Compounds** – Prepare and confirm synthesized inorganic compounds through qualitative tests. 6. **Evaluate Thermodynamic Parameters** – Calculate enthalpy changes for various chemical processes, including neutralization and ionization reactions. 7. **Determine Molecular Properties** – Use cryoscopic and refractive index methods to find molecular weights and association behavior in solutions. 8. **Enhance Lab Safety and Documentation Skills** – Follow proper laboratory safety protocols and accurately record experimental data for interpretation and reporting.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	1. Molecular Structure and Bonding: Apply VSEPR theory using molecular models to predict geometries. Construct MO diagrams to determine bond order and magnetic properties of diatomic molecules. 2. Buffer Preparation and Quantitative Analysis: Prepare and analyze acetate buffer solutions. Perform volumetric estimations of acid-base mixtures and synthesize inorganic compounds, confirming identities through qualitative tests. 3. Thermochemistry and Phase Transitions: Measure enthalpy changes using calorimetry. Determine transition temperatures of salts and analyze phase behavior. 4. Molecular Properties and Determinations: Determine molecular weights via cryoscopy. Measure refractive indices and calculate molar refraction. Study solubility variations with temperature.	• **Experiential Learning:** Hands-on experimentation using molecular model kits facilitates understanding of VSEPR geometries. Synthesis and qualitative confirmation of inorganic compounds enhance practical skills, while titrations and calorimetric measurements reinforce theoretical concepts. • **Inquiry-Based Learning:** Students hypothesize molecular structures and validate predictions using models. Discrepancies in experimental pH values of buffer solutions are analyzed, fostering critical thinking. Investigation of phase transitions and enthalpy changes promotes a deeper understanding of thermodynamic principles. • **Collaborative Learning:** Group-based synthesis and titration experiments encourage teamwork and peer learning. Discussions on molecular orbital theory and reaction mechanisms enhance conceptual clarity and knowledge retention. • **Technology-Enhanced Learning:** Digital tools, including molecular simulation software, pH meters, and digital thermometers, improve
Inorganic Chemistry practical	1. To visualize and predict the shapes of simple molecules based on VSEPR theory. (Use molecular model kits to construct models of various molecules (e.g., $BeCl_2$, BF_3, CH_4, NH_3, H_2O). Identify the number of bonding pairs and lone pairs around the central atom. Predict the molecular geometry based on electron pair repulsion and confirm by comparing with the constructed models.) 2. To understand the formation of molecular orbitals of simple diatomic molecules like H_2, He_2, N_2, and O_2 and predict their magnetic properties and bond orders. (Draw molecular orbital diagrams of these molecules. Fill in the electrons according to the Aufbau principle, Pauli exclusion principle, and Hund's rule. Calculate bond	

	orders and predict magnetic properties (paramagnetic or diamagnetic) based on unpaired electrons.) **3.** Calculate amount of sodium acetate (0.1M) and acetic acid (0.1M) for the preparation of acetate buffer of pH = 4.0, 4.5, 5.0, 5.5 and 6. Prepare series of acetate buffer and determination of their pH by pH-meter. Compare observed value with theoretically expected values. Calculate H^+ ion conc. in each of these solution **Experiments: (At least 4)** 4. Application of mole concept in determining the molar mass of an unknown acid through titration. 5. Estimation of sodium carbonate and sodium bicarbonate present together in a mixture volumetrically. 6. Estimation of sodium carbonate and sodium hydroxide present together in a mixture volumetrically. 7. Determination the percentage of calcium carbonate in precipitated chalk volumetrically by acid-base titration. 8. Estimation of oxalic acid using standardized KMnO4 as an intermediate solution. 9. Estimation of Fe(II) (FAS) using standardized KMnO4 as an intermediate solution. 10. Estimation of Fe(II) (FAS) with K2Cr2O7 using internal (diphenylamine, anthranilic acid) or external indicator potassium ferricyanide. 11. Determination of equivalent weight of oxidizing agent $KMnO_4$ or $K_2Cr_2O_7$ by titration with standard Fe(II) (FAS) solution **Inorganic preparations (At least 2)** **(Note:** In synthesized compound student must confirm the particular Cation and anion by performing qualitative tests) 1. Synthesis of Mohr's Salt (FAS), $\{FeSO_4.(NH_4)_2SO_4•6H_2O\}$ from ferrous sulphate and ammonium sulphate. 2. Synthesis of potash alum, $\{K_2SO_4.Al_2(SO_4)_3.24H_2O\}$ from aluminum sulphate or scrap aluminum metal. 3. Synthesis of $FeSO_4•7H_2O$ either from iron or ferrous sulphate (Kipp's waste) 4. Preparation of cuprous oxide, Cu_2O: a dark red inorganic pigment, from copper sulphate using glucose.	precision in data collection and analysis. Virtual simulations supplement experimental learning, providing additional insights into complex concepts. • **Reflective and Analytical Learning:** Maintaining laboratory records supports systematic documentation of observations, calculations, and deviations. Post-experiment discussions encourage critical evaluation and correlation of experimental results with theoretical principles and real-world applications. **Any other innovative pedagogy as applicable.**
Physical Chemistry Practical	**(At least 6 experiments)** 1. To determine the enthalpy of displacement reaction of Cu from $CuSO_4$ by Zn metal. 2. To determine the transition temperature of $MnCl_2$. 3. To determine the transition temperature of $Na_2SO_4.10H_2O$ by thermometric method. 4. To find the water equivalent of the calorimeter and find out the heat of dilution of H_2SO_4 5. To determine the heat of neutralization of NaOH and HCl by calorimetry. 6. To determine solubility of benzoic acid at different temperature and heat of solution. 7. To determine the enthalpy of ionization of	

	acetic acid by calorimetric method. 8. To determine the molecular weight of nonvolatile solute by Rast's method. 9. To find out molecular weight of sulphur/ α-naphthol by freezing point method using naphthalene as solvent. 10. To determine the molecular weight of solute by cryoscopy using benzene as a solvent. 11. To determine the degree of hydrolysis of sodium acetate near 0° C by cryoscopy. 12. To study the association of benzoic acid in benzene/ cyclohexane by cryoscopy. (Note: For Cryoscopic measurement a digital thermometer (-40 to 250 ° C) can be used instead of Beckmann's Thermometer) 13. To find refractive index of the given liquid samples and find Molar refraction and specific refraction. A) Ethyl Alcohol and Water. B) Sugar solution and Water. C) Oil and Water.	
References	1. Advanced Practical Physical Chemistry – J.B. Yadav, Goel Publishing House. 2. Experimental Physical Chemistry – R.C. Das, B. Behera, McGraw Hill. 3. *Advanced Practical Inorganic Chemistry* – Gurdeep Raj, Goel Publishing. 4. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Inorganic Chemistry: Qualitative Analysis, University Press. 5. Vogel's Textbook of Quantitative Chemical Analysis – J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, Pearson. 6. Practical Chemistry (For B.Sc. I, II and III Year Students). By Pandey O.P. & Bajpai D.N. & Giri S., S.Chand. 7. *Handbook of Organic Analysis: Qualitative and Quantitative* – H. T. Clarke, CBS Publishers. 8. Krishna's Advanced Practical Physical Chemistry – J. B. Yadav. 9. Advanced Physical Chemistry Experiments by J. N. Gurtu, Amit Gurtu, Pragati Prakashan. **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 (Organic Chem Practical) 10 Marks
- Exercise 2 (Physical Chem Practical) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

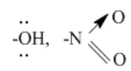
Course Category: **Minor (Theory)**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5	III	108215	Minor Chemistry-1	2	30	2 Hrs	30+20=50

Course Objectives:	1. To aware the students about Fundamentals of organic chemistry and functional group approach for hydrocarbons. 2. To make the students proficient in thermodynamic principles and their basic mathematical formulations. 3. To equip the students with a basic understanding of colligative properties
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Compare the reactivity of Hydrocarbons. 2. Rationalize for regioselectivity in addition 3. Describe the structure of benzene and its stability 4. Write the mechanism of ArES reactions 5. Predict and rationalize the directive influence of a group in ArES. 6. Derive Gibbs-Helmholtz equation 7. Define Colligative Properties and associated terms 8. Apply Thermodynamic Principles to Colligative Properties 9. Solve numerical related to Thermodynamics and Colligative properties.

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit-I	**Aliphatic Hydrocarbons:** A) **Alkanes**: Formation of alkanes, Wurtz Reaction, Free radical substitutions: Halogenation - relative reactivity and selectivity. B) **Alkenes:** Formation of alkenes by elimination reactions, Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti- Markownikoff addition). 1,2-& 1,4-addition reactions in Dienes, Diels-alder reaction. Allylic and benzylic bromination reactions. C) **Alkynes:** Preparation of alkynes: by Double Dehydrohalogenation of vicinal and germinal dihalides. Acidity of terminal alkynes. Reactions: Addition of halogens, hydrogen halides and hydration.	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	A) ***Arenes:*** Introduction**,** derivatives of benzene and their nomenclature (mono, di and tri substituted benzenes). Structure of benzene: Kekules, Resonance Structures, and Molecular orbital picture. B) **Reactivity of benzene**: Mechanism of Electrophilic substitution reactions: Nitration, Sulphonation, Nuclear Halogenation and Friedel - Crafts reaction with mechanism, oxidation of side chain, reduction of benzene.	7 Hrs	7 Marks	

	C) **Orientation Effect**: Effects of substituent groups (o/p and meta directing groups), activating and deactivating groups. Directive influence of various groups (-OH, $-CH_3$, -Cl, $-NO_2$) on the basis of modern electronic theory.		
Unit-III	**Thermodynamics:** Introduction, Important terms: Gibbs and Helmholtz free energy (Work function). Physical significance of Gibbs free energy and Helmholtz free energy, change in free energy as a criterion of spontaneity and equilibrium, Derivation of Gibbs-Helmholtz equation and it's applications, Nernst heat theorem, Statement of third law, Derivation of Vant Hoff's reaction isotherm, Numericals.	8 Hrs	8 Marks
Unit-IV	**Colligative Properties of Dilute Solutions:** Introduction, Important terms: Colligative properties, Lowering of Vapor pressure, Relative lowering of vapor pressure, Elevation of boiling point, Depression of freezing point and Osmotic pressure. Importance and applications of colligative properties. Rault's law of relative lowering of vapor pressure. **Elevation of boiling point**: Thermodynamic derivation of the relationship between elevation of boiling point and the molar mass of non-volatile solute. Cottrell's method for the determination of elevation of boiling point and hence the molar mass of solute. **Depression of freezing point**: Relationship between depression of freezing point and the molar mass of non-volatile solute (only equation). Rast's method for the determination of molar mass of solute. **Osmotic Pressure, and osmosis**: Determination of Molecular weight of solute by osmotic pressure. Measurement of Osmotic pressure by Berkeley and Hartley's Method, Isotonic solutions. Numericals.	7 Hrs	7 Marks
References	**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 7. mechanism, Kluwer Academic Publisher, (2000). 8. Organic Chemistry by S.K. Ghosh.		

