



ZIAUDDIN UNIVERSITY
EXAMINATION BOARD

HSSC A Chemistry Syllabus



For exams in 2026 & onwards

INTRODUCTION TO ZUEB

The Ziauddin University Examination Board (ZUEB) is not only an awarding body but also a solution-driven educational organization dedicated to upholding the highest standards of academic excellence. ZUEB believes in excellence, integrity, and innovation in education. Established with a vision to foster a robust educational environment, ZUEB is committed to nurturing intellectual growth and development that meets international standards in an effective manner. The Ziauddin University Examination Board (ZUEB) was established through the Government Gazette No. XLI on June 6th, 2018. Its purpose is to ensure high quality, maintain global standards, and align the syllabi with national integrity within Pakistan's examination system. ZUEB manages student appeals, regulates assessments, and reviews policies to maintain high standards.

WHY CHOOSE HSSC-A AT ZUEB?

Ziauddin University Examination Board (ZUEB) offers the HSSC-A (Higher Secondary School Certificate Advance) program, designed for students from international educational backgrounds. This program provides a structured, affordable, and academically strong pathway for learners to align with Pakistan's education system. It allows students to fulfil national curriculum requirements, including Urdu, Islamiyat, Pakistan Studies, or Sindhi, with academic integrity and flexible learning options. ZUEB believes no student should be left behind due to financial limitations or cross-system transitions, and HSSC-A serves as a bridge between past efforts and future ambitions. It is the trusted choice for higher education in Pakistan.

HSSC-ADVANCE CHEMISTRY

HSSC-Advance Chemistry at ZUEB is a foundation for exploring the principles of matter and its interactions, designed for students aspiring to pursue higher education in medicine, engineering, pharmacy, chemical sciences, and environmental studies. The course offers a rigorous, concept-driven curriculum aligned with both national and international standards, covering key topics such as atomic structure, chemical bonding, thermodynamics, organic chemistry, electrochemistry, and environmental chemistry. Students develop a strong grasp of chemical principles and practical applications, while enhancing their analytical, experimental, and critical thinking skills, ensuring they are both examination-ready and future-ready.

Aligned with national and international standards, HSSC-Advance Chemistry at ZUEB equips students with a comprehensive understanding of physical, inorganic, and organic chemistry, alongside modern applications in medicine, industry, and research. Designed for students aiming for careers in medicine, applied sciences, chemical engineering, and research, the course builds essential skills in scientific reasoning, laboratory practices, and problem-solving.

Whether you are preparing for admission into top universities in science and technology, or planning a career in pharmacy, industrial chemistry, or scientific research, HSSC-Advance Chemistry ensures you are academically prepared and nationally aligned, with a flexible, student-focused learning approach. Explore more on what HSSC-Advance Chemistry offers [ZUEB HSSC-Advance Official Page](#).

SYLLABUS OVERVIEW

No.	Content	XII	XIII	AO	Exams
1	Atomic structure	P1	P3	AO1, AO2 and AO3	Combination of written exam papers (externally set and marked) and a practical demonstration of skills. <u>XII</u> Paper 1 Questions and Answers Duration: 1 hour 45 minutes Weighting: 25% Paper 2 Questions and Answers Duration: 1 hour 45 minutes Weighting: 25% <u>XIII</u> Paper 3 Multiple Choice Questions, Theoretical Questions, Practical Questions Duration: 2 hours 30 minutes Weighting: 50%
2	Mole calculations	P1	P3	AO1, AO2 and AO3	
3	Bonding	P1	P3	AO1, AO2 and AO3	
4	Enthalpy and Entropy	P2	P3	AO1, AO2 and AO3	
5	Redox	P2	P3	AO1, AO2 and AO3	
6	Equilibria	P2	P3	AO1, AO2 and AO3	
7	Rate of reaction	P2	P3	AO1, AO2 and AO3	
8	Acids and Bases	-	P3	AO1, AO2 and AO3	
9	Group 2 Elements	P1	P3	AO1, AO2 and AO3	
10	Group 7 Elements	P1	P3	AO1, AO2 and AO3	
11	Period 3 Elements and Oxides	P1	P3	AO1, AO2 and AO3	
12	Transition Metals	-	P3	AO1, AO2 and AO3	
13	Introduction to Organic Chemistry	P1	P3	AO1, AO2 and AO3	
14	Alkanes	P1	P3	AO1, AO2 and AO3	
15	Alkenes	P1	P3	AO1, AO2 and AO3	
16	Halogenoalkanes	P2	P3	AO1, AO2 and AO3	
17	Alcohols	P2	P3	AO1, AO2 and AO3	
18	Aromatic Chemistry	-	P3	AO1, AO2 and AO3	
19	Carbonyl Compounds	-	P3	AO1, AO2 and AO3	
20	Chiral Compounds	-	P3	AO1, AO2 and AO3	
21	Nitrogen Compound	-	P3	AO1, AO2 and AO3	
22	Condensation Polymers	-	P3	AO1, AO2 and AO3	
23	Organic Synthesis	-	P3	AO1, AO2 and AO3	

24	Analytical Techniques (mass spectroscopy, infra-red spectroscopy, NMR spectroscopy and chromatography)	P2	P3	AO1, AO2 and AO3	
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NOTE: For P2 [Only SLO 24.1.1 And 24.1.4 is included]

Description of Assessment Objectives

AO1 – Show knowledge and understanding of:

- scientific concepts and principles
- relevant methods, techniques, and procedures

AO2 – Apply knowledge and understanding to:

- use scientific ideas in various contexts
- perform and explain investigations, techniques, and procedures

AO3 – Analyse and interpret to:

- evaluate information and data
- draw reasoned conclusions and judgements
- suggest improvements to experimental methods

Weighting of Assessment Objectives

Assessment Objectives	P1 (%)	P2 (%)	P3 (%)
AO1	30	30	30
AO2	40	40	50
AO3	30	30	20

1: Atomic Structure

Aim: The aim of this content is to give an understanding of the structure of the atom.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand the structure of an atom in terms of sub atomic mass and particles.	1.1.1	Equate protons, neutrons, and electrons based on their relative charges and relative masses.	AO1
		1.1.2	Describe the distribution of mass and charge inside an atom.	AO1
		1.1.3	Identify the atomic number and mass number of a given element.	AO1
		1.1.4	Calculate the number of protons, neutrons, and electrons in atoms and ions using atomic number, mass number, and charge.	AO2
		1.1.5	State the definition of relative atomic mass, relative isotopic mass, molecular mass, and formula mass.	AO1
		1.1.6	Write meaning of the term orbital.	AO1
		1.1.7	Describe the arrangement of electrons in terms of shells, sub-shells, and orbitals.	AO1
		1.1.8	Construct electronic configurations of atoms and ions using s, p, and d notation up to atomic number 36 (4p sub-shell).	AO2
		1.1.9	Draw orbital diagrams of elements to show all electrons.	AO2
		1.1.10	Illustrate the shapes of s and p orbitals.	AO2
		1.1.11	State the meaning of the term ionization energy.	AO1

