Questions

Q1.

A titration is to be carried out to find the concentration of a solution of sodium hydroxide.

The sodium hydroxide solution is titrated with dilute sulfuric acid.

The available apparatus includes a burette, a pipette, a funnel, a conical flask and an indicator.

(a) State one safety precaution that must be taken when using sodium hydroxide solution and dilute sulfuric acid.

(1)

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(b) The sodium hydroxide solution is made by dissolving 4.3 g of sodium hydroxide in water and making the solution up to 250 cm^3 with water.

Calculate the concentration of the solution in g dm^{-3}.

(2)

concentration = ... g dm^{-3}

(c) Write the balanced equation for the reaction of dilute sulfuric acid, H_2SO_4, with sodium hydroxide.

(2)

.....

(d) The results of titrations to determine how much of an acid is required to neutralise a given volume of an alkaline solution are shown in Figure 14.

	titration 1	titration 2	titration 3	titration 4
final burette reading (cm^3)	27	27.40	29.20	29.30
initial burette reading (cm^3)	0	2.10	4.00	3.50
volume of acid used (cm^3)	27	25.30	25.20	25.80

Figure 14

Two of the titrations in Figure 14 should **not** be used to calculate the mean volume of acid required.
Identify each titration and give a reason why it should not be used in the calculation of the mean.

(2)

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(Total for question = 7 marks)

Q2.

The pylons are made of steel.

The steel is mainly iron.

Iron is extracted from iron oxide, Fe_2O_3.

In the production of the iron, carbon dioxide is also produced.

(i) Calculate the relative formula mass of carbon dioxide, CO_2.
(relative atomic masses: C = 12, O = 16)

(2)

relative formula mass = ...

(ii) The equation for the reaction used in the extraction of iron is

$$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$$

Calculate the maximum mass of iron that could be obtained from 640 tonnes of iron oxide, Fe_2O_3.
(relative atomic mass: Fe = 56; relative formula mass Fe_2O_3 = 160)

(3)

mass = ... tonnes

(Total for question = 5 marks)

Q3.

Figure 11 shows the apparatus that can be used to electrolyse sodium sulfate solution using inert electrodes.

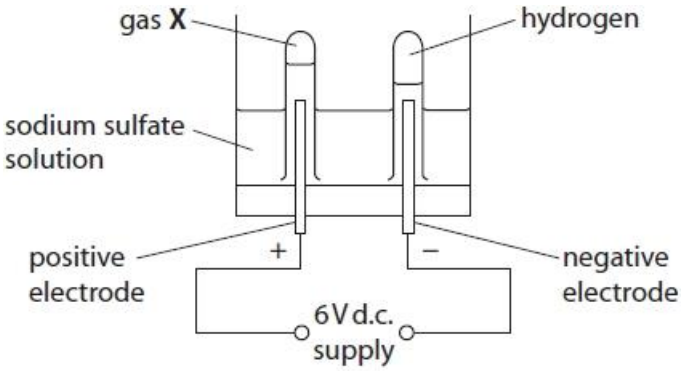

Figure 11

The sodium sulfate solution was made by dissolving 28.4 g of sodium sulfate in water to make 250 cm^3 of solution.

Calculate the concentration of this solution in g dm^{-3}.

Give your answer to three significant figures.

(3)

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concentration = ... g dm^{-3}

(Total for question = 3 marks)

Q4.

When copper sulfate solution reacts with sodium hydroxide solution, a precipitate of copper hydroxide and a solution of sodium sulfate are formed.

The equation is

$$CuSO_4 + 2NaOH \rightarrow Cu(OH)_2 + Na_2SO_4$$

The copper sulfate solution had been prepared by dissolving 6.36 g of solid copper sulfate in water and making the volume up to 250 cm^3.

Calculate the concentration of the copper sulfate solution in g dm^{-3}.

Give your answer to three significant figures.

(3)

concentration of copper sulfate solution = ... g dm^{-3}

(Total for question = 3 marks)

Q5.

3.14 g of solid copper sulfate was dissolved in water and made up to 250 cm^3 of solution.

$$\text{concentration (g dm}^{-3}) = \frac{\text{mass of solid (g)}}{\text{volume of solution (dm}^3)}$$

Calculate the concentration of this copper sulfate solution in g dm^{-3}.

(2)

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concentration ..... g dm^{-3}

(Total for question = 2 marks)

Q6.

A sample of aluminium chloride was analysed.
It was found that 0.270 g of aluminium was combined with 1.065 g of chlorine in this chloride.

Calculate the empirical formula of aluminium chloride.
(relative atomic masses: Al = 27, Cl = 35.5)

You must show your working.

(3)

empirical formula of aluminium chloride = ...

(Total for question = 3 marks)

Q7.

In Figure 8, the letters **A**, **E**, **G**, **J**, **X** and **Z** show the positions of six elements in the periodic table.

These letters are not the symbols of the atoms of these elements.

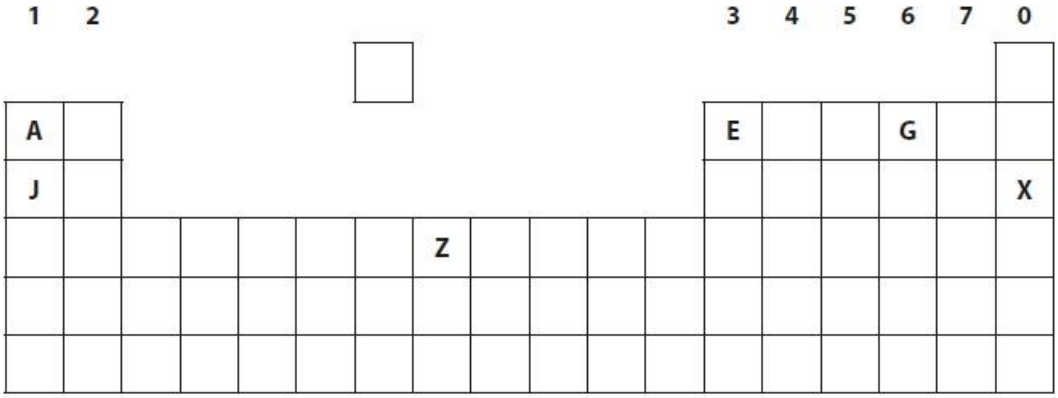

Figure 8

In an experiment, 3.5 g of element **A** reacted with 4.0 g of element **G** to form a compound.