	9. Reaction Mechanism in Organic Chemistry by S.M. Mukharjee and S.P. Singh. 10. Stereochemistry and mechanism through solved problems by P.S. Kalsi. 11. Organic Chemistry by TWG Solomons, 8th edition, John Wiley 12. Organic Chemistry by R. K. Bansal 13. Physical Chemistry: Walter, J. Moore, 5th edn., New Delhi. 14. Physical Chemistry: G.M. Barrow, McGraw Hill, Indian Edn. 15. Principles of Physical Chemistry: Maron and Prutton. 16. Principles of Physical Chemistry: Puri, Sharma, and Pathania. 17. Physical Chemistry: P.W. Atkins, 6th Edn. 18. Physical Chemistry: Levine **Web resource:** **1.** Introductory Organic Chemistry I- https://nptel.ac.in/courses/104106119 **2.** **https://chem.libretexts.org** **3.** **https://nowgonggirlscollege.co.in/attendence/classnotes/files/1631169122.pdf** **4.** **https://epgp.inflibnet.ac.in/Home/ViewSubject** **5.** **https://tech.chemistrydocs.com/Books/Physical/Physical-chemistry-by-R-L-Madan.pdf**
Model Questions:	**Short Type (At least 8)** 1. Arrange the following in increasing order of boiling point. n-pentane, (ii) isopentane and (iii) neopentane 2. Comment on Saytzeff rule 3. Comment on Hofmann elimination reaction 4. Define activating group. 5. Name the intermediate involved in ArES. 6. Which of the following groups are ortho-para directing and meta directing? -COOH, -CHO, $-CH_3$, $-NH_2$, -Cl, $-SO_3H$  **7.** Define Gibbs Free energy **8.** Define boiling point
	Long Type (At least 4) 1. Explain the Formation of alkanes using Wurtz Reaction, Wurtz- Fittig Reactions, 2. Explain Mechanism of E_1, E_2 and E_1cB reactions with suitable example. 3. Explain the acidity of terminal hydrogen in alkyne. 4. What are ring activating and ring deactivation groups? Explain with suitable examples. 5. Discuss the mechanism of acetylation of benzene 6. How does benzene react with - i) H_2 in presence of nickel catalyst ii) Cl_2 in presence of halogen carrier iii) Conc. HNO_3 and Conc. H_2SO_4 iv) CH_3Cl in presence of anhydrous $AlCl_3$ 7. How will you obtain the following from benzene? i) Toluene ii) Acetophenone iii) Chlorobenzene iv) Nitrobenzene. 8. Derive Gibbs-Helmholtz equation. 9. Derive Gibb's-Duhem equation 10. Derive Vant Hoff's reaction isotherm
	MCQs for Internal Assessment (At least 8) 1. The addition of HBr on 2-butene in presence of peroxide follows (a) Electrophilic addition **(b) Free radical addition** (c) Nucleophilic addition (d) None of these 2. During debromination of meso-dibromobutane, the major compound formed is (a) n-butane (b) 1-butene (c) cis-2-butene **(d) trans-2-butene** 3. Toluene on reaction with Cl_2 in presence of $FeCl_3$ gives predominantly- a) Benzoyl chloride b) Benzyl chloride c) o- and p- chloro toluene d) m-chlorotoluene 4. Which of the following is o-p directing group? a) $-NH_2$ b) –CN c) –CHO d) $-NO_2$ 5. Chlorine substituent is_____. a) o,p- directing b) m-directing c) both (a) and (b) d) None of these 6. Benzene on reduction with sodium in liquid ammonia gives. a) Cyclohexane b) n-hexane c) 1, 4 cyclohexadiene d) 1, 4 hexadiene 7. Toluene preferably undergoes ArES at___position. a) ortho b) meta c) para d) either ortho or para 8. For a reaction to occur spontaneously a) $\Delta G < 0$ b) $\Delta G > 0$ c) $\Delta S < 0$ d) $\Delta H = 0$

Course Category: **Minor Lab**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	III	108216	Minor Chemistry Lab 7	2	60	4 h	25+25= 50

Course Objectives:	Develop preliminary skills in qualitative analysis of organic compounds, organic preparations, thermochemical and colligative properties measurements through hands-on laboratory experiments, fostering a comprehensive understanding of key techniques in organic and physical chemistry.	
Course Outcomes:	At the end of this course students will be able to: 1. Identify extra elements through qualitative analysis techniques 2. Perform preparations of simple organic compounds. 3. Acquire skills in common techniques for the purification and identification of organic compounds. 4. Develop precision in measuring and recording physical properties. 5. Analyze the relationship between colligative properties with melting and boiling points of solution. 6. Develop skills in recording and reporting experimental procedures and results.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	1. Introduction to qualitative analysis of organic compounds 2. Importance of thermochemistry and colligative properties	• 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 simulations for certain experiments to enhance accessibility and understanding. • **Flipped Classroom Model:** Encourage students to come to class prepared, promoting active participation. • **Interactive Workshops:** Provide opportunities for students to engage in discussions, ask questions, and seek clarification. • **Technology Integration:** Incorporate digital tools for data analysis and presentation. • **Guest Lectures and Industry Connections:** Establish connections with professionals in the field to provide students with a broader perspective on chemical lab practices. • **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. • **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge
Organic Chemistry practical	1. Identification of extra elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid, amides and amines, etc. of compounds. **(At least 6 compounds)** 2. **Organic Preparations** (Collected solid samples may be used for recrystallization, melting point and TLC) **(At least 4 preparations)** i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) (Using conventional method) ii. Benzolyation of one of the amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) iii. Oxidation of ethanol/ isopropanol (Iodoform reaction). iv. Bromination of (either a or b) a. Acetanilide by conventional methods b. Acetanilide using green approach (Bromate-bromide method) v. Nitration of (either a or b) a. Acetanilide by conventional method b. Salicylic acid by green approach (using ceric ammonium nitrate). vi. Hydrolysis of benzamide. vii. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde. viii. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid). ix. Aldol condensation with either conventional or green method.	
Physical Chemistry Practical	**(At least 6 experiments)** 1. To determine the enthalpy of displacement reaction of Cu from $CuSO_4$ by Zn metal 2. To determine the transition temperature of $MnCl_2$ 3. To determine the transition temperature of $Na_2SO_4.10H_2O$ by thermometric method 4. To find the water equivalent of the calorimeter and find out the heat of dilution of H_2SO_4 5. To determine the heat of neutralization of NaOH and HCl by calorimetry. 6. To determine solubility of benzoic acid at different temperature and heat of solution. 7. To determine the enthalpy of ionization of acetic acid by calorimetric method. 8. To determine the molecular weight of nonvolatile	

	solute by Rast's method. 9. To find out molecular weight of sulphur/ α-naphthol by freezing point method using naphthalene as solvent. 10. To determine the molecular weight of solute by cryoscopy using benzene as a solvent. 11. To determine the degree of hydrolysis of sodium acetate near 0° C by cryoscopy. 12. To study the association of benzoic acid in benzene/ cyclohexane by cryoscopy. **(Note: For Cryoscopic measurement a digital thermometer (-40 to 250 ° C) can be used instead of Beckmann's Thermometer)** 13. Preparation of a buffer solution of pH= 4 and its measurement by pH meter. 14. Preparation of a buffer solution of pH= 7 and its measurement by pH meter. 15. Preparation of a buffer solution of pH= 9.2 and its measurement by pH meter.	
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. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press. 3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R.(2012),Vogel's Textbook of Practical Organic Chemistry, Pearson. 4. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press. 5. Advanced practical Organic Chemistry: O P Agrawal 6. Advanced Physical Chemistry Experiments: J N Gurtu and Amit Gurtu (Pragati Prakashan) 7. Experimental Physical Chemistry: V D Athawale and Parul Mathur (New Age Int. Publishers) 8. Advanced Practical Physical Chemistry: J B Yadav 9. Experiments in Chemistry: D V Jahagirdar **Web resources:** 1. https://vlab.amrita.edu/?sub=2 2. https://chemcollective.org/vlabs 3. https://chem.libretexts.org/ 4. To set up calorimeter using Styrofoam cups watch: https://youtu.be/3s8G_hK7dsE 5. MIT OpenCourseWare: https://ocw.mit.edu 6. 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 (Organic Chem Practical) 10 Marks
- Exercise 2 (Physical Chem Practical) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category: **GE/OE-3**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	**III**	**108217**	**Chemistry for Competitive Examinations**	2	30	2 Hrs	30+20 =50

Course Objectives:	This course aims to provide a fundamental understanding chemistry for competitive examinations, with a special focus on elements and classification, carbon and its compounds, physical and chemical changes; acids, bases and salts. Students will apply this knowledge in competitive examinations conducted by UPSC, MPSC etc.			
Course Outcomes:	By the end of this course, the students will be able to: 1. Explain meaning of basic terms in chemistry like element, compounds etc 2. Classify elements 3. Explain the Carbon and its compounds. 4. Analyze how baking soda, washing soda useful in daily life. 5. Evaluate the importance of pH in everyday life. 6. Explain the phenomenon of rusting of iron and galvanization			
Unit System	**Contents**	**Workload Allotted**	**Weightage of Marks Allotted**	**Incorporation of Pedagogies**
Unit I	**Elements and Classifications** Introduction, Definition of Element, Attempts at the classification of elements, The Modern Periodic Table, Position of Elements in the Modern Periodic Table, Some Periodic Properties-Atomic Size and Ionization Potential, Metals, Non-metals, Metalloids, Extraction of metals, Corrosion.	8 Hrs	8 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-on Activity:** Collection of allotropes of Carbon. **Case Study:** Find out harmful effects caused by drinking illegal liquor. Read the daily newspapers and make a report. **Field Study:** Survey minimum 10 household to find out which brand of washing powder people use in your neighborhood. To correlation relevance of theoretical knowledge with real world. **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. **Practical-Based Learning:** Compare samples of Bleaching powder, Baking soda, Washing soda and Plaster of Paris available in market. Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit II	**Carbon and its Compounds** Introduction, Definition of Compound, Covalent bond, Allotropes of Carbon, Saturated and Unsaturated Carbon Compounds, Homologous Series, Nomenclature of Carbon Compounds, Chemical Properties of Carbon Compounds, Some Important Carbon Compounds-Ethanol and Ethanoic acid, Soaps and Detergents.	7 Hrs	7 Marks	
Unit III	**Acids, Bases and Salts** Introduction, Definitions of Acid, Base and Salt, Reactions of Acids and Bases with Metals, Reactions of metal carbonates and metal hydrogen carbonates with acids, Reactions of Acids and Bases with each other, Reaction of metallic oxides with acids, Reaction of Non-metallic oxide with Base, pH Scale, Importance of pH in everyday life, Bleaching powder, Baking soda, Washing soda, Plaster of paris.	8 Hrs	8 Marks	
Unit IV	**Physical and Chemical Changes** Introduction, Physical Changes, Chemical Changes, Rusting of Iron, Galvanization, Crystallization. Chemical Effects of Electric Current, Electroplating	7 Hrs	7 Marks	
References:	**1.** CHEMISTRY by Catherine E. Housecroft & Edwin C. Constabel, Pearson-Prentice Hall **2.** Basic Training in Chemistry by Steven L. Hoenig, Kluwer Academic Publishers **3.** Encyclopedia of Chemistry by Don Rittner & Ronald A. Bailey, Facts On File, Inc.			

