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EDEXCEL GCSE CHEMISTRY: QUESTIONS BY TOPIC

Extracting Metals and Equilibria (4)

GCSE Chemistry (Foundation) Topic 4

10 questions · 102 marks · Mark schemes included

Pearson Edexcel GCSE (9-1) Chemistry 1CH0, Foundation Tier, June 2018 - June 2025

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HOW TO USE THIS BOOKLET

Questions run from the lowest mark tariff to the highest, so similar questions sit together.

Click any row below to jump straight to that question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

10 questions · 102 marks · lowest tariff first



7-MARK QUESTIONS

1 question in this booklet



- 1 (a) Figure 1 shows a bag of NPK fertiliser.



Figure 1

N, P and K are the symbols of three elements that are essential for plant growth.

N is the symbol for nitrogen.

Name the other two elements, P and K, that are essential for plant growth.

You may want to refer to the periodic table.

(2)

P

K

- (b) Many fertilisers are produced using ammonia.

Ammonia is produced on an industrial scale from the reaction of nitrogen with hydrogen.

The equation for the reaction is



- (i) State the name of this industrial process.

(1)

.....

(ii) State the meaning of the $\rightleftharpoons$ symbol in the equation.

(1)

(iii) Figure 2 shows the electronic configurations for an atom of nitrogen and an atom of hydrogen.

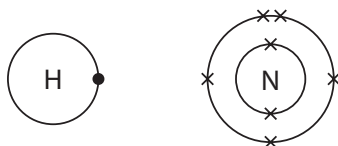
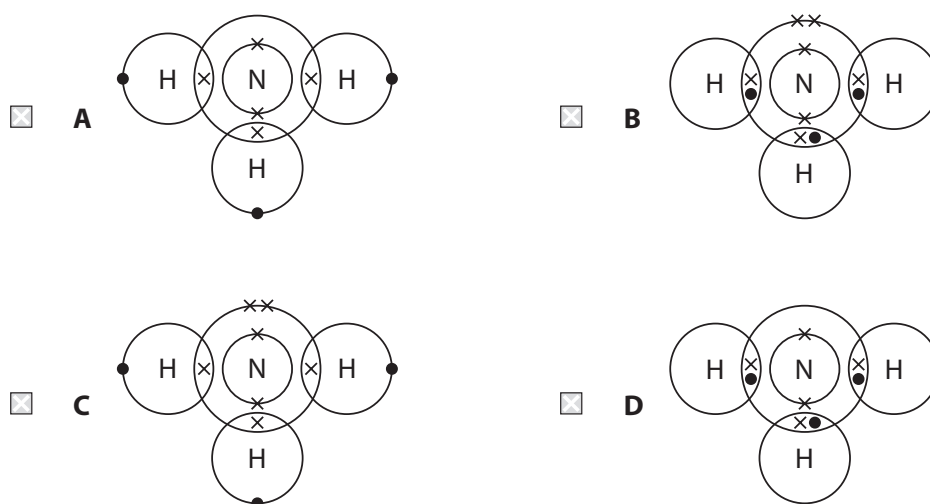


Figure 2

Which dot and cross diagram for ammonia, NH_3 , is correct?

(1)



(c) Ammonia reacts with nitric acid to produce ammonium nitrate.

Write the word equation for this reaction.

(2)

..... + ... →

(Total for Question 1 = 7 marks)

8-MARK QUESTIONS

2 questions in this booklet



3 In industry, ammonia is manufactured by reacting nitrogen with hydrogen.

(a) (i) Give the name of the industrial process used to manufacture ammonia.

(1)

(ii) Write the word equation for this reaction, including the correct symbol to show that the reaction is reversible.

(3)

(b) The formula of ammonia is NH_3 .

State what the formula of ammonia shows about the number of nitrogen atoms and the number of hydrogen atoms combined in a molecule of ammonia.

(1)

(c) Most of the ammonia manufactured in industry is used to produce fertilisers.

(i) A fertiliser is made by reacting ammonia with nitric acid.

What is the name of this fertiliser?

(1)

- ☐ **A** ammonia nitrate
- ☐ **B** ammonia nitric
- ☐ **C** ammonium nitrate
- ☐ **D** ammonium nitric

(ii) Explain the importance of fertilisers in farming.

(2)

(Total for Question 3 = 8 marks)



1 (a) Fertilisers are sometimes added to soil.

(i) State why fertilisers are added to soil.

(1)

.....

.....

(ii) Fertilisers contain compounds of different elements.
Three of these elements have the symbols K, N and P.

Use the periodic table to state the names of these three elements.

(2)

K

N

P



- (b) The fertiliser ammonium sulfate may be made by titrating ammonia solution with dilute sulfuric acid.

