Subject matter

Topic 1: Intermolecular forces and gases (13 hours)

Science understanding

Intermolecular forces

- Apply the valence shell electron pair repulsion (VSEPR) theory to determine the shape and bond angles of linear, bent, trigonal planar, tetrahedral and pyramidal molecules. (Hybridization involving d-orbitals are not required.)
- Determine the polarity of molecules using molecular shape, understanding of symmetry, and comparison of the electronegativity of elements.
- Explain the relationship between vapour pressure, melting point, boiling point and solubility, and the nature and strength of intermolecular forces (e.g. dispersion forces, dipole-dipole attractions, and hydrogen bonding) within molecular covalent substances.

Chromatography techniques

- Identify that paper and thin layer chromatography can be used to determine the composition and purity of substances.
- Explain how variations in the strength of the interactions between atoms, molecules or ions in the mobile and stationary phases can be used to separate components.
- Analyse paper and thin layer (TLC) chromatographs to determine the composition and purity of substances, including calculating R_F values.

Gases

- State the relationship between the volume of a gas, number of moles and molar volume at standard temperature and pressure (STP).
- Apply the kinetic theory of gases to explain the relationships between pressure, temperature, and volume of a gas.
- Identify that the kinetic theory of gases applies to ideal gases.
- Apply the ideal gas equation to calculate the mass of chemicals and/or the volume of a gas (STP) involved in a chemical reaction. (Formula: $PV = nRT$)
- Analyse data to determine the relationships between pressure, temperature, and volume of a gas.

Science as a human endeavour (SHE)

- Appreciate that science relies on chemical processes to analyse materials in order to determine the identity, nature or source of the material.
- Explore how chromatography techniques, including gas and high-performance liquid chromatography, can be used to determine the composition and purity of substances.
- Appreciate that safe scuba diving requires knowledge of the behaviour of gases.
- Explore Jacques Cousteau and Emile Gagnan's role in the invention of SCUBA.
- Appreciate that two- and three-dimensional graphical models have been developed and adopted by chemists to represent and communicate the shapes of molecules.
- Consider the limitations associated with the VSEPR theory.

Science inquiry

Investigate:

- Boyle's law or the molar volume of a gas
- the separation of a mixture using paper or thin layer chromatography* (TLC)
- 3D models of linear, bent, trigonal planar, tetrahedral and pyramidal molecules.*

***Note:** Simulations may be used.

Topic 2: Aqueous solutions and acidity (22 hours)

Science understanding

Aqueous solutions and molarity

- Explain that the unique properties of water are related to molecular shape and hydrogen bonding between molecules.
- Discriminate between the terms *solute*, *solvent*, *solution*.
- Discriminate between the terms *strength* and *concentration*, e.g. acidic/basic solutions.
- State that square brackets ([ ]) are used to denote concentration.
- Discriminate between unsaturated, saturated and supersaturated solutions.
- Apply the mole concept to calculate moles of solute, concentration and volume of a solution. (Formula: $\text{Molarity/Concentration (c)} = \frac{\text{moles of solute } (n)}{\text{volume of solution (V)}}$)

Identifying ions in solution

- Apply ionic and chemical formulas to construct balanced ionic and chemical equations (including states) for precipitation reactions.
- Apply solubility rules to predict if a precipitation will be formed.
- Analyse data, including precipitation and acid-carbonate reactions, to determine the presence of specific ions in solutions.

Solubility

- Compare the solubility of ionic and molecular substance in water, and the intermolecular forces between species in the substances and water molecules.
- Identify that changes in solvent temperature can affect the solubility of solid and gaseous solutes (solids and gases).
- Analyse data, including solubility curves, to determine the solubility of ionic compounds and the concentration of ions in aqueous solutions.

pH

- State that pH is dependent on the concentration of hydrogen ions in solution.
- Identify that the pH scale is a logarithmic scale.
- Apply the pH scale to compare the levels of acidity or alkalinity of aqueous solutions.
- Apply the Arrhenius model to explain the behaviour of strong and weak acids and bases in aqueous solutions.

Reactions of acids

- Determine balanced chemical and ionic equation (including states) for the reactions of acids with bases, metals and carbonates.

Science as a human endeavour (SHE)

- Appreciate that most sulfur dioxide released to the atmosphere comes from burning coal or oil in electric power stations.
- Explore the chemistry of acid rain.
- Appreciate that blood plasma is an aqueous solution containing a range of ionic and molecular substances.
- Explore why blood is red and the chemistry of blood types.
- Appreciate that knowledge of the composition of water from different sources informs decisions about how that water is treated and used.
- Evaluate the measurable properties of water that are used to determine the water quality of a local water way.
- Explore the different water treatment methods used to provide safe drinking water.

Science inquiry

Investigate:

- precipitation reactions to identify cations and anions
- factors that affect solubility in aqueous solutions
- reactions of acids with bases, metals and carbonates.

Topic 3: Rates of chemical reactions (10 hours)

Science understanding

Rates of reactions

- Explain how temperature, surface area, pressure (gaseous systems), concentration and the presence of a catalyst can affect the rate of the reaction.
- Apply the collision theory to determine the effect of concentration, temperature, pressure and surface area on the rate of chemical reactions.
- Sketch Maxwell-Boltzmann distribution curves for reactions with and without catalysts.
- Describe activation energy (E_a).
- Explain the relationship between the strength and number of the existing chemical bonds, the magnitude of the activation energy and the rate of a chemical reaction.
- Sketch energy profile diagrams for reactions with and without catalysts.
- Analyse energy profile diagrams for reactions with and without catalysts, to determine the enthalpy change and activation energy.
- Explain how catalysts affect the rate of a chemical reaction.
- Calculate the rate of chemical reactions by measuring the rate of formation of products or the depletion of reactants. (Formula: $\text{rate of reaction } = \frac{\text{increase in product concentration } (\Delta[\text{P}])}{\text{time taken}}$ or $\frac{\text{decrease in reactant concentration } (-\Delta[\text{R}])}{\text{time taken}}$)
- Analyse data and graphical representations of relative changes in the concentration, volume and mass against time to determine rate of reaction. (Order of reaction is not required.)

Science as a human endeavour (SHE)

- Appreciate that catalysts work in a variety of ways, and knowledge of the structure of enzyme molecules helps scientists to explain and predict how they are able to lower the activation energy for reactions.
- Explore Mildred Cohn’s use of isotopic tracers and NMR spectroscopy to study the mechanism of enzymatic catalysis.
- Appreciate that most contemporary methods of corrosion prevention rely on knowledge of chemical and electrochemical redox processes.
- Explore the historical theories on corrosion from the introduction of iron in Antiquity through to the impact of air pollution on the life span of modern metal structures.
- Appreciate that collision theory enables chemists to explain and predict the rates of a vast range of chemical reactions in many different contexts.
- Explore the history of collision theory, its uses and its limitations.

Science inquiry

- Investigate factors that affect the rate of chemical reactions.