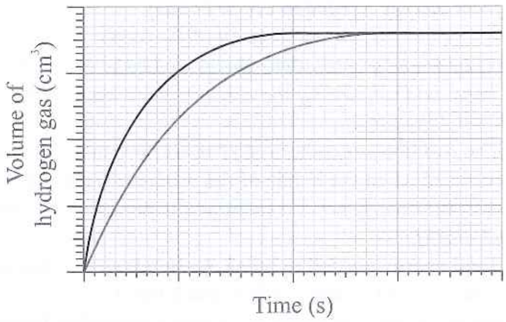
1.2 activation energy *[1 mark]*

1.3 A catalyst decreases the activation energy *[1 mark]*.

2 Produced most product: C *[1 mark]*
Finished first: B *[1 mark]*
Started at the slowest rate: A *[1 mark]*

3.1



[1 mark for curve with steeper gradient at the start of the reaction, 1 mark for curve reaching the final volume earlier, 1 mark for final volume being the same as for the other curve]

3.2 The frequency of the collisions *[1 mark]* and the energy of the colliding particles *[1 mark]*.

3.3 There are more particles in a given volume/the particles are closer together *[1 mark]*, so the collisions between particles are more frequent *[1 mark]*.

3.4 The rate would increase *[1 mark]*.

3.5 Smaller pieces have a higher surface area to volume ratio *[1 mark]*. So for the same volume of solid, the particles around it will have more area to work on and collisions will be more frequent *[1 mark]*.

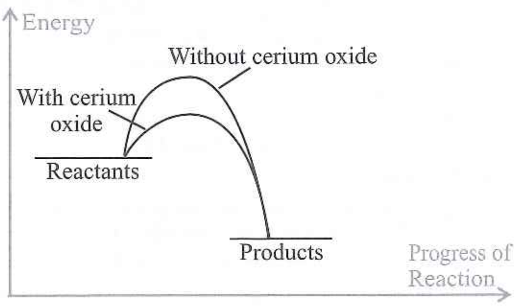
3.6 E.g. changing the temperature / adding a catalyst *[1 mark]*.

4.1 E.g. increasing the volume of the reaction vessel would decrease the pressure of the reacting gases *[1 mark]*. So the particles would be more spread out and would collide less frequently *[1 mark]*, so the reaction rate would decrease *[1 mark]*. Increasing the temperature would cause the particles to move faster, so the frequency of collisions would increase *[1 mark]* and the reaction rate would increase *[1 mark]*.

4.2 It's a catalyst *[1 mark]*.

4.3 The reaction equation won't change *[1 mark]*. Cerium oxide isn't used up in the reaction, so doesn't appear in the reaction equation *[1 mark]*.

4.4



[1 mark for correct relative energies of products and reactants, 1 mark for start and end energies being the same for reactions with and without cerium oxide, 1 mark for reaction with cerium oxide rising to a lower energy than reaction without cerium oxide]

Pages 68-70 — Measuring Rates of Reaction

Warm-up

The rate of a reaction can be measured by dividing the amount of **reactants** used up or the amount of **products** formed by the **time**. To find the rate at a particular time from a graph with a curved line of best fit, you have to find the **gradient** of the **tangent** at that time.

1 mass *[1 mark]*, volume of gas *[1 mark]*

2.1 time taken for the solution to go cloudy *[1 mark]*

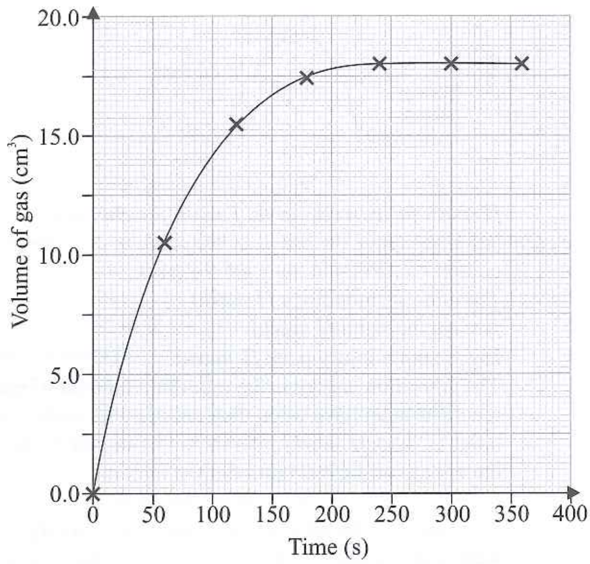
2.2 temperature *[1 mark]*

2.3 Any one from: e.g. the concentration of the reactants / the volume of the reactants / the depth of the reaction mixture *[1 mark]*.

2.4 It would be more accurate to measure the volume of gas produced *[1 mark]* as this method less subjective *[1 mark]*.

3.1 E.g. a gas syringe / a measuring cylinder inverted in a bowl of water *[1 mark]*.

3.2



[2 marks for all points plotted correctly, or 1 mark for at least 5 points plotted correctly, 1 mark for line of best fit.]

3.3 Any value between 210-240 s *[1 mark]*

When no more gas is produced, the reaction has stopped.

3.4 E.g. Mean rate of reaction = $\frac{\text{amount of product formed}}{\text{time for reaction to stop}}$

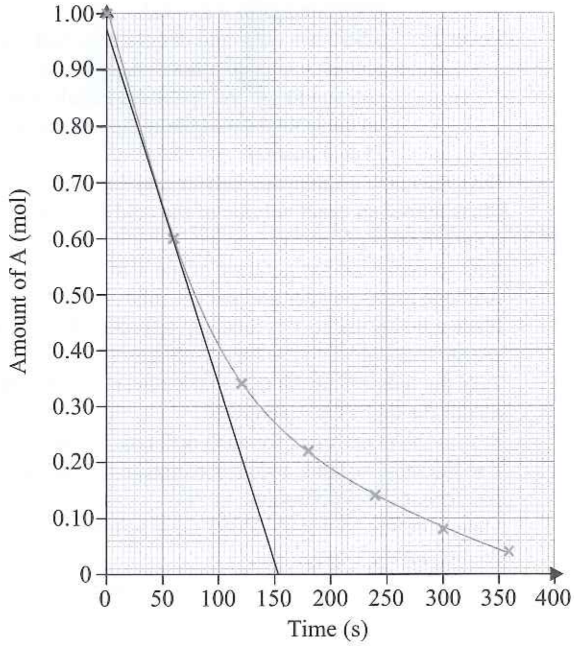
$= \frac{18.0}{240} = \mathbf{0.075\ cm^3/s}$

[2 marks for correct answer between 0.075-0.086 cm^3/s, otherwise 1 mark for correct equation]

If you got the wrong answer in 3.3, but used it correctly here as the change in y, you still get all the marks.