Three pieces of apparatus, **P**, **Q** and **R**, used to measure volumes of liquid are shown in Figure 1.

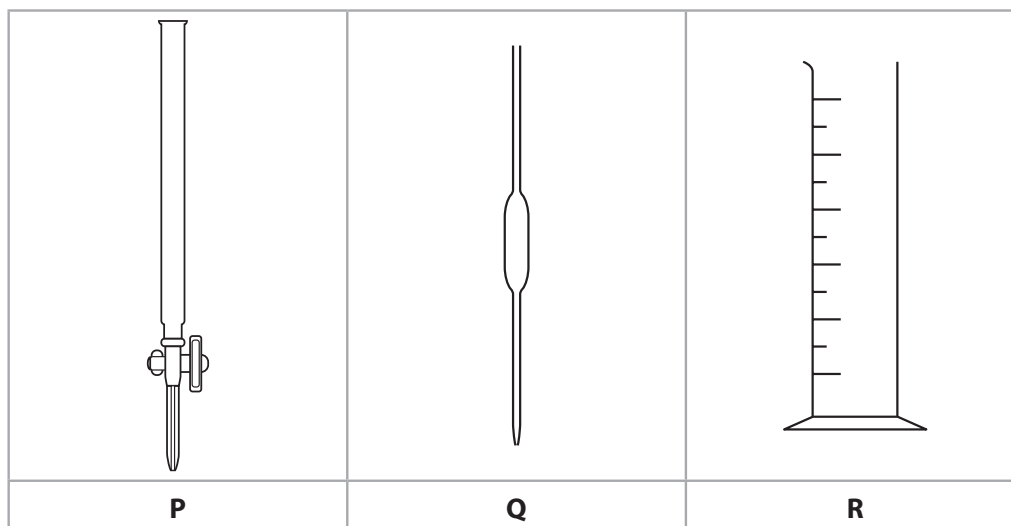


Figure 1

- (i) Give the names of the pieces of apparatus **P** and **Q**.

(2)

P

Q

- (ii) In the titration experiment, small volumes of dilute sulfuric acid are added gradually to the ammonia solution in a flask.

Give the letter, **P**, **Q** or **R**, of the piece of apparatus in Figure 1 that should be used to add the dilute sulfuric acid.

(1)

.....

(iii) The titration experiment is used to produce a solution of ammonium sulfate.

Describe how solid ammonium sulfate should be obtained from this solution.

(2)

.....

.....

.....

.....

(Total for Question 1 = 8 marks)



9-MARK QUESTIONS

2 questions in this booklet

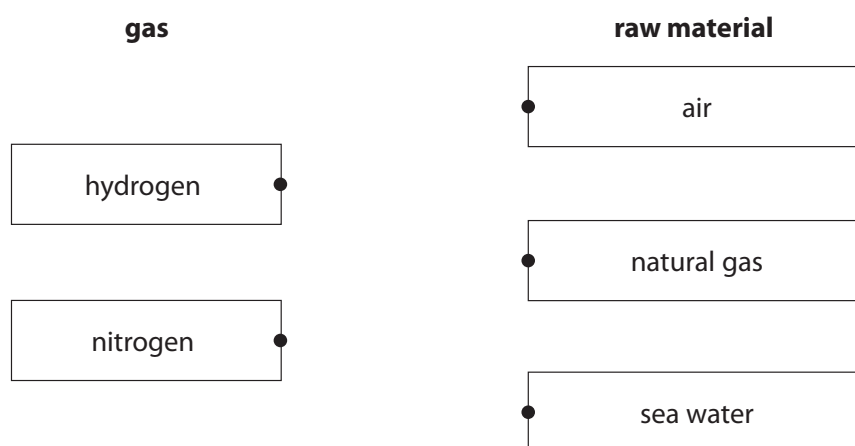


5 Ammonia is made by reacting nitrogen with hydrogen.

(a) The nitrogen and hydrogen are obtained from raw materials.

Draw one straight line from each gas to the raw material it is obtained from.

(2)



(b) When nitrogen and hydrogen are reacted together, the reaction can reach a dynamic equilibrium.

Use words from the box to complete the sentences about dynamic equilibrium.

(2)

backward
different
equal
faster
reversible

In a dynamic equilibrium two reactions occur at the same time.

These are the forward reaction and the reaction.

The rates of the two reactions are

(c) The reaction between nitrogen and hydrogen happens at a pressure of 200 atmospheres.

Another unit of pressure is Pascals, Pa (1 atmosphere = 101 325 Pa).

Calculate the value of 200 atmospheres in Pascals.

(2)

.....

.....

pressure = ... Pa



(d) Figure 5 shows molecules of nitrogen, hydrogen and ammonia before the reaction and at equilibrium.

