OCR A Comb Sci Chemistry

Topic C1: Particles

C1.1 The particle model

C1.1a — describe the main features of the particle model in terms of states of matter and change of state

1. What are the three states of matter?
2. How are particles arranged in a solid?
3. How are particles arranged in a liquid?
4. How are particles arranged in a gas?
5. How do particles move in a solid?
6. How do particles move in a liquid?

C1.1b — explain in terms of the particle model the distinction between physical changes and chemical changes

1. What is a physical change?
2. What is a chemical change?
3. What happens to the particles during a physical change?
4. What happens to the particles during a chemical change?
5. Is melting a physical change or a chemical change?
6. Is the formation of a new substance a physical change or a chemical change?

C1.1c — explain the limitations of the particle model in relation to changes of state when particles are represented by inelastic spheres (e.g. like bowling balls)

1. What type of forces between particles are not included in the simple particle model?
2. Why is the size of particles not accurately represented by the simple particle model?
3. Why is the space between particles not accurately represented by the simple particle model?

4. What does the simple model assume about the particles when they are represented as inelastic spheres?
5. Why can the simple particle model not fully explain changes of state?
6. What three features of particles are not taken into account by the simple inelastic-sphere model?

Topic C2: Elements, compounds and mixtures

C2.1 Purity and separating mixtures

C2.1a — explain what is meant by the purity of a substance, distinguishing between the scientific and everyday use of the term 'pure'

1. What does the term pure mean in chemistry?
2. What is a pure substance made up of?
3. What does pure mean in everyday language?
4. How is the scientific meaning of pure different from the everyday meaning?
5. What is an impurity?
6. How can impurities affect the properties of a substance?

C2.1b — use melting point data to distinguish pure from impure substances

1. What happens to the melting point of a pure substance when it melts?
2. What happens to the melting point of an impure substance compared with the pure substance?
3. How can melting point data be used to identify a pure substance?
4. What would a sharp melting point suggest about the purity of a substance?
5. What would a range of melting temperatures suggest about the purity of a substance?
6. A substance melts over a range of temperatures rather than at one temperature. What does this suggest about its purity?

C2.1c — calculate relative formula masses of species separately and in a balanced chemical equation

1. What is relative atomic mass (Ar)?

2. What is relative molecular mass (Mr)?
3. What is relative formula mass?
4. How do you calculate the relative formula mass of a compound?
5. Calculate the relative formula mass of H_2O. (Ar: H = 1, O = 16)
6. Calculate the relative formula mass of $CaCO_3$. (Ar: Ca = 40, C = 12, O = 16)

C2.1d — deduce the empirical formula of a compound from the relative numbers of atoms present or from a model or diagram and vice versa

1. What is an empirical formula?
2. What does an empirical formula show about the atoms in a compound?
3. How do you determine an empirical formula from the numbers of atoms present?
4. What is the empirical formula of a compound containing 2 carbon atoms and 4 hydrogen atoms?
5. What is the empirical formula of a compound containing 1 carbon atom and 2 oxygen atoms?
6. How can you determine the relative numbers of atoms in a compound from its empirical formula?

C2.1e — explain that many useful materials are formulations of mixtures

1. What is a formulation?
2. What is a mixture?
3. Why are formulations useful?
4. What is an alloy?
5. Why are alloys described as mixtures?
6. Give one example of an alloy.

C2.1f — describe, explain and exemplify the processes of filtration, crystallisation, simple distillation, and fractional distillation

1. What type of mixture can be separated by filtration?
2. How does filtration separate a solid from a liquid?
3. What is crystallisation used to separate?
4. How does crystallisation produce a solid from a solution?
5. What is simple distillation used to separate?
6. What is the difference between simple distillation and fractional distillation?

C2.1g — describe the techniques of paper and thin layer chromatography using aqueous and non-aqueous solvents and locating agents

1. What is paper chromatography used to separate?
2. What is the stationary phase in paper chromatography?
3. What is used as the stationary phase in thin layer chromatography?
4. What is the solvent used for in chromatography?
5. What is a locating agent used for in chromatography?
6. How can aqueous and non-aqueous solvents be used in chromatography?

C2.1h — recall that chromatography involves a stationary and a mobile phase and that separation depends on the distribution between the phases

1. What is the stationary phase in chromatography?
2. What is the mobile phase in chromatography?
3. What happens to a substance that has a greater attraction to the stationary phase?
4. What happens to a substance that has a greater attraction to the mobile phase?
5. What causes different substances to separate during chromatography?
6. What determines how far a substance travels during chromatography?

C2.1i — interpret chromatograms, including measuring Rf values

1. What is a chromatogram?
2. What does a single spot at one position on a chromatogram show?
3. What do several spots on a chromatogram show?
4. What does the Rf value measure?
5. What is the formula for calculating Rf?
6. A substance travels 4 cm and the solvent front travels 8 cm. What is its Rf value?

C2.1j — suggest suitable purification techniques given information about the substances involved

1. Which separation technique is suitable for separating an insoluble solid from a liquid?
2. Which purification technique is suitable for obtaining crystals of a dissolved solid?
3. Which distillation technique is suitable for separating a solvent from a solution?

4. Which distillation technique is suitable for separating two miscible liquids with different boiling points?
5. What information about substances should be considered when choosing a purification technique?
6. Why can differences in boiling point be used to separate liquids by distillation?

C2.1k — suggest chromatographic methods for distinguishing pure from impure substances

1. How can paper chromatography be used to distinguish a pure substance from an impure substance?
2. How can thin layer chromatography be used to distinguish a pure substance from an impure substance?
3. What would a single spot on a chromatogram usually suggest about a substance?
4. What would several spots on a chromatogram suggest about a substance?
5. What type of chromatography can be used to separate and identify components in a gas mixture?
6. How can chromatography provide evidence that a substance is impure?