Calculate the empirical formula of this compound.
(relative atomic masses: **A** = 7, **G** = 16)

You must show your working.

(3)

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empirical formula of this compound = ...

(Total for question = 3 marks)

Q8.

Aluminium reacts with bromine to form aluminium bromide.
A sample of aluminium bromide contains 1.35 g of aluminium atoms and 12.00 g of bromine atoms.

Calculate the empirical formula of this sample of aluminium bromide.

(relative atomic masses: Al = 27.0, Br = 80.0)

(3)

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empirical formula = ...

(Total for question = 3 marks)

Q9.

Some metals are found in the Earth's crust as uncombined elements.
Reactive metals are found in ores.

In ores, metals are combined with other elements.

A titanium ore was analysed and found to contain 12 g of titanium atoms combined with 8.0 g of oxygen atoms.

Calculate the empirical formula of this titanium compound.
(relative atomic masses: Ti = 48, O = 16)

You must show your working.

(3)

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.....

empirical formula = ...

(Total for question = 3 marks)

Q10.

Hydrated copper sulfate has the formula $CuSO_4.5H_2O$.
The formula tells us that each mole of copper sulfate contains 5 moles of water.

A sample of $CuSO_4.5H_2O$ was heated gently until all the water was removed to form anhydrous copper sulfate, $CuSO_4$.

$$CuSO_4.5H_2O \rightarrow CuSO_4 + 5H_2O$$

The mass of water formed was 4.5 g.

Calculate the mass of hydrated copper sulfate that was heated.

(relative atomic masses: H = 1.0, O = 16.0;
relative formula mass: $CuSO_4.5H_2O$ = 249.5)

(4)

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mass of $CuSO_4.5H_2O$ = ... g

(Total for question = 4 marks)

Q11.

Pieces of zinc react with copper sulfate solution.
Zinc sulfate solution is colourless.

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

In another experiment, 0.043 mol of copper sulfate, $CuSO_4$, is used.

Calculate, to one decimal place, the minimum mass of zinc that must be added to react with all the copper sulfate.
(relative atomic mass: Zn = 65)

(2)

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mass = ... g

(Total for question = 2 marks)

Q12.

In another stage, the pure titanium chloride, TiCl4 , is reacted with 500 moles of magnesium, an excess.

$$TiCl_4 + 2Mg \rightarrow Ti + 2MgCl_2$$

(i) Calculate the number of moles in 45 000 grams of titanium chloride.

(relative atomic masses: Cl = 35.5, Ti = 48.0)

(2)

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.....

number of moles titanium chloride = ...

(ii) Show that the 500 moles of magnesium added is an excess.

(1)

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(Total for question = 3 marks)

Q13.

Calculate the number of atoms combined in one mole of copper iodide, CuI_2.
(Avogadro constant = 6.02×10^{23})

(2)

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.....

.....

number of atoms = ...

(Total for question = 2 marks)

Q14.

Alloys of gold are often used to make jewellery.
The purity of gold is measured in carats.
Different alloys of gold have different carats.

A gold ring contains 3.94 g of gold.

Calculate the number of gold atoms in the ring.
(relative atomic mass: Au = 197,
Avogadro constant = 6.02×10^{23})

Show your working.

(2)

.....

.....

number of gold atoms = ...

(Total for question = 2 marks)

Q15.

Some food colourings are a mixture of soluble, coloured substances.
Mixtures of soluble substances can be separated by paper chromatography.

A food colouring has a molecular formula $C_{16}H_{12}N_2O$.

(i) Calculate the number of moles of this food colouring, $C_{16}H_{12}N_2O$, in a 0.50 g sample.
(relative atomic masses: H = 1, C = 12, N = 14, O = 16)

(2)

number of moles = ...

(ii) Calculate the number of molecules in 2 moles of the food colouring, $C_{16}H_{12}N_2O$.
(Avogadro constant = 6.02×10^{23})

(1)

number of molecules = ...

(Total for question = 3 marks)

Q16.

Pieces of zinc react with copper sulfate solution.
Zinc sulfate solution is colourless.

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

The copper sulfate solution used has a concentration of 15.95 g dm^{-3}.

Calculate the number of moles of copper sulfate, $CuSO_4$, in 50.00 cm^3 of this solution.
(relative atomic masses: O = 16, S = 32, Cu = 63.5)

(3)

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number of moles of copper sulfate = ... mol

(Total for question = 3 marks)

Q17.

Magnesium carbonate has the formula $MgCO_3$.

Calculate the percentage by mass of magnesium in magnesium carbonate, $MgCO_3$.

(relative atomic masses: C = 12.0, O = 16.0, Mg = 24.0)

(3)

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percentage by mass of magnesium = ...

(Total for question = 3 marks)

Q18.

Calcium carbonate decomposes on heating to form calcium oxide and carbon dioxide.

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

(i) Calculate the relative formula mass of calcium carbonate, $CaCO_3$.
(relative atomic masses: C = 12, O = 16, Ca = 40)

(2)

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.....

relative formula mass = ...

(ii) Calculate the atom economy for the formation of calcium oxide in this reaction.

$$CaCO_3 \rightarrow CaO + CO_2$$

You must show your working.
(relative atomic masses: C = 12, O = 16, Ca = 40;
relative formula mass: calcium oxide = 56)

(2)

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.....

.....

atom economy = ... %

(Total for question = 4 marks)

Q19.

The formula of aluminium sulfate is $Al_2(SO_4)_3$.

Calculate the total number of atoms that combine to form 5.13 g of aluminium sulfate.

(relative atomic masses: O = 16.0, Al = 27.0, S = 32.0
Avogadro number = 6.02×10^{23})

(4)

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number of atoms = ...

(Total for question = 4 marks)

Q20.

Copper sulfate solution was mixed with sodium hydroxide solution.

A precipitate of copper hydroxide and a solution of sodium sulfate were formed.

The mass of the copper sulfate solution used = 10.32 g.
The mass of the sodium hydroxide solution used = 5.12 g.

Calculate the total mass of the mixture after the precipitate has formed when these two solutions are mixed together.

(1)

..... g

(Total for question = 1 mark)

Q21.

Calculate the mass, in g, of a hydrogen atom, using the data below.

(relative atomic mass: H = 1.00;

Avogadro constant = 6.02×10^{23})

(3)

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mass of hydrogen atom = ... g

(Total for question = 3 marks)

Q22.