		1.1.12	Formulate equations for 1st, 2nd, and 3rd ionization energies of elements, including state symbols.	AO2
		1.1.13	Describe the trends in 1st ionization energy across a period and down a group in the Periodic Table.	AO1
		1.1.14	Analyze the dips in 1st ionisation energy trends between elements in groups 2 and 3, and groups 5 and 6.	AO3
		1.1.15	Interpret graphs of ionisation energy versus number of electrons to identify elements in a period.	AO3
		1.1.16	Deduce the group number of an element using successive ionisation energy data	AO3
2	Understand the role and function of isotopes.	1.2.1	State the meaning of the term isotope.	AO1
		1.2.2	Describe the meaning of chemical properties in relation to isotopes.	AO1
		1.2.3	Represent isotopes using standard notation ${}^x_y\text{A}$, where x is the mass number and y is the atomic number.	AO2
3	Understand the function of a mass spectrometer.	1.3.1	Describe the working of a mass spectrometer in terms of ionisation and detection of the sample.	AO1
		1.3.2	Determine the relative atomic mass of an element using isotopic abundances or mass spectrum data.	AO2
		1.3.3	Determine the abundances of isotopes using the relative atomic mass and the mass number of each isotope.	AO2
		1.3.4	Examine mass spectra of elements (including diatomic ones) to identify isotopic abundances and m/z values.	AO3

2: Mole Calculations

Aim: The aim of this content is to explore the scope of mole calculations and carry out titration experiments.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand a variety of mole calculations using chemical equations.	2.1.1	State the meaning of empirical formula and molecular formula.	AO1
		2.1.2	Determine empirical formulae using combustion data or mass composition.	AO2
		2.1.3	Derive molecular formulae from empirical formulae and relative molecular mass.	AO2
		2.1.4	Formulate balanced chemical equations.	AO2
		2.1.5	Generate ionic equations from balanced chemical equations. Generate ionic equations from balanced chemical equations.	AO2
		2.1.6	Perform mole calculations using chemical equations for: i. reacting masses, ii. gas volumes (using molar volume), iii. volumes and concentrations of solutions.	AO2
		2.1.7	Compute percentage atom economy and percentage yield using chemical equations and experimental data.	AO2
		2.1.8	Write the definition of Avogadro's constant.	AO1
		2.1.9	Apply Avogadro's constant to calculate mass of atoms/molecules or number of particles in a given mass.	AO2
		2.1.10	Apply the ideal gas equation ($pV = nRT$) to solve numerical problems.	AO2

2	Be able to demonstrate practical application of iteration experiments.	2.2.1	Prepare an accurately concentrated acid or base solution using pipette, volumetric flask, and balance.	AO2
		2.2.2	Design experiments to identify the end point of an acid-base titration.	AO3
		2.2.3	Operate a burette to measure an accurate volume.	AO2
		2.2.4	Compute the unknown concentration of an acid or base using titration data.	AO2

3: Bonding

Aim The aim of this content is to understand the various types of chemical bonds and to introduce the concepts of electronegativity and intermolecular forces.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand various forms of bonding, electronegativity and polarity.	3.1.1	State the meaning of an ionic bond.	AO1
		3.1.2	Draw dot-and-cross diagrams for ionic compounds such as NaCl and MgCl ₂	AO2
		3.1.3	Construct formulae of ionic compounds including group ions like NH ₄ ⁺ , CO ₃ ²⁻ , OH ⁻ , NO ₃ ⁻ , and SO ₄ ²⁻ .	AO2
		3.1.4	State the meaning of a covalent bond.	AO1
		3.1.5	Draw dot-and-cross diagrams for covalent compounds like CH ₄ , NH ₃ , H ₂ O, O ₂ , N ₂ , CO ₂ , and ethane.	AO2
		3.1.6	State the meaning of a dative covalent bond.	AO1
		3.1.7	Draw dot-and-cross diagrams for dative covalent compounds such as NH ₄ ⁺ and H ₂ O ⁺ .	AO2
		3.1.8	Justify the formation of dative covalent bonds in compounds like Al ₂ Cl ₆ and NH ₃ BF ₃	AO3
		3.1.9	Relate covalent bond strength to bond length.	AO1
		3.1.10	Classify covalent bonds as polar or non-polar.	AO2

		3.1.11	Assign dipoles and partial charges to atoms in a covalent molecule.	AO2
		3.1.12	State the meaning of electronegativity.	AO1
		3.1.13	Describe the trend in electronegativity across periods and down groups.	AO1
2	Understand basic shapes of simple molecular compounds.	3.2.1	Forecast and sketch the shapes and bond angles of molecules/ions using wedged and dashed notation.	AO2
3	Understand the concept and function of intermolecular forces.	3.3.1	Justify molecular non-polarity based on shape and dipole distribution.	AO3
		3.3.2	Analyze the similarities and differences between van der Waals, dipole-dipole, and hydrogen bonding interactions.	AO3
		3.3.3	Describe how electron motion gives rise to van der Waals forces.	AO1
		3.3.4	Illustrate hydrogen bonding in molecules like NH ₃ and H ₂ O.	AO2
		3.3.5	Justify the low boiling points of molecules like CH ₄ and Br ₂ based on intermolecular forces.	AO3
		3.3.6	Describe the boiling point trend in Group 6 hydrides and Group 7 hydrogen halides.	AO1
		3.3.7	Describe how simple covalent compounds dissolve in various solvents.	AO1
4	Understand metallic bonding and properties of metals.	3.4.1	Describe the unusual properties of water, including its boiling point in relation to other Group 6 hydrides and it being less dense in the solid state.	AO1
		3.4.2	State the meaning of metallic bonding.	AO1
		3.4.3	Illustrate metallic bonding using labeled diagrams.	AO2
		3.4.4	Justify the thermal and electrical conductivity of metals.	AO3

		3.4.5	Describe the melting point trend of period 3 metals from Group 1 to 3.	AO1
		3.4.6	Recognize bonding types (ionic, metallic, covalent) from given chemical formulae.	AO2
		3.4.7	Categorize compounds as giant lattice structures based on bonding.	AO2
		3.4.8	Analyze the similarities and differences between macromolecular structures of graphite, diamond, SiO ₂ and graphene.	AO3
		3.4.9	Relate properties and uses of macromolecular structures to their bonding and structure.	AO3