3.5 E.g. repeat the experiment using the same method *[1 mark]* and check that the results are similar *[1 mark]*.

4.1

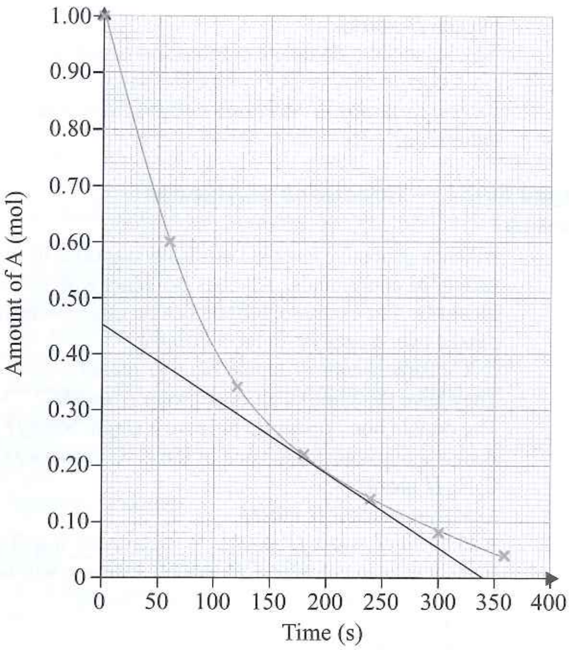


Gradient = $\frac{\text{change in } y}{\text{change in } x} = \frac{0.97}{153} = \mathbf{0.0063\ mol/s}$

(allow between 0.0053 mol/s and 0.0073 mol/s)

[4 marks for correct answer, otherwise 1 mark for correctly drawn tangent to curve at 50 s, 1 mark for answer to 2 s.f., 1 mark for correct units]

4.2



Gradient = $\frac{\text{change in } y}{\text{change in } x} = \frac{0.45}{340}$ = **0.0013 mol/s**
(allow between 0.0008 mol/s and 0.0018 mol/s)
[4 marks for correct answer, otherwise 1 mark for correctly drawn tangent to curve at 200 s, 1 mark for answer to 2 s.f., 1 mark for correct units]

4.3 The rate decreases ***[1 mark]***. This is because, as the amount of reactant A falls, so does its concentration and so the frequency of collisions between the reactant particles decreases ***[1 mark]***.

Page 71 — Reversible Reactions

1.1 That the reaction is reversible / can go both ways ***[1 mark]***.
1.2 At equilibrium, the rate of the forward reaction is equal to the rate of the backwards reaction ***[1 mark]***.
2.1 It will be exothermic ***[1 mark]***. The same amount of energy will be released in the reverse reaction as is taken in by the forward reaction ***[1 mark]***.
2.2 The system has reached equilibrium ***[1 mark]***. This mixture contains both blue copper(II) ions and the yellow copper compound, so the colours mix to form green ***[1 mark]***.
2.3 E.g. by changing the temperature / by changing the concentration of one of the reactants ***[2 marks — 1 mark for each correct answer]***.

Pages 72-73 — Le Chatelier's Principle

Warm-up

more reactants
more reactants
more products

1.1 If you change the conditions of a reversible reaction at equilibrium, the system will try to counteract that change ***[1 mark]***.
1.2 E.g. the temperature / the concentration of the reactants ***[2 marks — 1 mark for each correct answer]***
2.1 At higher temperatures there will be more ICl and less ICl_3 / the equilibrium will shift to the left ***[1 mark]***. This is because the reverse reaction is endothermic so opposes the increase in temperature ***[1 mark]***.
2.2 There would be more ICl_3 and less ICl ***[1 mark]*** because the increase in pressure ***[1 mark]*** causes the equilibrium position to move to the side with the fewest molecules of gas ***[1 mark]***.
3.1 At higher temperature there's more product (brown NO_2) in the equilibrium mixture ***[1 mark]***. This suggests that the equilibrium has moved to the right/forward direction ***[1 mark]***, so the forward reaction is endothermic ***[1 mark]***.

From Le Chatelier's principle, you know that increasing the temperature will favour the endothermic reaction as the equilibrium tries to oppose the change. So the forward reaction must be endothermic, as there's more NO_2 in the equilibrium mixture at higher temperatures.

3.2 The mixture would go a darker brown ***[1 mark]***, as the decrease in pressure causes the equilibrium to move to the side with the most molecules of gas ***[1 mark]***, meaning more NO_2 is formed ***[1 mark]***.
4 Observation 1: Increasing amounts of red $FeSCN^{2+}$ are formed, so the solution becomes a darker red ***[1 mark]***. When equilibrium is reached, the amount of each substance stops changing, and so does the colour ***[1 mark]***.
Observation 2: The concentration of Fe^{3+} initially increases, so the solution becomes more orangey ***[1 mark]***. The equilibrium then shifts to make more $FeSCN^{2+}$, so the solution becomes darker red in colour ***[1 mark]***.
Observation 3: The concentration of $FeSCN^{2+}$ initially increases, so the solution becomes darker red ***[1 mark]***. The equilibrium then shifts to produce more reactants, so the solution becomes more orangey ***[1 mark]***.

Topic 7 — Organic Chemistry

Pages 74-75 — Hydrocarbons

Warm-up

Hydrocarbon	Not a hydrocarbon
propane ethene C_2H_6 C_2H_4	butanoic acid CH_3CH_2Cl hydrochloric acid

1.1 A compound that is formed from hydrogen and carbon atoms only ***[1 mark]***.
1.2 butane, propane, ethane, methane ***[1 mark]***
1.3 C_nH_{2n+2} ***[1 mark]***
1.4 hydrocarbon + oxygen → **carbon dioxide** + **water** ***[1 mark]***
1.5 oxidised ***[1 mark]***
2.1 **B** ***[1 mark]***
2.2 **B**, **D**, and **E** ***[1 mark]***. They have the general formula C_nH_{2n+2} ***[1 mark]***.
2.3 **E** ***[1 mark]***. Boiling point increases with increasing molecular size/number of carbons ***[1 mark]***.
3.1 Diesel will be more viscous than petrol ***[1 mark]***. The higher boiling point of diesel means it contains larger molecules/molecules with longer chains ***[1 mark]***.
3.2 Petrol ***[1 mark]***. The lower boiling point of petrol means it contains smaller molecules/molecules with shorter chains ***[1 mark]***.
3.3 $C_{20}H_{42}$ ***[1 mark]***
3.4 $\mathbf{2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O}$ ***[1 mark for correct formulas of products, 1 mark for balancing]***

Any correct balance of the equation is correct, e.g. C_8H_{18} + $12½O_2$ → $8CO_2$ + $9H_2O$.

Page 76 — Fractional Distillation

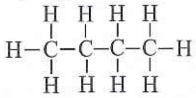
1.1 The remains of ancient organisms/plankton ***[1 mark]***.
1.2 A resource which is being used quicker than it is being replaced so will run out eventually ***[1 mark]***.
1.3 alkanes ***[1 mark]***
2.1 boiling point ***[1 mark]***
2.2 The fractionating column is hot at the bottom and cool at the top ***[1 mark]***. So longer hydrocarbons, which have higher boiling points, will condense and be drained off near the bottom ***[1 mark]***. Meanwhile, shorter hydrocarbons, with lower boiling points, will condense and be drained off further up the column ***[1 mark]***.
2.3 They contain similar numbers of carbon atoms / they have a similar chain length ***[1 mark]***.

Pages 77-78 — Uses and Cracking of Crude Oil

1.1 Any two from: e.g. solvents / lubricants / polymers / detergents ***[2 marks — 1 mark for each correct answer]***
1.2 cracking ***[1 mark]***
1.3 E.g. shorter chain hydrocarbons are more useful/can be used for more applications ***[1 mark]***.
2.1 thermal decomposition / endothermic ***[1 mark]***
2.2 Hydrocarbons are vaporised / heated to form gases ***[1 mark]***. The vapours are then passed over a hot catalyst / the vapours are mixed with steam and heated to very high temperatures ***[1 mark]***.
2.3 E.g. $C_{10}H_{22} \rightarrow C_7H_{16} + C_3H_6$ ***[1 mark]***

Cracking equations must always be balanced and have a shorter alkane and an alkene on the right-hand side.