Iron is more reactive than lead.
Iron reacts with lead nitrate solution to form solid lead.
Two possible balanced equations for the reaction are

Equation **1** $Fe + Pb(NO_3)_2 \rightarrow Fe(NO_3)_2 + Pb$

Equation **2** $2Fe + 3Pb(NO_3)_2 \rightarrow 2Fe(NO_3)_3 + 3Pb$

In one experiment, it was found that 4.48 g of iron reacted with excess lead nitrate solution to form 24.84 g of lead.

Carry out a calculation, using the information above, to show which equation represents the reaction taking place.

(relative atomic masses: Fe = 56.0, Pb = 207)

(3)

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(Total for question = 3 marks)

Q23.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The word equation for the reaction between copper carbonate and dilute sulfuric acid is

$$\text{copper carbonate} + \text{sulfuric acid} \rightarrow \text{copper sulfate} + \text{carbon dioxide} + \text{water}$$

(i) Complete the balanced equation for this reaction.

(2)

$$CuCO_3 + \text{.....} \rightarrow \text{.....} + CO_2 + H_2O$$

(ii) Calculate the relative formula mass of copper carbonate, $CuCO_3$.
(relative atomic masses: C = 12.0, O = 16.0, Cu = 63.5)

(2)

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.....

.....

relative formula mass of $CuCO_3$ = ...

(iii) What is the chemical test to show that a gas is carbon dioxide?

(1)

- ☒ **A** bubble the gas through limewater, limewater turns cloudy
- ☒ **B** put damp blue litmus paper in the gas, litmus paper turns red
- ☒ **C** put a lighted splint into the gas, splint is extinguished
- ☒ **D** measure the pH of the gas, pH = 4

(Total for question = 5 marks)

Q24.

When copper sulfate solution reacts with sodium hydroxide solution, a precipitate of copper hydroxide and a solution of sodium sulfate are formed.

The equation is

$$CuSO_4 + 2NaOH \rightarrow Cu(OH)_2 + Na_2SO_4$$

10 cm^3 samples of copper sulfate solution were placed in five test tubes. Different volumes of sodium hydroxide solution were added to these test tubes. The volumes of sodium hydroxide solution added were 1 cm^3, 2 cm^3, 3 cm^3, 4 cm^3 and 5 cm^3.

In each test tube a precipitate of copper hydroxide was formed. The precipitate was allowed to settle and the height of the precipitate was measured with a ruler as shown in Figure 1.

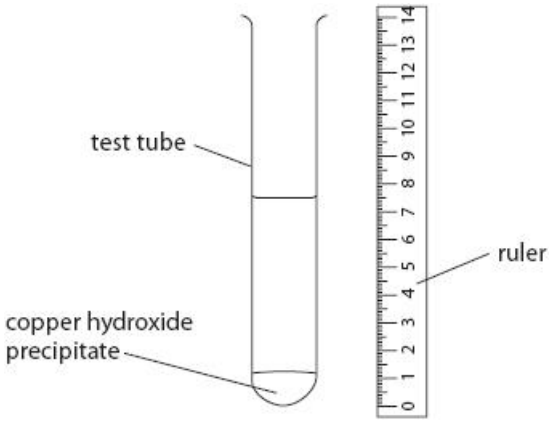

Figure 1

The results are shown in Figure 2.

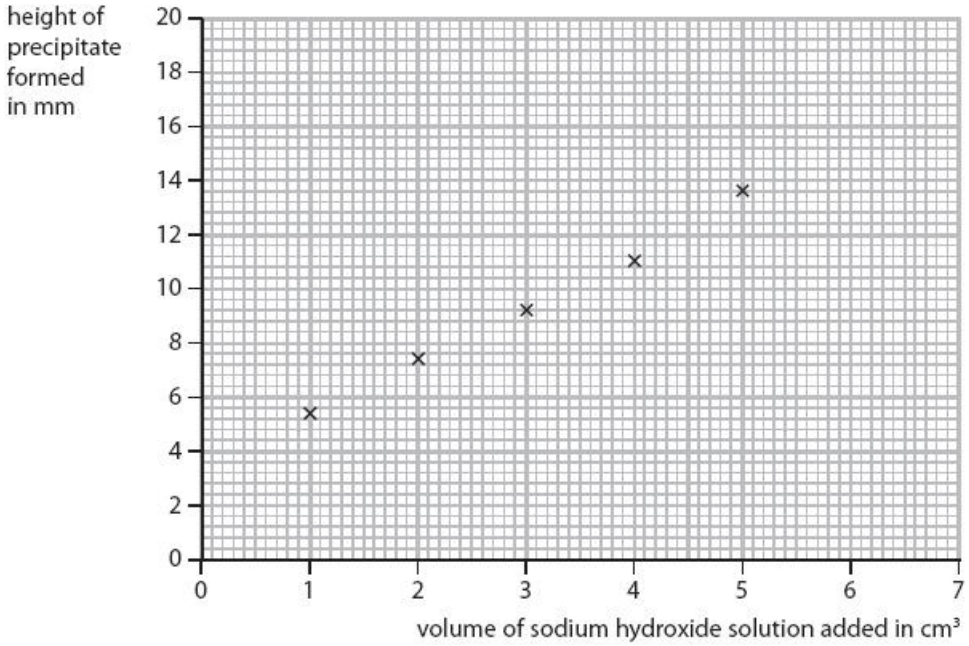

Figure 2

(i) Draw the line of best fit to complete the graph.

(1)

(ii) Predict the height of precipitate that would be formed if 6 cm^3 of sodium hydroxide solution was added to 10 cm^3 of copper sulfate solution.

This mixture would contain excess copper sulfate solution.

(2)

..... mm

(Total for question = 3 marks)

Q25.

A nickel sulfate solution is made by dissolving 23.5 g of nickel sulfate to make 250 cm^3 of solution.

Calculate the concentration of the solution in g dm^{-3}.

(2)

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concentration = ... g dm^{-3}

(Total for question = 2 marks)

Q26.

In an experiment to determine the empirical formula of magnesium oxide, the mass of oxygen combined with a known mass of magnesium must be found.

Describe an experiment to determine the mass of oxygen that combines with a known mass of magnesium, in a crucible and lid of known mass.

(3)

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(Total for question = 3 marks)

Q27.

Titanium and iron are examples of transition metals.

2.24 g of iron combines with 0.96 g of oxygen to form an oxide of iron.

Determine the formula of this oxide of iron and use it to complete the balanced equation.