4: Enthalpy and Entropy

Aim: The aim of this content is to look at various ways to calculate enthalpy and entropy changes.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand the purposes and functions of enthalpy and entropy.	4.1.1	State the meaning of enthalpy change.	AO1
		4.1.2	Recall standard conditions as 298 K and 100 kPa.	AO1
		4.1.3	Apply the terms exothermic and endothermic to bond breaking and bond formation.	AO2
		4.1.4	Draw reaction profile diagrams for exothermic and endothermic reactions, labelling ΔH , E_a , reactants and products.	AO2
		4.1.5	State the meaning of mean bond enthalpy.	AO1
		4.1.6	Compute the enthalpy change of a reaction using mean bond enthalpy values.	AO2
		4.1.7	Determine a mean bond enthalpy using mean bond enthalpy data and the enthalpy change of a reaction.	AO2
		4.1.8	Justify differences between calculated and literature enthalpy values using bond enthalpies.	AO3
		4.1.9	State the meaning of the followings: i. enthalpy of combustion ii. enthalpy formation iii. enthalpy neutralisation.	AO1
		4.1.10	Illustrate Hess cycles using combustion enthalpy data.	AO2

		4.1.11	Determine enthalpy changes from Hess cycles.	AO2
		4.1.12	State the meaning of lattice enthalpy, atomisation enthalpy, and electron affinity.	AO1
		4.1.13	Recognize enthalpy changes in Born-Haber cycles of ionic compounds..	AO2
		4.1.14	Illustrate Born-Haber cycles for ionic compounds.	AO2
		4.1.15	Compute enthalpy values using Born-Haber cycles.	AO2
		4.1.16	Estimate lattice enthalpy trends based on ionic compound formulae.	AO2
		4.1.17	Describe polarization in the context of lattice enthalpy.	AO1
		4.1.18	Analyze similarities and differences between experimental and theoretical lattice enthalpy values.	AO3
		4.1.19	State meaning of the following i. enthalpy of solution ii. enthalpy of hydration.	AO1
		4.1.20	Estimate enthalpy of hydration trends from ionic formulae.	AO2
		4.1.21	Build energy cycles showing enthalpy of solution, hydration, and lattice formation.	AO2
		4.1.22	Compute solution, hydration, or lattice enthalpy using energy cycles.	AO2
		4.1.23	Interpret the significance of solution enthalpy in determining ionic compound solubility	AO3
		4.1.24	State the meaning of entropy.	AO1
		4.1.25	Describe the influence of entropy on ionic compound solubility.	AO1

		4.1.26	Forecast the sign of entropy change (ΔS) from a given reaction.	AO2
		4.1.27	Compute entropy change using standard entropy data.	AO2
		4.1.28	Recall the Gibbs free energy equation: $\Delta G = \Delta H - T\Delta S$.	AO1
		4.1.29	Compute ΔG using the Gibbs free energy equation.	AO2
		4.1.30	Evaluate feasibility of a reaction using ΔG value.	AO3
		4.1.31	Forecast the effect of temperature on the feasibility of a reaction given enthalpy and entropy values.	AO2
		4.1.32	Describe how kinetics influences the feasibility of a reaction.	AO1
		4.1.33	Design experiments to measure enthalpy change of neutralisation and combustion.	AO3
		4.1.34	Plot temperature-time graphs for reactions.	AO2
		4.1.35	Determine ΔT using temperature-time graphs.	AO2
		4.1.36	Compute enthalpy change using $q = mc\Delta T$ from experimental data.	AO2
		4.1.37	Justify discrepancies between experimental and reference enthalpy values.	AO3

5: Redox

Aim: The aim of this content is to look at redox reactions in terms of oxidation numbers, oxidising/reducing agents and half-equations.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand how redox can be used in writing chemical equations and in electrochemistry.	5.1.1	Determine oxidation numbers in compounds and ions.	AO2
		5.1.2	Apply changes in oxidation numbers to balance chemical equations.	AO2
		5.1.3	State the definition of oxidizing and reducing agents.	AO1
		5.1.4	Recognize oxidizing and reducing agents using equations and oxidation states.	AO2
		5.1.5	Write half-equations for oxidation and reduction reactions.	AO2
		5.1.6	Combine half-equations to form complete redox equations	AO2
		5.1.7	State the definition of standard electrode potential (E°).	AO1
		5.1.8	Recall standard conditions of pressure, temperature, and concentration.	AO1
		5.1.9	Describe the use and characteristics of the standard hydrogen electrode.	AO1
		5.1.10	Draw diagrams of the equipment used to measure standard electrode potentials, E° , and cell potentials, E_{cell} , of metals or non-metals in contact with their ions in aqueous solution, as well as for half-cells containing ions of the same element in different oxidation states.	AO2

		5.1.11	Forecast the strength of oxidising and reducing agents using E° values.	AO3
		5.1.12	Compute Ecell values using standard electrode potentials.	AO2
		5.1.13	Judge reaction feasibility using Ecell values	AO3
		5.1.14	Forecast E° and Ecell changes under non-standard conditions.	AO3
		5.1.15	Describe how redox reactions are applied in hydrogen-oxygen fuel cells.	AO1
		5.1.16	Write half-equations for hydrogen-oxygen fuel cells under acidic and alkaline conditions.	AO2
		5.1.17	Design practicals to light a bulb or measure Ecell in redox setups.	AO3
		5.1.18	Design experiments to establish the end point of common redox titrations such as $\text{Fe}^{2+}/\text{MnO}_4^-$ and $\text{I}_2/\text{S}_2\text{O}_3^{2-}$	AO3
		5.1.19	Compute concentration, percentage by mass, and Mr using titration data.	AO2

6: Equilibria

Aim: The aim of this content is to look at the concept of reversible equations and apply Le Chatelier's principle.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand the concept and meaning of equilibrium.	6.1.1	Describe dynamic equilibrium with reference to reaction rates and concentration stability.	AO1
		6.1.2	Apply Le Chatelier's principle to predict equilibrium shifts due to temperature, pressure, or concentration.	AO2
		6.1.3	Describe how a catalyst influences the position of equilibrium.	AO1
		6.1.4	Analyze the similarities and differences between the conditions applied in industrial equilibrium processes.	AO3
		6.1.5	Derive K _c expressions from balanced chemical equations.	AO2
		6.1.6	Compute the value of K _c : (i) given the concentrations of the reactants and products for a reaction at equilibrium, or (ii) given the moles of the reactants and products for a reaction at equilibrium.	AO2
		6.1.7	Derive K _p expressions from balanced chemical equations.	AO2
		6.1.8	Compute the value of K _p given the partial pressure of the reactants and products for a reaction at equilibrium.	AO2
		6.1.9	Determine the units of K _c and K _p for a given equilibrium	AO2
		6.1.10	Describe how temperature, pressure, concentration, and catalysts affect K _c and K _p values.	AO1