	4. Selected Topics In Inorganic Chemistry by Wahid U. Malik, G.D. Tuli, R.D. Madan, S.Chand **5.** Principles of Physical Chemistry by Puri, Sharma, Pathania, Vishal Publishing Co. **6.** Physical Chemistry by Robert G. Mortimer, Elsevier **7.** Organic Chemistry by R.L. Madan, S.Chand **8.** Essentials of Physical Chemistry by B.S. Bahl, G.D. Tuli, Arun Bahl, S.Chand **9.** Inorganic Chemistry by Yu.V. Khodakov, D.A. Epshtein, P.A. Gloriozov. CBS Publishers & Distributors **Web resources:** **1. https://youtu.be/okolv1y6IlE** **2. https://youtu.be/cn_Vom--b4A**
Model Questions:	Short Type (At least 6) **1.** Define atomic size. **2.** What is corrosion? **3.** What is element? **4.** What is the meaning of compound? **5.** Which functional group is present in ethanol? **6.** What are allotropes? **7.** What is the meaning of galvanization? **8.** What is crystallization? **9.** What is electroplating? **10.** What is pH scale? **11.** What is the formula of washing soda? **12.** Write examples of acid and base.
	Long Type (At least 4) **1.** Draw the outline of the modern form of periodic table and indicate s,p,d and f-block in it. **2.** What is atomic size? How it vary along periods and groups in periodic table? **3.** Differentiate between metals and non-metals. **4.** Explain extraction of metals. **5.** What are allotropes? Write different allotropes of Carbon. **6.** Write any four types of organic compounds indicating functional group present in each? **7.** What different chemical properties carbon compounds shows? **8.** Explain: soaps and detergents. **9.** Explain: Rusting of Iron. **10.** Explain: Crystallization. **11.** Explain the concept electroplating. **12.** Explain the chemical effects of electric current. **13.** Differentiate between acids and bases. **14.** Explain: importance of pH in everyday life. **15.** Explain: pH scale. **16.** What is baking soda? Write its uses.
	MCQ (At least 8) **1. Modern periodic table is based on which property of elements?** a) Atomic mass b) Atomic number c) Valency d) Density 2. **The elements in a group of the periodic table have the same:** a) Atomic number b) Number of neutrons c) Number of valence electrons d) Atomic size 3. What is the name of Group 18 elements in the periodic table? a) Alkali metals b) Alkaline earth metals c) Halogens d) **Noble gases** **4. Which metal is liquid at room temperature?** a) Iron b) Mercury c) Aluminium d) Lead 5. Which of the following is an example of an allotrope of carbon? a) Graphite b) Diamond c) Fullerene d) **All of the above** 6. The ability of carbon to form long chains is called: a) **Catenation** b) Allotropy

	c) Isomerism d) Hybridization 7. Which type of bond is present in a diamond? a) Ionic bond b) **Covalent bond** c) Metallic bond d) Hydrogen bond 8. Ethanol belongs to which homologous series? a) Alkanes b) Alkenes c) **Alcohols** d) Carboxylic acids 9. What is galvanization? a) **Coating of iron with zinc** b) Coating of iron with copper c) Coating of zinc with iron d) Coating of copper with aluminum 10. The primary purpose of galvanization is to: a) Make iron heavier b) Improve electrical conductivity c) **Prevent rusting of iron** d) Improve the appearance of iron 11. What is the role of cooling in crystallization? a) Increases solubility b) **Helps crystals to form** c) Prevents crystallization d) Converts solids into gases 12. Crystallization is used to purify which type of substances? a) Liquids b) Gases c) **Solids** d) Plasma 13. Which gas is produced when acids react with metals? a) Oxygen b) **Hydrogen** c) Nitrogen d) Carbon dioxide 14. What happens when an acid reacts with a base? a) **Neutralization** b) Precipitation c) Oxidation d) Reduction 15. Which base is commonly used in soap making? a) Ammonia b) **Sodium hydroxide** c) Magnesium hydroxide d) Calcium hydroxide 16. Which of the following solutions will turn red litmus blue? a) Vinegar b) Lemon juice c) **Sodium hydroxide** d) Carbonic acid

Course Category: **Vocational Skill Course VSC-2**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	III	108218	Chemistry Lab- 8 (Preparation of Commercial products)	2	60	4 Hrs	50

Course Objectives:	The intended objectives are: 1. To understand raw materials, their sources, costs, and functions in cleaning and personal care products. 2. To learn soap-making techniques and prepare hand wash, sanitizer, dish wash, and toilet cleaners. 3. To develop skills in testing product quality and understanding costing, packaging, and marketing.	
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Identify and source raw materials required for making various commercial cleaning and personal care products. 2. Explain the chemical and functional significance of different ingredients used in soap and detergent formulations. 3. Demonstrate proficiency in preparing soaps using cold process, hot process, and melt-and-pour techniques. 4. Formulate and prepare a variety of cleaning products such as hand wash, hand sanitizer, dish wash, and toilet cleaners. 5. Assess the physicochemical properties of soaps and detergents through experiments like saponification value, CMC determination, and pH analysis. 6. Calculate the production cost of selected products and understand packaging, labelling, and marketing strategies for commercial viability.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	1. **Ingredients and Their Functions** – Discuss the role of raw materials in soaps, shampoos, and cleaning agents. Compare natural vs. synthetic ingredients. 2. **Soap-Making Techniques** – Compare cold process, hot process, and melt-and-pour methods. Analyze the impact of oils and additives. 3. **Quality Control & Testing** – Explore saponification value, pH testing, and cleaning power assessment. Discuss product safety standards. 4. **Commercialization & Sustainability** – Examine cost-effectiveness, packaging, labelling, and eco-friendly alternatives in product development.	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 simulations for certain experiments to enhance accessibility and understanding. • **Flipped Classroom Model:** Encourage students to come to class prepared, promoting active participation. • **Interactive Workshops:** Provide opportunities for students to engage in discussions, ask questions, and seek clarification. • **Technology Integration:**
Preparation of Commercial products	Experiments: 1. List the material required for soap, shampoo, hand wash, dish wash, toilet and bathroom cleaning. Find out their sources and cost. Function of some ingredients in the soap and soap making. 2. Saponification value of oil. 3. Soap making – cold process (prepare two three types of soaps by cold process such as - awesome Bar Soap, Bay Rum Soap Bar, Big 'N' Beautiful Bubbles Soap Bar, Bubble Gum Kid-Approved Soap Bar, Bug Repellent Soap, etc). 4. Soap making – hot process (prepare two three types of soaps by cold process such as - marbled Clay Soap, Lard-Base Soap, Bastille Soap, Lemon Poppy Seed Soap, etc.). 5. Melt and Pour soap making. 6. Facial and Shaving Soap Products - almond & Tea Tree Oil Facial Wash, Almond Oil & Black Tea Facial Scrub, Aloe Vera & Tea Tree Shaving Soap, Foaming Shave Soap.	

	7. Preparation of hand wash (different types) 8. Preparation of hand sanitizer (different types) 9. Preparation of dish wash (different types) 10. Preparation of Toilet Cleaner. 11. Determination of CMC of detergent / soap. 12. Determination of cleaning power of detergent by Stalagmometer. 13. Determination pH of different detergent / soap solution by universal pH paper. 14. Calculating costing of production of at least two products, their packaging, labelling and marketing.	Incorporate digital tools for data analysis and presentation. • **Guest Lectures and Industry Connections:** Establish connections with professionals in the field to provide students with a broader perspective on chemical lab practices.
References	1. Soap Making Step-by-Step Guide to Make Homemade Soaps. Advanced and Beginner Recipes Included, Carol Varney. 2. Handbook of Detergents, Part A: Properties by Guy Broze, CRC Press 3. Modern Technology of Soaps, Detergents & Toiletries by P. K. Chattopadhyay, NIIR PROJECT CONSULTANCY SERVICES 4. Soapmaker's Companion: A Comprehensive Guide with Recipes, Techniques & Know-How by Susan Miller Cavitch, Storey Publisher **Web resources:** 1. https://5.imimg.com (Swachh herbal manufacture of cleaning and hygiene products) 2. Royal Society of Chemistry (www.rsc.org/learn-chemistry) – Learning resources on surfactants and cleaning products 3. American Cleaning Institute (www.cleaninginstitute.org) – Information on soap, detergent formulations, and safety guidelines. 4. Practical Chemistry (www.practicalchemistry.org) – Laboratory guides for pH testing, saponification, and cleaning power analysis. 5. Essential Soap – DIY soap-making techniques (https://www.soap-making-resource.com/). 6. NPTEL Chemistry – Lectures on surfactants and detergents.	
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: **FP/CEP-I**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	III	108219	Chemistry Lab- 9 (FP/ CEP in Chemistry - I)	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. II of Semester III and IV 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: **Major (Theory)**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108220	Organic Chemistry-1	2	30	2 Hrs	30+20=50

Course Objectives:	Students will familiarize about 1. classes of organic compounds and their methods of preparation, reactions and reaction mechanisms. 2. stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Compare the reactivity of halogenated hydrocarbons. 2. Write the mechanisms of SN reactions. 3. Design syntheses of organic molecules containing C-X, C-O and C=O. 4. Differentiate between enantiomers and diastereomers. 5. Assign configurations to the stereoisomers. 6. Rationalize the relative stability of different conformers

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Chemistry of Halogenated Hydrocarbons:** A) *Alkyl halides:* Methods of preparation, nucleophilic substitution reactions – SN1, SN2 and SNi mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination. B) *Aryl halides:* Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl and vinyl/aryl halides towards nucleophilic substitution reactions.	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	**Alcohols, Phenols, Ethers and Epoxides:** *A) Alcohols:* preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement. *B) Phenols:* Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries rearrangement and Claisen rearrangement. *C) Ethers:* Preparation (Williamson synthesis and Continuous etherification), reactions with HI. *D) Epoxides:* Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$.	7 Hrs	7 Marks	
Unit III	**Carbonyl Compounds:** A) Structure, reactivity and preparation; Nucleophilic addition-elimination reactions with ammonia derivatives (NH_2OH, NH_2NH_2, $PhNHNH_2$) with mechanism; Mechanisms of Aldol and Benzoin condensation. Reactions only: Knoevenagel condensation, Claisen-Schmidt, Perkin, and Cannizzaro reaction, Wittig reaction, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, LiAlH4, NaBH4 and MPV). B) Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.	8 Hrs	8 Marks	
Unit IV	**Basic Stereochemistry:** **A) Optical isomerism:** Stereoisomerism, Optical isomerism, asymmetric carbon atom, Element of symmetry, chirality (up to two carbon atoms), enantiomers, diastereoisomers, meso compounds, configuration, relative and absolute configurations, DL and RS nomenclature (for up to 2 chiral carbon atoms), optical isomerism in allenes and biphenyls.	7 Hrs	7 Marks	

	B) Geometrical isomerism: Cis-trans & E-Z nomenclature (for up to two C=C systems) with examples and applications. **C) Conformational isomerism:** Conformational isomers, Newman & Sawhorse projection formulae, conformations of ethane, n-butane and cyclohexane, their energy level diagrams.			

