1. A student repeats Haber's experiment.

He works out the theoretical yield for making some ammonia.

(i) 14.0g of nitrogen was reacted with excess hydrogen to produce ammonia.
Here is the equation for the reaction.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Calculate the theoretical yield of ammonia.

Relative formula mass of N_2 = 28.0

Relative formula mass of NH_3 = 17.0

theoretical yield = _____ g **[3]**

He separates the ammonia he makes at the end of the reaction and measures its mass.

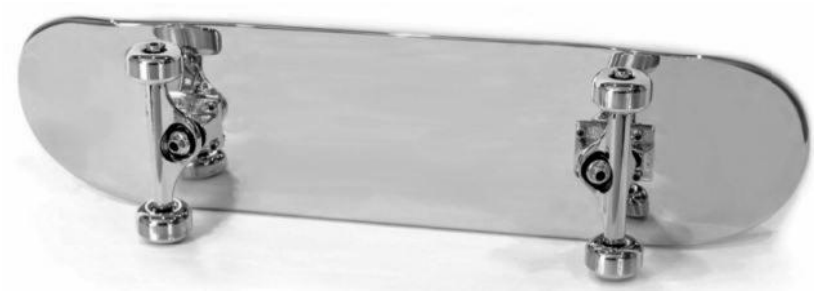
The table shows his results.

Mass of container and ammonia at the end (g)	59.5
Mass of container (g)	51.0
Mass of ammonia (g)	8.5

(ii) Calculate the **percentage yield** of ammonia.

percentage yield _____ % **[2]**

2. Sam works for a company that makes skateboards.



Customers complain that their skateboards lose performance once they have got wet.

Skateboards have bearings in each wheel to help the wheels rotate smoothly and freely.

Sam thinks that the mass increase caused by the ball bearings rusting will be very small and will not affect the performance of the skateboard.

(i) Calculate the percentage by mass of iron in rust.

Give your answer to 2 decimal places.

Relative formula mass of rust = 213.6

_____ % **[2]**

(ii) Each bearing contains seven smaller ball bearings.

Calculate the increase in mass of the skate board if 2 g of the iron in each ball bearing turns to rust.

Give your answer to the nearest gram.

_____ g **[3]**

3. Fertilisers are used to help to grow food.

The first stage of making fertilisers uses hydrogen to make ammonia. Very large amounts of hydrogen are needed. The equation for the process is:

methane + steam ⇌ hydrogen + carbon dioxide

$CH_4 + 2H_2O \rightleftharpoons 4H_2 + CO_2$

All of the methane is never used up in this reaction, there is always some left over.

(i) Jack uses this equation to calculate the atom economy of the process.

$$\textbf{Atom economy} = \frac{\textbf{Total mass of hydrogen molecules made}}{\textbf{Total mass of molecules used}} \times 100\ \%$$

Equation: $CH_4 + 2H_2O \rightleftharpoons 4H_2 + CO_2$

Calculate the atom economy for this process.

atom economy = _____ % **[3]**

(ii) The information says that the atom economy is < 20 %.

Does the value you have calculated agree with this?

Explain your reasoning.

_____

_____

_____ **[2]**

4(a). The table shows some information about the relative formula masses for some compounds.

Name of compound	Formula	Relative atomic masses of atoms in the formula		Relative formula mass of compound
lithium chloride	LiCl	Li	7	7 + 35.5 = 42.5
		Cl	35.5	
sodium chloride	NaCl	Na	23	23 + 35.5 = 58.5
		Cl	35.5	
potassium chloride	KCl	K	39	39 + 35.5 = 74.5
		Cl	35.5	

Explain the differences between the relative formula masses of these three compounds.

---

[2]

(b). Lithium fluoride is another compound of lithium.

The formula for lithium fluoride is LiF.

(i) Use the Periodic Table to find the relative atomic mass of fluorine.

Relative atomic mass of fluorine = _____

[1]

(ii) Use your answer to work out the relative formula mass of lithium fluoride.

Relative formula mass of lithium fluoride, LiF = _____

[1]

5(a). Magnesium sulfate is used to make medicines.

Elly makes some magnesium sulfate by reacting magnesium oxide with sulfuric acid.

She uses this formula to work out her theoretical yield of magnesium sulfate.

theoretical yield = 3 × mass of magnesium oxide used

In her experiment, she uses **5 g of magnesium oxide**.

Use Elly's formula to work out her **theoretical yield**.

_____ g **[1]**

(b). Elly makes some more magnesium sulfate crystals using a different amount of magnesium oxide.