C2.2 Bonding

C2.2a — describe metals and non-metals and explain the differences between them on the basis of their characteristic physical and chemical properties

1. What are two typical physical properties of metals?
2. What are two typical physical properties of non-metals?
3. What type of ion do metals usually form?
4. What type of ion do non-metals usually form?
5. What is formed when a metal reacts with oxygen?
6. What is the general word equation for a metal reacting with oxygen?

C2.2b — explain how the atomic structure of metals and non-metals relates to their position in the Periodic Table

1. Where are metals found in the Periodic Table?
2. Where are non-metals found in the Periodic Table?
3. What happens to the number of outer-shell electrons across a period from left to right?
4. Why do metals tend to lose electrons when they react?
5. Why do non-metals tend to gain or share electrons when they react?

6. How does the arrangement of electrons help explain whether an element is a metal or non-metal?

C2.2c — explain how the position of an element in the Periodic Table is related to the arrangement of electrons in its atoms and hence to its atomic number, group number and period number

1. What does the atomic number of an element tell you?
2. What does the group number tell you about the electrons in the outer shell of a main-group element?
3. What does the period number tell you about an atom?
4. How is the atomic number related to the number of electrons in a neutral atom?
5. How can the electron arrangement of an atom be used to identify its group?
6. How can the electron arrangement of an atom be used to identify its period?

C2.2d — describe and compare the nature and arrangement of chemical bonds in: i. ionic compounds ii. simple molecules iii. giant covalent structures iv. polymers v. metals

1. What type of bonding occurs in ionic compounds?
2. How are particles arranged in an ionic compound?
3. What type of bonding holds the atoms together in simple molecules?
4. How are atoms arranged in a giant covalent structure?
5. How are atoms joined together in polymers?
6. What holds the positive metal ions and delocalised electrons together in a metal?

C2.2e — explain chemical bonding in terms of electrostatic forces and the transfer or sharing of electrons

1. What is meant by the transfer of electrons?
2. What happens to electrons when a positive ion forms?
3. What happens to electrons when a negative ion forms?
4. What is meant by the sharing of electrons?
5. What electrostatic attraction holds oppositely charged ions together?
6. What electrostatic attraction holds the particles together in metallic bonding?

C2.2f — construct dot and cross diagrams for simple covalent and binary ionic substances

1. What do the dots and crosses represent in a dot-and-cross diagram?
2. What does a dot-and-cross diagram show about the electrons involved in bonding?
3. How many electrons are shared in a single covalent bond?
4. How would you show the electron transfer when sodium forms a sodium ion and chlorine forms a chloride ion?
5. How would you use a dot-and-cross diagram to show bonding in a chlorine molecule, Cl_2?
6. How would you use a dot-and-cross diagram to show bonding in a magnesium oxide compound, MgO?

C2.2g — describe the limitations of particular representations and models

1. What is one limitation of a dot-and-cross diagram?
2. What is one limitation of a ball-and-stick model?
3. Why does a ball-and-stick model not show the actual sizes of atoms?
4. What is one limitation of a two-dimensional representation of a molecule?
5. What is one limitation of a three-dimensional representation of a molecule?
6. Why can no single model give a complete representation of a chemical structure?

C2.2h — explain how the reactions of elements are related to the arrangement of electrons in their atoms and hence to their atomic number

1. Which electrons are mainly involved when elements react?
2. Why are outer-shell electrons important in chemical reactions?
3. What happens to electrons when a metal reacts with a non-metal?
4. How does an element's atomic number determine the number of electrons in a neutral atom?
5. How does electron arrangement affect the way an element reacts?
6. Why do elements in the same group have similar chemical reactions?

C2.2i — explain in terms of atomic number how Mendeleev's arrangement was refined into the modern Periodic Table

1. What did Mendeleev use to arrange the elements in his Periodic Table?
2. What important information did Mendeleev use to identify patterns in the elements?
3. What is the modern Periodic Table arranged in order of?
4. What does atomic number represent?

5. Why did the modern Periodic Table need to be refined from Mendeleev's arrangement?
6. How does arranging elements by atomic number produce repeating patterns in their properties?

C2.3 Properties of materials

C2.3a — recall that carbon can form four covalent bonds

1. How many covalent bonds can one carbon atom form?
2. How many electrons are in the outer shell of a carbon atom?
3. Why can carbon form four covalent bonds?
4. How many covalent bonds does carbon form in methane, CH_4?
5. How many covalent bonds does each carbon atom form in ethane, C_2H_6?
6. How does carbon's ability to form four covalent bonds allow it to form many different compounds?

C2.3b — explain that the vast array of natural and synthetic organic compounds occur due to the ability of carbon to form families of similar compounds, chains and rings

1. What is an organic compound?
2. Why can carbon form chains of atoms?
3. Why can carbon form rings of atoms?
4. What is a family of similar organic compounds?
5. How does carbon's ability to form chains and rings produce many different organic compounds?
6. What is the difference between a natural organic compound and a synthetic organic compound?

C2.3c — explain the properties of diamond, graphite, fullerenes and graphene in terms of their structures and bonding

1. What type of bonding is found in diamond?
2. Why is diamond very hard?
3. How are carbon atoms arranged in graphite?
4. Why can graphite conduct electricity?
5. What are fullerenes?
6. How is graphene structured and why is it strong?