7: Rate of reaction

Aim: The aim of this content is to deepen understanding of rates of reaction and how they can be calculated experimentally, as well as to introduce the Maxwell–Boltzmann distribution.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand the concept, functions, purpose and meaning of reactions in chemistry.	7.1.1	Define rate of reaction and activation energy.	AO1
		7.1.2	Apply collision theory to relate concentration, pressure, temperature and surface area to reaction rate.	AO2
		7.1.3	Describe how a catalyst accelerates a reaction.	AO1
		7.1.4	Define the term 'initial rate' and calculate initial rate from concentration-time data.	AO2
		7.1.5	Describe the information conveyed by a Maxwell-Boltzmann energy distribution.	AO1
		7.1.6	Recognize significant points in a Maxwell-Boltzmann distribution e.g. the most probable energy, the mean energy and the area under the curve.	AO2
		7.1.7	Interpret Maxwell-Boltzmann curves at varied temperatures to explain rate changes.	AO3
		7.1.8	Modify a Maxwell-Boltzmann plot to illustrate catalytic lowering of activation energy and its impact on rate.	AO2
		7.1.9	Evaluate the differences between homogeneous and heterogeneous catalysts	AO3
		7.1.10	Describe how a heterogeneous catalyst works in terms of providing a surface for a reaction to take place on.	AO1
		7.1.11	Assess the industrial economic advantages of using catalysts.	AO3

		7.1.12	Formulate rate equations of the form $\text{rate} = k[\text{A}]^x[\text{B}]^y$ where x and y are the orders of each reactant.	AO2
		7.1.13	Evaluate the order of a reactant from: i) concentration vs time curves ii) rate vs concentration curves	AO3
		7.1.14	Determine the overall order of a reaction from the orders of the reactants.	AO3
		7.1.15	Infer reactant order via half-life analysis of a concentration-time graph..	AO3
		7.1.16	Infer the rate-determining step from a rate equation and vice versa.	AO3
		7.1.17	Estimate: i) the rate constant, k, from the rate equation and initial rates data ii) the order of a reactant from concentrations and initial rates data	AO2
		7.1.18	Forecast the reaction mechanism for a multistep reaction from the rate equation and chemical equation	AO3
		7.1.19	Apply a graphical method and the Arrhenius equation to calculate the activation energy when given rate constant (k) and temperature (T) data.	AO2
		7.1.20	Design experiments (e.g., gas-volume collection) to measure reaction rate.	AO3
		7.1.21	Analyze the data from experiments to: i) construct plots e.g., volume vs time ii) draw tangents iii) calculate the rate	AO3
		7.1.22	Design clock-reaction experiments to determine order of a reactant (e.g., propanone / I ₂).	AO3
		7.1.23	Calculate initial rate and reactant orders from clock-reaction data.	AO2
		7.1.24	Design temperature-varied clock-reaction experiments to measure rate.	AO3

8: Acids and Bases

Aim: The aim of this content is to deepen understanding of acids and bases and their reactions.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand the functions of acids and bases.	8.1.1	State the meaning of Bronsted–Lowry acid and base.	AO1
		8.1.2	Write equations to represent Bronsted–Lowry conjugate acid–base pairs.	AO2
		8.1.3	Analyze the similarities and differences between strong and weak acids and bases.	AO3
		8.1.4	State the meaning of pH.	AO1
		8.1.5	Determine: i.) the pH of a solution of strong monoprotic and diprotic acids ii.) $[H^+]$ for strong monoprotic and diprotic acids.	AO2
		8.1.6	Explain what is meant by the term K_w .	AO1
		8.1.7	Compute the following using the K_w expression: i. pH of water at different temperatures ii. pH of a basic solution iii. K_w value at different temperatures	AO2
		8.1.8	Illustrate: i.) why the pH of water changes with temperature ii.) why water is ‘neutral’ at any pH	AO3
		8.1.9	State the meaning of pKa.	AO1
		8.1.10	Determine K_a and pKa values of acids.	AO2
		8.1.11	Formulate the K_a expression for a given weak acid.	AO2

		8.1.12	Compute the following using the K_a expression: i.) pH of a weak acid concentration of a weak acid ii.) K_a	AO2
		8.1.13	Describe the assumptions made in weak acid calculations.	AO1
		8.1.14	Explain pH/titration curves for any given combination of weak and strong acids and bases	AO3
		8.1.15	Sketch pH curves for various combinations of weak and strong acids and bases.	AO2
		8.1.16	Choose suitable indicators from a given list for a titration based on the pH curve	AO2
		8.1.17	Determine the following using pH curves and given data: i. the equivalence point ii. the concentration of an acid or base	AO2
		8.1.18	State the meaning of buffer solution	AO1
		8.1.19	Describe preparation and function of buffer solutions in resisting pH changes.	AO1
		8.1.20	Describe the H_2CO_3/HCO_3^- buffer system in blood.	AO1
		8.1.21	Determine: i. the pH of a buffer solution ii. the mass of salt required to give a desired pH in a buffer solution.	AO2

9: Group 2 Metals

Aim: The aim of this content is to study the reactions and properties of group 2 elements.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand the forms. Functions and reactions of group 2 metals	9.1.1	Write balanced equations and report observations for reactions of Mg–Ba with oxygen, chlorine, and water.	AO2
		9.1.2	Write balanced equations and report observations for reactions of group 2 oxides, hydroxides, and carbonates with water and acids.	AO2
		9.1.3	Describe the solubility trends of group 2 hydroxides and sulfates in water.	AO1
		9.1.4	List the uses of magnesium and calcium hydroxides and barium sulfate.	AO1
		9.1.5	State the meaning of thermal decomposition.	AO1
		9.1.6	Describe the decomposition trends of group 2 nitrates and carbonates and compare them with group 1 compounds.	AO3
		9.1.7	Describe how the trends in decomposition could be established in a laboratory.	AO1
		9.1.8	Write balanced equations for thermal decomposition of group 1 and 2 nitrates and carbonates.	AO2

