Topic 5 – Separate chemistry 1

Transition metals, alloys and corrosion

Students should:		Maths skills
5.1C	Recall that most metals are transition metals and that their typical properties include: a high melting point b high density c the formation of coloured compounds d catalytic activity of the metals and their compounds as exemplified by iron	
5.2C	Recall that the oxidation of metals results in corrosion	
5.3C	Explain how rusting of iron can be prevented by: a exclusion of oxygen b exclusion of water c sacrificial protection	
5.4C	Explain how electroplating can be used to improve the appearance and/or the resistance to corrosion of metal objects	
5.5C	Explain, using models, why converting pure metals into alloys often increases the strength of the product	5b
5.6C	Explain why iron is alloyed with other metals to produce alloy steels	
5.7C	Explain how the uses of metals are related to their properties (and vice versa), including aluminium, copper and gold and their alloys including magnalium and brass	

Suggested practicals

- Carry out an activity to show that transition metal salts have a variety of colours.
- Investigate the rusting of iron.
- Electroplate a metal object.
- Make an alloy or investigate the properties of alloys.

Quantitative analysis

Students should:		Maths skills
5.8C	**Calculate the concentration of solutions in mol dm^{-3} and convert concentration in g dm^{-3} into mol dm^{-3} and vice versa**	1a, 1b, 1c, 1d 2a 3b, 3c
5.9C	*Core Practical: Carry out an accurate acid-alkali titration, using burette, pipette and a suitable indicator*	
5.10C	**Carry out simple calculations using the results of titrations to calculate an unknown concentration of a solution or an unknown volume of solution required**	1a, 1c, 1d 2a, 2b 3a, 3b, 3c
5.11C	Calculate the percentage yield of a reaction from the actual yield and the theoretical yield	1a, 1c, 1d 2a 3b, 3c
5.12C	Describe that the actual yield of a reaction is usually less than the theoretical yield and that the causes of this include: a incomplete reactions b practical losses during the experiment c competing, unwanted reactions (side reactions)	
5.13C	Recall the atom economy of a reaction forming a desired product	
5.14C	Calculate the atom economy of a reaction forming a desired product	1a, 1c, 1d 2a 3c
5.15C	**Explain why a particular reaction pathway is chosen to produce a specified product, given appropriate data such as atom economy, yield, rate, equilibrium position and usefulness of by-products**	
5.16C	**Describe the molar volume, of any gas at room temperature and pressure, as the volume occupied by one mole of molecules of any gas at room temperature and pressure** **(The molar volume will be provided as 24 dm^3 or 24000 cm^3 in calculations where it is required)**	
5.17C	**Use the molar volume and balanced equations in calculations involving the masses of solids and volumes of gases**	1a, 1c, 2a 3b, 3c
5.18C	**Use Avogadro's law to calculate volumes of gases involved in a gaseous reaction, given the relevant equation**	1a, 1c, 1d

Use of mathematics

- Arithmetic computation when calculating yields and atom economy (1a and 1c).
- Arithmetic computation, ratio, percentage and multistep calculations permeates quantitative chemistry (1a, 1c and 1d).
- Change the subject of a mathematical equation (3b and 3c).
- Provide answers to an appropriate number of significant figures (2a).
- **Convert units where appropriate particularly from mass to moles (1c)**.

Suggested practicals

- Prepare a substance and calculate the percentage yield, given the theoretical yield.
- Determine the volume of one mole of hydrogen gas by using the reaction of magnesium with hydrochloric acid.