She weighs an empty dish.

She puts her crystals into the dish and weighs it again.

weight of dish and crystals	206.5 g
weight of empty dish	201.0 g

(i) What mass of crystals has Elly made?

_____ g **[1]**

(ii) For this experiment, Elly works out that her theoretical yield is 10.0 g.

Work out Elly's percentage yield.

Use this formula.

$$\text{percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

_____ % **[2]**

6. Fred needs to calculate the relative formula mass of ethanol to work out the overall yield of a chemical reaction he has completed.

Calculate the relative formula mass of ethanol, C_2H_5OH.

In your answer, use the relative atomic masses from the Periodic Table.

_____ **[1]**

7. The UK makes 3000 tonnes of ammonia every day using the Haber process.
For every tonne of ammonia, 1.6 tonnes of carbon dioxide are made.
Half of this carbon dioxide can be captured.

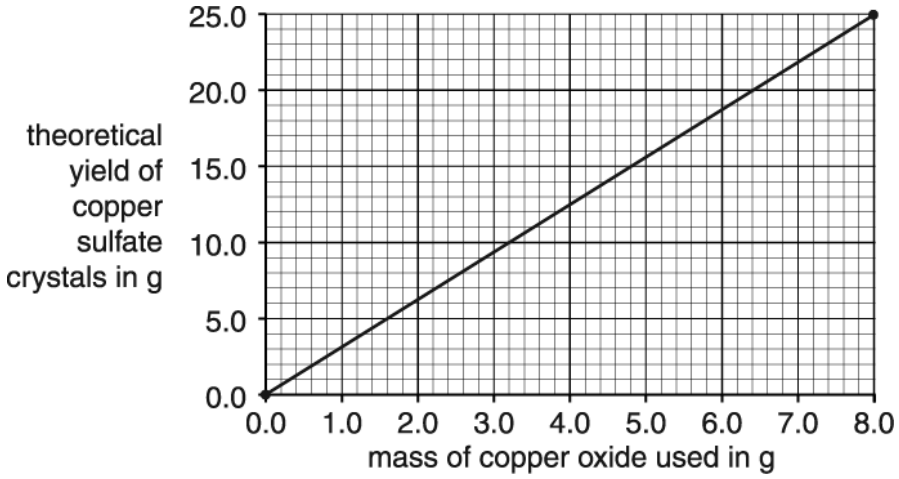
How much carbon dioxide can be captured each day?

_____ tonnes **[2]**

8. Sam works for a company that makes chemicals to kill fungi on plants.

One of the chemicals the company makes is copper sulfate.

Sam draws a graph to show the theoretical yield of copper sulfate crystals that can be made from copper oxide.



(i) What mass of copper oxide would Sam need to make 10 g of copper sulfate crystals?

_____ [1]

(ii) The company makes the fungicide in large quantities.

Use your answer to **(i)** to work out how much copper oxide would be needed to make 5 kg of copper sulfate crystals.

_____ [2]

(iii) In practice, Sam finds that he makes a lower mass of copper sulfate crystals than he predicts.

Which statements can explain why this happens?

Put a tick (✓) in the boxes next to the **two** correct answers.

There are impurities in the copper oxide. ☐

Sam adds too much acid. ☐

Sam has not dried his crystals thoroughly. ☐

Some chemicals are lost during the experiment. ☐

The rate of the reaction was too fast. ☐

[2]

9. Jak makes some zinc sulfate crystals from solid zinc carbonate and dilute sulfuric acid.

He starts with 20 cm^3 of dilute sulfuric acid.

Jak puts his zinc sulfate crystals in a weighing bottle.

He records some data about his experiment.

volume of dilute sulfuric acid used	20 cm^3
mass of zinc carbonate at the start	10.0 g
mass of empty weighing bottle	18.5 g
mass of weighing bottle and crystals	21.7 g

(i) What is the **actual yield** of crystals in Jak's experiment?

answer = _____ g **[1]**

(ii) Jak works out that the theoretical yield of crystals is 4.0 g.

He works out his percentage yield using this equation.

$$\text{percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

Use your answer to part **(i)** to work out Jak's percentage yield.

answer = _____ % **[2]**

10. Some rockets which go into space use the reaction between hydrogen and oxygen.

$$2H_2 + O_2 \rightarrow 2H_2O$$

(i) How many molecules of water are shown in this equation?

answer _____ [1]

(ii) The rocket uses different masses of hydrogen and oxygen.
Two molecules of H_2 react with one molecule of O_2.
Relative atomic masses are given in the Periodic Table on the back page.