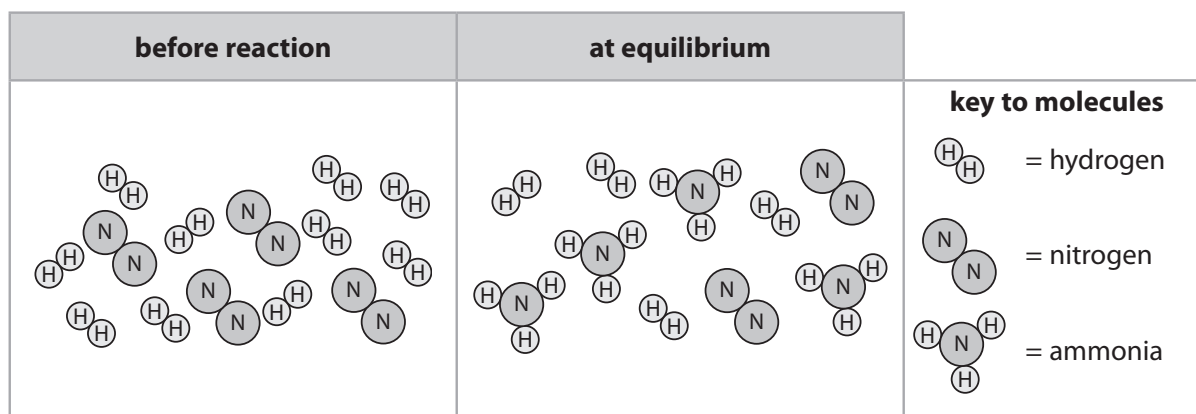


Figure 5

(i) Complete the table showing

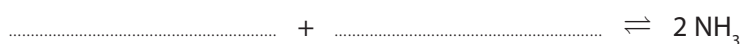
- the number of hydrogen molecules before reaction
- the number of hydrogen molecules at equilibrium
- the change in the number of hydrogen molecules.

(1)

	number of molecules before reaction	number of molecules at equilibrium	change in number of molecules
nitrogen	4	2	-2
hydrogen			
ammonia	0	4	+4

(ii) Complete the equation for this reaction.

(2)



(Total for Question 5 = 9 marks)

4 This question is about metals and their reactions with acids.

(a) Place ticks (✓) in boxes to show which elements in the table are metals.

Use the periodic table to help you answer this question.

(2)

element	(✓)
phosphorus, P	
rubidium, Rb	
rhodium, Rh	
strontium, Sr	
tellurium, Te	

(b) Three equal sized pieces of the metals **E**, **F**, **G** and **H** are put into separate test tubes containing equal volumes of dilute sulfuric acid.

The results in Figure 7 show the test tubes after half a minute.

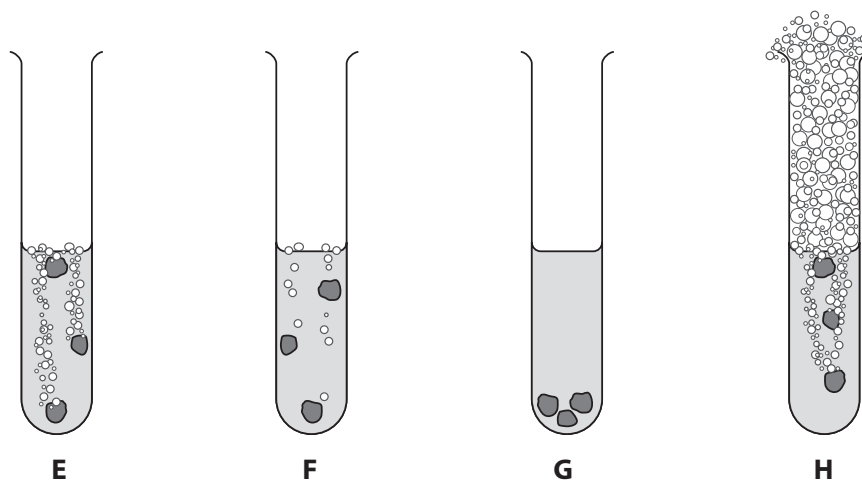


Figure 7

(i) Arrange the metals **E, F, G** and **H** in order of reactivity.

(2)

metal	
	most reactive
	least reactive

(ii) The bubbles that form are hydrogen.

Which row of the table shows the test and result that confirm the gas is hydrogen?

(1)

	test	result
☐ A	put a glowing splint into the gas	the splint relights
☐ B	put a lighted splint into the gas	the gas ignites with a squeaky pop
☐ C	test the gas with damp litmus paper	the litmus paper turns pink
☐ D	test the gas with damp litmus paper	the litmus paper turns white

(c) When zinc reacts with very dilute nitric acid, zinc nitrate is formed.