Dynamic equilibria

Students should:		Maths skills
5.19C	Describe the Haber process as a reversible reaction between nitrogen and hydrogen to form ammonia	
5.20C	**Predict how the rate of attainment of equilibrium is affected by:** **a changes in temperature** **b changes in pressure** **c changes in concentration** **d use of a catalyst**	
5.21C	**Explain how, in industrial reactions, including the Haber process, conditions used are related to:** **a the availability and cost of raw materials and energy supplies** **b the control of temperature, pressure and catalyst used produce an acceptable yield in an acceptable time**	
5.22C	Recall that fertilisers may contain nitrogen, phosphorus and potassium compounds to promote plant growth	
5.23C	Describe how ammonia reacts with nitric acid to produce a salt that is used as a fertiliser	
5.24C	Describe and compare: a the laboratory preparation of ammonium sulfate from ammonia solution and dilute sulfuric acid on a small scale b the industrial production of ammonium sulfate, used as a fertiliser, in which several stages are required to produce ammonia and sulfuric acid from their raw materials and the production is carried out on a much larger scale (details of the industrial production of sulfuric acid are not required)	

Suggested practicals

- Prepare a sample of ammonium sulfate from ammonia solution and dilute sulfuric acid.

Chemical cells and fuel cells

Students should:		Maths skills
5.25C	Recall that a chemical cell produces a voltage until one of the reactants is used up	
5.26C	Recall that in a hydrogen–oxygen fuel cell hydrogen and oxygen are used to produce a voltage and water is the only product	
5.27C	Evaluate the strengths and weaknesses of fuel cells for given uses	

Topic 9 – Separate chemistry 2

Qualitative analysis: tests for ions

Students should:		Maths skills
9.1C	Explain why the test for any ion must be unique	
9.2C	Describe flame tests to identify the following ions in solids: a lithium ion, Li^+ (red) b sodium ion, Na^+ (yellow) c potassium ion, K^+ (lilac) d calcium ion, Ca^{2+} (orange-red) e copper ion, Cu^{2+} (blue-green)	
9.3C	Describe tests to identify the following ions in solids or solutions as appropriate: a aluminium ion, Al^{3+} b calcium ion, Ca^{2+} c copper ion, Cu^{2+} d iron(II) ion, Fe^{2+} e iron(III) ion, Fe^{3+} f ammonium ion, NH_4^+ using sodium hydroxide solution	
9.4C	Describe the chemical test for ammonia	
9.5C	Describe tests to identify the following ions in solids or solutions as appropriate: a carbonate ion, CO_3^{2-}, using dilute acid and identifying the carbon dioxide evolved b sulfate ion, SO_4^{2-}, using dilute hydrochloric acid and barium chloride solution c chloride ion, Cl^-, bromide ion, Br^-, iodide ion, I^-, using dilute nitric acid and silver nitrate solution	
9.6C	*Core Practical: Identify the ions in unknown salts, using the tests for the specified cations and anions in 9.2C, 9.3C, 9.4C, 9.5C*	
9.7C	Identify the ions in unknown salts, using results of the tests above	
9.8C	Describe that instrumental methods of analysis are available and that these may improve sensitivity, accuracy and speed of tests	

Students should:	Maths skills
9.9C Evaluate data from a flame photometer: a to determine the concentration of ions in dilute solution using a calibration curve b to identify metal ions by comparing the data with reference data (no knowledge of the instrument or how it works is required)	4a

Use of mathematics

- Interpret charts, particularly in spectroscopy (4a).

Hydrocarbons

Students should:	Maths skills
9.10C Recall the formulae of molecules of the alkanes, methane, ethane, propane and butane, and draw the structures of these molecules, showing all covalent bonds	5b
9.11C Explain why the alkanes are saturated hydrocarbons	
9.12C Recall the formulae of molecules of the alkenes, ethene, propene, butene, and draw the structures of these molecules, showing all covalent bonds (but-1-ene and but-2-ene only)	5b
9.13C Explain why the alkenes are unsaturated hydrocarbons, describing that their molecules contain the functional group C=C	
9.14C Recall the addition reaction of ethene with bromine, showing the structures of reactants and products, and extend this to other alkenes	5b
9.15C Explain how bromine water is used to distinguish between alkanes and alkenes	
9.16C Describe how the complete combustion of alkanes and alkenes involves the oxidation of the hydrocarbons to produce carbon dioxide and water	

Suggested practicals

- Test for unsaturation using bromine water.