Calculate the relative masses of

two molecules of H_2 _____ **one** molecule of O_2 _____ [2]

11(a) Millions of tonnes of hydrogen are made every year.

.

The hydrogen is usually made from methane.

The process starts with methane and steam, and makes hydrogen and carbon dioxide.

In this process 52 tonnes of methane and steam make 8 tonnes of hydrogen.

(i) The waste product of this reaction is carbon dioxide.
What mass of carbon dioxide is made from 52 tonnes of methane and steam?

answer _____ tonnes **[1]**

(ii) Why does this suggest that the process is not very green?

---**[2]**

(b). A new process for making hydrogen is by heating wood from trees.
Both processes for making hydrogen make carbon dioxide.
Suggest why this new process might be greener than the old one.

---**[2]**

12. 132 g of ammonium sulfate contain 28 g of nitrogen.

Calculate the mass of nitrogen in **1.0 kg** of ammonium sulfate.

Give your answer in kg and to **2** decimal places.

Mass = ---------- kg **[3]**

13. Milk of magnesia cures indigestion.

It neutralises acid in the stomach.

Milk of magnesia is a mixture of magnesium hydroxide and water.

The formula of magnesium hydroxide is $Mg(OH)_2$.

Kai buys two bottles of milk of magnesia, called **Gutcalm** and **Milkomag**.

He has a solution of hydrochloric acid.

He finds out how much acid is needed to neutralise 25 cm^3 from each bottle.

Here are Kai's results.

	Medicine	
	Gutcalm	Milkomag
Cost of a 250 cm^3 bottle	£1.75	£1.50
Volume of acid needed to neutralise 25.0 cm^3	24.0 cm^3	21.0 cm^3

(i) Which medicine gives the best value for money for neutralising acid?

[2]

(ii) Kai measures the 25 cm^3 of milk of magnesia using a beaker.

What could he do to measure the volume **more** accurately?

Tick (✓) **one** box.

Use a volumetric pipette. ☐

Use a conical flask. ☐

Use a large measuring cylinder. ☐

Use a gas syringe. ☐

[1]

14.

(i) CeO_2 contains O^{2-} ions.

What is the charge on the cerium ion?

Put a (ring) around the correct answer.

1+ **2+** **3+** **4+** **5+** **6+**

[1]

(ii) 160 g of CeO_2 contains 30 g of oxygen.

Calculate the percentage of **cerium** in CeO_2.

Percentage of cerium = ---------- % **[2]**

15. 0.10 g of calcium carbonate makes 24 cm^3 of carbon dioxide.

Jack uses 0.070 g of calcium carbonate.

What volume of carbon dioxide does he make?

Give your answer to **2** significant figures.

Volume = ---------- cm^3 **[2]**

16(a) Fizzy water can be found naturally.

.

The water is fizzy because it contains dissolved carbon dioxide gas. The carbon dioxide comes from the decomposition of rocks that contain carbonate compounds.

One compound found in rocks is magnesium carbonate.

Ali investigates the decomposition of magnesium carbonate by heating a small amount in a test tube. This is the equation for the reaction.

$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$

Ali weighs the test tube before and after heating.

The mass of the test tube after heating is less.

Ali says that this means the **law of conservation of mass** is not correct.

Explain why Ali is **wrong**.

--- [2]

(b). In theory, 42.0 g of $MgCO_3$ loses 22.0 g of carbon dioxide when it completely decomposes.

Ali heats 4.2 g of $MgCO_3$.

(i) Calculate the mass of carbon dioxide lost when 4.2 g of $MgCO_3$ completely decomposes.

Mass = ---------- g **[1]**

(ii) In Ali's experiment, the mass of carbon dioxide lost is 1.8 g.

Calculate the percentage yield of carbon dioxide in Ali's experiment.

Percentage yield = ---------- % **[1]**

17(a) Amir makes some copper chloride. He reacts copper oxide with dilute hydrochloric acid.

.

This is an equation for the reaction.

copper oxide	+	hydrochloric acid	→	copper chloride	+	water
CuO	+	$2HCl$	→	$CuCl_2$	+	H_2O

Amir does a calculation to work out how much copper chloride he can make from some copper oxide (the **theoretical yield**).

(i) He starts by working out the relative formula masses of the compounds in the equation.

Complete **Table 6.1** by working out the missing relative formula masses.

Use the Periodic Table to help you.

