Question	Answers	Extra information	Mark	AO / Specification reference
01.1	percentage yield: $\frac{\text{mass of product actually made}}{\text{maximum theoretical mass of product}} \times 100\%$ atom economy: $\frac{\text{relative formula mass of desired product from equation}}{\text{sum of relative formula masses of all reactants from equations}}$ × 100%		1 1	AO1 4.3.3.1 4.3.3.2
01.2	**two** from: • sustainable development/preserves Earth's resources • economic reasons • reduce waste		1 1	AO1 4.3.3.2
01.3	some remains on the filter paper/is not scraped off		1	AO3
02.1	**two** from: • wear eye protection • use a safety screen between students and reaction • stand back immediately when reaction starts	allow any other suitable precaution	1 1	AO3

Question	Answers	Extra information	Mark	AO / Specification reference
02.2	M_r of iron(III) oxide is (2 × 56) + (3 × 16) = 160 g 8.0 g of iron(III) oxide is $\frac{8}{160}$ = 0.050 mol 2.7 g of aluminium is $\frac{2.7}{27}$ = 0.10 mol from balanced equation, one mol of iron(III) oxide reacts with two mol of aluminium, so 0.050 mol of iron(III) oxide needs 0.10 mol of aluminium.		1 1 1 1	AO2 4.3.2.1 4.3.2.4
02.3	from balanced equation, one mol of iron(III) oxide makes two mol of iron, so 0.050 mol of iron(III) oxide makes 0.10 mol of iron this has a mass of 0.10 × 56 = 5.6 g		1 1	AO2 4.3.2.1
02.4	percentage yield: $\frac{\text{mass of product actually made}}{\text{maximum theoretical mass of product}} \times 100\%$ $\frac{4.6}{5.6} \times 100 = 82.1\%$	allow error carried forward	1	AO1 x 1 AO2x1 4.3.3.1
02.5	some of the aluminium reacts with oxygen from the air some of the iron made is not collected	allow other suitable reasons	1 1	AO3 4.3.3.1

Question	Answers	Extra information	Mark	AO / Specification reference
03.1	number of moles of NaOH = $\frac{25}{1000}$ × 0.100 = 0.00 250 from balanced equation, one mol of H_2SO_4 reacts with two mol of NaOH, so number of moles of acid in 25.0 cm^3 = $\frac{0.00250}{2}$ = 0.00 125 mol concentration of acid = 0.00 125 × $\frac{1000}{25}$ = 0.05 mol/dm^3 = 0.0500 mol /dm^3		1 1 1 1 1	AO1 x 1 AO2 x 4 4.3.4
03.2	M_r of H_2SO_4 = (2 × 1) + 32 + (4 × 16) = 98 g mass of 0.0500 mol = 0.0500 × 98 g = 4.9 g, so concentration = 4.9 g/dm^3		1 1	AO2 4.3.2.1
03.3	M_r of NaOH = 23 + 16 + 1 = 40 g mass of 0.0100 mol = 40 × 0.100 = 4.0 g		1 1	AO2 4.3.2.1
04.1	M_r of C_2H_5OH = (2 × 12) + (5 × 1) + 16 + 1 = 46		1	AO2 4.3.1.2
04.3	atom economy of process 1 = $\frac{46}{(28+18)}$ × 100 = 100% atom economy of process 2 = $\frac{(2\times46)}{180}$ × 100 = 51.1 % the atom economy process of 1 is approximately double that of process 2		1 1 1	AO2 4.3.3.2