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)
3. Pvt. Ltd. (Pearson Education).
4. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007)
5. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008).
6. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford Universitiy Press.
7. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and
8. mechanism, Kluwer Academic Publisher, (2000).
9. Organic Chemistry by S.K. Ghosh.
10. Reaction Mechanism in Organic Chemistry by S.M. Mukharjee and S.P. Singh.
11. Stereochemistry and mechanism through solved problems by P.S. Kalsi.
12. Organic Chemistry by TWG Solomons, 8th edition, John Wiley
13. Organic Chemistry by R. K. Bansal

Web resources:

1. Introductory Organic Chemistry I- https://nptel.ac.in/courses/104106119
2. https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Introductory_Chemistry_(CK-12)/25%3A_Organic_Chemistry/25.11%3A_Aldehydes_and_Ketones
3. https://archive.nptel.ac.in/content/storage2/courses/104103071/pdf/mod6.pdf
4. https://archive.nptel.ac.in/content/storage2/courses/104103071/pdf/mod8.pdf
5. https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Introduction_to_Organic_and_Biochemistry_(Malik)/03%3A_Stereochemistry/3.01%3A_Introduction_to_stereochemistry

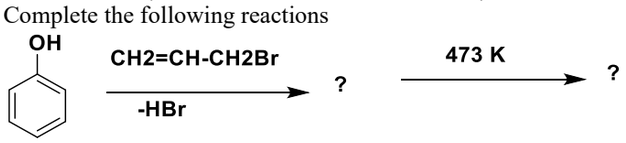
Model Questions:

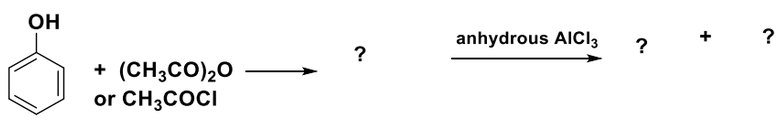
Short Type (At least 8)

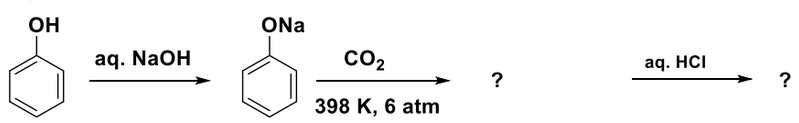
12. Name the intermediate involved in SN1 Mechanism.
13. What are ethers?
14. What is the action of the following on diethyl ether 1) cold HI and 2) hot HI
15. What is the hybridization of Cabon attached to chlorine in chlorobenzene?
16. What are reactive methylene compounds?
17. Define asymmetric carbon.
18. What is center of symmetry?
19. Place the following groups in proper priority order according to sequence rules?
    CHO, -COOH, -NH2, -H.
    -CH3, -CN, -OH, -C2H5.
    -CH3, -Cl, -H, -C2H5.
    -H, -CH2OH, -OH, -CHO
    –H, -N(CH3)2, -OCH3, -CH3

Long Type (At least 4)

1. How will you prepare: 1) vinyl chloride from acetylene 2) vinyl alcohol from vinyl chloride 3) acetylene from vinyl chloride 4) allyl chloride from propene 5) ethylene glycol from ethane 5) ethylene glycol from ethylene oxide
2. Chlorine in vinyl chloride is less reactive towards nucleophillic substitution than that in allyl chloride. Why?
3. Explain acidic nature of phenol.
4. Explain Benzyne intermediate mechanism.
5. Explain with mechanism 1) Aldol condensation 2) Benzoin condensation 3) Knoevenagel condensation 4) Claisen-Schmidt condensation 5) Perkin reaction and 6) Cannizzaro reaction
6. Complete the following reactions

1. 

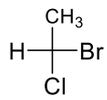
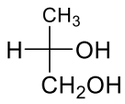
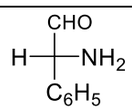
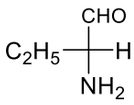
2. 

3. 

phenol

4. $C_2H_5O\text{-}Na$ + $C_2H_5\text{-}Br$ ⟶ ? + ?
sodium ethoxide ethyl bromide

7. Determine the R/S configuration of the following structures clearly indicating the steps involved-

I)  II)  iii)  IV) 

8. Draw Fischer projection of R and S configuration of lactic acid?

MCQs for Internal Assessment (At least 8)

1. Chlorobenzene is an example of ____
   a) alkyl halide b) alkenyl halide c) aryl halide d) haloalkane
2. Benzyl chloride is also known as ____
   a) ∝-chlorotoluene b) benzal chloride c) chlorobenzene d) none of the above
2. Dihydric alcohols are also known as_____
   a) diols b) triols c) geraniols d) none of the above
3. Arrangements of molecules that can be obtained by rotation around C-C single bond are called ___
   a) conformations b) configurations c) enantiomers d) geometric isomers
4. The number of extreme conformation possible for ethane are
   a) 1 b) 2 c) 3 d) 4
5. The number of extreme conformation possible for n-butane are
   b) 1 b) 2 c) 3 d) 4
6. If the two groups of higher priority are on the same side of the double bond then it is assigned ___ configuration
   a) E b) Z c) R d) S
7. Ketone can be reduced to alkane using
   a) $LiAlH_4$ b) Clemenson reduction c) Zn/Acetic acid d) MPV reduction
8. Which of the following will not show iodoform reaction?
   a) Ethanol b) acetone c) acetaldehyde d) benzaldehyde

Course Category: **Major (Theory)**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108221	Physical Chemistry-1	2	30	2 Hrs	30+20=50

Course Objectives:	To help the students acquire a comprehensive understanding of the principles and applications related to chemical kinetics, photochemistry, molecular structure, and electrochemistry, equipping them with the skills necessary for advanced studies and practical applications in chemistry.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Define and explain key terms such as reaction rate, order of reaction, and molecularity. 2. Distinguish between zero, first, and second-order reactions, providing examples and deriving their respective rate equations 3. Distinguish between polar and non-polar molecules, understand dipole moments, and discuss polarization, including the Clausius-Mossotti equation qualitatively. 4. Differentiate between paramagnetic and diamagnetic substances, understand the origins of various magnetic behaviors 5. Analyze factors leading to high or low quantum yields and describe methods for their experimental determination 6. Describe phenomena such as fluorescence and phosphorescence utilizing the Jablonski Diagram. 7. Explain ion migration under electric fields, determine transport numbers using Hittorf's and moving boundary methods 8. Apply Kohlrausch's law to evaluate ion migration. 9. Calculate the degree of dissociation for weak electrolytes and determine their dissociation constants

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Chemical Kinetics:** Introduction, Important terms: rate of reaction, Order of a reaction, and molecularity of reaction (explanation, unit, types and examples). Difference between order and molecularity of reaction. Derivation of rate equation for Zero, first, and second order reaction with equal initial concentration and different initial concentrations of reactants, Characteristics of zero and first order reaction (Graphical representation, half-life period) Kinetics study with modified rate equation viz. the reactions (1) hydrolysis of methyl acetate catalyzed by acid, (2) saponification of ethyl acetate by NaOH, and (3) inversion of cane sugar. Methods for determination of order reaction: Integration, Graphical, Equifractional change or half-life, Vant-Hoff's differential method, and Ostwald's isolation method. Effect of temperature on the rate of reaction, Arrhenius equation, Activation energy and its determination using Arrhenius equation. 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 theoretical knowledge. **Any other innovative pedagogy as**
Unit II	**Photochemistry** Introduction, Important terms: Photochemical and Thermal reactions (Explanation and Examples). Difference between Photochemical and Thermal reactions. Lambert's law (Statement and derivation). Beer's law (Statement and derivation). Reasons for deviations from Beer's law. Laws of photochemistry- (1) Grotthus-Draper law (2) Stark-Einstein law. Quantum yield of photochemical reaction. Reasons for high and low quantum yields. Experimental determination of quantum yield. Photosensitized reactions. Kinetics of photochemical decomposition of HI. Fluorescence and Phosphorescence (Explanation and Examples). Selection rule for electronic transitions. Internal conversion and Intersystem crossing. Explanation of Fluorescence and Phosphorescence based on Jablonski Diagram. Chemiluminescence and Bioluminescence (Explanation and Examples). Numericals.	7 Hrs	7 Marks	
Unit III	**Physical Properties and Molecular Structure** Introduction to Physical Properties and Molecular structure, **Electrical Properties**: Introduction, Important terms: Polar, Non-polar molecules, and Dipole moment. (Explanation and Examples).	8 Hrs	8 Marks	

	Induced polarization and orientation polarization. Clausius Mossotti equation (only qualitative treatment). Measurement of dipole moment by temperature and refractivity methods. Applications of dipole moment for determining molecular structure (Percentage ionic character of covalent bonding, molecular geometry, cis-trans isomers, ortho, meta, and para isomers of disubstituted benzene). Numericals **Magnetic Properties**: Introduction, Important terms: Magnetic Moment, Magnetic Permeability, Magnetic Susceptibility (Explanation). Types of Magnetic Susceptibility (Volume Susceptibility, Specific Susceptibility, Mass Susceptibility, and Molar Susceptibility) Relationship between Molar Susceptibility and Mass Susceptibility. Origin Of Magnetism, Paramagnetism, Diamagnetism, Ferromagnetism, and Antiferromagnetism (Properties, Explanation, and Examples). Effect of temperature on magnetics Susceptibility, Relationship between Magnetic Moment and Number of unpaired electrons. Gouy's balance method for Determination of Magnetic Susceptibility. Application of magnetic moment in the determination of molecular structure. Numericals.			**applicable.**
Unit IV	**Electrochemistry -I** Introduction, Important terms: Conductor and Types of Conductors, Resistance, Specific Resistance, Conductance, Specific Conductance, and their units (Explanation), Conductance of Electrolytes, Types of Conductance (Specific, Equivalent, and Molar Conductance). Determination of conductance of electrolyte solution, Variation of Specific and Equivalent Conductance with dilution. Conductometric Titrations, Applications of Conductometric Titration. Migration of ions under the influence of electric field. The transport number of ions. Hittorf's theoretical Device. Kohlrausch's law of independent migration of ions. Determination of association and degree of dissociation of a weak electrolyte. 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 **Web resources:** 1. https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Chemistry_-_The_Central_Science_(Brown_et_al.) 2. https://faculty.gvsu.edu/mcbaneg/notes-358.pdf			
Model Questions:	**Short Type (At least 8)** 1. Define the order of a reaction. How is it different from molecularity? 2. Write the integrated rate equation for a first-order reaction and explain the terms. 3. What is the effect of temperature on the rate of a chemical reaction? 4. How can we determine the order of a reaction using the graphical method? 5. Differentiate between photochemical and thermal reactions 6. State Stark-Einstein Law 7. What is the Jablonski diagram? 8. Why do some photochemical reactions have high quantum yield? 9. Differentiate between polar and non-polar molecules with examples. 10. What is orientation polarization? 11. State the relationship between magnetic moment and unpaired electrons. 12. What is the significance of dipole moment in determining molecular structure? 13. Define resistance, specific resistance, and conductance. 14. Define conductometric titration 15. Define the transport number of an ion 16. State Kohlrausch's Law			
	Long Type (At least 4) 1. Derive the rate equation for a first-order reaction. Show how half-life is related to the rate constant.			