Name of compound	Formula	Relative formula mass
copper oxide	CuO	79.5
hydrochloric acid	HCl	
copper chloride	$CuCl_2$	134.5
water	H_2O	

Table 6.1

[2]

(ii) Amir uses 8 g of copper oxide in his experiment.

What is the theoretical yield of copper chloride from 7.95 g of copper oxide?
Use **Table 6.1** and the equation to help you.

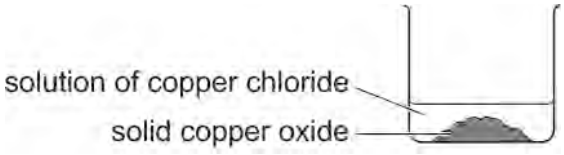
Put a (ring) around the correct answer.

0.1345 g **1.345 g** **13.45 g** **134.5 g**

[1]

(b). Amir adds 8 g of solid copper oxide to a small amount of dilute hydrochloric acid in a beaker. Some of the copper oxide does not react.

He now has a mixture which contains a solution of copper chloride and some solid copper oxide.



(i) Amir uses different techniques to separate solid copper oxide and to obtain crystals of copper chloride from the mixture.

Draw lines from each **substance** to the correct **technique**.

Substance	Technique
	Distillation
Solid copper oxide	Evaporation
Copper chloride crystals	Filtration
	Titration

[2]

(ii) Amir's percentage yield for this experiment is very low.

Suggest a reason why.

---

[1]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1		i	FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 17 (g) award 3 marks ratio of N_2 : NH_3 = 1:2 ✓ $\frac{\text{amount of ammonia}}{17.0}$ = 2 x 14/28 ✓ amount of ammonia = 2 × 14/28 × 17 = 17 (g) ✓	3	
		ii	correct substitution. 8.5 ÷ 17.0 (ECF) × 100 ✓ correct computation: 50 % ✓	2	ALLOW ECF from (b)(i)
			Total	5	
2		i	FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 52.25 (%) award 2 marks 2 iron atoms in a rust atom RAM iron = 55.8 therefore $\frac{2 \times 55.8}{213.6} \times 100$ ✓ = 52.247 = 52.25 (%) to 2dp ✓	2	
		ii	FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 51 (g) award 3 marks mass of iron turned to rust = 2 × 7 × 4 = 56 g✓ mass of rust = $\frac{\text{mass of iron}}{0.5225} = \frac{56}{0.5225}$ = 107.177✓ increase in mass of skate board = 107.177 – 56 = 51.177 = 51 (g) to the nearest gram ✓	3	ALLOW ECF from (b)(i)
			Total	5	

Question			Answer/Indicative content	Marks	Guidance
3		i	FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 15.38 (%) award 3 marks Total mass of H_2 molecules = 4 × 2 = 8 ✓ Total mass of molecules used = (2 × 18) + (1 × 16) = 52 ✓ atom economy = 8 ÷ 52 × 100 = 15.38 (%) ✓	3	ALLOW total mass of molecules used = (4 × 2) + 44 = 52 ALLOW 2 or more sig figs, correctly rounded.
		ii	idea that < means 'less than' ✓ (yes because) 15.38 is less than 20 ✓	2	ALLOW ECF on incorrect value from (d)(i)
			Total	5	