C2.3d — use ideas about energy transfers and the relative strength of chemical bonds and intermolecular forces to explain the different temperatures at which changes of state occur

1. What happens to particles when a substance changes state?
2. What happens to energy during melting?
3. What happens to energy during boiling?
4. What is an intermolecular force?
5. How does the strength of intermolecular forces affect the temperature at which a substance changes state?
6. Why do substances with stronger intermolecular forces generally have higher boiling points?

C2.3e — use data to predict states of substances under given conditions

1. What information can be used to predict the state of a substance?
2. What happens to a substance when its temperature reaches its melting point?
3. What happens to a substance when its temperature reaches its boiling point?
4. A substance has a melting point of 20°C. What state is it likely to be at 10°C?
5. A substance has a boiling point of 80°C. What state is it likely to be at 100°C?
6. A substance has a melting point of 0°C and a boiling point of 100°C. What state is it at 50°C?

C2.3f — explain how the bulk properties of materials (ionic compounds; simple molecules; giant covalent structures; polymers and metals) are related to the different types of bonds they contain, their bond strengths in relation to intermolecular forces and the ways in which their bonds are arranged

1. What is meant by the bulk properties of a material?
2. Why do ionic compounds generally have high melting points?
3. Why do simple molecular substances generally have low melting and boiling points?
4. Why do giant covalent structures generally have very high melting points?
5. Why can metals conduct electricity?
6. Why do the bulk properties of a material depend on its bonding and structure rather than the properties of individual atoms?

Topic C3: Chemical reactions

C3.1 Introducing chemical reactions

C3.1a — use chemical symbols to write the formulae of elements and simple covalent and ionic compounds

1. What is the chemical symbol for sodium?
2. What is the chemical formula for oxygen gas?
3. What is the chemical formula for water?
4. What is the chemical formula for carbon dioxide?
5. What is the chemical formula for sodium chloride?
6. What is the chemical formula for magnesium oxide?

C3.1b — use the names and symbols of common elements and compounds and the principle of conservation of mass to write formulae and balanced chemical equations and half equations

1. What is the chemical symbol for calcium?
2. What is the chemical formula for calcium chloride?
3. Write the balanced equation for magnesium reacting with oxygen to form magnesium oxide.
4. Write the balanced equation for hydrogen reacting with oxygen to form water.
5. What must be conserved when balancing a chemical equation?
6. What does a half equation show about the electrons transferred during a reaction?

C3.1c — use the names and symbols of common elements from a supplied Periodic Table to write formulae and balanced chemical equations where appropriate

1. What is the chemical symbol for potassium?
2. What is the chemical symbol for chlorine?
3. What is the chemical symbol for iron?
4. What is the chemical symbol for copper?
5. Write the formula for aluminium oxide.
6. Write the balanced equation for calcium reacting with water to form calcium hydroxide and hydrogen.

C3.1d — use the formula of common ions to deduce the formula of a compound

1. What is the charge on a sodium ion, Na^+?
2. What is the charge on a chloride ion, Cl^-?
3. What is the formula of the compound formed from Na^+ and Cl^-?
4. What is the formula of the compound formed from Mg^{2+} and Cl^-?
5. What is the formula of the compound formed from Ca^{2+} and O^{2-}?
6. What is the formula of the compound formed from Al^{3+} and O^{2-}?

C3.1e — construct balanced ionic equations

1. What is an ionic equation?
2. What should be removed from a complete ionic equation to produce a net ionic equation?
3. Write the ionic equation for the reaction between hydrogen ions and hydroxide ions.
4. Write the ionic equation for the formation of a precipitate of silver chloride.
5. How must the total charge compare on both sides of a balanced ionic equation?
6. How must the number of each type of atom compare on both sides of a balanced ionic equation?

C3.1f — describe the physical states of products and reactants using state symbols (s, l, g and aq)

1. What does the state symbol (s) mean?
2. What does the state symbol (l) mean?
3. What does the state symbol (g) mean?
4. What does the state symbol (aq) mean?
5. What state symbol would be used for solid sodium chloride?
6. What state symbol would be used for sodium chloride dissolved in water?

C3.1g — describe tests to identify selected gases

1. What test is used to identify oxygen gas?
2. What result is seen when a glowing splint is placed in oxygen?
3. What test is used to identify hydrogen gas?
4. What result is seen when a lit splint is placed in hydrogen?
5. What test is used to identify carbon dioxide?
6. What test and result can be used to identify chlorine gas?

C3.1h — recall and use the definitions of the Avogadro constant (in standard form) and of the mole

1. What is the Avogadro constant?
2. What is the value of the Avogadro constant?
3. What is the unit of the Avogadro constant?
4. What is a mole?
5. How many particles are there in one mole of a substance?
6. How can the Avogadro constant be used to calculate the number of particles in a given amount of substance?

C3.1i — explain how the mass of a given substance is related to the amount of that substance in moles and vice versa

1. What is the formula linking mass, moles and molar mass?
2. What is the unit of amount of substance?
3. What is the unit of mass commonly used in mole calculations?
4. What is the unit of molar mass?
5. Calculate the amount of substance in 18 g of water. (Mr of H_2O = 18)
6. Calculate the mass of 0.5 mol of carbon dioxide. (Mr of CO_2 = 44)

C3.1j — explain how the mass of a solute and the volume of the solution is related to the concentration of the solution

1. What is a solute?
2. What is a solution?
3. What is concentration?
4. What is the formula linking concentration, mass of solute and volume of solution?
5. Calculate the concentration in g/dm^3 of a solution containing 20 g of solute in 2 dm^3 of solution.
6. Calculate the mass of solute needed to make 500 cm^3 of a solution with a concentration of 40 g/dm^3.