3.1 C_7H_{16} ***[1 mark]***
3.2



[1 mark for correct number of carbons, 1 mark for correct displayed formula]

3.3 E.g. to produce polymers / as a starting material for other chemicals ***[1 mark]***.
4 How to grade your answer:

Level 0: Nothing written worth of credit ***[No marks]***.
Level 1: Basic outline of how some fractions are processed but lacking detail. Some mention of the uses of cracking products ***[1 to 2 marks]***.
Level 2: Reason for cracking explained and some detail given about the process. The uses of cracking products are covered in detail ***[3 to 4 marks]***.
Level 3: Reasons for cracking and the process of cracking are explained in detail, including an accurate balanced symbol or word equation. Examples given of the uses of the products of cracking ***[5 to 6 marks]***.

Here are some points your answer may include:

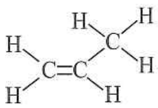
Reasons for cracking
There is a higher demand for short chain hydrocarbons as these make good fuels.
Long chain hydrocarbons are less useful than short chain hydrocarbons, so there is less demand for them.
Cracking helps the supply of short chain hydrocarbons to meet the demand.

Cracking process
The long chain hydrocarbons are heated and vaporised.
The vapours are passed over a hot catalyst / mixed with steam and heated to a high temperature so that they thermally decompose.
Any relevant word equation: e.g. decane → octane + ethene
Any relevant balanced equation:
e.g. $C_{12}H_{26} \rightarrow C_8H_{18} + 2C_2H_4$

Uses of cracking products
The products of cracking are useful as fuels.
Alkenes are used as a starting material when making lots of other compounds and can be used to make polymers.

Page 79 — Alkenes

1.1 A hydrocarbon with a double carbon-carbon bond ***[1 mark]***.
1.2 C_nH_{2n} ***[1 mark]***
1.3



[1 mark]

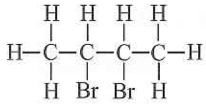
2.1 **B** and **E** ***[1 mark]***
2.2 C_6H_{12} ***[1 mark]***
2.3 **B** undergoes incomplete combustion in low amounts of oxygen ***[1 mark]***.
Any balanced incomplete combustion equation:
e.g. $2C_2H_4 + 5O_2 \rightarrow 2CO_2 + 2CO + 4H_2O$ ***[1 mark for correct formulas of reactants and products, 1 mark for balancing]***

Pages 80-81 — Reactions of Alkenes

Warm-up

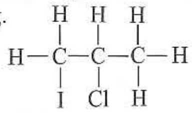
Alkenes generally react via **addition** reactions to form a variety of compounds. Alkenes can react with steam to form **alcohols**. For example, **ethene** can be mixed with steam and passed over a catalyst to form ethanol.

1.1 C=C / carbon-carbon double bond ***[1 mark]***
1.2 They have the same functional group ***[1 mark]***.
1.3 The double bond opens up to leave a single bond ***[1 mark]***. A new atom is added to each of the C=C carbons ***[1 mark]***.
2.1 C_3H_6 ***[1 mark]***
2.2 a catalyst / nickel ***[1 mark]***
2.3 Add bromine water ***[1 mark]***. With propene it will change from orange to colourless ***[1 mark]***. Propane will not react and there will be no colour change ***[1 mark]***.
3.1



[1 mark]

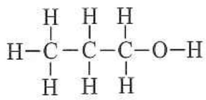
3.2 The product of the reaction is saturated ***[1 mark]***. It doesn't contain any carbon-carbon double bonds ***[1 mark]***.
4.1 E.g.



[1 mark]

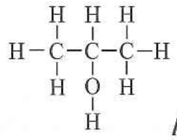
You still get the mark if you have the chlorine and iodine atoms swapped around.

4.2



[1 mark]

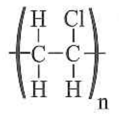
and



[1 mark]

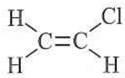
Page 82 — Addition Polymers

1.1 ethene ***[1 mark]***
1.2 addition polymerisation ***[1 mark]***
1.3 carbon-carbon double bond / C=C ***[1 mark]***
2.1



[1 mark]

2.2

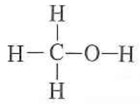


[1 mark]

2.3 chloroethene ***[1 mark]***

Pages 83-84 — Alcohols

1.1 –OH ***[1 mark]***
1.2 Any two from: e.g. fuels / solvents / in alcoholic drinks ***[2 marks — 1 mark for each correct answer]***.
1.3 Methanol dissolves. The indicator remains green ***[1 mark]***.
1.4 CO_2 and H_2O ***[1 mark]***
2.1 Ethanoic acid ***[1 mark]***, a carboxylic acid ***[1 mark]***.
2.2 Yeast ***[1 mark]***. The reaction conditions are a temperature of approximately 37 °C ***[1 mark]***, absence of oxygen / anaerobic conditions ***[1 mark]*** and a slightly acidic pH ***[1 mark]***.

3.1 
[1 mark]

3.2 Methanol only has only one carbon atom where as butanol has four/methanol has the formula CH_3OH whereas butanol has the formula of C_4H_9OH ***[1 mark]***. Both methanol and butanol contain an –OH group ***[1 mark]***.

3.3 They both contain the same functional (–OH) group ***[1 mark]***.

3.4 hydrogen ***[1 mark]***

4.1 $C_2H_4(OH)_2/C_2H_6O_2$ ***[1 mark]***

4.2 E.g. react it with sodium ***[1 mark]***.

4.3 $2C_2H_4(OH)_2 + 5O_2 \rightarrow 4CO_2 + 6H_2O$ ***[1 mark for the formulas of the reactants and products, 1 mark for balancing]***

Any correct balance of the equation is correct, e.g. $C_2H_4(OH)_2 + 2\frac{1}{2}O_2 \rightarrow 2CO_2 + 3H_2O$.

4.4 7/neutral ***[1 mark]***

Pages 85-86 — Carboxylic Acids

1.1 –COOH ***[1 mark]***

1.2 Methanoic acid would dissolve ***[1 mark]*** and the Universal indicator would change to red/orange ***[1 mark]***.

1.3 carbon dioxide/CO_2 ***[1 mark]***

2.1 butanoic acid ***[1 mark]***, $C_3H_7COOH/C_4H_8O_2$ ***[1 mark]***

2.2 It does not ionise completely when dissolved in water ***[1 mark]***.

2.3 An acid catalyst ***[1 mark]***.

2.4 ester ***[1 mark]***

3.1 Accept anywhere between 2 and 6 ***[1 mark]***.

3.2 magnesium carbonate/$MgCO_3$ ***[1 mark]***

3.3 ethanol/C_2H_5OH ***[1 mark]***

4.1 Na_2CO_3 ***[1 mark]***

4.2 H_2O ***[1 mark]***

4.3 **D** ***[1 mark]***. Propanoic acid is a weak acid ***[1 mark]*** and therefore weakly ionised ***[1 mark]***.