	2. Describe the characteristics of first and second-order reactions with suitable examples. 3. Explain how Ostwald isolation method and integration are used to determine order of reaction 4. Discuss the Arrhenius equation and describe how activation energy is determined graphically. 5. State and derive Lambert's Law 6. State and derive Beer's Law. 7. Define the quantum yield of a photochemical reaction and explain its experimental determination. 8. Explain the Jablonski Diagram. 9. Explain the concept of dipole moment and its applications in determining molecular structure. 10. Derive the relationship between magnetic moment and unpaired electrons 11. Describe Gouy's method for determining magnetic susceptibility. 12. Explain the measurement of dipole moment by temperature method. 13. Explain the effect of dilution Specific equivalent and molar conductivities. 14. Describe Hittorf's method for determining the transport number.
	MCQs for Internal Assessment (At least 8) The unit of rate constant for a first-order reaction is: a) L mol^{-1} s^{-1} **b) s^{-1}** c) mol L^{-1} s^{-1} d) L^2 mol^{-2} s^{-1} 2. Which of the following statements is true about molecularity of a reaction? a) It can be a fraction. b) It is determined experimentally. **c) It is always a whole number**. d) It depends on temperature. 3. The half-life of a first-order reaction depends on: a) Initial concentration b) Final concentration **c) Rate constant** d) Both (a) and (c) 4. The Arrhenius equation is used to determine: a) Molecularity of reaction **b) Activation energy** c) Order of reaction d) Rate of diffusion 5. Which of the following is a photochemical reaction? a) Rusting of iron **b) Photosynthesis** c) Burning of wood d) Evaporation of water 6. Beer's Law states that the absorption of light is proportional to the: a) Thickness of the solution b) Concentration of the solution c) Wavelength of light **d) Both (a) and (b)** 7. The Grotthus-Draper law states that: **a) Light must be absorbed for a reaction to occur** b) Every absorbed photon causes a reaction c) Light intensity does not affect reaction rate d) Energy is conserved in photochemical reactions 8. Which of the following is an example of chemiluminescence? **a) Fireflies glowing** b) Burning of coal c) Reflection of sunlight d) Formation of rust 9.Which of the following molecules is polar? a) CO_2 b) CH_4 **c) H_2O** d) BF_3 10. Which of the following is a paramagnetic substance? a) NaCl **b) O_2** c) N_2 d) H_2O 11. Clausius-Mossotti equation relates: a) Dipole moment and temperature b) Polarizability and refractivity **c) Dielectric constant and polarizability** d) Molar mass and dipole moment 12.Gouy's balance is used to determine: a) Refractive index **b) Magnetic susceptibility** c) Dipole moment d) Ionic character 13.Which of the following has the unit S cm^{-1}?

	a) Resistance b) Conductance **c) Specific conductance** d) Transport number 14. The conductance of an electrolyte solution generally _____ with dilution. a) **Increases** b) Decreases c) Remains constant d) First decreases, then increases 15. Kohlrausch's law states that at infinite dilution, the conductivity of an electrolyte is due to: a) **Independent migration of ions** b) Movement of cations only c) Movement of anions only d) Ion-pair formation 16.Which method is NOT used to determine the transport number of an ion? a) Hittorf's method b) Moving boundary method c**) Conductometric titration** d) Kohlrausch's method

Course Category: **Major Lab**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108222	Chemistry Lab 10	2	60	4 h	25+25= 50

Course Objectives:	To develop necessary skills in qualitative analysis of organic compounds, chemical kinetics and conductometric measurements through hands-on laboratory experiments, fostering a comprehensive understanding of key techniques in organic and physical chemistry.	
Course Outcomes:	At the end of this course students will be able to: 1. Identify extra elements through qualitative analysis techniques 2. Identify simple unknown organic compounds containing 1 or 2 functional groups. 3. Determine the rate constant of various reactions 4. To determine the molar refractivity and calculate the refraction equivalence of elements. 5. To perform various conductometric titrations 6. Apply conductometric measurement for determination of dissociation constant of weak acids and solubility products of sparingly soluble salts. 7. Develop precision in measuring and recording physical properties. 8. Develop skills in recording and reporting experimental procedures and results.	
Unit System	**Contents**	**Incorporation of Pedagogies**
Tutorial and Discussion	1. Introduction to qualitative analysis of organic compounds 2. Importance of Chemical Kinetics and Conductometry	• 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 simulations for certain experiments to enhance accessibility and understanding. • **Flipped Classroom Model:** Encourage students to come to class prepared, promoting active participation. • **Interactive Workshops:** Provide opportunities for students to engage in discussions, ask questions, and seek clarification. • **Technology Integration:** Incorporate digital tools for data analysis and presentation. • **Guest Lectures and Industry Connections:** Establish connections with professionals in the field to provide students with a broader perspective on chemical lab practices. • **Inquiry-Based Learning:** Explore topics through questioning, investigation, and research. • **Case-Based Learning:** Analyze and discuss real cases to apply theoretical knowledge
Organic Chemistry practical	1. Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid, amide and amine group of compounds. **(at least 6)** 2. 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. **(at least 8)**	
Physical Chemistry Practical	**(At least 8 experiments)** **Chemical Kinetics** 1. To determine the rate constant of the hydrolysis of ethyl acetate catalyzed by an acid 2. To determine the order of saponification reaction of ethyl acetate with NaOH 3. To study the kinetics of the iodination of acetone in the presence of an acid 4. To Study the kinetics of iodine clock reaction **Physical properties and Molecular structure** 5. To determine refractive index of liquid by using Abbe's refractometer 6. To determine the molar refractivity of methyl acetate, ethyl acetate, n-hexane and carbon tetrachloride and calculate the refraction equivalence of C, H and Cl atom by using Abbe's refractometer 7. To study the variation of refractive index with composition of mixture of carbon tetrachloride and ethyl acetate. **Conductometry** 8. To determine the cell constant of a conductivity cell. 9. To find out the strength of HCl solution by titrating against standard NaOH solution conductometrically. 10. To find out the strength of acetic acid solution by titrating against standard NaOH solution conductometrically.	

	11. To find out the strength of HCl and acetic acid in mixture of both by titrating against standard NaOH solution conductometrically. 12. To determine the dissociation constant of weak acid (acetic acid) conductometrically. 13. To determine the solubility and solubility product of a sparingly soluble salt conductometrically. 14. To find out strength of acetic acid in commercial vinegar sample by conductometric titration.	
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. Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press. 3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R.(2012),Vogel's Textbook of Practical Organic Chemistry, Pearson. 4. Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press. 5. Advanced practical Organic Chemistry: O P Agrawal 6. Advanced Physical Chemistry Experiments: J N Gurtu and Amit Gurtu (Pragati Prakashan) 7. Experimental Physical Chemistry: V D Athawale and Parul Mathur (New Age Int. Pub.) 8. Advanced Practical Physical Chemistry: J B Yadav 9. Experiments in Physical Chemistry: D V Jahagirdar **Web resources:** 1. https://vlab.amrita.edu/?sub=2 2. https://chemcollective.org/vlabs 3. https://chem.libretexts.org/ 4. MIT OpenCourseWare: https://ocw.mit.edu 5. 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 (Organic Chem Practical) 10 Marks
- Exercise 2 (Physical Chem Practical) 10 Marks
- Viva-Voce (external) 05 Marks

Total **25 Marks**

Course Category**: Minor (Theory)**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5	IV	108223	Minor Chemistry-2	2	30	2 Hrs	30+20=50

Course Objectives:	1. To develop a comprehensive understanding of bonding theories and are able to apply theoretical principles to analyze and predict molecular structures. 2. To develop the fundamental theoretical understanding of quantitative chemistry 3. To develop an understanding about C-X and C-O bond chemistry along with basic stereochemistry of organic molecules.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Describe Born-Haber's cycle. 2. Predict molecular geometries using hybridization 3. Define the mole in terms of mass, volume, and number of particles. 4. Solve problems on concentrations (molarity, normality, molality, mole fraction). 5. Explain the requirements for standard solutions and primary standard substances. 6. Compare the reactivity of halogenated hydrocarbons. 7. Write the mechanisms of SN reactions. 8. Design syntheses of organic molecules containing C-X, and C-O bonds. 9. Differentiate between enantiomers and diastereomers. 10. Assign configurations to the stereoisomers.