Polymers

Students should:	Maths skills
9.17C Recall that a polymer is a substance of high average relative molecular mass made up of small repeating units	
9.18C Describe: a how ethene molecules can combine together in a polymerisation reaction b that the addition polymer formed is called poly(ethene) (conditions and mechanisms not required)	5b
9.19C Describe how other addition polymers can be made by combining together other monomer molecules containing C=C, to include poly(propene), poly(chloroethene) (PVC) and poly(tetrafluoroethene) (PTFE) (conditions and mechanisms not required)	5b
9.20C Deduce the structure of a monomer from the structure of an addition polymer and vice versa	5b
9.21C Explain how the uses of polymers are related to their properties and vice versa: including poly(ethene), poly(propene), poly(chloroethene) (PVC) and poly(tetrafluoroethene) (PTFE)	
9.22C **Explain:** **a why polyesters are condensation polymers** **b how a polyester is formed when a monomer molecule containing two carboxylic acid groups is reacted with a monomer molecule containing two alcohol groups** **c how a molecule of water is formed each time an ester link is formed**	5b
9.23C Describe some problems associated with polymers including the: a availability of starting materials b persistence in landfill sites, due to non-biodegradability c gases produced during disposal by combustion d requirement to sort polymers so that they can be melted and reformed into a new product	
9.24C Evaluate the advantages and disadvantages of recycling polymers, including economic implications, availability of starting materials and environmental impact	
9.25C Recall that: a DNA is a polymer made from four different monomers called nucleotides (names of nucleotides not required) b starch is a polymer based on sugars c proteins are polymers based on amino acids	5b

Alcohols and carboxylic acids

Students should:		Maths skills
9.26C	Recall the formulae of molecules of the alcohols, methanol, ethanol, propanol (propan-1-ol only) and butanol (butan-1-ol only), and draw the structures of these molecules, showing all covalent bonds	5b
9.27C	Recall that the functional group in alcohols is –OH and that alcohols can be dehydrated to form alkenes	
9.28C	*Core Practical: Investigate the temperature rise produced in a known mass of water by the combustion of the alcohols ethanol, propanol, butanol and pentanol*	1a, 1c 2c
9.29C	Recall the formulae of molecules of the carboxylic acids, methanoic, ethanoic, propanoic and butanoic acids, and draw the structures of these molecules, showing all covalent bonds	5b
9.30C	Recall that the functional group in carboxylic acids is –COOH and that solutions of carboxylic acids have typical acidic properties	
9.31C	Recall that ethanol can be oxidised to produce ethanoic acid and extend this to other alcohols (reagents not required)	
9.32C	Recall members of a given homologous series have similar reactions because their molecules contain the same functional group and use this to predict the products of other members of these series	
9.33C	Describe the production of ethanol by fermentation of carbohydrates in aqueous solution, using yeast to provide enzymes	
9.34C	Explain how to obtain a concentrated solution of ethanol by fractional distillation of the fermentation mixture	

Suggested practicals

- Prepare a solution of ethanol by fermentation.

Bulk and surface properties of matter including nanoparticles

Students should:		Maths skills
9.35C	Compare the size of nanoparticles with the sizes of atoms and molecules	1b, 1d 2h
9.36C	Describe how the properties of nanoparticulate materials are related to their uses including surface area to volume ratio of the particles they contain, including sunscreens	1c 5c
9.37C	Explain the possible risks associated with some nanoparticulate materials	
9.38C	Compare, using data, the physical properties of glass and clay ceramics, polymers, composites and metals	2c

Students should:		Maths skills
9.39C	Explain why the properties of a material make it suitable for a given use and use data to select materials appropriate for specific uses	2c

Use of mathematics

- Estimate size and scale of atoms and nanoparticles (1d).
- Interpret, order and calculate with numbers written in standard form when dealing with nanoparticles (1b).
- Use ratios when considering relative sizes and surface area to volume comparisons (1c).
- Calculate surface areas and volumes of cubes (5c).