Question			Answer/Indicative content	Marks	Guidance
4	a		**first mark (one of):** all the compounds have different / higher / greater / bigger (relative formula) masses going down the group; the mass increases by 16 as you go down the group; each has a different **metal** (atom); lithium chloride has the lowest / potassium chloride has the highest **second mark (one of):** the (relative atomic) masses of lithium, sodium and potassium are all different; there are different numbers of protons and neutrons in each (metal)	2	**Examiner's Comments** Very few candidates achieved both marks, and less than half achieved on mark. Marks were lost as candidates often discussed reactivity instead of formula or atomic mass.
	b	i	19	1	**Examiner's Comments** This was answered really well; correct numbers were selected and then used to calculate formula mass.
		ii	26	1	allow ecf from 8(b)(i) **Examiner's Comments** This was answered really well; correct numbers were selected and then used to calculate formula mass.
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
5	a		15 g	1	**Examiner's Comments** Many candidates were able to correctly give 15g as the answer.
	b	i	5.5 g	1	**Examiner's Comments** The no responses in (i) suggests these candidates did not have a calculator.
		ii	shows 5.5 anywhere in calculation (1) 55% (1)	2	Correct answer with no working = 2 marks **allow** ecf from (i) **Examiner's Comments** A number of candidates correctly used the formula given and were able to give 55% as their response; many were not sure how to do it. There were a few random numbers given, even after having got 5.5g in (i).
			Total	**4**	
6			46	1	**Examiner's Comments** Over half of all candidates correctly calculated the relative formula mass of ethanol. Candidates need to take care to look at the numbers of each type of atom in the formula before beginning their calculation (in this case there were two carbon atoms and six hydrogen atoms to be taken into account).
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
7			2400 (2) 1.6 x 3000 (1)	2	Examiner's Comments Most candidates gained at least partial credit. Some did not divide by two, implying that they had not read all of the information. Some who were unsure how to do the calculation showed good technique by trying different ways of multiplying and dividing the numbers until they reached a plausible number.
			Total	2	
8		i	3.2(g); (1)	1	Accept 3.2 alone Examiner's Comments When answering this question most candidates were able to use the graph in to find the mass of copper oxide needed. Others did not use the scale correctly to get an answer of 3.1 instead of 3.2.
		ii	1600 g / 1.6 kg; (2) Uses 1000 in calculation / 1000 g = 1 kg / 1.6 or 1600 with no units or incorrect units (1)	2	Answer with units (2) Allow ecf for incorrect answer to (i) Examiner's Comments There were some good responses to this question where candidates used ratios correctly to scale up to the required amount. Many struggled with the units, with the use of 100 instead of 1000 to convert from g to kg appearing frequently.
		iii	Box 1; (1) Box 4; (1)	2	Examiner's Comments Many candidates could successfully identify the statements which explained why mass of product could be lower. The most common misconception was that the loss in mass could be caused by the rate of reaction being too fast.
			Total	5	

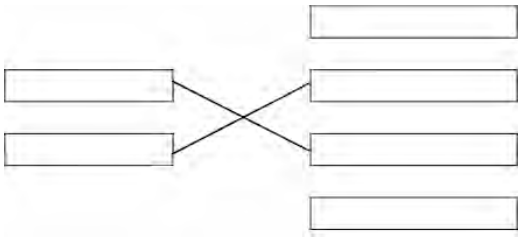
Question			Answer/Indicative content	Marks	Guidance
9		i	3.2 (1)	1	Examiner's Comments Many candidates successfully subtracted the mass of the weighing bottle to calculate the mass of product formed. Others did not do a calculation and just chose one of the masses from the table. Candidates were more successful in substituting appropriate values into the formula given.
		ii	80 % (or ecf for bi ×25) with or without working scores (2)	2	Allow 1 mark for answer to (b)(i) divided by 4 Examiner's Comments Were able to correctly calculate the percentage based on the value they had given in part b(i).
			Total	3	
10		i	2	1	Examiner's Comments Many candidates were able to correctly identify the number of molecules in a reaction.
		ii	4, 32	2	Ignore any units Examiner's Comments Candidates demonstrated a lack of understanding of the calculation of masses of numbers of molecules.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
11	a	i	44 [tonnes]	1	**Examiner's Comments** Answered correctly by many candidates; the principle of conservation of mass had been taught well in centres, and candidates recognised how to arrive at the correct response of 44 tonnes.
		ii	One from waste, and one from effect **Waste:** Most of reactants form a product which is not useful / a lot of waste / carbon dioxide (gas) is made / process has a low / poor atom economy (1) **Effect:** Product is a greenhouse gas / causes global warming / Product causes air / atmospheric pollution (1)	2	**Examiner's Comments** Many candidates achieved at least one mark here – usually for recognising that alot of waste was produced by the reaction, and many were able to state that carbon dioxide is a greenhouse gas. Some candidates did not achieve full marks because they stated that the reaction makes carbon dioxide (already given in the stem).
	b		Discusses both production and intake of CO_2: When trees are burned the CO_2 is released, however, this CO_2 was taken in by trees for photosynthesis = 2 marks Carbon neutral / attempts a description of carbon dioxide being given out being used by trees (1)	2	If no other mark is achieved then allow 1 mark for: wood is renewable / you can grow more trees ORA **Examiner's Comments** This question posed challenges for the majority of candidates. Two marks were rarely achieved. Despite the question stating that *both* processes produced carbon dioxide, candidates still used this as a response. This question required candidates to discuss both the intake and production of carbon dioxide; trees absorb carbon dioxide was sometimes given as a response, but candidates also needed to explain that this offsets the carbon dioxide produced in combustion.
			Total	**5**	