C3.1k — recall and use the law of conservation of mass

1. What does the law of conservation of mass state?
2. What happens to the total mass during a chemical reaction?
3. Why must the total mass of the reactants equal the total mass of the products?
4. What happens to atoms during a chemical reaction that explains conservation of mass?
5. A reaction starts with 15 g of reactants. What is the total mass of the products?

6. A reaction produces 24 g of products from two reactants. If one reactant has a mass of 9 g, what is the mass of the other reactant?

C3.1l — explain any observed changes in mass in non-enclosed systems during a chemical reaction and explain them using the particle model

1. Why can the measured mass change during a reaction in an open container?
2. What happens to the measured mass if a gas escapes from an open reaction?
3. What happens to the measured mass if a gas from the air enters an open reaction?
4. Why does the total mass of all particles remain constant even when the measured mass changes?
5. Why can burning a substance in an open container cause an increase in measured mass?
6. How can the particle model explain an apparent change in mass in an open system?

C3.1m — deduce the stoichiometry of an equation from the masses of reactants and products and explain the effect of a limiting quantity of a reactant

1. What does the stoichiometry of a chemical equation describe?
2. How can a balanced equation show the ratio in which substances react?
3. What is meant by the limiting reactant?
4. What happens to the limiting reactant during a reaction?
5. What happens to an excess reactant when the limiting reactant is completely used up?
6. What mass of aluminium oxide is formed when 135g of aluminium is burned in air?

C3.1n — use a balanced equation to calculate masses of reactants or product

1. What information from a balanced equation is needed to calculate the mass of a reactant or product?
2. What calculation can be used to convert mass into moles?
3. What calculation can be used to convert moles into mass?
4. Calculate the mass of magnesium oxide produced when 0.5 mol of MgO is formed. (Mr of MgO = 40)

5. Calculate the amount in moles of carbon dioxide in 88 g of CO_2. (Mr of CO_2 = 44)
6. Why must a balanced chemical equation be used when calculating the mass of a reactant or product?

C3.2 Energetics

C3.2a — distinguish between endothermic and exothermic reactions on the basis of the temperature change of the surroundings

1. What is an exothermic reaction?
2. What happens to the temperature of the surroundings during an exothermic reaction?
3. What is an endothermic reaction?
4. What happens to the temperature of the surroundings during an endothermic reaction?
5. A reaction causes the temperature of the surroundings to increase. Is the reaction exothermic or endothermic?
6. A reaction causes the temperature of the surroundings to decrease. Is the reaction exothermic or endothermic?

C3.2b — draw and label a reaction profile for an exothermic and an endothermic reaction

1. What does a reaction profile show?
2. What does the vertical axis represent on a reaction profile?
3. What does the horizontal axis represent on a reaction profile?
4. What is activation energy shown as on a reaction profile?
5. How does the energy level of the products compare with the reactants in an exothermic reaction?
6. How does the energy level of the products compare with the reactants in an endothermic reaction?

C3.2c — explain activation energy as the energy needed for a reaction to occur

1. What is activation energy?
2. Why is activation energy needed for a chemical reaction?
3. Where is activation energy shown on a reaction profile?
4. What happens if reacting particles do not have enough energy to overcome the activation energy?
5. Does an exothermic reaction still require activation energy?
6. Does an endothermic reaction still require activation energy?

C3.2d — calculate energy changes in a chemical reaction by considering bond making and bond breaking energies

1. What happens to energy when chemical bonds are broken?
2. What happens to energy when chemical bonds are formed?
3. What calculation is used to determine the overall energy change from bond energies?
4. A reaction requires 500 kJ/mol to break bonds and releases 700 kJ/mol when new bonds form. What is the overall energy change?
5. If more energy is released when bonds form than is absorbed when bonds break, is the reaction exothermic or endothermic?
6. If more energy is absorbed when bonds break than is released when bonds form, is the reaction exothermic or endothermic?

C3.3 Types of chemical reactions

C3.3a — explain reduction and oxidation in terms of loss or gain of oxygen, identifying which species are oxidised and which are reduced

1. What is oxidation in terms of oxygen?
2. What is reduction in terms of oxygen?
3. What happens to a substance when it is oxidised?
4. What happens to a substance when it is reduced?
5. In the reaction copper oxide + carbon → copper + carbon dioxide, which substance is reduced?
6. In the same reaction, which substance is oxidised?

C3.3b — explain reduction and oxidation in terms of gain or loss of electrons, identifying which species are oxidised and which are reduced

1. What is oxidation in terms of electrons?
2. What is reduction in terms of electrons?
3. What happens to electrons when a substance is oxidised?
4. What happens to electrons when a substance is reduced?
5. Which substance is oxidised when magnesium reacts to form Mg^{2+}?
6. Which substance is reduced when Cu^{2+} gains electrons to form copper?

C3.3c — recall that acids form hydrogen ions when they dissolve in water and solutions of alkalis contain hydroxide ions

1. Which ions do acids form when they dissolve in water?
2. Which ions are present in aqueous alkali solutions?
3. What is the formula for a hydrogen ion?
4. What is the formula for a hydroxide ion?
5. What ion makes an aqueous solution acidic?
6. What ion makes an aqueous solution alkaline?

C3.3d — describe neutralisation as acid reacting with alkali or a base to form a salt plus water

1. What is neutralisation?
2. What are the products of an acid reacting with an alkali?
3. What are the products of an acid reacting with a base?
4. What is the general word equation for an acid reacting with an alkali?
5. What salt is formed when hydrochloric acid reacts with sodium hydroxide?
6. What salt is formed when sulfuric acid reacts with potassium hydroxide?