4.4 Carbon dioxide/CO_2 ***[1 mark]*** and water/H_2O ***[1 mark]***.

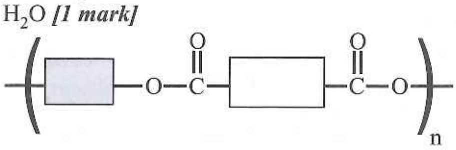
Page 87 — Condensation Polymers

1.1 A small molecule is lost when condensation polymers are formed ***[1 mark]***.

1.2 two ***[1 mark]***

1.3 E.g. carboxylic acids ***[1 mark]*** and alcohols / amines ***[1 mark]***.

2.1 H_2O ***[1 mark]***

2.2 

[1 mark for correct ester link connecting monomers, 1 mark for rest of the structure being correct]

2.3 No ***[1 mark]***. As two different functional groups that react with each other are needed ***[1 mark]***.

Page 88 — Naturally Occurring Polymers

1.1 two ***[1 mark]***

1.2 Any one from: carboxylic acid / amine ***[1 mark]***

1.3 condensation polymerisation ***[1 mark]***

1.4 water ***[1 mark]***

2.1 sugars ***[1 mark]***

2.2 e.g. cellulose ***[1 mark]***

2.3 DNA contains genetic instructions ***[1 mark]*** for the operation and functioning of living organisms and viruses ***[1 mark]***.

2.4 Two polymer chains ***[1 mark]*** made from four different nucleotide monomers ***[1 mark]*** linked together by cross links to give a double helix structure ***[1 mark]***.

Topic 8 — Chemical Analysis

Page 89 — Purity and Formulations

1.1 A single element or compound not mixed with any other substance ***[1 mark]***.

1.2 Sample **A** ***[1 mark]***. The purer the substance, the smaller the range of the melting point / purer substances melt at higher temperatures than impure substances ***[1 mark]***.

1.3 Sample **A** ***[1 mark]***.

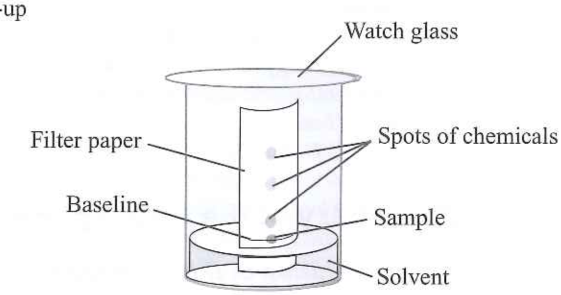
2.1 It is a mixture that has been designed to have a precise purpose ***[1 mark]***. Each of the components is present in a measured quantity ***[1 mark]*** and contributes to the properties of the formulation ***[1 mark]***.

2.2 By making sure each component in the mixture is always present in exactly the same quantity ***[1 mark]***.

2.3 Any one from: e.g. medicines / cleaning products / fuels / cosmetics / fertilisers / metal alloys ***[1 mark]***.

Pages 90-91 — Paper Chromatography

Warm-up



1.1 **E**: $R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}} = \frac{3.6}{9.5} = \mathbf{0.38}$

[2 marks for correct answer, otherwise 1 mark for using correct equation to calculate R_f]

F: $R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}} = \frac{8.0}{9.5} = \mathbf{0.84}$

[2 marks for correct answer, otherwise 1 mark for using correct equation to calculate R_f]

1.2 E.g. they're distributed differently between the mobile phase and the stationary phase ***[1 mark]***.

1.3 They're all pure substances ***[1 mark]***.

1.4 **D** and **E** ***[1 mark]***.

2.1 E.g. to stop any solvent evaporating ***[1 mark]***.

2.2 **A** spends more time in the mobile phase compared to the stationary phase than **B** does ***[1 mark]***.

2.3 **B** and **C** ***[1 mark]***.

2.4 The student is incorrect ***[1 mark]***. Substances have different R_f values in different solvents as the attraction between the substance and solvent changes ***[1 mark]***.

2.5 It suggest that there are at least 3 substances in **W** ***[1 mark]***.

2.6 There were only two spots in the chromatogram shown because two of the substances in **W** are similarly distributed between the mobile phase/water and stationary phase / they had similar R_f values ***[1 mark]***.

Pages 92-93 — Tests for Gases and Anions

1.1 A burning splint which results in a popping noise ***[1 mark]***.

1.2 oxygen/O_2 ***[1 mark]***

1.3 Bubble the gas through an aqueous solution of calcium hydroxide/limewater ***[1 mark]***. The limewater turns milky/cloudy ***[1 mark]***.

1.4 Damp litmus paper ***[1 mark]*** put into the gas. If chlorine gas is present, the paper is bleached and turns white ***[1 mark]***.

2.1 Potassium, K^+ ***[1 mark]***

2.2 Clean a platinum wire loop ***[1 mark]*** by dipping it in some dilute HCl and then placing it in a blue flame from a Bunsen burner until it burns without colour ***[1 mark]***. Dip the loop into the sample you want to test and put it back into the flame ***[1 mark]***. Record the colour of the flame ***[1 mark]***.

2.3 yellow ***[1 mark]***

3.1 sulfate/SO_4^{2-} ***[1 mark]***

3.2 $Ba^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \rightarrow BaSO_{4(s)}$ ***[1 mark for balanced equation, 1 mark for state symbols]***
3.3 copper(II)/Cu^{2+} ***[1 mark]***
3.4 copper sulfate/$CuSO_4$ ***[1 mark]***
4.1 Substance **P**: CaI_2/calcium iodide ***[1 mark for correct anion, 1 mark for correct cation]***
Substance **R**: LiBr/lithium bromide ***[1 mark for correct anion, 1 mark for correct cation]***
4.2 The anion cannot be identified ***[1 mark]***.
4.3 **D**: white precipitate ***[1 mark]***
E: green ***[1 mark]***
4.4 The flame colours of some ions may be hidden by / mixed with the colour of others ***[1 mark]***.

Page 94 — Flame Emission Spectroscopy

1.1 Any two from: e.g. faster / more sensitive / more accurate ***[2 marks —1 mark for each correct answer]***
1.2 The identity ***[1 mark]*** and the concentration of metal ions in solution ***[1 mark]***.
1.3 line spectra ***[1 mark]***
2.1 A sample is placed in a flame and as the ions in the sample heat up they transfer energy as light ***[1 mark]***. This light passes through a spectroscope and produces a line spectrum specific to that ion ***[1 mark]***.
2.2 Metal **A** and metal **C** ***[1 mark]***.

Topic 9 — Chemistry of the Atmosphere

Pages 95-96 — The Evolution of the Atmosphere

Warm-up
1 False
2 True
3 True
4 False
1.1 One-fifth oxygen and four-fifths nitrogen ***[1 mark]***.
1.2 Any two from: e.g. carbon dioxide / water vapour / named noble gas ***[2 marks — 1 mark for each correct answer]***
1.3 By algae and plants photosynthesising ***[1 mark]***.
1.4 By volcanic activity ***[1 mark]***.
1.5 200 million years ***[1 mark]***
2.1 E.g. photosynthesis by plants and algae / carbon dioxide dissolved in the oceans ***[1 mark]***.
2.2 From matter that is buried and compressed over millions of years ***[1 mark]***.
2.3 Coal: from thick plant deposits ***[1 mark]***.
Limestone: from calcium carbonate deposits from the shells and skeletons of marine organisms ***[1 mark]***.
3.1 E.g. the long timescale means there's a lack of evidence ***[1 mark]***.
3.2 $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ ***[1 mark]***
3.3 Oxygen is produced by photosynthesis ***[1 mark]*** and there are no plants or algae / there isn't any photosynthesis ***[1 mark]*** on Mars.
3.4 The fact that the red beds formed about 2 billion years ago suggests that before this time there wasn't enough oxygen in the air for iron oxide to form / from this time there was enough oxygen in the air for iron oxide to form ***[1 mark]***.