(relative atomic masses: Fe = 56.0, O = 16.0)

You must show your working.

(4)

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balanced equation for the reaction is

..... Fe + ... O_2 → .....

(Total for question = 4 marks)

Q28.

The molecular formula of butene is C_4H_8.

Which of the following is the empirical formula of butene?

(1)

- ☒ **A** CH
- ☒ **B** CH_2
- ☒ **C** C_4H_8
- ☒ **D** $(CH_2)_4$

(Total for question = 1 mark)

Q29.

Calcium carbonate decomposes on heating to form calcium oxide and carbon dioxide.

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

Another sample of calcium carbonate is heated and the mass of solid remaining is measured each minute.

The results are shown in Figure 3.

time in minutes	0	1	2	3	4	5	6	7
mass of solid remaining in g	9.0	8.1	7.2	6.4	6.0	5.6	5.3	5.2

Figure 3

(i) Explain the trend shown by the data in Figure 3.

(2)

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.....

(ii) It is impossible to be sure from this data that the reaction is complete.

State why.

(1)

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.....

.....

(Total for question = 3 marks)

Q30.

Most metals are extracted from ores found in the Earth's crust.

The method used to extract a metal from its ore is linked to the reactivity of the metal.

Part of the reactivity series is shown in Figure 14.

Figure 14

Iron ore contains iron oxide.

Iron is extracted from iron oxide by heating the oxide with carbon.

$$\text{iron oxide} + \text{carbon} \rightarrow \text{iron} + \text{carbon dioxide}$$

(i) In this reaction

(1)

- ☒ **A** carbon is reduced
- ☒ **B** iron oxide is neutralised
- ☒ **C** iron oxide is reduced
- ☒ **D** iron is oxidised

(ii) The formula of the iron oxide is Fe_2O_3.

Calculate the maximum mass of iron that can be obtained from 240 tonnes of iron oxide, Fe_2O_3.
(relative atomic masses: O = 16, Fe = 56)

(3)

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mass of iron = ... tonnes

(Total for question = 4 marks)

Q31.

The formula of ammonium sulfate is $(NH_4)_2SO_4$.

What is the empirical formula of ammonium sulfate?

(1)

- ☒ **A** NHSO
- ☒ **B** NH_2SO_2
- ☒ **C** NH_4SO_4
- ☒ **D** $N_2H_8SO_4$

(Total for question = 1 mark)

Q32.

The scientist John Dalton lived over 200 years ago.

Dalton also investigated different gases.

One of the gases that Dalton investigated was ethene.

The structure of one molecule of ethene is shown in Figure 8.

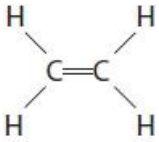

Figure 8

Give the molecular formula and the empirical formula of ethene.

(2)

molecular formula .....

empirical formula .....

(Total for question = 2 marks)

Q33.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Titanium and iron are examples of transition metals.

Iron, when heated in air, reacts with oxygen to form iron oxide.

(i) This reaction is an example of

(1)

- ☐ **A** crystallisation
- ☐ **B** distillation
- ☐ **C** neutralisation
- ☐ **D** oxidation

(ii) The equipment shown in Figure 7 can be used to find the mass of oxygen that combines with iron.

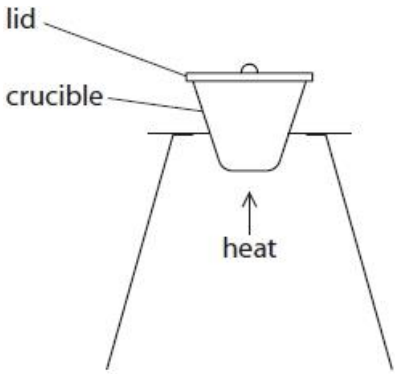

Figure 7

Describe how the equipment shown in Figure 7 could be used to find the mass of oxygen that combines with 0.500 g of iron wool in a crucible and lid of known mass.

(3)

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(Total for question = 4 marks)

Q34.

Two compounds of barium are barium sulfide and barium chloride.

(i) A beaker of barium chloride solution and a beaker of dilute sulfuric acid were placed on a balance, as shown in Figure 6.

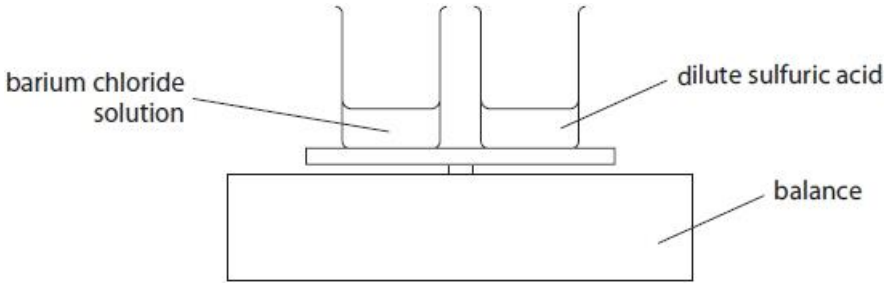

Figure 6

The total mass reading on the balance was 25.7 g.

The dilute sulfuric acid was poured into the barium chloride solution and the beaker replaced on the balance, as shown in Figure 7.

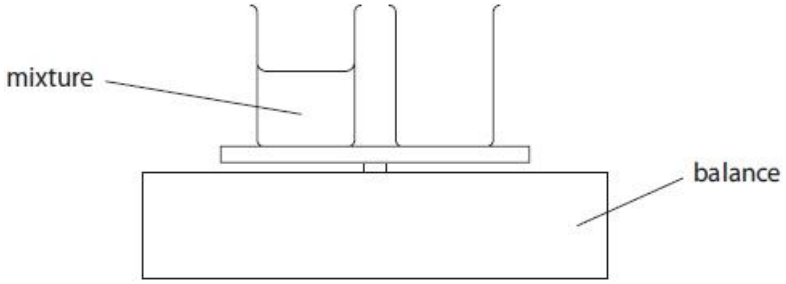

Figure 7

The mixture formed contained a white precipitate.

State the total mass reading on the balance after the reaction.

(1)

.....

(ii) Give the name of the white precipitate formed by the reaction of barium chloride solution with dilute sulfuric acid.

(1)

.....

(Total for question = 2 marks)

Q35.

When iron reacts with copper sulfate solution, solid copper is formed.