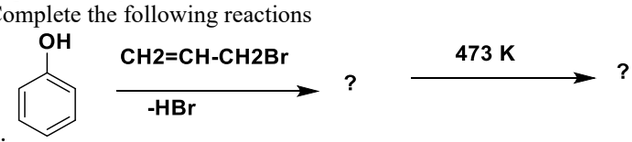
Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Ionic bonding:** Definition of ionic bond, Factors affecting ionic bond formation (energetic of ionic bond formation ionization energy, electron affinity and lattice energy). Born-Haber's cycle to determine lattice energy. **Covalent bonding:** Directional nature of covalent bond. Valance Bond Theory (VBT), Limitations of VBT, Hybridization, Need of Hybridization, Types of hybridization to explain geometries of $BeCl_2$, BF_3, CH_4, $PC1_5$, SF_6 and IF_7.	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, thermodynamics). **3. Digital & Flipped Learning** • **Pre-Class Video Lectures & Online Quizzes** for self-
Unit II	**A) The mole concept** Definition of mole in terms of mass, volume and number of particles. Avogadro's law, Atomic mass, average atomic mass and Molar Mass, Terms to express concentrations of solutions namely- molarity, normality, molality, mole fraction (Simple numerical expected). **B] Volumetric Analysis:** Important terms: titrant, titrate, end point, equivalence point, indicator, etc. Requirements and advantages of volumetric analysis. Definition of standard solution, Primary standard substance and its requirements.	7 Hrs	7 Marks	
Unit III	*A) Alkyl halides:* Methods of preparation, nucleophilic substitution reactions of ethyl bromide. *B) Aryl halides:* Preparation from diazonium salts. nucleophilic aromatic substitution; Benzyne mechanism. *C) Alcohols:* Preparation and reactions of ethyl alcohol.	8 Hrs	8 Marks	

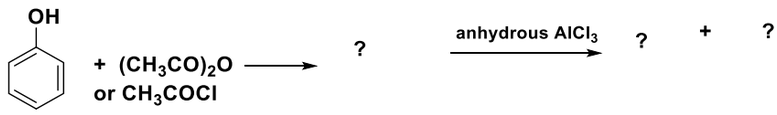
	D) Phenols: Preparation and properties; Acidity of phenol, Reactions only: Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries rearrangement and Claisen rearrangement. *E) Ethers:* Classification. Preparation (Williamson synthesis and Continuous etherification), reactions of diethyl ether with hot and cold HI.			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. This **integrated approach** fosters **engagement, critical thinking, and practical competence**, ensuring a **dynamic and research-oriented** chemistry learning experience.
Unit IV	**Stereochemistry:** **A) Optical isomerism:** Stereoisomerism, Optical isomerism, asymmetric carbon atom, Element of symmetry, chirality (up to two carbon atoms), enantiomers, diastereoisomers, meso compounds, configuration, DL and RS nomenclature (for up to 2 chiral carbon atoms). **B) Geometrical isomerism:** Cis-trans & E-Z nomenclature (for up to two C=C systems) with examples and applications. **C) Conformational isomerism:** Conformational isomers, Newman & Sawhorse projection formulae, conformations of ethane, n-butane.	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, 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. Stereochemistry and mechanism through solved problems by P.S. Kalsi. 17. Organic Chemistry by TWG Solomons, 8th edition, John Wiley 18. Organic Chemistry by R. K. Bansal **Web resources:** 1. https://wou.edu/chemistry/courses/online-chemistry-textbooks/ch105-consumer-chemistry/chapter-3-ionic-covelent-bonding/ 2. https://gchem.cm.utexas.edu/bonding/index.php 3. https://chem.libretexts.org/Courses/East_Tennessee_State_University/CHEM_3110%3A_Descriptive_Inorganic_Chemistry/03%3A_Bonding_Theories? 4. https://courses.lumenlearning.com/suny-mcc-introductorychemistry/chapter/formula-mass-and-mole-concept-from-che100/ 5. Introductory Organic Chemistry I- https://nptel.ac.in/courses/104106119 6. https://archive.nptel.ac.in/content/storage2/courses/104103071/pdf/mod8.pdf 7. https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Introduction_to_Organic_and_Biochemistry_(Malik)/03%3A_Stereochemistry/3.01%3A_Introduction_to_stereochemistry			
Model Questions:	**Short Type (At least 8)** 1. Define ionic bond 2. What is lattice energy? 3. Identify the hybridization of central atom in the following: $BeCl_2$, BF_3, CH_4, $PC1_5$, SF_6 and IF_7 4. Sate Avogadro's law 5. What is standard solution? 6. Name any two primary standard acids 7. Name the intermediate involved in SN1 Mechanism.			

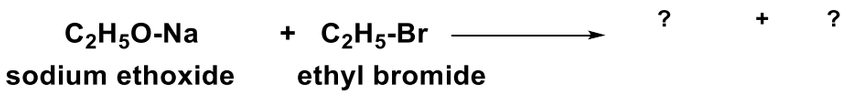
8. What are ethers?
9. What is the action of the following on diethyl ether 1) cold HI and 2) hot HI
10. What is the hybridization of Cabon attached to chlorine in chlorobenzene?
11. What are reactive methylene compounds?
12. Define asymmetric carbon.
13. What is center of symmetry?
14. Place the following groups in proper priority order according to sequence rules?
    CHO, -COOH, -NH2, -H. -CH3, -CN, -OH, -C2H5

Long Type (At least 4)

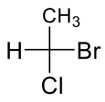
1. Describe Born-Haber's cycle to determine lattice energy
2. Explain geometries of (any one) $BeCl_2$, BF_3, CH_4, $PC1_5$, SF_6 and IF_7 using concept of hybridization.
3. Calculate the normality of 0.1 M H_2SO_4
4. Calculate the mole fractions of H_3PO_4 and water in a solution of 14.5 g of H_3PO_4 in 125 g of water?
5. Explain acidic nature of phenol.
6. Explain Benzyne intermediate mechanism.
7. Complete the following reactions

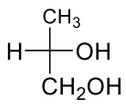
1. 

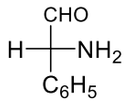
2. 

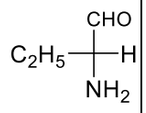
3. 

8. Determine the R/S configuration of the following structures clearly indicating the steps involved-

I) 

II) 

iii) 

IV) 

9. Draw Fischer projection of R and S configuration of lactic acid?

MCQs for Internal Assessment (At least 8)

1. The hybridization of P in $PC1_5$__
   a) sp3 b) sp3d c) sp3d2 d) sp2
2. The hybridization of S in SF_6 is___
   a) sp3 b) sp3d c) sp3d2 d) sp2
3. The hybridization of I in IF_7 is —
   a) sp3 b) sp3d3 c) sp3d2 d) sp2
4. According to VSEPR theory, the shape of NH_3 is__
   a) Tetrahedral b) pyramidal c) trigonal bipyramidal d) trigonal planar
5. According to VSEPR theory, the shape of SF_4 is _
   a) Tetrahedral b) pyramidal c) 'see-saw' shaped d) trigonal planar
6. According to VSEPR theory, the shape of SO_2, is__
   a) 'V' shaped b) pyramidal c) 'see-saw' shaped d) trigonal planar
7. According to VSEPR theory, the shape of XeF_4 is_
   a) Tetrahedral b) square planar c) 'see-saw' shaped d) trigonal planar
8. The mole is used in chemistry to represent ____of something
   a) 6.022×10^{23} b) 6.23×10^{23} c) 8.022×10^{23} d) 6.022×10^{32}
9. Arrangements of molecules that can be obtained by rotation around C-C single bond are called ___
   a) conformations b) configurations c) enantiomers d) geometric isomers
10. The number of extreme conformation possible for ethane are
    a) 1 b) 2 c) 3 d) 4
11. The number of extreme conformation possible for n-butane are
    a) 1 b) 2 c) 3 d) 4
12. If the two groups of higher priority are on the same side of the double bond then it is assigned ___ configuration
    a) E b) Z c) R d) S

Course Category**: Minor Lab**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108224	Minor Chemistry Lab- 11	2	60	4 h	25+25= 50

Course Objectives:	The intended objectives are: 1. To develop practical skills in the preparation, dilution, and standardization of solutions essential for quantitative chemical analysis. 2. To apply qualitative and quantitative techniques for the identification of organic compounds based on their functional groups.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Prepare and standardize various solutions with precise concentration for laboratory applications. 2. Understand dilution principles and concentration calculations (molarity, normality, molality, and strength). 3. Apply volumetric techniques to determine unknown solution concentrations. 4. Perform qualitative analysis of organic compounds containing mono- and bifunctional groups. 5. Interpret chemical reactions to identify characteristic functional groups in organic compounds. 6. Demonstrate proficiency in handling laboratory glassware, chemicals, and instruments. 7. Enhance analytical problem-solving skills through accurate solution preparation and titration. 8. Apply theoretical concepts to experimental work, reinforcing the principles of chemical analysis. 9. Develop essential laboratory safety practices and documentation skills.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	• Theoretical Background: Explanation of concentration terms, dilution methods, and principles of solution preparation. • Numerical Applications: Practice problems on molarity, normality, and dilution calculations. • Experimental Techniques: Stepwise procedures for standardization, titration, and qualitative organic analysis. • Case-Based Learning: Interpretation of experimental results and discussion on error minimization in quantitative analysis.	• **Hands-on Experimental Learning –** Practical laboratory sessions for solution preparation, titration, and organic compound identification. • **Inquiry-Based Learning –** Encouraging students to analyze unknown solutions and predict concentrations based on calculations. • **Conceptual Visualization –** Demonstrations, charts, and digital simulations for understanding solution chemistry and functional group identification. • **Collaborative Learning –** Group discussions and peer review of experimental procedures and results. • **Problem-Based Learning (PBL) –** Application of theoretical concepts to real-world scenarios, such as industrial and pharmaceutical solution preparations.
Inorganic Experiments	**Preparation and standardization of solution** 1. Preparation of 1% and 2% w/v solutions of NaCl and glucose. 2. Preparation of 1 and 2% v/v solutions of acetic acid, HCl, HNO_3 or H_2SO_4. 3. Preparation of 0.1 M solutions of ammonia. 4. Preparation of 0.1 M and 0.01 M solutions of HCl. 5. Preparation of 10 ppm and 1 ppm solutions $KMnO_4$ from its 100 ppm stock solution 6. Preparation of 0.5 M, 0.1 M, 0.01 M, and 0.05 M NaOH solution by dilution method from its 1 M stock solution. 7. Preparation of 0.1 N solution of oxalic acid and calculate its molarity. 8. Preparation of 0.1 N solutions of sulfuric acid and calculate its molarity. 9. Determination of concentrations of given oxalic acid solution (0.6 g in 100 mL) in terms of normality, molarity, molality and strength. 10. Determination of concentrations of given sodium carbonate solution (0.5 g in 100 mL) in terms of normality, molarity, molality and strength. 11. Preparation of 1% NaOH solution and determine its normality and molarity by using standard 0.1 N Oxalic acid solution. 12. Preparation of 0.1 N H_2SO_4 solution and find out its	

	exact normality using NaOH as an intermediate solution and 0.1 N Oxalic acid as standard solution. 13. Determination of molarity and strength of unknown hydrochloric acid solution with the help of standard 0.05M sodium carbonate solution. 14. Standardization of given NaOH solutions using standard 0.02 N Na_2CO_3.	• **Digital & Flipped Learning** – Pre-lab instructional videos, online quizzes, and virtual lab simulations for self-paced understanding. This integrated approach ensures students develop technical competence, analytical skills, and a deeper understanding of solution chemistry and organic qualitative analysis.
Organic Experiments	1. 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. **(At least 6)**	
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**: GE/OE -4**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108225	Chemistry for Sustainable Agriculture	2	30	2 Hrs	30+20=50

Course Objectives:	This course aims to provide a fundamental understanding of the role of chemistry in sustainable agriculture, with a special focus on chemical and biopesticides. Students will learn how to apply this knowledge to improve crop yield while ensuring environmental safety.
Course Outcomes:	After successful completion of the course, a student will be able to- 1. Define the principles of sustainable agriculture and explain the role of chemistry in it. 2. Explain the chemical composition and properties of chemical and biopesticides. 3. Analyze how chemical and biopesticides affect crop yield and pest control. 4. Evaluate the environmental impact of chemical and biopesticides, including their degradation, persistence, and potential hazards. 5. Apply chemical principles to optimize agricultural practices and promote sustainable farming methods.