Pages 97-98 — Greenhouse Gases and Climate Change

1.1 Nitrogen ***[1 mark]***
1.2 They help to keep Earth warm ***[1 mark]***.
1.3 Any two from: e.g. deforestation / burning fossil fuels / agriculture / producing waste ***[2 marks — 1 mark for each correct answer]***
2.1 Greenhouse gases absorb long-wave (thermal) radiation ***[1 mark]*** reflected from Earth's surface ***[1 mark]***. They then reradiate this thermal radiation in all directions, including back towards Earth, helping to warm the atmosphere ***[1 mark]***.
2.2 E.g. flooding ***[1 mark]*** and coastal erosion ***[1 mark]***.
2.3 Any one from: e.g. changes in rainfall patterns / the ability of certain regions to produce food might be affected / the frequency/severity of storms might increase / the distribution of wild species might change ***[1 mark]***.
3 <u>How to grade your answer:</u>
Level 0: There is no relevant information ***[No marks]***.
Level 1: Unstructured and no logic. The trends in the variables are described but reasons are not given ***[1 to 2 marks]***.
Level 2: Some structure and logic but lacking clarity. The trends in the variables are described and there is some explanation of how the increase in carbon dioxide may have come about and how this might be linked to temperature ***[3 to 4 marks]***.
Level 3: Clear, logical answer. The trends in the variables are described and there is a clear explanation of how the increase in carbon dioxide may have come about and how this may be linked to temperature ***[5 to 6 marks]***.
<u>Here are some points your answer may include:</u>
The graph shows an increase in carbon dioxide levels in the atmosphere between 1960 and 2015.
The increase in carbon dioxide levels is likely to be due to human activities which release carbon dioxide into the atmosphere.
These activities include increased burning of fossil fuels, increased deforestation and increased waste production.
The graph shows that the increase in carbon dioxide appears to correlate with an increase in global temperatures.
The increase in global temperatures is likely to be due to the increase in carbon dioxide in the atmosphere, as carbon dioxide is a greenhouse gas so helps to keep Earth warm.
4.1 The global warming potential for methane is significantly greater than for carbon dioxide ***[1 mark]***.
4.2 It has a very high global warming potential compared to other gases ***[1 mark]*** and stays in the atmosphere for a long time ***[1 mark]***.

Page 99 — Carbon Footprints

1.1 A measure of the amount of carbon dioxide and other greenhouse gases ***[1 mark]*** released over the full life cycle of something ***[1 mark]***.
1.2 E.g. using renewable or nuclear energy sources ***[1 mark]*** and using more energy efficient appliances ***[1 mark]***.
1.3 E.g. lack of education / reluctance to change their lifestyle / cost of changing lifestyle ***[1 mark]***.
2.1 Any two from, e.g: specialist equipment is needed to capture the carbon dioxide / it's expensive to capture and store the carbon dioxide / it could be difficult to find suitable places to store the carbon dioxide ***[2 marks — 1 mark for each correct answer]***.
2.2 E.g. governments could tax companies based on the amount of greenhouse gases they emit ***[1 mark]***. They could also put a cap on the emissions produced by a company ***[1 mark]***. Governments might be reluctant to impose these methods if they think it will affect economic growth / could impact on people's well-being ***[1 mark]***, especially if other countries aren't using these methods either / the country is still developing ***[1 mark]***.

Page 100 — Air Pollution

1.1 Coal can contain sulfur impurities ***[1 mark]***
1.2 Acid rain: sulfur dioxide / nitrogen oxides/nitrogen monoxide/nitrogen dioxide/dinitrogen monoxide ***[1 mark]***
Global dimming: e.g. (carbon) particulates ***[1 mark]***
1.3 Any two from: e.g. damage to plants / buildings / statues / corrodes metals ***[2 marks — 1 mark for each correct answer]***.

2.1 The reaction of nitrogen and oxygen from the air *[1 mark]* at the high temperatures produced by combustion *[1 mark]*.
2.2 Nitrogen oxides cause respiratory problems *[1 mark]* and contribute to acid rain *[1 mark]*.
2.3 E.g. they can cause respiratory problems *[1 mark]*.
2.4 Carbon monoxide *[1 mark]*. It is colourless and odourless *[1 mark]*.

Topic 10 — Using Resources

Page 101 — Ceramics, Polymers and Composites

1.1 limestone, sand, sodium carbonate
[3 marks — 1 mark for each correct answer]
1.2 Because borosilicate glass has a higher melting point than soda-lime glass *[1 mark]*.
1.3 Wet clay is shaped *[1 mark]* then fired at a high temperature *[1 mark]*.
2.1 They are made at different temperatures/pressures *[1 mark]* with a different catalyst *[1 mark]*.
2.2 thermosoftening *[1 mark]*
2.3 Poly(ethene) chains are entwined together with weak forces between the chains *[1 mark]*. Polyester resin can form crosslinks between polymer chains *[1 mark]*.
2.4 Composites consist of fibres/fragments of a material known as the reinforcement *[1 mark]* surrounded by a matrix/binder *[1 mark]*.

Page 102 — Properties of Materials

1.1 Bronze — Copper and tin *[1 mark]*
Steel — Iron and carbon *[1 mark]*
Brass — Copper and zinc *[1 mark]*
1.2 Any one from: e.g. water taps / door fittings *[1 mark]*
2.1 strength increases *[1 mark]*
2.2 high carbon steel *[1 mark]*
2.3 Aluminium is much less dense than the other metals *[1 mark]*.

Page 103 — Corrosion

1.1 iron + water + oxygen → hydrated iron(III) oxide *[1 mark]*
1.2 Galvanising is coating iron with zinc *[1 mark]*. Zinc is more reactive than iron *[1 mark]* so, unlike other methods of barrier protection, even if the coating is scratched it will still prevent the iron from rusting as it will oxidise before iron does *[1 mark]*.
1.3 Any three from: e.g. painting / coating with grease / electroplating / using a barrier / sacrificial protection
[3 marks — 1 mark for each correct answer]
2.1 The reaction of a material with substances in its environment so it is gradually destroyed *[1 mark]*.
2.2 The oxide that forms when aluminium reacts in the air forms a protective layer over the surface of the metal *[1 mark]*, preventing chemicals reaching the rest of the metal and reacting further *[1 mark]*.
2.3 Oxygen and water react with the magnesium instead of the steel *[1 mark]*.

Page 104 — Finite and Renewable Resources

1.1 Coal *[1 mark]*. It does not form fast enough to be considered replaceable *[1 mark]*.
1.2 A resource that reforms at a similar rate to, or faster, than humans can use it *[1 mark]*.
2.1 E.g. the development of fertilisers has meant higher yields of crops *[1 mark]*.
2.2 Any one from: e.g. synthetic rubber has replaced natural rubber / poly(ester) has replaced cotton in clothes / bricks are used instead of timber in construction *[1 mark]*.
3 Any one advantage from: e.g. allows useful products to be made / provides jobs / brings money into the area *[1 mark]*.
Any one disadvantage: e.g. uses large amounts of energy / scars the landscape / produces lots of waste / destroys habitats *[1 mark]*.