Two possible equations for this reaction are

A $CuSO_4 + Fe \rightarrow Cu + FeSO_4$
B $3CuSO_4 + 2Fe \rightarrow 3Cu + Fe_2(SO_4)_3$

It was found that 10.00 g of iron powder reacted with excess copper sulfate solution to produce 11.34 g of copper.

Carry out a calculation to decide which equation, **A** or **B**, represents the reaction taking place.

(relative atomic masses: Fe = 56.0, Cu = 63.5)

(2)

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.....

.....

.....

(Total for question = 2 marks)

Q36.

Calculate the relative formula mass of butene, C_4H_8.

(relative atomic masses: H = 1, C = 12)

(2)

.....

relative formula mass .....

(Total for question = 2 marks)

Q37.

When heated, zinc carbonate decomposes to form zinc oxide and carbon dioxide gas.

$$ZnCO_3 \rightarrow ZnO + CO_2$$

A student investigated the decomposition of a sample of zinc carbonate.

The student used the following method.

step 1 the mass of an empty crucible was determined
step 2 a sample of zinc carbonate was placed into the crucible
step 3 the mass of the crucible and the zinc carbonate was determined
step 4 the crucible and zinc carbonate was heated for five minutes
step 5 the mass of the crucible and contents was determined.

Figure 1 shows the apparatus used.

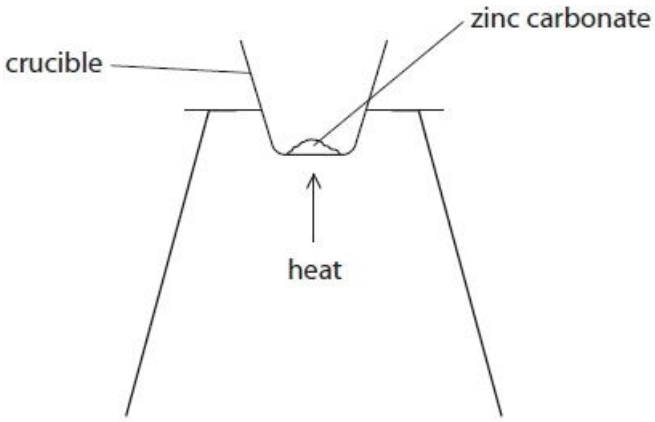

Figure 1

Suggest how the student could confirm that the decomposition was complete.

(3)

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(Total for question = 3 marks)

Q38.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

When chromium reacts with oxygen, chromium oxide is formed.

(i) Write the word equation for this reaction.

(1)

..... + ... →
.....

(ii) What type of reaction occurs when chromium reacts with oxygen?

(1)

- ☐ **A** condensation
- ☐ **B** evaporation
- ☐ **C** neutralisation
- ☐ **D** oxidation

(iii) Calculate the relative formula mass of chromium oxide, Cr_2O_3.

(relative atomic masses: O = 16, Cr = 52)

(2)

.....

.....

relative formula mass = ...

(Total for question = 4 marks)

Mark Scheme

Q1.

Question number	Answer	Mark
(a)	any **one** precaution from: • wear gloves to prevent contact with skin/safety (1) • spectacles to prevent contact with eyes (1)	(1)

Question number	Answer	Additional guidance	Mark
(b)	1000 cm^3 contain $\frac{4.3 \times 1000}{250}$ (1) 1 dm^3 contains 17.2 ($g\,dm^{-3}$) (1)	Award full marks for correct numerical answer without working.	(2)

Question number	Answer	Additional guidance	Mark
(c)	$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$ • correct formulae (1) • balancing (1)	Do not award 2 if incorrect balancing added.	(2)

Question number	Answer	Mark
(d)	• {titration 1/27 cm^3} should not be used because burette readings {not precise/not accurate/not read to 2 d.p.} (1) • {titration 4/25.80 cm^3} should not be used because volume of used (25.80 cm^3) not concordant with other two (1)	(2)

Q2.

Question number	Answer	Additional guidance	Mark
(i)	12 + (16 x 2) (1) = 44 (1)	Award full marks for correct numerical answer without working.	(2)

Question number	Answer	Additional guidance	Mark
(ii)	320 tonnes iron oxide → 224 tonnes iron (1) 640 tonnes iron oxide → $\frac{224 \times 640}{320}$ (tonnes) iron (1) = 448 (tonnes) (1) OR 160 tonnes iron oxide → 112 tonnes iron (1) 640 tonnes iron oxide → $\frac{112 \times 640}{160}$ (tonnes) iron (1) = 448 (tonnes) (1) OR 160 tonnes iron oxide → 112 tonnes iron (1) 4 x 160 → 4 x 112 (1) = 448 (tonnes) (1)	award full marks for correct numerical answer without working. allow 2 marks for 224 as a final answer with or without working. allow $\frac{640}{160}$ (1) (= 4) 4 x 112 = (1) = 448 (tonnes) (1) if no other marks scored allow 1 mark for 320 and 224 or 160 and 112 seen	**(3)**

Q3.

Question number	Answer	Additional guidance	Mark
	final answer of 114 (g dm^{-3}) with or without working (3) OR $\frac{28.4}{250}$ (1) (= 0.1136) 0.1136 x 1000 (1) (= 113.6) = 114 (g dm^{-3}) (1)	allow ECF throughout $\frac{250}{1000}$ (dm^3) (1) (= 0.250 (dm^3)) $\frac{28.4}{0.250}$ (1) (= 113.6) OR $\frac{1000}{250}$ (1) = 4 4 x 28.4 (1) (= 113.6) Must have 3sf for MP3 0.114 scores 2 Lose MP1 if rounded incorrectly e.g, to 0.11 or 0.113 but mark on	**(3)**

Q4.

Question number	Answer	Additional guidance	Mark
	250 cm^3 contains 6.36 g (1 cm^3 solution contains) $\frac{6.36}{250}$ (g) (1) (=0.02544) (1000 cm^3 solution contains) $\frac{6.36}{250}$ x 1000 (g) (1) concentration = 25.44 (g dm^{-3}) = 25.4 (g dm^{-3}) (1) OR volume of solution = 250/1000 (1) (=0.250) (mass) concentration = $\frac{\text{mass (in g)}}{\text{volume (in } dm^3\text{)}}$ = $\frac{6.36 \times 1000}{250}$ g (1) concentration = 25.44 (g dm^{-3}) = 25.4 (g dm^{-3}) (1)	0.02544 25.44 with or without working (2) 25.4 with or without working (3) (answer to 3 sig fig) other allows: 2.544 1 mark 2.54 2 marks 0.0254 2 marks 2.544 x 10^{-5} 1 mark 2.54 x 10^{-5} 2 marks with working: 39.31 0 marks 39.3 1 mark (answer to 3 sig fig)	**(3)** **EXP**

Q5.