C3.3e — recognise that aqueous neutralisation reactions can be generalised to hydrogen ions reacting with hydroxide ions to form water

1. Which ions react during aqueous neutralisation?
2. What is the formula of the hydrogen ion?
3. What is the formula of the hydroxide ion?
4. What is the formula of the water molecule formed during neutralisation?
5. Write the balanced ionic equation for neutralisation.
6. What happens to hydrogen ions and hydroxide ions during neutralisation?

C3.3f — recall that carbonates and some metals react with acids and write balanced equations predicting products from given reactants

1. What gas is produced when a carbonate reacts with an acid?
2. What are the three products formed when a carbonate reacts with an acid?
3. What gas is produced when a reactive metal reacts with an acid?
4. What are the two products formed when a metal reacts with an acid?
5. Write the word equation for calcium carbonate reacting with hydrochloric acid.
6. Write the balanced equation for magnesium reacting with hydrochloric acid.

C3.3g — use and explain the terms dilute and concentrated (amount of substance) and weak and strong (degree of ionisation) in relation to acids

1. What does dilute mean when describing an acid?
2. What does concentrated mean when describing an acid?
3. What does strong mean when describing an acid?
4. What does weak mean when describing an acid?
5. What is the difference between acid concentration and acid strength?
6. Which term describes the amount of acid per volume of solution: concentration or strength?

C3.3h — recall that relative acidity and alkalinity are measured by pH

1. What does the pH scale measure?
2. What pH value represents a neutral solution?
3. What pH values represent acidic solutions?
4. What pH values represent alkaline solutions?
5. Which is more acidic, pH 2 or pH 5?
6. Which is more alkaline, pH 12 or pH 9?

C3.3i — describe neutrality and relative acidity and alkalinity in terms of the effect of the concentration of hydrogen ions on the numerical value of pH

1. What happens to pH when the concentration of hydrogen ions increases?
2. What happens to pH when the concentration of hydrogen ions decreases?
3. What does pH 7 indicate about a solution?
4. Which has the greater hydrogen ion concentration: pH 2 or pH 4?
5. Which has the lower hydrogen ion concentration: pH 9 or pH 12?
6. What does a lower pH value indicate about hydrogen ion concentration?

C3.3j — use the idea that as hydrogen ion concentration increases by a factor of ten, the pH value of a solution decreases by one

1. What happens to pH when hydrogen ion concentration increases by a factor of 10?
2. What happens to pH when hydrogen ion concentration decreases by a factor of 10?
3. A solution changes from pH 5 to pH 4. By what factor has its hydrogen ion concentration increased?
4. A solution changes from pH 3 to pH 5. By what factor has its hydrogen ion concentration decreased?

5. Which has 100 times the hydrogen ion concentration: pH 2 or pH 4?
6. A solution has pH 6. What would its pH become if its hydrogen ion concentration increased by a factor of 100?

C3.3k — describe techniques and apparatus used to measure pH

1. What indicator can be used to estimate the pH of a solution?
2. What instrument can measure pH more precisely than universal indicator?
3. What colour range does universal indicator show across the pH scale?
4. How is universal indicator used to estimate the pH of a solution?
5. How is a pH meter used to measure the pH of a solution?
6. Which gives a more precise pH measurement: universal indicator or a pH meter?

C3.4 Electrolysis

C3.4a — recall that metals (or hydrogen) are formed at the cathode and non-metals are formed at the anode in electrolysis using inert electrodes

1. What is electrolysis?
2. What type of ion moves towards the cathode?
3. What type of ion moves towards the anode?
4. What is formed at the cathode during electrolysis of a molten ionic compound?
5. What is formed at the anode during electrolysis of a molten ionic compound?
6. What are cations and anions?

C3.4b — predict the products of electrolysis of binary ionic compounds in the molten state

1. What happens to an ionic compound when it is molten?
2. Which ion is discharged at the cathode during electrolysis of a molten ionic compound?
3. Which ion is discharged at the anode during electrolysis of a molten ionic compound?
4. What are the products of electrolysis of molten sodium chloride?
5. What is the half equation for the formation of sodium at the cathode?
6. What is the half equation for the formation of chlorine at the anode?

C3.4c — describe competing reactions in the electrolysis of aqueous solutions of ionic compounds in terms of the different species present

1. What additional particles are present when an ionic compound is dissolved in water?
2. Which two possible products can form at the cathode when aqueous sodium chloride is electrolysed using inert electrodes?
3. Which two possible products can form at the anode when aqueous sodium chloride is electrolysed using inert electrodes?
4. What are the products of electrolysis of aqueous sodium chloride using inert electrodes?
5. What are the products of electrolysis of aqueous copper sulfate using inert electrodes?
6. Why can water compete with the ions from an ionic compound during electrolysis of an aqueous solution?

C3.4d — describe electrolysis in terms of the ions present and reactions at the electrodes

1. What happens to positive ions at the cathode?
2. What happens to negative ions at the anode?
3. What type of reaction occurs at the cathode?
4. What type of reaction occurs at the anode?
5. Write the half equation for the formation of hydrogen from hydrogen ions.
6. Write the half equation for the formation of chlorine from chloride ions.

C3.4e — describe the technique of electrolysis using inert and non-inert electrodes

1. What is an inert electrode?
2. Give one example of an inert electrode.
3. Why do inert electrodes generally not react during electrolysis?
4. What is a non-inert electrode?
5. How can a non-inert electrode take part in electrolysis?
6. What should be connected to the electrodes to provide the electrical energy needed for electrolysis?