Pages 105-106 — Reuse and Recycling

1.1 An approach to development that takes account of the needs of present society *[1 mark]* while not damaging the lives of future generations *[1 mark]*.
1.2 E.g. chemists can develop and adapt processes that use less resources/do less damage to the environment *[1 mark]*. For example, chemists have developed catalysts that reduce the amount of energy required for industrial processes *[1 mark]*.
2.1 The raw materials for the jute bag are more sustainable *[1 mark]* as plant fibres are a renewable resource, whilst crude oil is a finite resource *[1 mark]*.
2.2 The production of the poly(ethene) bag is more sustainable *[1 mark]* as it needs less energy to be produced from its raw materials than the jute bag *[1 mark]*.
2.3 The jute bag can be reused and the poly(ethene) bag can be recycled, improving both their sustainability *[1 mark]*. However, the jute bag is more sustainable if the bags are disposed of in landfill *[1 mark]*, as it is biodegradeable, whilst the poly(ethene) bag isn't *[1 mark]*.
3.1 Any two from: e.g. often uses less energy / conserves the amount of raw materials on Earth / cuts down on waste sent to landfill *[2 marks — 1 mark for each correct answer]*.
3.2 Any one from: e.g. glass / metal *[1 mark]*
E.g. glass is crushed and melted down to form other glass products/other purpose / metal is melted and cast into the shape of a new product *[1 mark]*.
3.3 reusing *[1 mark]*
4.1 Plants are grown on soil containing copper compounds *[1 mark]*, so as they grow, copper builds up in their leaves *[1 mark]*. The plants are burned *[1 mark]*. The resulting ash contains the copper compounds *[1 mark]*.
4.2 By electrolysis of a solution containing the copper compounds *[1 mark]* or by displacement using scrap iron *[1 mark]*.
4.3 Copper is a finite resource *[1 mark]* and will eventually run out *[1 mark]*. Recycling copper makes it more sustainable *[1 mark]*.

Page 107 — Life Cycle Assessments

Warm-up
Getting the Raw Materials — Coal being mined from the ground.
Manufacturing and Packaging — Books being made from wood pulp.
Using the Product — A car using fuel while driving.
Product Disposal — Plastic bags going on to landfill.
1.1 Any two from: e.g. if a product is disposed of in landfill sites, it will take up space / may pollute land/water / energy is used to transport waste to landfill / pollution can be caused by incineration *[2 marks — 1 mark for each correct answer]*.
1.2 Any one from: e.g. energy / water / some natural resources / certain types of waste *[1 mark]*
1.3 They can be subjective / they are difficult to measure *[1 mark]*.
1.4 No *[1 mark]*. Some elements of the LCA are not objective/ require the assessors to make value judgements/cannot be quantified reliably *[1 mark]*, therefore different people are likely to make a different judgement/estimate *[1 mark]*.
1.5 Selective LCAs could be written so they only show elements that support a company's claims / they could be biased *[1 mark]* in order to give them positive advertising *[1 mark]*.

Pages 108-109 — Potable Water

Warm-up
1 False
2 True
3 False
1.1 pure water ***[1 mark]***
1.2 e.g. from the ground / lakes / rivers ***[1 mark]***.
1.3 passing water through filter beds — solid waste ***[1 mark]*** sterilisation — microbes ***[1 mark]***
1.4 E.g. chlorine, ozone, ultraviolet light ***[3 marks — 1 mark for each correct answer]***.
2.1 **A**: Bunsen burner ***[1 mark]***
B: round bottom flask ***[1 mark]***
C: thermometer ***[1 mark]***
D: condenser ***[1 mark]***
2.2 Pour the salt water into the flask and secure it on top of a tripod ***[1 mark]***. Connect the condenser to a supply of cold water ***[1 mark]*** that goes in at the bottom and out at the top ***[1 mark]***. Heat the flask and allow the water to boil ***[1 mark]***. Collect the water running out of the condenser in a beaker ***[1 mark]***.
2.3 Reverse osmosis / a method which uses membranes ***[1 mark]***
2.4 Desalination requires a lot of energy compared to the filtration and sterilisation of fresh water ***[1 mark]***. Since the UK has a plentiful supply of fresh water there is no need to use desalination processes ***[1 mark]***.

Page 110 — Waste Water Treatment

1.1 organic matter, harmful microbes ***[2 marks — 1 mark for each correct answer]***
1.2 It may contain harmful chemicals which need to be removed ***[1 mark]***.
2.1 To remove grit ***[1 mark]*** and large bits of material/twigs/ plastic bags ***[1 mark]***.
2.2 Substance **A**: sludge ***[1 mark]***
Substance **B**: effluent ***[1 mark]***
2.3 anaerobic digestion ***[1 mark]***

Page 111 — The Haber Process

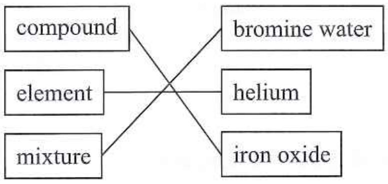
1.1 Nitrogen, Hydrogen ***[1 mark for both]***
1.2 ammonia ***[1 mark]***
1.3 Because ammonia is used to make fertilisers ***[1 mark]***.
2.1 Low temperature ***[1 mark]***. Low temperatures cause the position of equilibrium to shift in favour of the exothermic, forward reaction ***[1 mark]*** which means more ammonia is produced/you get a higher yield of ammonia ***[1 mark]***.
2.2 A higher temperature is used to get a reasonable rate of reaction ***[1 mark]***.
2.3 High pressure causes the yield to increase ***[1 mark]***. There are fewer moles of gas in the products than reactants/ on the right hand side of the equation than on the left hand side ***[1 mark]***. Since high pressure favours the production of fewer moles of gas, the position of equilibrium would move right/to the product side as pressure is increased ***[1 mark]***.
2.4 Any one from: e.g. safety / cost / rate ***[1 mark for any correct answer]***.

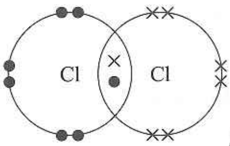
Page 112 — NPK Fertilisers

1.1 potassium chloride, potassium sulfate ***[1 mark for each correct answer]***
1.2 They are mined ***[1 mark]***.
2.1 calcium nitrate ***[1 mark]***
2.2 Phosphate rock + sulfuric acid: calcium phosphate ***[1 mark]*** and calcium sulfate ***[1 mark]***.
Phosphate rock + phosphoric acid: calcium phosphate ***[1 mark]***.
2.3 The reaction is carried out at lower concentrations in the lab so that it's safer for the person carrying it out ***[1 mark]***. Crystallisation isn't used in industry as it's very slow ***[1 mark]***.

Mixed Questions

Pages 113-124 — Mixed Questions

1.1


[2 marks if all three correct, otherwise 1 mark if 1 correct]
1.2 Mixtures with a precise purpose ***[1 mark]*** that are made by following a formula / a recipe ***[1 mark]***.
2.1 Dissolve the rock salt in water and filter ***[1 mark]***.
2.2 It contains two elements/more than one element in fixed proportions ***[1 mark]*** held together by chemical bonds ***[1 mark]***.
2.3 ionic ***[1 mark]***
3.1 Group: 6 ***[1 mark]***
Explanation: There are 6 electrons in the outer shell ***[1 mark]***.
3.2 2– ions ***[1 mark]***, as oxygen atoms need to gain two electrons to get a full outer shell ***[1 mark]***.
3.3 Oxidation ***[1 mark]***
4.1