10: Group 7 Elements

Aim: The aim of this content is to study the reactions and properties of group 7 elements.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand the properties, reactivity limits and reactions of group 7 elements	10.1.1	Identify the physical state and colour of chlorine, bromine and iodine.	AO1
		10.1.2	Describe the trend in boiling points across Group 7 elements.	AO1
		10.1.3	Describe the trend in reactivity of the group 7 elements with reference to the halogens as oxidising agents.	AO1
		10.1.4	Apply the observations of the redox reactions of group 7 elements with halide ions to show the order of reactivity of the halogens.	AO2
		10.1.5	Write balanced chemical and ionic equations for halogen–halide redox reactions.	AO2
		10.1.6	State the meaning of disproportionation..	AO1
		10.1.7	Write equations for the reactions of chlorine with cold and hot NaOH and water	AO2
		10.1.8	Apply oxidation numbers to show that these reactions are disproportionation reactions	AO2
		10.1.9	Justify the use of Chlorine in water purification.	AO3
		10.1.10	Interpret halide–H ₂ SO ₄ reactions to assess halide reducing strength.	AO3
		10.1.11	Write balanced equations for reactions between halide ions and Sulphuric acid	AO2
		10.1.12	Design tests to identify CO ₃ ²⁻ , SO ₄ ²⁻ , NH ₄ ⁺ , and halide ions.	AO2

11: Period 3 Elements and Oxides

Aim: The aim of this content is to study the reactions and properties of period 3 elements and oxides.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand the properties and reaction rates of period 3 elements and oxides.	11.1.1	Describe the trends in atomic and ionic radii across Period 3.	AO1
		11.1.2	Relate the trend in melting point and electrical conductivity of Period 3 elements to their structure and bonding.	AO1
		11.1.3	Identify the flame colours of Na, Mg, Al, Si, S, and P.	AO1
		11.1.4	Write equations for the reactions of the period 3 elements with oxygen, chlorine and water (water with Na and Mg only).	AO2
		11.1.5	Report observations for reactions of Period 3 elements with O ₂ , Cl ₂ , and H ₂ O.	AO1
		11.1.6	Write balanced equations for reactions of acidic/basic Period 3 oxides with water, acids, or bases.	AO2
		11.1.7	Report observations for reactions of acidic/basic oxides of Period 3 elements with water, acids, or bases.	AO1
		11.1.8	Describe how Al ₂ O ₃ behaves as an amphoteric oxide.	AO1

12: Transition Metals

Aim: The aim of this content is to explore the properties and reactions of the transition metals and d-block elements.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand the forms, functions and properties of transition metals.	12.1.1	State the meaning of the terms: i. transition element ii. d-block element	AO1
		12.1.2	Work out the electronic configuration of atoms and ions from Sc to Zn.	AO2
		12.1.3	Describe why transition metals exhibit variable oxidation states.	AO1
		12.1.4	State the meaning of ligand, complex ion, and coordination number.	AO1
		12.1.5	Apply the terms monodentate, bidentate, and multidentate to ligand types.	AO2
		12.1.6	Describe the formation of a complex ion.	AO1
		12.1.7	Apply the terms linear, square planar, tetrahedral and octahedral in reference to the geometry of complex ions	AO2
		12.1.8	Exemplify complex ions with linear, square planar, tetrahedral, and octahedral geometries.	AO1
		12.1.9	Draw the shapes of linear, square planar, tetrahedral, and octahedral complex ions.	AO3
		12.1.10	Illustrate why ligands such as chloride ions might not form octahedral complexes..	AO3
		12.1.11	Forecast i.) the charge on a complex ion from the metal ion and ligands ii.) the charge on the metal ion from the complex ion formula	AO2
		12.1.12	Analyze the following types of complex ion isomers that have monodentate or/and bidentate ligands: i.) cis-trans ii.) optical	AO3

		12.1.13	Describe how cis-platin acts as an anticancer drug by reference to its interaction with DNA.	AO1
		12.1.14	Describe how haemoglobin acts as a complex ion and transports oxygen around the body.	AO1
		12.1.15	Describe the origin of colour in transition metal complexes with reference to d-orbitals.	AO1
		12.1.16	Deduce whether a complex is coloured based on its electronic configuration.	AO2
		12.1.17	Identify the factors affecting colour in transition metal complexes.	AO1
		12.1.18	State the meaning of ligand exchange reactions	AO1
		12.1.19	Analyze ligand exchange reactions of complex ions that contain monodentate ligands with bidentate and multidentate ligands in terms of changes in entropy.	AO3
		12.1.20	Write equations for the reactions of Cu^{2+} and Co^{2+} complex ions with chloride ions.	AO2
		12.1.21	Report observations for reactions between $\text{Cu}^{2+}/\text{Co}^{2+}$ complex ions and Cl^- .	AO1
		12.1.22	Describe the catalytic role of transition metals.	AO1
		12.1.23	Write equations showing the role of the transition metal as a catalyst in the following reactions: i.) $\text{SO}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{SO}_3$ using V_2O_5 ii.) $2\text{I}^- + \text{S}_2\text{O}_8^{2-} \rightarrow \text{I}_2 + 2\text{SO}_4^{2-}$ using Fe^{2+} or Fe^{3+}	AO2
		12.1.24	Analyze the observations for the reactions of Cr^{3+} , Cu^{2+} , Fe^{2+} and Fe^{3+} ions with dilute NaOH and dilute NH_3 solutions, including in excess.	AO3
		12.1.25	Write ionic equations for the reactions of Cr^{3+} , Cu^{2+} , Fe^{2+} and Fe^{3+} with dilute NaOH and NH_3	AO2

13: Introduction to Organic Chemistry

Aim: The aim of this content is to introduce basic organic chemistry concepts, rules and molecules.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand types of formulae, terminology and structures of organic chemistry.	13.1.1	Apply the following terms to represent simple organic compounds: structural, displayed, general, molecular, empirical and skeletal formulae.	AO2
		13.1.2	Name alkanes, alkenes, and halogenoalkanes (up to 8 carbon atoms) using IUPAC rules.	AO2
		13.1.3	State the meaning of hydrocarbon..	AO1
		13.1.4	State the meaning of i.) aliphatic ii.) functional group iii.) saturated iv.) unsaturated	AO1
		13.1.5	State the meaning of homologous series.	AO1
		13.1.6	List the distinguishing features of a homologous series.	AO1
		13.1.7	State the meaning of structural isomerism.	AO1
		13.1.8	Sketch structural isomers showing chain, positional, and functional group differences.	AO2
		13.1.9	State the meaning of stereoisomerism.	AO1
		13.1.10	Describe the conditions for stereoisomerism in alkenes.	AO1
		13.1.11	Draw cis/trans isomers of suitable alkenes.	AO2
		13.1.12	Distinguish between cis/trans and E/Z nomenclature for stereoisomers.	AO3
		13.1.13	Sketch E/Z isomers using Cahn-Ingold-Prelog priority rules.	AO2