Question number	Answer	Additional guidance	Mark
	12.56 with or without working scores 2 $\frac{3.14}{250}$ (1) (= 0.01256) 0.01256 x 1000 (1) (= 12.56) OR $\frac{250}{1000}$ (1) (= 0.250) $\frac{3.14}{0.250}$ (1) (= 12.56)	0.01256 / 0.0126 / 0.013 scores 1 ECF for MP2 final answer of: 12.6 scores 2 13 **with working** scores 2 200.96 scores 1 0.0796 scores 1 2.0096×10^{-4} scores 1 2.0096×10^{-7} scores 0	**(2)** **AO2-1**

Q6.

Question number	Answer	Additional guidance	Mark
	Al : Cl 0.270/27 : 1.065/35.5 (1) 0.01 : 0.03 (1) OR 1 : 3 empirical formula $AlCl_3$ (1)	allow ECF Al : 0.270/27 = 0.01 (1) Cl : 1.065/35.5 = 0.03 (1) 27/0.27 : 35.5/1.065 100 : 33.3 (1) OR 3 : 1 Al_3Cl (1) formula alone with no working scores no marks.	**(3)** **EXP**

Q7.

Question number	Answer	Additional guidance	Mark
	MP1 for dividing by atomic mass A : G $\frac{3.5}{7}$: $\frac{4.0}{16}$ (1) **MP2 for deriving ratio from MP1** 0.5 : 0.25 OR 2 : 1 (1) **MP3 for ratio in MP2 to formula** empirical formula A_2G (1)	A_2G with no relevant working (1) ONLY AG_2 (0) For MP2: If they go on to calculate a different ratio in addition to 0.5:0.25 or 2:1 do not award MP2 ecf on step 1: if inverted, $\frac{7}{3.5}$: $\frac{16}{4.0}$ (0) = 2 : 4 or 1 : 2 (1) AG_2 (1) allow 1 in empirical formula allow Li for A and O for G do not penalise incorrect case in formula	(3)

Q8.

Question number	Answer	Additional guidance	Mark
	fractions $\frac{1.35}{27}$ and $\frac{12.00}{80}$ (1) **ratios derived from two fractions into simplest whole number ratio** (0.05 0.15) 1 3 (1) **whole number ratio to formula** $AlBr_3$ (1)	answer with no working scores 0 MP2 depends fractions being shown to give ratio allow ECF for MP2 and MP3 inverted fractions correctly followed through to Al_3Br scores 2 allow Al_1Br_3 allow errors in case or using superscript e.g. albr^3	(3) **AO2-1**

Q9.

Question number	Answer	Additional guidance	Mark
	Ti $\frac{12}{48}$ = 0.25 and O $\frac{8.0}{16}$ = 0.5 (1) simplest ratio 1:2 (1) empirical formula TiO_2 (1)	working must be shown to gain full marks allow TE Ti $\frac{48}{12}$ = 4 and O $\frac{16}{8.0}$ = 2 (0) simplest ratio 2:1 (1) empirical formula Ti_2O (1) allow (1) for formula with numbers obtained from 1st step with no simplest ratio	(3)

Q10.

Question number	Answer	Additional guidance	Mark
	M_r H_2O = 18.0 (1) then moles of H_2O = 4.5 / 18.0 (= 0.25) (1) moles $CuSO_4.5H_2O$ = 1/5 x 0.25 (= 0.05)(1) mass $CuSO_4.5H_2O$ = 0.05 x 249.5 (= 12.475 g) (1) OR 5 H_2O : 1 $CuSO_4.5H_2O$ (1) 5 x 18 : 249.5 (1) mass $CuSO_4.5H_2O$ = 249.5 / 90 x 4.5 (= 12.475 g) (1)	12.475 / 12.48 (g) with or without working scores 4 Allow TE throughout Answer must be to 2 or more sig figs	(4) AO2

Q11.

Question number	Answer	Additional guidance	Mark
	2.8g with or without working scores 2 0.043 x 65 (1) (=2.795) = 2.8 g (1)	allow 1 mark for a different calculation using 65 and 0.043, correctly evaluated, with working, rounded to 1 decimal place	(2)

Q12.

Question number	Answer	Additional guidance	Mark
(i)	M_r $TiCl_4$ = 48.0 + (4 x 35.5) (1) (= 190) moles of $TiCl_4$ = 45 000/190 = 236.8 (1)	ecf allow two or more sig figs	(2) AO2

Question number	Answer	Additional guidance	Mark
(ii)	(minimum) moles of Mg needed = 236.8 x 2 = 473.6 (1) 500 moles of Mg added > minimum 473.6 moles required	allow ecf from (i) for moles of $TiCl_4$	(1) AO2

Q13.

Question number	Answer	Additional guidance	Mark
	1.8... x 10^{24} with or without working scores 2 • 3 x 6.02 x 10^{23} (1) • = 1.8 x 10^{24} (1)	allow 18 x 10^{23} , 1.81 x 10^{24} , 1.806 x 10^{24} or any other form of correct answer to 2-4 sig figs allow 2 x 6.02 x 10^{23} = 1.2 x 10^{24} (1)	(2)

Q14.

Question number	Answer	Additional guidance	Mark
	final answer of $1.2(04) \times 10^{22}$ with or without working (2) OR $\frac{3.94}{197} = 0.02$ (1) $0.02 \times 6.02 \times 10^{23} = 1.2(04) \times 10^{22}$ (1)	allow ECF allow $0.12(04) \times 10^{23}$	**(2)**

Q15.

Question number	Answer	Additional guidance	Mark
(i)	relative formula mass $= 192 + 12 + 28 + 16$ (1) $= 248$ number of moles $= 0.50/248$ or 0.002 or 2.0×10^{-3} or 2.02×10^{-3} (1)	award full marks for correct numerical answer without working. allow 1 mark max for ecf using incorrectly calculated value for relative formula mass allow any number of sig figs	**(2)** **EXP**

Question number	Answer	Additional guidance	Mark
(ii)	number of molecules $= 2 \times 6.02 \times 10^{23}$ (1) $= 1.2(04) \times 10^{24}$	allow $12(.04) \times 10^{23}$ without working	**(1)** **GRAD**

Q16.