[1 mark for shared pair of electrons, 1 mark for six further electrons in the outer shell of each chlorine atom]
4.2 E.g. atoms with the same number of protons / of the same element / with the same atomic number ***[1 mark]*** with different numbers of neutrons / different mass numbers ***[1 mark]***.
4.3 Hold a piece of damp litmus paper in the unknown gas ***[1 mark]***. It will be bleached white in the presence of chlorine ***[1 mark]***.
4.4 Chlorine is more reactive than iodine ***[1 mark]***, so would displace iodine from sodium iodide solution / the solution would go from colourless to brown ***[1 mark]***.
5.1 endothermic ***[1 mark]***
5.2 higher ***[1 mark]***
5.3 It takes more energy to break the bonds in the reactants than is released when the bonds in the products form ***[1 mark]***, so overall energy is taken in from the surroundings ***[1 mark]***.
5.4 E.g. in a sports injury pack ***[1 mark]***.
6.1 alkanes ***[1 mark]***
6.2 (fractional) distillation ***[1 mark]***
6.3 cracking ***[1 mark]***
6.4 Decane ***[1 mark]***, because the molecules are bigger ***[1 mark]***, so will have stronger intermolecular forces / more energy is needed to break the forces between the molecules ***[1 mark]***.
6.5 $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$ ***[1 mark for correct reactants and products, 1 mark for balancing]***
7.1 The electrons in the outer shell ***[1 mark]*** of the metal atoms are delocalised ***[1 mark]***. There is strong electrostatic attraction between the positive metal ions and the shared negative electrons ***[1 mark]***.
7.2 Iron: solid ***[1 mark]***. Silver: liquid ***[1 mark]***
7.3 Iron ***[1 mark]***, because it has a higher melting/boiling point ***[1 mark]***, so more energy is needed to break the bonds ***[1 mark]***.
8.1 The reactant that is used up first / limits the amount of product that's formed ***[1 mark]***.
8.2 $M_r(\text{LiOH}) = A_r(\text{Li}) + A_r(\text{O}) + A_r(\text{H}) = 7 + 16 + 1 = \mathbf{24}$ ***[1 mark]***
8.3 Number of moles = mass ÷ molar mass = 1.75 ÷ 7 = **0.25 mol** ***[2 marks for correct answer, otherwise 1 mark for using the correct equation to calculate moles]***

8.4 From the reaction equation, 0.50 mol Li forms 0.50 mol LiOH.
Mass of LiOH = number of moles × molar mass = 0.50 × 24 = **12 g** ***[3 marks for correct answer, otherwise 1 mark for number of moles of LiOH produced, 1 mark for using the correct equation to calculate mass]***

9.1 It described atoms as having a tiny, positively charged nucleus at the centre ***[1 mark]***, surrounded by a cloud of electrons ***[1 mark]***.

9.2 Atoms consist of a small nucleus ***[1 mark]*** which contains the protons and neutrons ***[1 mark]***. The electrons orbit the nucleus in fixed energy levels/shells ***[1 mark]***.

10.1 The particles in a gas expand to fill any container they're in ***[1 mark]***. So the particles of carbon dioxide formed will expand out of the unsealed reaction vessel ***[1 mark]***, causing the mass of substance inside the reaction vessel to decrease ***[1 mark]***.

10.2 E.g. add a set volume and concentration of hydrochloric acid to the reaction vessel ***[1 mark]***. Add a set volume and concentration of sodium carbonate solution ***[1 mark]***, connect the reaction flask to a gas syringe ***[1 mark]*** and start the stop-watch ***[1 mark]***. Record the volume of gas collected at regular intervals until the reaction is finished ***[1 mark]***. Repeat the experiment, keeping everything the same except for the concentration of acid ***[1 mark]***.

10.3 Change in volume = 12.0 cm^3

$$\text{Mean rate of reaction} = \frac{\text{amount of product formed}}{\text{time}} = \frac{12.0}{30}$$

= **0.40 cm^3/s** ***[2 marks for correct answer, otherwise 1 mark for using the correct equation to calculate rate]***

11.1 Any two from: e.g. it dissolved in oceans / photosynthesis / trapped in rocks and fossil fuels ***[2 marks — 1 mark for each correct answer]***

11.2 E.g. methane ***[1 mark]***. It is increasing due to more agriculture / waste production ***[1 mark]***.

11.3 How to grade your answer:

Level 0: There is no relevant information. ***[No marks]***

Level 1: There are a few examples of other pollutant gases, but little discussion of how they are made or what their impacts could be. ***[1 to 2 marks]***

Level 2: There are a number of examples of other pollutant gases, with some discussion of how they are made and what their impacts could be. ***[3 to 4 marks]***

Level 3: There are a number of examples of other pollutant gases, with a detailed discussion of how they are made and what their impacts could be. ***[5 to 6 marks]***

Here are some points your answer may include:
Other pollutant gases include carbon monoxide, sulfur dioxide and nitrogen oxides.
Carbon monoxide is produced when fuels undergo incomplete combustion.
Carbon monoxide can cause fainting, coma or even death.
Sulfur dioxide is produced when fuels that contain sulfur impurities are burned.
Sulfur dioxide can mix with water in clouds to produce sulfuric acid, so cause acid rain.
Sulfur dioxide can cause respiratory problems.
Nitrogen oxides are produced when nitrogen and oxygen from the air react/combine due to the heat of burning.
Nitrogen oxides can mix with water in clouds to produce nitric acid, so cause acid rain.
Nitrogen oxides can cause respiratory problems.

12.1 Iron, tin, copper ***[2 marks if all correct, or 1 mark if 1 correct]***

12.2 $2AgCl_{(aq)} + Cu_{(s)} \rightarrow CuCl_{2(aq)} + 2Ag_{(s)}$ ***[1 mark for correct equation, 1 mark for balancing, 1 mark for state symbols]***

13.1 Copper is lower in the reactivity series/less reactive than carbon ***[1 mark]***, so can be extracted by reduction using carbon ***[1 mark]***.

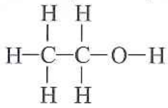
13.2 Bacteria are used to convert copper compounds in the ore into soluble copper compounds ***[1 mark]***. This produces a leachate that contains copper ions ***[1 mark]*** which can be extracted by electrolysis/displacement with iron ***[1 mark]***.

13.3 The atoms in copper form layers which slide over each other, so it can be drawn out into wires ***[1 mark]***. Copper contains delocalised electrons which are free to move and carry an electric current ***[1 mark]***.

13.4 The tin atoms in bronze distort the structure of the copper ***[1 mark]***. This means the layers can no longer slide over each other ***[1 mark]***, so bronze is harder than copper ***[1 mark]***.

14.1 Polymer **A** has weak forces between the chains ***[1 mark]***. Polymer **B** has cross links between the chains ***[1 mark]***.

14.2 Polymer **B** ***[1 mark]*** as it's rigid, so would keep the shape of the mug ***[1 mark]*** and it wouldn't be softened by the hot drinks ***[1 mark]***.

15.1


[1 mark for correct number of each atom, 1 mark for atoms joined up correctly]

15.2 Ethanol can be made by reacting ethene with steam ***[1 mark]*** in the presence of a catalyst ***[1 mark]***. It can also be made by fermenting sugars with yeast ***[1 mark]*** at around 37 °C ***[1 mark]*** and slightly acidic conditions ***[1 mark]*** in the absence of oxygen ***[1 mark]***.