14: Alkanes

Aim: The aim of this content is to study the properties and reactions of alkanes.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand forms, functions and properties of alkanes.	14.1.1	Describe why alkanes are not reactive.	AO1
		14.1.2	Write balanced equations for the combustion of alkanes.	AO2
		14.1.3	Highlight the consequences of incomplete combustion in an internal combustion engine by referring to the formation and environmental effects of carbon monoxide, oxides of nitrogen and unburnt hydrocarbons.	AO1
		14.1.4	Describe how gases produced by combustion contribute to the enhanced greenhouse effect.	AO1
		14.1.5	Write chemical equations that show how catalytic converters reduce pollution.	AO1
		14.1.6	Summarize the processes of fractional distillation, cracking, and reforming of crude oil	AO1
		14.1.7	Write balanced equations for the cracking of alkanes.	AO2
		14.1.8	Write balanced equations for the reforming of alkanes	AO2
		14.1.9	State the meaning of the term "free radical."	AO1
		14.1.10	Distinguish between homolytic and heterolytic bond fission.	AO3
		14.1.11	Write equations for initiation, propagation, and termination steps in the free radical substitution of alkanes (and halogenoalkanes).	AO2
		14.1.12	Explain why free radical substitution results in a low product yield	AO1

15: Alkenes

Aim: The aim of this content is to look at the properties and reactions of alkenes.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand forms, functions and properties of alkenes.	15.1.1	Describe the terms sigma and pi bonds by discussing the differences of orbitals used and resulting bond strength.	AO1
		15.1.2	State a chemical test used to identify the presence of an alkene.	AO1
		15.1.3	Describe the following reactions of alkenes, including conditions and products: i.) addition of hydrogen ii.) reaction with steam iii.) reaction with hydrogen halides or halogens iv.) oxidation with cold KMnO ₄	AO1
		15.1.4	Write balanced chemical equations for alkene reactions using [O] for oxidising agents.	AO2
		15.1.5	State the meaning of the term "electrophile."	AO1
		15.1.6	Illustrate the electrophilic addition mechanism of alkenes, e.g., ethene with HCl or Cl ₂ .	AO2
		15.1.7	Predict major and minor products of electrophilic addition between unsymmetrical alkenes and hydrogen halides by using Markovnikov's rule	AO3
		15.1.8	Explain why major and minor products are obtained in terms of the stability of carbocations.	AO1
		15.1.9	State that alkenes undergo addition polymerisation	AO1
		15.1.10	Assign the terms monomer, polymer, and repeat unit correctly in the context of addition polymerisation.	AO1
		15.1.11	Draw the repeating unit of a polymer using the structure of its monomer.	AO2

		15.1.12	Write chemical equations to represent the formation of an addition polymer from a monomer.	AO2
		15.1.13	Recognize the monomer(s) from a given polymer structure	AO2
		15.1.14	Compare the physical properties of different addition polymers such as polyethene and PVC	AO3
		15.1.15	Assess the environmental issues related to the disposal of addition polymers.	AO3
		15.1.16	Describe how alternative fuels provide solutions to issues in polymer disposal	AO1

16: Halogenoalkanes

Aim: The aim of this content is to study the properties and reactions of halogenoalkanes.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand forms, functions and properties of halogenoalkanes.	16.1.1	Categorize halogenoalkanes as primary, secondary and tertiary	AO2
		16.1.2	State the meaning of the term "nucleophile."	AO1
		16.1.3	Illustrate the nucleophilic substitution mechanisms of halogenoalkanes with aqueous KOH, KCN, and NH ₃ .	AO2
		16.1.4	Distinguish between the different products formed when NH ₃ or the halogenoalkane is used in excess	AO3
		16.1.5	Highlight the trend in reactivity among primary, secondary, and tertiary halogenoalkanes.	AO1
		16.1.6	Describe the trend in reactivity of chloro-, bromo-, and iodo- halogenoalkanes using bond enthalpy considerations.	AO1
		16.1.7	Analyze the SN ₁ and SN ₂ mechanisms by referring to the transition state, intermediate, and stereochemical outcomes.	AO3
		16.1.8	Forecast the alkene product(s) of elimination reactions of symmetrical and asymmetrical halogenoalkanes with ethanolic KOH	AO2
		16.1.9	Explain why chlorofluorocarbons (CFCs) are harmful to the ozone layer and describe actions taken to reduce their impact.	AO1
		16.1.10	Write balanced equations to show how chlorine free radicals decompose ozone	AO2
		16.1.11	Design experiments to show the reactivity of different halogenoalkanes using aqueous silver nitrate in ethanol.	AO2

17: Alcohols

Aim: The aim of this content is to study the properties and reactions of alcohols.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand forms, functions and properties of alcohols.	17.1.1	Categorize alcohols as primary, secondary, or tertiary.	AO1
		17.1.2	Outline the following reactions of alkanes, including conditions and products: i.) combustion ii.) substitution with PCl_5 , $\text{NaBr}/\text{H}_2\text{SO}_4$ or red P/I ₂ iii.) with sodium iv.) dehydration using concentrated H_3PO_4	AO1
		17.1.3	Formulate chemical equations for reactions of alcohols.	AO2
		17.1.4	Recognize oxidation products of primary and secondary alcohols using acidified $\text{K}_2\text{Cr}_2\text{O}_7$.	AO
		17.1.5	Report observations from the oxidation of alcohols.	AO1
		17.1.6	Describe how varying conditions affect the products in alcohol oxidation.	AO1
		17.1.7	Write chemical equations using [O] to represent the oxidising agent.	AO2
		17.1.8	Design experiments to oxidise primary and secondary alcohols.	AO2
		17.1.9	Draw and label diagrams for heating under reflux and for distillation.	AO2
		17.1.10	Explain the purpose of heating under reflux and distillation.	AO1
		17.1.11	Design experiments to prepare and purify an organic liquid using the following techniques and apparatus: i.) heat under reflux ii.) separating funnel with aqueous Na_2CO_3 iii.) drying with an anhydrous salt such as MgSO_4 or CaCl_2 iv.) distillation.	AO2

		17.1.12	Draw and label the structure of a separating funnel.	AO2
		17.1.13	Explain the purpose of the separating funnel and the use of Na ₂ CO ₃	AO1
		17.1.14	Describe the purpose of the drying agent.	AO1
		17.1.15	Interpret boiling point data to assess purity of an organic compound	AO2
		17.1.16	Apply IUPAC naming conventions to carboxylic acids, esters, and acyl chlorides.	AO2