Question			Answer/Indicative content	Marks	Guidance
12			FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.21 (kg) award 3 marks 28/132 ✓ = 0.21 (kg) ✓ 2 decimal places ✓	3 (AO 2.2 × 2) (AO 1.2)	212.12 = 2 marks 212.1212 = 1 mark ALLOW the two decimal places as an independent mark. Examiner's Comments This question demanded an ability to handle ratios, and many candidates were able to score at least some credit. The requirement for two decimal places was generally well understood, though not by all. Almost half the candidates did not to answer this question correctly, but still gained some credit by showing their working.
			Total	3	
13		i	Idea of dividing cost by cm^3 ORA✓ Some comparison of unit costs, eg: Gutcalm £1.75 / 24 = £0.073 per cm^3 Milkomag £1.50 / 21 = £0.071 per cm^3 so better ✓	2 (AO 3.1a) (AO 3.2a)	There must be some indication that a calculation has been performed IGNORE incorrect rounding as assessed elsewhere Examiner's Comments A minority of candidates realised that this question required a division calculation involving cost and price, and so gained at least some credit.
		ii	Use a volumetric pipette ✓	1 (AO 2.2)	Examiner's Comments The use of a volumetric pipette was well recognised.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
14		i	4+ ✓	1 (AO 2.1)	Examiner's Comments By far the most frequent choice was 2+.
		ii	FIRST CHECK ANSWER ON ANSWERLINE If answer = 81 / 81.25 / 81.3 (%) award 3 marks Mass Ce = 160 – 30 OR 130g ✓ = 130 × 100/160 ✓ = 81 (%)	3 (AO 1.2 × 3)	ALLOW ecf if % oxygen calculated. Working is then essential eg 30x100/160 ✓ = 18.75(%) or 19(%) ✓ But 19(%) without working gains no credit Examiner's Comments Most candidates gained at least some credit on this question, usually for showing working that proved that the mass of cerium had been calculated. The higher ability candidates often gained full credit.
			Total	4	
15			FIRST CHECK ANSWER ON ANSWER LINE If answer = 17 (cm^3) award 3 marks 0.07 / 0.10 or 0.10/0.07 ✓ (uses 24)= 16.8 ✓ = 17 (cm^3) ✓	3 (AO 2.2 × 2) (AO 1.2)	IGNORE 17.0 ALLOW MP3 for (incorrect) answer with working rounded to 2sf Examiner's Comments This question discriminated well, with many candidates gaining at least some credit. This was usually because they had some intuitive sense of what to do with the numbers, and so gained credit for their working even when the answer was, as was often the case, incorrect. The requirement for two significant figures was also often noted and acted upon.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
16	a		No overall loss (in mass) idea/No elements /mass/atoms/chemicals/particles/compounds lost / law states that matter is neither (created nor) destroyed in a chemical reaction / AW ✓ Carbon dioxide is a gas / Carbon dioxide leaves the test tube / a gas is given off / idea that all products are not in the test tube / AW ✓	2 (AO 3.1b × 2)	ALLOW It is an open system Examiner's Comments Question 13 is targeted at standard demand and is an overlap question with the higher tier paper. A significant minority of candidates did not to attempt one or more parts of this question as a whole. For part a), higher ability candidates often appreciated that a gas had been given off. This was most commonly described as 'evaporation'. Some higher ability candidates realised that the gas has mass.
	b	i	2.2 (g)✓	1 (AO 2.2)	ALLOW 2 or more sf Examiner's Comments This question discriminated well.
		ii	82(%) ✓	1 (AO 2.2)	ALLOW 2 or more sf Examiner's Comments Candidates were expected to know how to calculate percentage yield. Most candidates realised that they had to divide one number by another and multiply by 100, but experienced great difficulty in choosing the correct two numbers. Variants of an atom economy were often carried out.
			Total	4	

Question			Answer/Indicative content	Marks	Guidance
17	a	i	(HCl) 36.5 ✓ (H_2O) 18(.0)✓	2 (AO 2× 2.2)	Examiner's Comments Despite the examples given in the table, a few candidates had no idea how to find the formula mass.
		ii	13.45g ✓	1 (AO 2.2)	
	b	i	solid copper oxide → filtration ✓ copper chloride crystals → evaporation ✓	2 (AO 1.2)	
		ii	not all copper oxide reacted / used up / copper oxide left at the end / not enough acid used ✓	1 (AO 2.2)	Examiner's Comments Despite the mention of a "small amount" of acid and the statement in the question stem that "some copper oxide does not react" few candidates could explain why the theoretical yield could not be achieved.
			Total	6	