Topic C4: Predicting and identifying chemical products

C4.1 Predicting chemical reactions

C4.1a — recall the simple properties of Groups 1, 7 and 0

1. What are the elements in Group 1 called?
2. What are the elements in Group 7 called?
3. What are the elements in Group 0 called?
4. What is one physical property of Group 1 metals?
5. What is one physical property of Group 7 elements?
6. What is one chemical property of Group 0 elements?

C4.1b — explain how observed simple properties of Groups 1, 7 and 0 depend on the outer shell of electrons of the atoms and predict properties from given trends down the groups

1. How many electrons are in the outer shell of Group 1 atoms?
2. How many electrons are in the outer shell of Group 7 atoms?
3. Why do Group 1 elements tend to lose one electron when they react?
4. Why do Group 7 elements tend to gain one electron when they react?
5. How does the reactivity of Group 1 metals change down the group?
6. How does the reactivity of Group 7 elements change down the group?

C4.1c — predict possible reactions and probable reactivity of elements from their positions in the Periodic Table

1. What information about an element's position can be used to predict its reactivity?
2. Which Group 1 element is more reactive: lithium or potassium?
3. Which Group 7 element is more reactive: fluorine or iodine?
4. What type of reaction occurs when a more reactive halogen reacts with a halide of a less reactive halogen?
5. Will chlorine displace bromine from potassium bromide?
6. Will iodine displace chlorine from potassium chloride?

C4.1d — explain how the reactivity of metals with water or dilute acids is related to the tendency of the metal to form its positive ion

1. What happens to a metal atom when it forms a positive ion?
2. Why do metals that readily lose electrons tend to be more reactive?
3. What gas is produced when a reactive metal reacts with water?
4. What gas is produced when a reactive metal reacts with a dilute acid?
5. What two products are formed when a metal reacts with dilute hydrochloric acid?

6. Why does a more reactive metal react more readily with water or dilute acid?

C4.1e — deduce an order of reactivity of metals based on experimental results

1. How can reactions with water be used to compare the reactivity of metals?
2. How can reactions with dilute acids be used to compare the reactivity of metals?
3. What does a faster reaction with dilute acid suggest about a metal's reactivity?
4. If metal A displaces metal B from its compound, which metal is more reactive?
5. If magnesium reacts with hydrochloric acid but copper does not, which metal is more reactive?
6. How can experimental results be used to place metals in order of reactivity?

Topic C5: Monitoring and controlling chemical reactions

C5.1 Controlling reactions

C5.1a — suggest practical methods for determining the rate of a given reaction

1. What is meant by the rate of a chemical reaction?
2. How can the volume of gas produced be used to measure the rate of a reaction?
3. How can the loss of mass be used to measure the rate of a reaction?
4. How can the time taken for a visible change to occur be used to compare reaction rates?
5. In a disappearing cross experiment, what is measured to compare the reaction rates?
6. What calculation can be used to compare rates when the same reaction endpoint is measured by time?

C5.1b — interpret rate of reaction graphs

1. What does the gradient of a volume-of-gas-against-time graph represent?

2. What does a steeper gradient on a rate graph indicate?
3. What does a horizontal section on a volume-of-gas-against-time graph show?
4. What does the final volume of gas on a graph show?
5. If two reactions reach the same final volume but one reaches it sooner, which reaction has the faster rate?
6. If a reaction takes 20 seconds to reach a given endpoint, what is its relative rate using 1/t?

C5.1c — describe the effect of changes in temperature, concentration, pressure, and surface area on rate of reaction

1. What happens to the rate of a reaction when temperature increases?
2. What happens to the rate of a reaction when the concentration of a reactant increases?
3. What happens to the rate of a reaction involving gases when pressure increases?
4. What happens to the rate of a reaction when the surface area of a solid reactant increases?
5. Which reacts faster with hydrochloric acid: large marble chips or powdered marble?
6. Which reacts faster: a gas reaction at high pressure or the same reaction at low pressure?

C5.1d — explain the effects on rates of reaction of changes in temperature, concentration and pressure in terms of frequency and energy of collision between particles

1. What must happen when particles collide for a chemical reaction to occur?
2. How does increasing temperature affect the frequency of successful collisions?
3. How does increasing temperature affect the energy of particles?
4. How does increasing concentration affect the frequency of collisions?
5. How does increasing pressure affect the frequency of collisions between gas particles?
6. Why does increasing temperature usually increase the rate of a chemical reaction?

C5.1e — explain the effects on rates of reaction of changes in the size of the pieces of a reacting solid in terms of surface area to volume

1. What happens to the surface area of a solid when it is broken into smaller pieces?
2. What happens to the surface area-to-volume ratio when a solid is broken into smaller pieces?
3. Why does increasing the surface area of a solid increase the rate of reaction?
4. Which has the greater surface area-to-volume ratio: a large lump or the same mass broken into small pieces?
5. Why do powdered solids generally react faster than large pieces of the same solid?
6. Why does increasing surface area increase the number of collisions between reactant particles?

C5.1f — describe the characteristics of catalysts and their effect on rates of reaction

1. What is a catalyst?
2. What does a catalyst do to the rate of a chemical reaction?
3. Is a catalyst used up during a reaction?
4. What happens to the activation energy when a catalyst is used?
5. Does a catalyst change the overall energy change of a reaction?
6. What happens to the reaction rate when a suitable catalyst is added?

C5.1g — identify catalysts in reactions

1. What catalyst is commonly used to catalyse the decomposition of hydrogen peroxide?
2. What is the role of manganese dioxide in the decomposition of hydrogen peroxide?
3. What happens to the rate of hydrogen peroxide decomposition when a suitable catalyst is added?
4. How can you identify whether a substance is acting as a catalyst in an experiment?
5. What happens to a catalyst at the end of a reaction?
6. Why can the same catalyst be used in small amounts?