18: Aromatic Chemistry

Aim: The aim of this content is to study the structure and reactions of benzene and related compounds.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand forms, functions and properties of aromatic chemistry.	18.1.1	Distinguish between the Kekule and delocalised models of benzene structure.	AO3
		18.1.2	Illustrate a diagram to show the bonding in benzene with particular reference to orbital overlap.	AO2
		18.1.3	Identify the H–C–C bond angle in benzene.	AO1
		18.1.4	Describe how the Kekule model was disproven with reference to the following: i.) reaction with Br ₂ ii.) bond lengths iii.) hydrogenation of benzene	AO1
		18.1.5	Distinguish between the reactivity of benzene and alkenes.	AO3
		18.1.6	Write balanced chemical equations for the combustion of benzene.	AO2
		18.1.7	Illustrate the electrophilic substitution mechanism for benzene with the following electrophiles: i.) NO ₂ ⁺ (nitration) ii.) R ⁺ (Friedel–Crafts alkylation) iii.) RCO ⁺ (Friedel–Crafts acylation) iv.) Cl ⁺ and Br ⁺ (halogenation)	AO2
		18.1.8	Identify the reagents used to generate various electrophiles for benzene substitution	AO1
		18.1.9	Write chemical equations for the formation of the electrophiles.	AO2
		18.1.10	Identify the reagents and conditions for reducing nitrobenzene to phenylamine.	AO1
		18.1.11	Write balanced chemical equations using [H] to represent the reducing agent.	AO2
		18.1.12	Distinguish between the reactivity of phenol with benzene.	AO3

		18.1.13	Write equations for the reactions between phenol and: i.) aqueous bromine ii.) NaOH iii.) Na	AO2
		18.1.14	Analyze phenol's reactivity with weak vs. strong bases.	AO3
		18.1.15	Predict the position of electrophilic substitution reactions for the following directing groups: i.) OH ii.) NH ₂ iii.) NO ₂	AO2

19: Carbonyl Compounds

Aim: The aim of this content is to study the properties and reactions of carbonyl compounds.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand forms, functions and properties of carbonyl compounds.	19.1.1	Analyze the boiling points of aldehydes and ketones compared to carboxylic acids.	AO3
		19.1.2	Describe why short-chain aldehydes, ketones and carboxylic acids are soluble in water.	AO1
		19.1.3	Illustrate nucleophilic addition mechanisms of aldehydes and ketones with: i.) NaBH ₄ or LiAlH ₄ ii.) KCN followed by acid.	AO2
		19.1.4	Describe the reactions of carboxylic acids with: i.) LiAlH ₄ ii.) bases iii.) PCl ₅ or SOCl ₂	AO1
		19.1.5	Write equations for the reactions of carboxylic acids (using [H] where necessary).	AO2
		19.1.6	Identify the reagents and conditions for hydrolysing a nitrile to a carboxylic acid and formulate the equation..	AO1
		19.1.7	Distinguish between ester formation via carboxylic acids and via acyl chlorides with alcohols.	AO3
		19.1.8	Write equations for the formation of esters.	AO2
		19.1.9	Analyze the hydrolysis of esters under acidic and alkaline conditions..	AO3
		19.1.10	Describe the reactions of acyl chlorides with: i.) primary and secondary amines ii.) water iii.) phenol	AO1
		19.1.11	Formulate balanced equations for acyl chloride reactions with nucleophiles	AO2
		19.1.12	Illustrate the nucleophilic addition–elimination mechanisms of acyl chlorides with: i. amines ii. water iii. alcohol.	AO2

20: Chiral Compounds

Aim: The aim of this content is to give an understanding of chiral compounds and optical isomers.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand forms, functions and properties of chiral compounds.	20.1.1	Explain the meaning of a chiral carbon (or chiral centre) in an organic molecule.	AO1
		20.1.2	Define the following terms: i.) chiral carbon/centre ii.) optical isomers/enantiomers	AO1
		20.1.3	Recognize chiral carbons in a variety of organic compounds	AO2
		20.1.4	Represent enantiomers using three-dimensional (wedged and dashed) bond notation.	AO2
		20.1.5	Describe how plane-polarised light is used to distinguish between enantiomers.	AO1
		20.1.6	Define the term racemic mixture.	AO1
		20.1.7	Explain how a racemic mixture forms with reference to the nucleophilic addition mechanism.	AO1

21: Nitrogen Compounds

Aim: The aim of this content is to give an understanding of the properties and reactions of amines, amino acids and amides.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand forms, functions and properties of nitrogen compounds	21.1.1	Describe the following reactions to form amines, including reagents, conditions and equations: i. reduction of a nitrile ii. reaction of NH_3 with halogenoalkanes iii. reduction of $\text{C}_6\text{H}_5\text{NO}_2$ to $\text{C}_6\text{H}_5\text{NH}_2$.	AO1
		21.1.2	Describe the following reactions of amines, including reagents, conditions and equations: i.) with H_2O ii.) with acids iii.) with acyl chlorides	AO1
		21.1.3	Analyze the basicity of various aliphatic and aromatic amines.	AO3
		21.1.4	Analyze the hydrolysis of amides under acidic and alkaline conditions.	AO3
		21.1.5	Apply IUPAC rules to name amines, amides, and amino acids.	AO2
		21.1.6	Sketch the general structure of an α -amino acid.	AO2
		21.1.7	Explain the high melting points of amino acids.	AO1
		21.1.8	Predict amino acid structures in acidic and alkaline solutions.	AO2
		21.1.9	Describe the formation of zwitterions.	AO1
		21.1.10	Sketch the zwitterionic form of an amino acid.	AO2
		21.1.11	Construct the structures of dipeptides and tripeptides from given amino acid units.	AO2

		21.1.12	Apply chromatography and Rf values to identify amino acids after peptide hydrolysis.	AO2
		21.1.13	Elaborate the purpose of ninhydrin in identifying amino acids in chromatography experiments.	AO1

22: Condensation Polymers

Aim: The aim of this content is to give an understanding of how polyesters and polyamides can be formed and some commercial uses of each.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand forms, functions and properties of condensation polymers.	22.1.1	Describe that polyesters and polyamides are formed through condensation polymerisation..	AO1
		22.1.2	Illustrate repeating units of polymers from the reactions of: i.) dicarboxylic acids and diols ii.) dicarboxylic acids and diamines iii.) amino acids	AO2
		22.1.3	Sketch the repeating units of Kevlar, Nylon 6,6, and Terylene.	AO2
		22.1.4	Draw repeating units from sections of a polymer.	AO2
		22.1.5	Recognize the monomer(s) from a section of a polymer.	AO2
		22.1.6	Describe how intermolecular forces influence the properties of polyesters and polyamides such as Kevlar..	AO1
		22.1.7	Explain why condensation polymers are classed as biodegradable. mechanism.	AO1

23: Organic Synthesis

Aim: To develop the ability to design synthetic pathways, purify organic compounds, and evaluate their purity in the context of laboratory and industrial organic synthesis.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand forms, functions and properties of organic synthesis.	23.1.1	Design multi-step organic synthesis routes (up to four steps) using any combination of syllabus-based reactions	AO2
		23.1.2	Explain the importance of synthesising a single optical isomer in pharmaceutical production.	AO1
		23.1.3	Summarize the steps involved to purify an organic solid by recrystallisation.	AO1
		23.1.4	Apply the melting point of an organic solid as an indicator of purity.	AO2

24: Analytical Techniques (mass spectroscopy, infra-red spectroscopy, NMR spectroscopy and chromatography)

Aim: The aim of this content is to give an understanding of infra-red, NMR spectroscopy and mass spectrometry as used in organic chemistry.