Unit System	Contents	Workload Allotted	Weightage of Marks Allotted	Incorporation of Pedagogies
Unit I	**Introduction to Sustainable Agricultural and the role of Chemistry:** **Overview of Sustainable Agricultural Chemistry**: Definition, scope, and importance in modern agriculture. **Basic Chemical Principles in Agriculture**: Atoms, molecules, chemical bonds, and reactions relevant to pest control. **Role of chemistry in pest management and crop nutrition.**	7 Hrs	7 Marks	**Interactive Lectures:** Use multimedia presentations, interactive slides, and animations. **Hands-on Activity: Identification of various pests in mono and dicotyledon plants samples;** to improve practical understanding **Case Study: Pesticide Overuse and Its Environmental Consequences**. Read the daily news papers and make a report. **Field Study: Common Pesticides Used in Local Farming Practices**. To correlation relevance of theoretical knowledge with real world. **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.
Unit II	**Pesticides Their Environmental Impact** **Classification of Pesticides**: Insecticides, herbicides, fungicides, and their chemical nature. **Mode of action and environmental impact:** How pesticides affect target organisms, soil, and water bodies. **Degradation, persistence, and bioaccumulation:** Chemical breakdown, residual toxicity, and effects on non-target species. **Safe handling, application, and government regulations** (e.g., **EPA, BIS standards**).	8 Hrs	8 Marks	
Unit III	**Chemical Pesticides – Uses, Benefits, and Risks** **Definition and classification** of **chemical pesticides** (synthetic vs. semi-synthetic). **Types of chemical pesticides**: Organophosphates, carbamates, pyrethroids, neonicotinoids, etc. **Mode of Action:** How **chemical pesticides** interact with **pests and crops**. **Advantages of chemical pesticides**: Cost-effectiveness, rapid action, and crop yield improvement. **Impact on human health and ecosystems**: Toxicity, bioaccumulation, and resistance development. Specify **examples of commonly used pesticides** (e.g., **DDT, Malathion, Glyphosate**)	7 Hrs	7 Marks	

	Alternatives to chemical pesticides: Integrated Pest Management (IPM) and reduced-chemical approaches.			**Practical-Based Learning: Making Neem-Based Biopesticide Solution"**. Analyze and discuss real cases to apply theoretical knowledge. **Any other innovative pedagogy as applicable.**
Unit IV	**Biopesticides: A Sustainable Alternative to Chemical Pesticides** **Definition and classification of biopesticides**: Microbial, botanical, and biochemical biopesticides. **Types of biopesticides**: Bacteria (*Bacillus thuringiensis*), fungi (*Beauveria bassiana*), and plant-based pesticides (neem extract, pyrethrin). **Mechanism of action**: How **biopesticides** target pests and diseases. **Global and local perspectives:** Trends, regulatory framework, and adoption barriers. **Challenges in commercializing biopesticides:** Cost, shelf-life and efficacy. **Environmental impact**: Biodegradability, effects on beneficial insects, and sustainability strategies.	8 Hrs	8 Marks	

References:

1. Introductory Agricultural Chemistry: Dr. D. P. Ray
2. Elements of Agricultural Chemistry: Thomas Andrson
3. Agricultural Chemistry: Ajay Singh
4. Neem: A Tree for Solving Global Problems by National Research Council
5. Biopesticides Handbook by L.G. Copping Eggshells: Waste to Wealth by Dr. S. Sharma
6. Biopesticides and Pest Management" by Dr. R.K. Upadhyay.
7. Soil Fertility and Fertilizers by J.L. Havlin
8. Chemistry and Technology of Agrochemical Formulations by A. Knowles
9. Organic Farming: Principles & Practices by K.P. Prabhakaran Nair

To further refine your syllabus and align it with established agricultural university curricula, consider the following insights drawn from various institutions:

1. **Biopesticides and Biofertilizers:**
Amrita Vishwa Vidyapeetham offers a course titled "Biopesticides & Biofertilizers" as part of their B.Sc. (Hons.) Agriculture program.

2. Practical Applications in Soil and Plant Analysis:
The College of Agriculture at CSK Himachal Pradesh Agricultural University emphasizes hands-on experience in their curriculum.

3. Integrated Pest Management and Entomology:
Vasantrao Naik Marathwada Krishi Vidyapeeth's College of Agriculture offers comprehensive courses in entomology and pest management.

TED and TEDx Talks:

1. **The Other Inconvenient Truth" by Jonathan Foley**
2. **Biopesticides: The Natural Solution to Pest Control" by Agnès Ricroch**
3. **MIT Open Course Ware :** Land, Water, Food, and Climate (Course 1.74)

Web resources:
https://chem.libretexts.org/Courses/Anoka-Ramsey_Community_College/Introduction_to_Chemistry/01%3A_What_is_Chemistry/1.02%3A_Chemistry_in_Agriculture

Model Questions:

Short Type (At least 6)

1. Define sustainable agriculture and explain its importance.
2. How does chemistry contribute to modern agricultural practices?
3. What is the role of soil pH in crop production?
4. Explain the difference between organic and inorganic compounds in agricultural chemistry.
5. What are the main types of pesticides used in agriculture? Give one example of each.
6. Explain the mode of action of herbicides in weed control.
7. How do pesticides persist in the environment, and what are the risks associated with their overuse?
8. Define chemical pesticides and classify them based on their chemical nature.
9. What are the advantages and disadvantages of using chemical pesticides?
10. Define biopesticides and list their different types.
11. Explain how neem-based biopesticides work against pests.

	12. What is pesticide resistance**,** and how does it develop in insect populations?
	Long Type (At least 4) 1. Define sustainable agriculture. Discuss its significance and challenges in modern farming. 2. Explain the role of chemistry in agriculture, highlighting its application in soil health, plant growth, and pest control. 3. Discuss the chemical composition of soil and explain how soil pH affects nutrient availability. 4. Describe the different types of chemical bonds and their importance in agricultural chemistry. 5. Explain the classification of pesticides with examples. Describe their chemical nature and mode of action. 6. What is pesticide degradation? Discuss the environmental impact of pesticide persistence and bioaccumulation. 7. Discuss the safe handling, application, and government regulations associated with pesticide use. 8. Compare synthetic fertilizers and organic fertilizers in terms of their composition, benefits, and drawbacks. 9. Define chemical pesticides and explain their types, advantages, and disadvantages. 10. Describe the mechanism of action of insecticides, herbicides, and fungicides in agricultural applications. 11. Explain the concept of pesticide resistance. How does excessive pesticide use lead to resistance development in pests? 12. Discuss alternative pest management strategies, including Integrated Pest Management (IPM) and chemical-free approaches. 13. Define biopesticides and describe their classification, advantages, and limitations. 14. Compare biopesticides and chemical pesticides in terms of mode of action, environmental impact, and effectiveness. 15. Explain the mechanism of action of microbial biopesticides with examples such as Bacillus thuringiensis (Bt) and Trichoderma. 16. Discuss the challenges and future prospects of biopesticides in sustainable agriculture.
	MCQ (At least 8) 1. **What is the primary goal of sustainable agriculture?** a) Maximizing pesticide use b) Increasing chemical fertilizer dependency c) Ensuring long-term soil fertility and environmental balance ✅ d) Encouraging monoculture farming 2. **Which chemical property of soil affects nutrient availability the most?** a) Soil texture b) Soil pH ✅ c) Soil color d) Soil depth 3. **Which of the following is NOT a macronutrient required by plants?** a) Nitrogen b) Phosphorus c) Potassium d) Iron ✅ 4. **Which branch of chemistry is most relevant to agriculture?** a) Organic chemistry b) Analytical chemistry c) Agricultural chemistry ✅ d) Physical chemistry 5. **Which type of pesticide is used to control fungal diseases in crops?** a) Herbicide b) Insecticide c) Fungicide ✅ d) Rodenticide 6. **What is the main environmental concern of synthetic pesticide overuse?** a) Increased crop yield b) Development of pesticide-resistant pests ✅ c) Faster plant growth d) Improved soil fertility 7. **Which of the following is a characteristic of persistent pesticides?** a) They break down quickly in the environment b) They accumulate in soil and water ✅ c) They do not affect non-target organisms d) They have no effect on biodiversity 8. **Which regulatory body in India oversees pesticide safety?** a) Food and Drug Administration (FDA)

b) Bureau of Indian Standards (BIS)
c) Central Insecticides Board and Registration Committee (CIBRC) ✅
d) Indian Council of Agricultural Research (ICAR)

9. **Which of the following is a synthetic insecticide?**
a) Neem extract
b) Bacillus thuringiensis
c) DDT ✅
d) Trichoderma
10. **What is the main advantage of chemical pesticides over biopesticides?**
a) They degrade faster in the environment
b) They provide immediate pest control ✅
c) They have no environmental impact
d) They improve soil microbial diversity
11. **Which pesticide component is responsible for harming pollinators like bees?**
a) Organophosphates ✅
b) Nitrogen fertilizers
c) Phosphate solubilizers
d) Biofertilizers
12. **Which of the following is a major disadvantage of chemical pesticides?**
a) They are cost-effective
b) They degrade soil health over time ✅
c) They increase biodiversity
d) They are non-toxic to humans

13. **Which of the following is an example of a microbial biopesticide?**
a) Neem oil
b) Bacillus thuringiensis (Bt) ✅
c) Glyphosate
d) DDT
14. **Why are biopesticides considered more sustainable than chemical pesticides?**
a) They require high doses for effectiveness
b) They degrade quickly without harming the environment ✅
c) They persist in the environment for a long time
d) They promote chemical dependency in farming
15. **Which plant-derived compound is commonly used in biopesticides?**
a) Glyphosate
b) Pyrethrin ✅
c) Malathion
d) DDT
16. **Which of the following is a limitation of biopesticides?**
a) They are highly toxic to humans
b) They have a shorter shelf-life than chemical pesticides ✅
c) They persist in the environment for decades
d) They kill beneficial insects along with pests

Course Category: **Vocational Skill Course VSC-3**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108226	Chemistry Lab- 12 (Synthesis and extraction of industrial products)	2	60	4 Hrs	50