C5.1h — explain catalytic action in terms of activation energy reaction profiles

1. What happens to the activation energy when a catalyst is used?
2. How is the activation energy of a catalysed reaction shown on a reaction profile?
3. Why does lowering activation energy increase the rate of a reaction?

4. What happens to the number of successful collisions when activation energy is lowered?
5. How would the reaction profile of a catalysed reaction differ from an uncatalysed reaction?
6. Does a catalyst change the energy of the reactants or products?

C5.1i — recall that enzymes act as catalysts in biological systems

1. What are enzymes?
2. What role do enzymes play in biological systems?
3. Are enzymes catalysts?
4. What do enzymes do to the activation energy of biological reactions?
5. Why are enzymes important for reactions in living organisms?
6. Give one example of a biological process that requires enzymes.

C5.2 Equilibria

C5.2a — recall that some reactions may be reversed by altering the reaction conditions

1. What is a reversible reaction?
2. What symbol is used to represent a reversible reaction?
3. What happens in the forward reaction?
4. What happens in the reverse reaction?
5. How can changing reaction conditions affect a reversible reaction?
6. What happens when a reversible reaction can produce the original reactants again?

C5.2b — recall that dynamic equilibrium occurs in a closed system when the rates of forward and reverse reactions are equal

1. What is dynamic equilibrium?
2. In what type of system can dynamic equilibrium be established?
3. What happens to the rate of the forward reaction at equilibrium?
4. What happens to the rate of the reverse reaction at equilibrium?
5. Are the concentrations of reactants and products constant at dynamic equilibrium?
6. Do the forward and reverse reactions stop at dynamic equilibrium?

C5.2c — predict the effect of changing reaction conditions on equilibrium position and suggest appropriate conditions to produce as much of a particular product as possible

1. What happens to the equilibrium position when the concentration of a reactant is increased?
2. For the Haber process, $N_2(g) + 3H_2(g) \leftrightharpoons 2NH_3(g)$, what happens to the equilibrium position when the pressure is increased?
3. For the Haber process, $N_2(g) + 3H_2(g) \leftrightharpoons 2NH_3(g)$, what happens to the equilibrium position when the concentration of ammonia is increased?
4. The forward Haber process is exothermic. What happens to the equilibrium position when the temperature is increased?
5. For the reaction $2SO_2(g) + O_2(g) \leftrightharpoons 2SO_3(g)$, what happens to the equilibrium position when the pressure is increased?
6. For an exothermic reversible reaction, what temperature would favour the greatest amount of product at equilibrium?

Topic C6: Global challenges

C6.1 Global challenges

C6.1a — explain, using the position of carbon in the reactivity series, the principles of industrial processes used to extract metals, including extraction of a non-ferrous metal

1. Where is carbon positioned in the reactivity series compared with metals such as iron and copper?
2. Why can carbon be used to extract iron from its ore?
3. What happens to a metal compound when it is heated with carbon?
4. What is the general word equation for extracting a metal from its oxide using carbon?
5. Why can carbon not be used to extract metals that are more reactive than carbon?
6. How can copper be extracted by heating copper oxide with carbon?

C6.1b — explain why and how electrolysis is used to extract some metals from their ores

1. Why is electrolysis needed to extract metals that are more reactive than carbon?
2. What happens to metal ions at the cathode during electrolysis?
3. What happens to negative ions at the anode during electrolysis?

4. Why must an ionic compound be molten or dissolved in water for electrolysis to occur?
5. Why is electrolysis an expensive method of extracting metals?
6. Why is electrolysis used to extract aluminium rather than carbon reduction?

C6.1c — evaluate alternative biological methods of metal extraction

1. What is bacterial extraction of metals?
2. How can bacteria help extract metals from ores?
3. What is phytoextraction?
4. How can plants be used to extract metals from contaminated soil?
5. What is one advantage of using biological methods to extract metals?
6. What is one disadvantage of using biological methods to extract metals?

C6.1d — describe the basic principles in carrying out a life-cycle assessment of a material or product

1. What is a life-cycle assessment?
2. What is considered when assessing the production of a material or product?
3. Why is the transport of a product considered in a life-cycle assessment?
4. Why is the use of a product considered in a life-cycle assessment?
5. Why is disposal of a product considered in a life-cycle assessment?
6. What types of environmental impacts can be considered during a life-cycle assessment?

C6.1e — interpret data from a life-cycle assessment of a material or product

1. What can data from a life-cycle assessment be used to compare?
2. What does a higher environmental impact score indicate?
3. How can a life-cycle assessment help identify the stage with the greatest environmental impact?
4. Why should data from all stages of a product's life cycle be considered?
5. How could life-cycle assessment data be used to compare two different materials?
6. Why can a material with a low impact during production still have a high overall life-cycle impact?

C6.1f — describe a process where a material or product is recycled for a different use, and explain why this is viable

1. What is recycling?

2. What is meant by recycling a material for a different use?
3. Give one example of a material being recycled for a different use.
4. Why does recycling reduce the need for new raw materials?
5. Why can recycling reduce the amount of waste sent to landfill?
6. What factors determine whether recycling a material for a different use is viable?

C6.1g — evaluate factors that affect decisions on recycling

1. Why does the availability of recycling facilities affect recycling decisions?
2. How does the cost of recycling affect whether a material is recycled?
3. Why does the energy required for recycling need to be considered?
4. How does the environmental impact of recycling affect decisions?
5. Why does the demand for recycled materials affect whether recycling is viable?
6. Why might a material not be recycled even when recycling is technically possible?