	The learner will:	SLO #	Assessment Criteria - The learner can:	Cognitive levels
1	Understand forms, functions and properties of analytical techniques.	24.1.1	Recognize molecular ion peak in a mass spectrum	AO1
		24.1.2	Apply m/z values of fragment peaks to determine the structure of an organic compound.	AO2
		24.1.3	Identify functional groups (C-H, C=C, C=O, O-H alcohol, O-H carboxylic acid) using IR spectra and data book values.	AO2
		24.1.4	Explain the role and limitations of the fingerprint region (0–1500 cm ⁻¹) in IR spectroscopy.	AO1
		24.1.5	Analyse ¹³ C NMR spectra to identify carbon environments and deduce possible organic structures.	AO3
		24.1.6	Predict ¹³ C NMR spectral features (number of environments and chemical shifts) from given structures.	AO2
		24.1.7	Analyse ¹ H NMR spectra to determine hydrogen environments, peak areas, splitting patterns (n+1 rule), and deduce structures.	AO3
		24.1.8	Predict ¹ H NMR features from given structures, including hydrogen environments, chemical shifts, relative peak areas, and splitting patterns.	AO2
		24.1.9	Explain the purpose of TMS and deuterated solvents (e.g., CDCl ₃) in NMR spectroscopy.	AO1
		24.1.10	Explain how D ₂ O can be used to identify O–H and N–H protons in ¹ H NMR.	AO1

		24.1.11	Describe the basic principles of chromatography with reference to mobile and stationary phases.	AO1
		24.1.12	Compute R _f values from thin layer chromatograms.	AO2
		24.1.13	Distinguish gas chromatography (GC) and high-performance liquid chromatography (HPLC) based on their phases, uses, and limitations.	AO3
		24.1.14	Explain the concept of retention time in chromatography.	AO1
		24.1.15	Analyse chromatograms to determine the percentage composition of components in a mixture.	AO2
		24.1.16	Describe how mass spectrometry can be used alongside gas chromatography to help identify components in a mixture.	AO1

Core Practical Competencies

As part of the course, candidates are expected to complete and provide evidence of practical work that demonstrates a broad set of competencies. These will be developed and reinforced through a minimum of 10 practical activities across the two-year program. It is not necessary to demonstrate every competency in each activity; rather, consistent application over time is expected.

Competencies

1. Following Instructions

- Accurately carries out experimental procedures as directed by written protocols.

2. Investigative Approaches and Use of Equipment

- Selects and correctly operates scientific instruments, apparatus, and materials (including ICT) with minimal guidance.
- Performs techniques in logical sequence, adapting to practical issues where required.
- Identifies and manages variables, choosing suitable equipment and measurement strategies to obtain reliable results.

3. Safe Practice

- Recognises hazards and evaluates risks, adjusting procedures accordingly.
- Employs appropriate safety measures and equipment with minimal prompting.

4. Observation and Data Recording

- Make clear, accurate observations.
- Collects sufficient, precise data, recording it systematically using correct units and conventions.

5. Research, Referencing, and Reporting

- Uses software or tools to process and present data effectively.
- Incorporates research and cites sources appropriately to support planning and conclusions.

Practical techniques to be completed by candidates

Candidates should be able to:

- Use appropriate apparatus to measure quantitative values (mass, time, volume, temperature, length, voltage, current).
- Employ suitable instruments for measurement (e.g. Vernier calipers for length).
- Correctly design and use circuits, including meters.
- Produce clear and appropriate graphs of experimental data.

Mathematical Requirements

Candidates are expected to demonstrate competence in the following areas.

Calculators may be used in all parts of the examination.

1. Perform arithmetic operations including addition, subtraction, multiplication, and division.
2. Use mathematical symbols such as $=$, $<$, $<<$, $>>$, $>$, $\propto$, and $\sim$ correctly.
3. Calculate percentages and percentage changes.
4. Convert data between graphical, numerical, and algebraic forms.
5. Rearrange formulae to determine unknown variables.
6. Estimate and account for uncertainties in measurements.
7. Convert between different units of measurement.
8. Solve algebraic equations, including those requiring substitution and correct units.
9. Work confidently with orders of magnitude and scale.
10. Use calculators for power, exponential, and logarithmic functions.
11. Calculate circumference, surface area, and volume of common shapes.
12. Determine rates of change from graphs.
13. Apply standard form appropriately to numerical data.
14. Round data and present results to an appropriate number of significant figures, aligned with measurement precision.
15. Interpret and apply linear relationships of the form $y = mx + c$, including identifying gradients and intercepts.
16. Manipulate logarithmic and exponential expressions.
17. Extract useful data from both the gradient and area under graphs.
18. Use melting points, boiling points, and other experimental data as indicators of purity where applicable.

Safety in Practical investigations

Candidates should be able to:

1. Identify hazards and assess risks of chemicals, equipment, and procedures before beginning an experiment.
2. Handle concentrated acids and alkalis safely, wearing protective equipment and adding acids to water carefully.
3. Recognise the risks of flammable or volatile substances and carry out experiments away from naked flames, preferably under a fume hood.
4. Set up and use apparatus for reflux and distillation securely and correctly.
5. Use separating funnels safely, releasing pressure when required.
6. Handle oxidising agents, reducing agents, and reactive metals with caution and in small quantities.
7. Generate gases in well-ventilated areas or fume cupboards.
8. Follow correct procedures when using electrical circuits and power supplies.
9. Dispose of chemical waste according to type and laboratory instructions.
10. Use chromatography solvents safely, avoiding inhalation of vapours.
11. Handle glassware carefully and replace damaged equipment immediately.
12. Wear lab coats and goggles, tie back hair, keep benches clear, and avoid eating or drinking in the laboratory.