16.1 Add a few drops of sodium hydroxide to a sample of the solution ***[1 mark]***. If iron(II) ions are present, a green precipitate should form ***[1 mark]***.
$FeSO_{4(aq)} + 2NaOH_{(aq)} \rightarrow Fe(OH)_{2(s)} + Na_2SO_{4(aq)}$ ***[1 mark for correct equation, 1 mark for balancing, 1 mark for state symbols]***

16.2 Add some barium chloride ***[1 mark]*** to the solution in the presence of hydrochloric acid ***[1 mark]***. If sulfate ions are present, a white precipitate should form ***[1 mark]***.
$BaCl_{2(aq)} + FeSO_{4(aq)} \rightarrow BaSO_{4(s)} + FeCl_{2(aq)}$ ***[1 mark for balanced equation, 1 mark for state symbols]***

16.3 Add iron(II) oxide to sulfuric acid until the reaction stops / the solid sinks to the bottom ***[1 mark]***. Filter off the excess iron(II) oxide ***[1 mark]***. Gently heat the iron(II) sulfate solution to evaporate some of the water and then leave to cool ***[1 mark]***. Filter and dry the crystals that form ***[1 mark]***.

17.1 Number of moles of carbon = mass ÷ A_r = 24 ÷ 12 = 2 mol
1 mol of carbon reacts to produce 2 mol of hydrogen gas, so 2 mol of carbon will react to produce 2 × 2 = 4 mol of hydrogen gas.
M_r of H_2 = 2 × 1 = 2
Mass = number of moles × molar mass = 4 × 2 = **8 g**
[4 marks for correct answer, or 1 mark for correct number of moles of carbon, 1 mark for correct number of moles of hydrogen, 1 mark for correct M_r of hydrogen]

17.2 1 mole of gas occupies 24 dm^3 at room temperature and pressure, so 4 moles of gas occupies 4 × 24 = **96 dm^3** ***[1 mark]***
If you got the answer to 13.1 wrong you still get the mark here if you used your answer to 13.1 correctly in this part.

17.3 Percentage yield

$$= \frac{\text{Mass of product actually made}}{\text{Maximum theoretical mass of product}} \times 100 = \frac{4.8}{8} \times 100$$

= **60%** ***[2 marks for correct answer, otherwise 1 mark for using the correct equation to calculate percentage yield]***

18.1 100% ***[1 mark]***. The reaction only has one product ***[1 mark]***.

18.2 E.g. the reaction is reversible / some of the products will always turn back into reactants / there might be side reactions / some of the product may be lost as it's separated from the reaction mixture ***[1 mark]***.

18.3 A low temperature shifts the position of equilibrium in favour of the forward, exothermic reaction ***[1 mark]***. This means there will be more product at equilibrium / the yield will be greater ***[1 mark]***. However, a low temperature decreases the rate of reaction ***[1 mark]***. So the temperature is a compromise in order to get a good yield at a reasonable rate ***[1 mark]***.

19.1 $H^+ + OH^- \rightarrow H_2O$ ***[1 mark]***

19.2 sodium sulfate ***[1 mark]***

19.3 Universal indicator doesn't have a sudden colour change at the endpoint ***[1 mark]***. An indicator such as methyl orange / phenolphthalein / litmus ***[1 mark]*** should be used instead.

19.4 volume in $dm^3 = 20.35 \div 1000 = 0.02035$ dm^3
moles = volume × concentration = 0.02035 × 0.10 =
0.0020 mol ***[3 marks for correct answer, otherwise 1 mark for volume in dm³, 1 mark for using the correct equation to calculate moles]***

19.5 mean titre = (20.05 + 19.95 + 20.00) ÷ 3 = **20.00 cm³**
[2 marks for correct answer, otherwise 1 mark for ignoring rough titre]

19.6 volume of H_2SO_4 to react in $dm^3 = 20.0 \div 1000 = 0.0200$ dm^3
moles of H_2SO_4 to react = 0.0200 × 0.10 = 0.0020 mol
$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$
1 mole of H_2SO_4 reacts with 2 moles of NaOH, so
0.0020 mol of H_2SO_4 reacts with 0.0040 mol of NaOH
Concentration of NaOH = number of moles ÷ volume
= 0.0040 ÷ 0.025 = **0.16 mol/dm³** ***[5 marks for correct answer, otherwise 1 mark for number of moles of H_2SO_4, 1 mark for number of moles of NaOH, 1 mark for balanced reaction equation, 1 mark for using the correct equation to calculate concentration]***

20.1 Aluminium ore is mixed with cryolite and melted ***[1 mark]***. An electric current is passed through the molten ore ***[1 mark]***. At the cathode/negative electrode, Al^{3+} ions are reduced to aluminium metal ***[1 mark]***: $Al^{3+} + 3e^- \rightarrow Al$ ***[1 mark]***. At the anode/positive electrode, O^{2-} ions are oxidised to oxygen ***[1 mark]***: $2O^{2-} \rightarrow O_2 + 4e^-$ ***[1 mark]***.

20.2 When aluminium corrodes it forms a protective layer of aluminium oxide ***[1 mark]*** that stops any further reaction taking place ***[1 mark]***.

20.3 Galvanising means covering iron with a layer of zinc ***[1 mark]***. This acts as a protective barrier to keep out water and oxygen ***[1 mark]***. If the layer is scratched, the zinc around the scratch reacts instead of the iron ***[1 mark]***.

21.1 Order: diamond, poly(propene), butane ***[1 mark]***.
Explanation: Diamond has the highest melting point as you need to break the strong covalent bonds ***[1 mark]***. Poly(propene) forms larger molecules than butane, so has stronger intermolecular forces ***[1 mark]***, which require more energy to break ***[1 mark]***.

21.2 Particles with a diameter between 1 nm and 100 nm / particles containing only a few hundred atoms ***[1 mark]***. They have a very high surface area to volume ratio compared to bulk materials ***[1 mark]***.

21.3 E.g. they could be used for drug delivery ***[1 mark]***. The effects of nanoparticles on health aren't understood / they could react with things in the body / they could damage cells ***[1 mark]***.

22.1 Zinc is more reactive than hydrogen ***[1 mark]***. This means zinc forms positive ions more easily than hydrogen ***[1 mark]***.

22.2 Reduction ***[1 mark]***, because the hydrogen ions gain electrons ***[1 mark]***.

22.3 $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$ ***[1 mark for correct reactants and products, 1 mark for balancing]***

If you had '$-4e^-$' on the left hand side of the equation instead of '$+4e^-$' on the right, you still get the marks.

23.1 Similarity: e.g. they both form positive ions / they both react with acid ***[1 mark]***. Difference: e.g. cobalt has a higher melting point / cobalt forms more than one positive ion / cobalt reacts less vigorously with acid ***[1 mark]***.

23.2 How to grade your answer:

Level 0: There is no relevant information. ***[No marks]***

Level 1: There is a brief description of the similarities and differences between lithium and sodium, but no explanation of these observations. ***[1 to 2 marks]***

Level 2: There is a detailed comparison of the similarities and differences between lithium and sodium, and some explanation of the observations. ***[3 to 4 marks]***

Level 3: There is a detailed comparison of the similarities and differences between lithium and sodium, and a good explanation of the observations. ***[5 to 6 marks]***

Here are some points your answer may include:
Both react to form positive, 1+ ions.
Both elements are in Group 1, so have one electron in their outer shell.
Not much energy is needed to remove this one outer electron and give the elements a full outer shell of electrons.
Both react with acid.
Sodium reacts more vigorously with acid than lithium.
Sodium is lower down in the group, so the outer electron in sodium is further away from the nucleus than the outer electron in lithium.
The attraction between the outer electron and the nucleus of sodium is less than the attraction between the outer electron and the nucleus in lithium.
Less energy is needed to remove the outer electron of sodium, making it more reactive than lithium.

23.3 Any answer in the range 80–160 °C ***[1 mark]***

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