C6.1h — describe the separation of crude oil by fractional distillation

1. What is crude oil?
2. What process is used to separate crude oil into fractions?
3. What happens to crude oil before fractional distillation?
4. What are fractions in crude oil?
5. Where do the fractions with lower boiling points collect in the fractionating column?
6. Name four fractions obtained from crude oil by fractional distillation.

C6.1i — explain the separation of crude oil by fractional distillation

1. Why can the compounds in crude oil be separated by fractional distillation?
2. How does molecular size affect the boiling point of hydrocarbons?
3. How do intermolecular forces change as hydrocarbon molecules become larger?
4. Why do larger hydrocarbon molecules generally have higher boiling points?
5. Why do hydrocarbons with similar boiling points collect in the same fraction?
6. Why do hydrocarbons condense at different heights in a fractionating column?

C6.1j — describe the fractions as largely a mixture of compounds of formula C_nH_{2n+2} which are members of the alkane homologous series

1. What is the general formula of the alkanes?
2. What is a homologous series?
3. What is the molecular formula of methane?
4. What is the molecular formula of propane?
5. How does the formula of one alkane differ from the next member of the series?
6. Why is each crude oil fraction a mixture rather than a single pure substance?

C6.1k — recall that crude oil is a main source of hydrocarbons and is a feedstock for the petrochemical industry

1. What is crude oil a major source of?
2. What is a hydrocarbon?
3. What is meant by a feedstock?
4. Why is crude oil used as a feedstock in the petrochemical industry?
5. What types of products can be made from hydrocarbons obtained from crude oil?
6. Why are crude oil fractions important raw materials for the chemical industry?

C6.1l — explain how modern life is crucially dependent upon hydrocarbons and recognise that crude oil is a finite resource

1. Why are hydrocarbons important to modern life?
2. Give two uses of hydrocarbons as fuels.
3. Give two useful products made from hydrocarbons that are not used as fuels.
4. What does it mean if a resource is finite?
5. Why is crude oil described as a finite resource?
6. Why is dependence on crude oil a long-term problem?

C6.1m — describe the production of materials that are more useful by cracking

1. What is cracking?
2. Why is cracking carried out on some long-chain hydrocarbons?
3. What conditions are needed for cracking?
4. What types of products are produced by cracking?
5. Why are alkenes produced by cracking useful?
6. Why is cracking useful when the demand for shorter-chain hydrocarbons is greater than the supply from fractional distillation?

Topic C6: Global challenges

C6.2 Interpreting and interacting with Earth systems

C6.2a — interpret evidence for how it is thought the atmosphere was originally formed

1. What gases are thought to have been released by volcanic activity on the early Earth?
2. How did volcanic activity contribute to the formation of the early atmosphere?
3. Which gas was present in very small amounts or absent from the early atmosphere?
4. How has the composition of Earth's atmosphere changed over time?
5. What evidence can scientists use to work out how Earth's atmosphere changed over time?
6. Why is the composition of Earth's early atmosphere uncertain?

C6.2b — describe how it is thought an oxygen-rich atmosphere developed over time

1. Which organisms first produced significant amounts of oxygen?
2. What process carried out by these organisms released oxygen?
3. How did increasing oxygen levels affect the atmosphere?
4. Why did oxygen levels increase as photosynthetic organisms became more widespread?
5. What happened to carbon dioxide as photosynthesis increased?
6. How did the development of plants contribute to an oxygen-rich atmosphere?

C6.2c — describe the greenhouse effect in terms of the interaction of radiation with matter within the atmosphere

1. What is the greenhouse effect?
2. What type of radiation from the Sun reaches Earth's surface?
3. What happens to the energy absorbed by Earth's surface?
4. What type of radiation is emitted by Earth's surface?
5. How do greenhouse gases interact with infrared radiation?
6. Why does the greenhouse effect warm Earth's surface?

C6.2d — evaluate the evidence for additional anthropogenic (human activity) causes of climate change and describe the uncertainties in the evidence base

1. What does the term anthropogenic mean?
2. How does burning fossil fuels affect the concentration of carbon dioxide in the atmosphere?
3. What relationship has been observed between atmospheric carbon dioxide concentration and fossil fuel consumption?
4. What evidence supports the idea that human activities contribute to climate change?
5. Why can correlation between two changes not by itself prove causation?
6. Why are there uncertainties when predicting the future effects of climate change?

C6.2e — describe the potential effects of increased levels of carbon dioxide and methane on the Earth's climate and how these effects may be mitigated

1. Why are carbon dioxide and methane called greenhouse gases?
2. What happens to the greenhouse effect when atmospheric carbon dioxide increases?
3. What happens to Earth's average temperature if the greenhouse effect becomes stronger?
4. What are two possible effects of increased global temperatures?
5. How could reducing the burning of fossil fuels help reduce climate change?
6. How could increasing the use of renewable energy help mitigate climate change?

C6.2f — describe the major sources of carbon monoxide, sulfur dioxide, oxides of nitrogen and particulates in the atmosphere and explain the problems caused by increased amounts of these substances

1. What is the main source of carbon monoxide from human activity?
2. Why is carbon monoxide harmful to humans?
3. What is a major source of sulfur dioxide in the atmosphere?
4. What environmental problem can sulfur dioxide cause?
5. What are major sources of oxides of nitrogen?
6. What health and environmental problems can particulates cause?

C6.2g — describe the principal methods for increasing the availability of potable water in terms of the separation techniques used

1. What is potable water?
2. How can filtration be used to make water potable?
3. Why is distillation used to obtain pure water from seawater?
4. How does distillation separate water from dissolved salts?
5. What is one advantage of treating water from waste or ground water rather than using seawater?
6. What factors affect the choice of method used to produce potable water?