Course Objectives:	The intended objectives are: 1. To learn the synthesis and extraction of important organic compounds. 2. To develop practical skills in reaction setup, purification, and product analysis. 3. To understand green chemistry and the isolation of bioactive compounds from natural sources.
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Synthesize key industrial organic compounds such as aspirin, paracetamol, and benzocaine using established chemical methods. 2. Perform extraction and isolation of natural products like caffeine, lycopene, and limonene from plant sources. 3. Apply green chemistry principles in organic synthesis to minimize environmental impact. 4. Utilize purification techniques such as recrystallization, melting point analysis, and thin-layer chromatography (TLC) for product characterization. 5. Understand the industrial relevance and applications of synthesized and extracted compounds in pharmaceuticals, cosmetics, and food industries.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	**A. Preparation of Organic Compounds** 1. **Reaction Mechanisms** – Understand key reactions like esterification, nitration, and condensation. 2. **Purification & Testing** – Learn recrystallization, melting point checks, and TLC analysis. 3. **Green Chemistry** – Compare traditional vs. eco-friendly synthesis methods. 4. **Real-World Applications** – Discuss industrial and pharmaceutical uses of synthesized compounds. **B. Extraction and Isolation** 5. **Extraction Methods** – Explore techniques like solvent extraction and steam distillation. 6. **Yield & Purity Factors** – Learn how solvent choice and conditions affect extraction. 7. **Analysis Techniques** – Use TLC, UV-Vis, and melting point to test extracted compounds. 8. **Uses of Natural Extracts** – Discuss their applications in medicine, cosmetics, and food.	To enhance student engagement and learning outcomes, the following pedagogical approaches will be incorporated: • **Experiential Learning (Hands-on Laboratory Work)** a. Conduct guided experiments on the synthesis of industrially relevant organic compounds. b. Perform extractions and isolations of natural products to develop technical proficiency. • **Inquiry-Based Learning** a. Encourage students to analyze reaction mechanisms and predict product yields. b. Promote critical thinking by comparing conventional and green synthesis approaches. • **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. • **Technology-Enhanced Learning** a. Use digital tools (e.g., molecular modeling software, virtual labs) to visualize reaction pathways.
Preparations	**(Collected solid samples may be used for recrystallization, melting point and TLC) (At least 8)** 1. Aspirin from Salicylic acid. 2. Methyl Salicylate from Salicylic Acid 3. Paracetamol from p-amino phenol 4. Benzocaine from p-nitro benzoic acid 5. Acetanilide from aniline 6. Diphenylhydantoin from Benzoin. 7. Diclofenac sodium from aniline. 8. Nitration of Salicylic acid by green approach (using ceric ammonium nitrate). 9. Reduction of *p*-nitrobenzaldehyde by sodium borohydride. 10. Hydrolysis of amides and esters. 11. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.	

	12. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid). 13. Aldol condensation with either conventional or green method. 14. Synthesis of Indigo (using aldol condensation reaction of 2-nitrobenzaldehyde with acetone in basic condition).	b. Integrate spectroscopy and chromatography techniques for product characterization. • **Case-Based and Problem-Solving Approach** a. Analyze industrial case studies related to pharmaceutical synthesis and natural product extraction. b. Discuss challenges in large-scale production and sustainability in chemical industries. • **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.
Extraction and Isolation	**(At least 4)** 1. Isolation of casein rom milk. 2. Isolation of lactose rom milk. 3. Isolation of caffeine from tea leaves. 4. Isolation of lycopene from tomato. 5. Extraction of limonene from orange peels. 6. Extraction of piperine from black pepper. 7. Extraction of Nimbin from Neem Seeds. 8. Extraction of Nicotine from Tobaco leaves. 9. Extraction of Citronella from lemon grass. 10. Extraction of Rose oil and rose hydrosol from rose petals. 11. Extraction of Anthocyanin from rose petals.	
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. Green Chemistry: Theory and Practice by Paul T. Anastas and John C. Warner, OUP UK 6. 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. 2. Organic Syntheses (www.orgsyn.org) – Peer-reviewed procedures for organic compound synthesis. 3. https://www.youtube.com/watch?v=bMFt1lOmlQ4; 4. MIT OpenCourseWare – Organic Chemistry" for lab demonstrations.	
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-3**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108227	Chemistry Lab- 13 **(Basic Cheminformatics)**	2	60	4 Hrs	50

Course Objectives:	The intended objectives are: 1. To introduce students to the fundamental concepts and applications of cheminformatics, including molecular modeling and structure elucidation. 2. To develop computational skills for molecular representation, database searching, and cheminformatics software utilization. 3. To enhance proficiency in scientific documentation, digital tools, and science communication through internet platforms
Course Outcomes:	Upon successful completion of this course, students will be able to: 1. Demonstrate a comprehensive understanding of cheminformatics principles, including molecular representation, structure elucidation, and computational methods. 2. Apply cheminformatics techniques to encode molecular structures using various formats such as SMILES, InChI, and MOL files. 3. Efficiently retrieve and analyze chemical information through database searches using PubChem, ChemSpider, and SciFinder. 4. Utilize molecular modeling and visualization tools for structure optimization, conformational analysis, and property prediction. 5. Develop scientific documentation and presentations using MS Office, Open Office, and other digital tools for effective communication of cheminformatics concepts. 6. Integrate cheminformatics knowledge with practical applications in molecular design, structural analysis, and chemical data interpretation.

Unit System	Contents	Incorporation of Pedagogies
Tutorial and Discussion	1. **Introduction to Cheminformatics**: History, Prospects of cheminformatics, Molecular Modelling and Structure elucidation 2. **Representation of molecules and chemical reactions:** Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits. 3. **Searching chemical structures:** Full structure search, sub-structure search, basic ideas, similarity search, three-dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization 4. Introduction to advanced functions of MS Word and its Open Office substitutes including tracking changes, inserting page numbers and automatic table of contents, Google Docs and Forms, MS Power point 5. Science outreach through internet: social media, Websites, Blogs, YouTube, Podcast etc.	To enhance student engagement and learning outcomes, the following pedagogical approaches will be incorporated: • **Experiential Learning (Hands-on Laboratory Work)** a. Conduct guided experiments on the synthesis of industrially relevant organic compounds. b. Perform extractions and isolations of natural products to develop technical proficiency. • **Inquiry-Based Learning** a. Encourage students to analyze reaction mechanisms and predict product yields. b. Promote critical thinking by comparing conventional and green synthesis approaches. • **Collaborative Learning** a. Facilitate group-based experimental work to enhance teamwork and problem-solving skills. b. Conduct peer discussions on challenges and improvements in
Exercise/ Experiments	**(At least 8) (Any suitable software other than the software mentioned can be used)** 1. Illustrate the complete resonance for directive influence of -OH, and -CH_3 groups on aromatic ring using curly arrows. Transferring it to MS Word and/or MS PowerPoint. 2. Illustrate the complete resonance for directive influence of - Cl, and -NO_2 groups on aromatic ring using curly arrows. Transferring it to MS Word and/or MS PowerPoint. 3. Drawing well labelled diagram of simple acid-base titration assembly using ChemSketch. 4. To visualize structural, isomers using MolView/ Kingsdraw. Example Butane (C_4H_{10}) - n-butane & isobutane 5. To visualize geometrical isomers using MolView/ Kingsdraw. Example: 2-Butene (C_4H_8) 6. To visualize optical isomers using MolView/ Kingsdraw. Example: Lactic Acid ($C_3H_6O_3$) - D & L isomers (optical isomers)	

	7. To study the 3D structure and molecular properties of paracetamol using PubChem's molecular visualization tools. 8. SMILES & InChI Encoding: Convert molecular structures into SMILES notation using software like ChemDraw, Open Babel, or Online SMILES generators. 9. To Perform Full and Sub-Structure Searching of Chemical Compounds Using PubChem, ChemSpider, and SciFinder. 10. To Read, Write, and Edit Molfile & SDF Formats Using RDKit or Open Babel or ChemAxon's Marvin. 11. Drawing the 2D-structures of different conformers of ethane, n-butane, and cyclohexane and their conversion to 3D- optimized structures using MMFF94 forcefield using Avogadro. 12. Drawing the 2D-structures of different conformers of mono- and di-substituted cyclohexane and their conversion to 3D- optimized structures using MMFF94 forcefield using Avogadro. 13. To measure and compare bond lengths and angles in different molecules using Jmol. (Example: Methane, Ammonia, Water, Carbon Dioxide). 14. To analyze the polarity and dipole moment direction, polarizability, surface tension, density in molecules using ChemSketch.	experimental procedures. • **Technology-Enhanced Learning:**Use digital tools (e.g., molecular modeling software, virtual labs) to visualize reaction pathways. • **Case-Based and Problem-Solving Approach** a. Analyze industrial case studies related to pharmaceutical synthesis and natural product extraction. b. Discuss challenges in large-scale production and sustainability in chemical industries. • **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.
Activities	To prepare a PowerPoint presentation using structure drawing software(s) and submit soft copy to the instructor. A few students may be asked to present a seminar on the topics: Suggested list of activities (may be extended according to the wisdom of the instructor): 1. Organic reaction with suitable mechanism. 2. Derivation of a equation in physical chemistry 3. Jablonskii Diagram to explain radiative and nonradiative processes 4. Conformational analysis ethane/ butane/ cyclohexane	
References	References: 1. Svehla, G., & Vogel, A. I. (1989). *Vogel's textbook of practical inorganic chemistry* (5th ed.). Pearson Education. 2. Vogel, A. I. (1996). *Qualitative inorganic analysis* (7th ed.). Prentice Hall. 3. Malik, W. U., Tuli, G. D., & Madan, R. D. (2009). *Laboratory manual of inorganic chemistry*. S. Chand Publishing. 4. Pandey, O. P., Bajpai, D. N., & Giri, S. (2010). *Practical chemistry*. S. Chand Publishing. 5. Agarwal, O. P. (2014). *Advanced practical inorganic chemistry*. Krishna Prakashan Media. 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://edu.rsc.org/resources/practical-chemistry 5. https://nptel.ac.in/courses/104/103/104103112/ 6. http://chemcollective.org/vlabs	
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/CEP-II**

Level	Semester	Course Code	Course Name	Credits	Teaching Hours	Exam Duration	Max Marks
5.0	IV	108228	Chemistry Lab- 14 (FP/ CEP in Chemistry - II)	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: 10. Gain an understanding of rural life, Indian culture and ethos and social realities 11. Develop a sense of empathy and bonds of mutuality with the local community 12. Appreciate significant contributions of local communities to Indian society and Economy 13. Learn to value the local knowledge and wisdom of the community 14. 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. II of Semester III and IV need to perform a Field Project (FP) for TWO (2) credits i.e. 50 Marks. The guidelines regarding the FP/CEP 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**