Question number	Answer	Additional guidance	Mark
	0.005/ 5 x 10^{-3} mol with or without working scores 3 Mr = 63.5 + 32 + 4 x 16 (1) (=159.5) AND EITHER mass of copper sulfate = 50/1000 x 15.95 (1) (= 0.7975 g) moles = 0.7975/159.5 (1) (= 0.005 mol) OR conc = 15.95/159.5 (1) (=0.1 moldm^{-3}) moles = 50/1000 x 0.1 = (0.005 mol)	2 marks for (MUST show working): 5 0.1 ecf in all stages	**(3)**

Q17.

Question number	Answer	Additional guidance	Mark
	MP1 – relative formula mass $MgCO_3$ 24.0 + 12.0 + 3x16.0 (1) (=84.0) MP2 – division $\frac{24(.0)}{84(.0)}$ (1) (= 0.28571429) MP3 – conversion to percentage (0.28571429) x 100 (= 28.57 / 28.6 / 29) (1)	28.57 / 28.6 / 29 with or without working gains 3 marks. allow ECF for MP2 and MP3 must have 2 or more sig figs for MP2 e.g Mr = 52 (0) $\frac{24}{52}$ = 0.4615 (1) x 100 = 46.2 (1) MP3 - x 100 mark only if using all 3 pieces of data in calculation allow any number of sig figs except 1 correctly rounded allow $\frac{84(.0)}{24(.0)}$ x 100 = 350 (2)	**(3)** **AO2-1**

Q18.

Question number	Answer	Additional guidance	Mark
(i)	100 with or without working scores 2 40 + 12 + 3 x 16 (1) =100 (1)	ignore any units ecf for MP2 if using 12,16 and 40, using addition and multiplication only	(2)
(ii)	**56% without working scores 0** $\frac{56}{100}$ (1) (x 100) = 56 (%) (1)	56/answer to 4(d)(i) (1) x 100 (1) MP2 only for correctly x 100 some figure derived from the data given 100% scores 0	(2)

Q19.

Question number	Answer	Additional guidance	Mark
	formula mass $Al_2(SO_4)_3$ = 2x27 + 3x(32 + 16x4) (1) (= 342) moles of $Al_2(SO_4)_3$ = $\frac{5.13}{342}$ (1) (=0.015) no of atoms in formula $Al_2(SO_4)_3$ = 17 no of atoms in 0.015 moles = 17 x 0.015 x 6.02 x 10^{23} (1) = 1.5351 x 10^{23} (1)	final answer of 1.5351 x 10^{23} scores full marks allow ECF from formula mass 0.015 scores 2 marks allow any number of sig figs except one 3.1 x 10^{24} scores 1 (mass x *L*) 1.0234 x 10^{25} scores 1 (no of atoms x *L*) 2.05884 x 10^{26} scores 2 (M_r x *L*) 9.03 x 10^{21} scores 3 (moles x *L*)	**(4)** AO2-1

Q20.

Question number	Answer	Mark
	10.32 + 5.12 (1)= (15.44) (g)	**(1)**

Q21.

Question Number	Answer	Additional guidance	Mark
	1 mol of hydrogen atoms = a mass of 1.00 g = 6.02×10^{23} atoms 6.02×10^{23} H atoms has mass = 1.00 g (1) mass of 1 H atom = $\frac{1.00}{6.02 \times 10^{23}}$ (1) $= 1.66 \times 10^{-24}$ (g) (1)	correct answer alone (3) if $1 \times 6.02 \times 10^{23}$ is followed by atoms or particles, then award 1st marking point on answer line 3.32×10^{-24} (g) (2) ignore sig figs except for one	**(3)** AO 2 1

Q22.

Question number	Answer	Additional guidance	Mark
	moles Fe = $\frac{4.48}{56.0}$ (1) (= 0.08) moles Pb = $\frac{24.84}{207}$ (1) (= 0.12) ratio moles Fe : moles Pb = 2 : 3 or 1 : 1.5 so equation 2 (1) **OR** mass ratio ratio equation 1 = 56 : 207 (1) ratio equation 2 = 112 : 621 (1) 112 : 621 = 4.48 : 24.84 so equation 2 (1) **OR** equation 1 mass of Pb (207/56) x 4.48 = 16.56 (2) OR equation 2 mass of Pb (621/112) x 4.48 = 24.84 (2) so equation 2 is correct (1)	There may be other methods – need to check calculation carefully allow shows that it is not 1:1 for final mark stating Equation 2 with no calculation to justify, scores 0	**(3)** AO3-1

Q23.

Question number	Answer	Additional guidance	Mark
(i)	Left : H_2SO_4 (1) Right : $CuSO_4$ (1)	reject superscript numbers reject superscript numbers incorrect balancing max 1	(2)

Question number	Answer	Mark
(ii)	63.5 + 12 + 3x16 (1) = 123.5 (1)	(2)

Question number	Answer	Mark
(iii)	**A** bubble the gas through limewater, limewater turns cloudy **The only correct answer is A** **B** is not correct because test shows only an acidic gas **C** is not correct because test shows only that the gas does not support combustion **D** is not correct because test shows only an acidic gas	(1)

Q24.

Question number	Indicative content	Additional guidance	Mark
(i)	straight line of best fit (1 cm^3 to 5 cm^3)	ignore line between 0 and 1 and after 5 must be a single ruled line	(1)

Question number	Indicative content	Additional guidance	Mark
(ii)	• any line extrapolated to 6cm^3 (1) • value read from their extrapolated line +/- 1 small square (1)	2nd mark dependent on 1st no line = 0	(2)

Q25.

Question Number	Answer	Additional guidance	Mark
	final answer of 94 (g dm^{-3}) with or without working (2) OR $\frac{23.5}{250}$ (1) (= 0.094) 0.094 x 1000 (1) OR $\frac{250}{1000}$ (dm^3) (1) (= 0.25 (dm^3)) $\frac{23.5}{0.25}$ (1) OR $\frac{1000}{250}$ (1) = 4 4 x 23.5 (1)	allow ECF (error carried forward) throughout other final answers: 0.094 / 9.4 (1) 0.000094 or 9.4 x 10^{-5} (1) 0.25 (dm^3) (1) allow $\frac{250}{}$ x 1000 or 10638(.3) (1) 23.5	**(2)** AO 2 1

Q26.

