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 | ✓ | ✓ | AO1, AO2 and AO3 | Combination of written exam papers (externally set and marked) and a practical demonstration of skills.<br><br>**XII**<br><br>**Paper 1**<br>Short and long answer questions.<br>Duration: 2 hours<br>Weighting: 50%<br><br>**Paper 2**<br>Short and long answer questions.<br>Duration: 2 hours<br>Weighting: 50%<br><br>**XIII**<br><br>**Paper 1**<br>Short and long answer questions.<br>Duration: 2 hours<br>Weighting: 25%<br><br>**Paper 2**<br>Short and long answer questions.<br>Duration: 2 hours<br>Weighting: 25%<br><br>**Paper 3**<br>Multiple choice questions, practical based skills and short and long answer questions.<br>Duration: 2 hours<br>Weighting: 50% |
| 2 | Mole calculations | ✓ | ✓ | AO1, AO2 and AO3 | |
| 3 | Bonding | ✓ | ✓ | AO1, AO2 and AO3 | |
| 4 | Enthalpy and Entropy | ✓ | ✓ | AO1, AO2 and AO3 | |
| 5 | Redox | ✓ | ✓ | AO1, AO2 and AO3 | |
| 6 | Equilibria | ✓ | ✓ | AO1, AO2 and AO3 | |
| 7 | Rate of reaction | ✓ | ✓ | AO1, AO2 and AO3 | |
| 8 | Acids and Bases | ✓ | ✓ | AO1, AO2 and AO3 | |
| 9 | Group 2 Elements | ✓ | ✓ | AO1, AO2 and AO3 | |
| 10 | Group 7 Elements | ✓ | ✓ | AO1, AO2 and AO3 | |
| 11 | Period 3 Elements and Oxides | ✓ | ✓ | AO1, AO2 and AO3 | |
| 12 | Transition Metals | - | ✓ | AO1, AO2 and AO3 | |
| 13 | Introduction to Organic Chemistry | ✓ | ✓ | AO1, AO2 and AO3 | |
| 14 | Alkanes | ✓ | ✓ | AO1, AO2 and AO3 | |
| 15 | Alkenes | ✓ | ✓ | AO1, AO2 and AO3 | |
| 16 | Halogenoalkanes | ✓ | ✓ | AO1, AO2 and AO3 | |
| 17 | Alcohols | ✓ | ✓ | AO1, AO2 and AO3 | |
| 18 | Aromatic Chemistry | ✓ | ✓ | AO1, AO2 and AO3 | |

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|---|---|---|---|---|---|
| 19 | Carbonyl Compounds | ✓ | ✓ | AO1, AO2 and AO3 | |
| 20 | Chiral Compounds | ✓ | ✓ | AO1, AO2 and AO3 | |
| 21 | Nitrogen Compound | - | ✓ | AO1, AO2 and AO3 | |
| 22 | Condensation Polymers | - | ✓ | AO1, AO2 and AO3 | |
| 23 | Organic Synthesis | - | ✓ | AO1, AO2 and AO3 | |
| 24 | Analytical Techniques (mass spectroscopy, infra-red spectroscopy, NMR spectroscopy and chromatography) | - | ✓ | AO1, AO2 and AO3 | |

## 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 |

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| | | 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 $^{x}_{y}\mathbf{A}$ , 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 |

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| 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 |
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| ***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 MgCl2 | 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 $CH_4$, $NH_3$, $H_2O$, $O_2$, $N_2$, $CO_2$, 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 $H_2O^+$. | AO2 |
| | | 3.1.8 | **Justify** the formation of dative covalent bonds in compounds like $Al_2Cl_6$ and $NH_3BF_3$ | AO3 |
| | | 3.1.9 | **Relate** covalent bond strength to bond length. | AO1 |
| | | 3.1.10 | **Classify** covalent bonds as polar or non-polar. | AO2 |

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| | | 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 $H_2O$. | 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 |

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| | | 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 |
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| ***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, Ea, 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:<br>i. enthalpy of combustion<br>ii. enthalpy formation<br>iii. enthalpy neutralisation. | AO1 |
| | | 4.1.10 | **Illustrate** Hess cycles using combustion enthalpy data. | AO2 |

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| | | 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<br>i. enthalpy of solution<br>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 |

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| | | 4.1.26 | **Forecast** the sign of entropy change ($\Delta S$) 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** $\Delta G$ using the Gibbs free energy equation. | AO2 |
| | | 4.1.30 | **Evaluate** feasibility of a reaction using $\Delta G$ 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** $\Delta T$ 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, Ecell, 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 |

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| | | 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 $Fe^{2+}/MnO_4^-$ and $I2/S_2O_3^{2-}$ | 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** Kc expressions from balanced chemical equations. | AO2 |
| | | 6.1.6 | **Compute** the value of Kc: (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** Kp expressions from balanced chemical equations. | AO2 |
| | | 6.1.8 | **Compute** the value of Kp given the partial pressure of the reactants and products for a reaction at equilibrium. | AO2 |
| | | 6.1.9 | **Determine** the units of Kc and Kp for a given equilibrium | AO2 |
| | | 6.1.10 | **Describe** how temperature, pressure, concentration, and catalysts affect Kc and Kp 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 |

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| | | 7.1.12 | **Formulate** rate equations of the form rate = k[A]^x[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 Kw. | AO1 |
| | | 8.1.7 | **Compute** the following using the Kw expression: i. pH of water at different temperatures ii. pH of a basic solution iii. Kw 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** Ka and pKa values of acids. | AO2 |
| | | 8.1.11 | **Formulate** the Ka expression for a given weak acid. | AO2 |

| | | | | |
|---|---|---|---|---|
| | | 8.1.12 | **Compute** the following using the Ka expression: i.) pH of a weak acid ii.) concentration of a weak acid iii.) Ka | 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–$H2SO4$ 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 $CO3^{2-}$, $SO4^{2-}$, $NH_4^+$, 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 $H_2O$. | 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 $Al_2O_3$ 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 |

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|---|---|---|---|---|
| | | 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 $Cu^{2+}$/$Co^{2+}$ 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:<br>i.) $SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$ using $V_2O_5$<br>ii.) $2I^- + S_2O_8^{2-} \rightarrow I_2 + 2SO_4^{2-}$ 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 KMnO4 | 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 Markovinkov'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 |

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|---|---|---|---|---|
| | | 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 SN1 and SN2 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 $PCl_5$, $NaBr/H_2SO_4$ 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 $K_2Cr_2O_7$. | 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 |

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|---|---|---|---|---|
| | | 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 $Na_2CO_3$ | 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 Br2 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 |

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|---|---|---|---|---|
| | | 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 $C_6H_5NO_2$ to $C_6H_5NH_2$. | 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 |

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|---|---|---|---|---|
| | | 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** 13C NMR spectra to identify carbon environments and deduce possible organic structures. | AO3 |
| | | 24.1.6 | **Predict** 13C NMR spectral features (number of environments and chemical shifts) from given structures. | AO2 |
| | | 24.1.7 | **Analyse** 1H NMR spectra to determine hydrogen environments, peak areas, splitting patterns (n+1 rule), and deduce structures. | AO3 |
| | | 24.1.8 | **Predict** 1H 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 $D_2O$ can be used to identify O–H and N–H protons in 1H NMR. | AO1 |

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|---|---|---|---|---|
| | | 24.1.11 | **Describe** the basic principles of chromatography with reference to mobile and stationary phases. | AO1 |
| | | 24.1.12 | **Compute** Rf 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 =, <, <<, >>, >, ∝, and ~ 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.