Question	Answers	Extra information	Mark	AO / Specification reference
04.3	**Level 3:** The comparisons are detailed and accurate. The writing is clear, coherent and logical and comparisons are clearly made.		5-6	AO3 4.3.3.2
	Level 2: The comparisons are generally correct, although may lack detail. The writing is mainly clear, although the structure may lack logic and comparisons are not always clear.		3-4	
	Level 1: Some comparisons are correct. The writing lacks clarity, coherence and logic, and the comparisons are not clearly expressed.		1-2	
	No relevant content		0	
	Indicative content • 1 occurs at a higher temperature and pressure than 2, so 2 is better for sustainable development in this respect • the raw material for 1 is obtained from crude oil, so 2 is better for sustainable development in this respect • 2 produces carbon dioxide, which is a greenhouse gas, so 1 is better for sustainable development in this respect • 1 has a higher atom economy than 2, so 1 is better for sustainable development in this respect			
05.1	$M_r = (3 \times 12) + (8 \times 1) = 44$ number of moles = $\frac{6000}{44}$ = 136 mol at room temperature and pressure, one mol of gas occupies 24 dm^3 136 mol occupies 136 × 24 = 3264 dm^3		1 1 1 1	AO1×1 AO2×3 4.3.5

Question	Answers	Extra information	Mark	AO / Specification reference
05.2	$50 \times 5 = 250\ cm^3$ $\frac{250}{1000} = 0.250\ dm^3$		1 1	AO1×1 AO2×1 4.3.5
05.3	number of moles of propane = $\frac{480}{44} = 10.9$ from balanced equation, one mol of propane makes three mol of CO_2 number of mol of $CO_2 = 3 \times 10.9 = 32.7$ mol $24 \times 32.7 = 784.8\ dm^3$ $= 785\ dm^3$		1 1 1 1	AO1 × 2 AO2 × 3 4.3.5
06.1	8.8 g		1	AO2 4.3.1.1 4.3.3.1
06.2	8.2 g		1	AO2 4.3.3.1
06.3	100%		1	AO2 4.3.3.2
07	**Level 3:** Appropriate equipment named and a detailed description of the various repeats required is provided.		5-6	AO1 4.4.2.5
	Level 2: Method provided. Some attempt at demonstrating need for repeats.		3-4	
	Level 1: A basic titration method provided. No mention of repeats.		1-2	

Question	Answers	Extra information	Mark	AO / Specification reference
	No relevant content.		0	
	Indicative content • use a pipette to measure out a known volume of sodium hydroxide. • put the sodium hydroxide into a conical flask. • add a few drops of a suitable indicator to the conical flask • place the conical flask on a white tile. • fill a burette with the hydrochloric acid. • add about one m^3 of acid to the conical flask and mix by swirling the flask. • repeat until the indicator changes colour. • record the volume of acid used as the rough titre. • repeat the process, but as the end point is approached, add the acid drop wise to obtain a precise measurement. • repeat until at least two concordant results are achieved.			

Question	Answers	Extra information	Mark	AO / Specification reference
08.1	M_r of CH_4 = 12 + (4 × 1) = 16 M_r of H_2O = (1 × 2) + 16 = 18 atom economy: $\frac{\text{relative formula mass of desired product from equation}}{\text{sum of relative formula masses of all reactants from equations}}$ × 100% $\frac{6}{(16+18)}$ × 100 = 17.6%		1 1 1	AO1 × 1 AO2 × 2 4.3.3.2
08.2	use electricity generated from renewable resources	allow suitable alternative answers	1	AO3
08.3	**Level 3:** The comparisons are detailed and accurate. The writing is clear, coherent and logical and comparisons are clearly made.		5-6	AO3 4.3.3.2
	Level 2: The comparisons are generally correct, although may lack detail. The writing is mainly clear, although the structure may lack logic and comparisons are not always clear.		3-4	
	Level 1: Some comparisons are correct. The writing lacks clarity, coherence and logic, and the comparisons are not clearly expressed.		1-2	
	No relevant content		0	

Question	Answers	Extra information	Mark	AO / Specification reference
	Indicative content • 1 occurs at a higher temperature than 2, so 2 is better for sustainable development in this respect • if the raw material for 1 is obtained from fossil fuels, 2 is better for sustainable development in terms of resources used • if the material for 1 is obtained from sewage, both processes have a similar impact on the environment in terms of resources used • 2 produces carbon monoxide, which is poisonous, so 1 is better for sustainable development in terms of pollutants made • 1 has a higher atom economy than 2, so 1 is better for sustainable development in this respect			
09.1	to allow oxygen to enter the crucible		1	AO3
09.2	percentage yield: $\frac{\text{mass of product actually made}}{\text{maximum theoretical mass of product}} \times 100\%$ $\frac{1.80}{2.00} \times 100\%$ = 90%		1 1 1	AO1 × 1 AO2 × 2 4.3.3.1