Question number	Answer	Additional guidance	Mark
	A description that combines three of the following points to provide a method: • heat the magnesium (in crucible) (1) and any two from • lift lid from time to time/allow to cool (1) • determine mass of crucible, lid and product (1) • subtract to find mass of oxygen combined (1)	 allow heat crucible (containing magnesium) allow use of weigh in place of determine mass ignore 'measure' alone allow heat to constant mass allow weigh at end /OWTTE	**(3)** **EXP**

Q27.

Question number	Answer	Additional guidance	Mark
	$\frac{2.24}{56.0} = 0.04$ and $\frac{0.96}{16.0} = 0.06$ (1) 1 : 1.5 / 2 : 3 (1) Fe_2O_3 (1) $4Fe + 3O_2 \rightarrow 2\mathbf{Fe_2O_3}$ (1)	allow ECF for MP2 and MP3 only. allow $\frac{2.24}{56.0} = 0.04$ and $\frac{0.96}{32.0} = 0.03$ (1) 1.33 : 1 / 4 : 3 (1) Fe_2O_3 (1) $4Fe + 3O_2 \rightarrow 2\mathbf{Fe_2O_3}$ (1) NOTE: equation alone gains no marks.	**(4)**

Q28.

Question Number	Answer	Mark
	B CH_2 **1. The only correct answer is B** ***A*** *is not correct because there are not equal C and H* ***C*** *is not correct because it is not simplest ratio* ***D*** *is not correct because it is not simplest ratio*	**(1)** AO 2 1

Q29.

Question number	Answer	Additional guidance	Mark
(i)	An explanation linking • {rate/ mass loss} is slowing down (1) • as amount of reactant falls (1) OR • mass decreases (1) • as further decomposition occurs/ reaction continues / {gas/CO_2} {is produced/ escapes/ lost} (1)	allow amount of calcium carbonate decreases do not allow 'as time goes on' for 2nd mark: must explain in terms of a reaction	(2)
(ii)	mass may decrease further / not heated to constant mass / last two mass figures not the same	allow mass is still decreasing ignore there is still 5.2g solid reject mass has not gone to zero	(1)

Q30.

Question Number	Answer	Mark
(i)	C iron oxide is reduced **1. The only correct answer is C** ***A*** *is not correct because carbon gains oxygen* ***B*** *is not correct because it is not an acid-base reaction* ***D*** *is not correct because iron oxide loses oxygen*	**(1)** AO 1 1

Question Number	Answer		Mark
(ii)	final answer of 168 (tonnes) with or without working (3) OR relative formula mass Fe_2O_3 = 2x56 + 3x16 (= 160) (1) 160 tonnes Fe_2O_3 produces {2x56 / 112} tonnes Fe (1) 240 tonnes Fe_2O_3 produces $\frac{2x56}{160}$ x 240 (1) = 168 (tonnes) OR relative formula mass Fe_2O_3 = 2x56 + 3x16 (= 160) (1) $\frac{240}{160}$ (1) = 1.5 1.5 x 112 (1) = 168 (tonnes) OR relative formula mass Fe_2O_3 = 2x56 + 3x16 (= 160) (1) $\frac{112}{160}$ (1) = 0.7 0.7 x 240 (1) = 168 (tonnes)	allow ECF throughout M_r $[Fe_2O_3]$= 160 seen without working (1) allow 320 tonnes : 224 tonnes (1) final answer 84 (tonnes) with or without working (2) Note : final answer 1.5 scores 2 overall	(3) AO 2 1

Q31.

Question number	Answer	Mark
	D	(1)

Q32.

Question number	Answer	Additional guidance	Mark
	molecular formula: C_2H_4 (1) empirical formula: CH_2 (1)	allow H_4C_2 allow H_2C allow use of small letter / superscripts / non-subscripts	(2) AO2

Q33.

Question number	Answer	Additional guidance	Mark
(i)	**D** oxidation Answers **A** and **B** are physical processes rather than chemical reactions. **C** is wrong because it is not neutralisation.		**(1)**

Question number	Answer	Additional guidance	Mark
(ii)	A description linking any three from: • lift lid from time to time/ leave small gap between crucible and lid (1) • find mass (of crucible, lid and product) (1) • {repeat / heat} to constant mass (1) • final mass – start mass = mass of oxygen (1)	 allow 'weigh' allow find the change in mass	**(3)**

Q34.

Question Number	Answer	Additional guidance	Mark
(i)	25.7 (g)	do not allow 25 answer may be written on the lower diagram	**(1)** AO 2 1

Question Number	Answer	Additional guidance	Mark
(ii)	barium sulfate	do not allow barium sulfide	**(1)** AO 1 2

Q35.

Question Number	Answer	Additional guidance	Mark
	iron $\frac{10.00}{56}$ = 0.179 / 0.18 / 0.2 and copper $\frac{11.34}{63.5}$ = 0.179 / 0.18 / 0.2 (1) (ratio 1:1) so reaction A (1)	allow max 1 mark for Fe : $\frac{56}{10.00}$ = 5.6 Cu : $\frac{63.5}{11.34}$ = 5.6 so reaction A other methods of calculation include 10.00 g Fe forms $\frac{10.00}{56}$ x 63.5 (1) g copper = 11.34 g copper so reaction A (1) second mark dependent on first	**(2)** AO 3 2a AO 3 2b

Q36.

Question Number	Answer	Additional guidance	Mark
	56 with or without working (2) OR (4 x 12) + (8 x 1) = (1) = 56 (1)	allow for ONE mark correctly evaluated expression of form: (4 x 12)+(Y x 1) = ... (X x 12)+(8 x 1) = ... OR (8 x 12) + (4 x 1) = 100 [In each case working and correctly evaluated answer required]	**(2)** AO 2 1

Q37.

Question number	Answer	Additional guidance	Mark
	• heat remaining solid/ heat it for longer / heat it again (1) • and determine mass (1) • repeat until mass after heating stays the same (1)	allow heat to a constant mass (3) allow remove sample (1) add acid (1) no fizz (1)	(3) AO3

Q38.

Question number	Answer	Mark
(i)	chromium + oxygen → chromium oxide	(1) AO2

Question number	Answer	Mark
(ii)	**D** oxidation is the only correct answer. **A, B** are incorrect because these are physical changes. **C** is incorrect because there is no acid-base reaction.	(1) AO1

Question number	Answer	Mark
(iii)	152 with or without working scores 2. (52 x 2) + (16 x 3) (1) = 152 (1)	(2) AO2