Question	Answers	Extra information	Mark	AO / Specification reference
09.3	**one** from: • some magnesium oxide escaped out of the crucible • not all the magnesium reacted • some of the magnesium oxide reacted with nitrogen from the air	allow other suitable answers	1	AO3 4.3.3.1
10.1	13.55		1	AO3 4.4.2.5
10.2	13.00		1	AO2 4.4.2.5
10.3	$HNO_3(aq) + NaOH(aq) \longrightarrow NaNO_3(aq) + H_2O(l)$	1 mark for reactants, 1 mark for products, 1 mark for state symbols	3	AO2 4.4.2.5
10.4	converting units, 25 cm^3 = 0.025 dm^3 and 13cm^3 = 0.013 dm^3 moles of NaOH = 0.1 × 0.025 = 2.5×10^{-3} concentration of $HNO_3 = \frac{2.5 \times 10^{-8}}{0.013}$ = 0.19 mol/dm^3	accept errors carried forward for ratios from question 10.3	1 1 1 1	AO1 AO2 4.4.2.5
11.1	F		1	AO1 4.1.2.1 4.1.2.5

Question	Answers	Extra information	Mark	AO / Specification reference
11.2	**two** from • A • B • C • D	two correct letters required for the mark	1	AO1 4.1.2.3
11.3	**Level 3:** The description is detailed and accurate. The writing is clear, coherent and logical.		5-6	AO1 4.1.2.2
	Level 2: The description is correct, although lacks detail. The writing is mainly clear, although the structure may lack logic.		3-4	
	Level 1: Some aspects of the description are correct. The writing lacks clarity, coherence and logic.		1-2	
	No relevant content		0	

Question	Answers	Extra information	Mark	AO / Specification reference
	Indicative content • before discovering sub-atomic particles, scientists attempted to classify the elements by arranging them in order of their atomic weights • early periodic tables were incomplete, and some elements were placed in inappropriate groups • Mendeleev overcame the problems by leaving gaps for elements that he thought had not been discovered • Mendeleev also changed the order of elements in some places based on atomic weights • elements predicted by Mendeleev were discovered and filled the gaps • knowledge of isotopes made it possible to explain why the order based on atomic weights was not always correct			
12.1	A		1	AO3 4.2.1.4
12.2	one dot and one cross in each of the four intersections		2	AO1 4.2.1.4
12.3	B ionic bonding, no free electrons only able to conduct electricity when molten because ions can move		1 1 1	AO3

Question	Answers	Extra information	Mark	AO / Specification reference
12.4	metallic giant structure of atoms/ions arranged in regular pattern electrons in the outer shell of metal atoms are delocalised and free to move throughout structure giving rise to strong metallic bonds		1 1 1 1	AO1 4.2.1.5
13.1	55.6 × 5 = 278 mol		1	AO2 4.3.2.5
13.2	M_r = (6 × 12) + (12 × 1) + (6 × 16) = 180 g concentration = 180 × 300 = 59 400 g/dm^3 = 59.4 kg/dm^3		1 1 1 1	AO1 × 2 AO2 × 2 4.3.2.1 4.3.2.5
13.3	$59.4 \times \frac{50}{1000}$ = 2.97 kg	award two marks for correct answer without working allow 2970 g	1 1	AO2 4.3.2.5
14.1	heat the solution until the water evaporates leaving potassium chloride crystals		1 1 1	AO1 4.1.1.2

Question	Answers	Extra information	Mark	AO / Specification reference
14.2	whole square filled with same-sized circle circles arranged in regular pattern all circles touching		1 1 1	AO1 4.2.2.1
14.3	potassium chloride has different properties as a compound to potassium and chlorine elements	allow named properties of K and Cl e.g., colour, electrical conductivities	1	AO1 4.1.1.2