(i) The formula of zinc nitrate is $\text{Zn}(\text{NO}_3)_2$

Calculate the relative formula mass of zinc nitrate, $\text{Zn}(\text{NO}_3)_2$

(relative atomic masses: Zn = 65, N = 14, O = 16)

(2)

.....

.....

.....

relative formula mass = ...



- (ii) A student investigates the reaction between a metal and a dilute acid using the apparatus shown in Figure 8.

Cotton wool is placed in the top of the apparatus as shown, to stop any acid from spraying out.

The total mass of the apparatus is shown at the start of the reaction and after the reaction has ended.

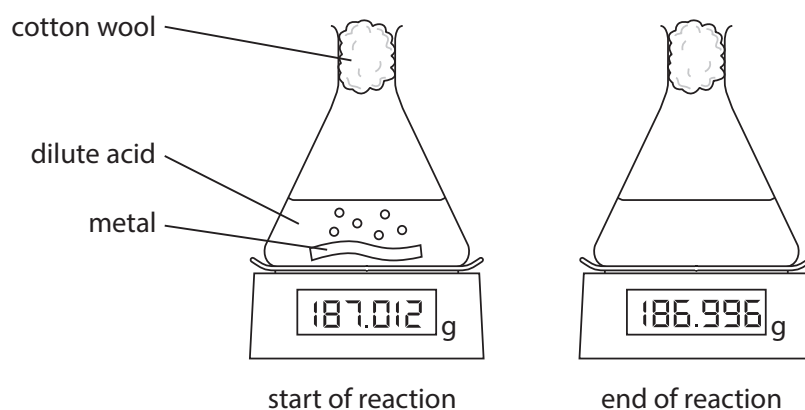


Figure 8

State **two** ways the student would know that the reaction has ended.

(2)

1

2

(Total for Question 4 = 9 marks)

11-MARK QUESTIONS

1 question in this booklet



- 6 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) Which of these metals is found as the uncombined element in the Earth's crust?

(1)

- ☐ A aluminium
- ☐ B gold
- ☐ C potassium
- ☐ D zinc

- (b) Give **two** advantages of recycling metals rather than extracting metals from their ores.

(2)

- 1
- 2

- (c) An ore of iron is mostly iron oxide, Fe_2O_3 .
Iron can be extracted from this iron oxide by heating it with carbon.

Balance this equation for the reaction that takes place.

(1)



- (d) Most copper ores are described as low grade.
This means that the percentage of copper in the ore is very small.

5000 kg of one copper ore was found to contain 42.5 kg of copper.

Calculate the percentage of copper in this ore.

(2)

-
-
-

percentage of copper in ore = ...



- (e) In one stage of the extraction of lead from its ore, lead oxide is heated strongly with carbon.

The equation for the reaction is



Explain, using this equation, which substance has been oxidised in this reaction.

(2)

.....

.....

.....

.....

- (f) 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)

.....

.....

.....

.....

.....

empirical formula = ...

(Total for Question 6 = 11 marks)



12-MARK QUESTIONS

2 questions in this booklet



- 7 (a) Figure 10 shows some information on a container of plant fertiliser.

contains	percentage by mass
ammonium nitrate (NH_4NO_3)	46 %
phosphorus oxide (P_2O_5)	0 %
potassium nitrate (KNO_3)	54 %

Figure 10

- (i) State which element, often present in fertilisers, is **not** present in this fertiliser.

(1)

- (ii) Ammonium nitrate, NH_4NO_3 , is prepared for use in fertilisers by neutralising ammonia with an acid.

Which acid reacts with ammonia to produce ammonium nitrate?

(1)

- ☐ A ethanoic acid
- ☐ B hydrochloric acid
- ☐ C nitric acid
- ☐ D sulfuric acid

- (iii) State why farmers spread fertilisers on their fields.

(1)

- (b) Ammonium sulfate is a fertiliser and is produced on a large scale in industry.

In this process, ammonia reacts with sulfuric acid.

- (i) Write the word equation for the reaction between ammonia and sulfuric acid.

(2)



- (ii) Ammonium sulfate can also be made in the laboratory by titrating ammonia solution with dilute sulfuric acid.

Give **one disadvantage** of using this laboratory method to produce ammonium sulfate as a fertiliser compared with an industrial method.

(1)

- *(c) In the laboratory, ammonium sulfate crystals can be made using ammonia solution and dilute sulfuric acid.

The volume of ammonia solution required to neutralise 25 cm^3 of dilute sulfuric acid is found by titration using an indicator.

The results of the titration can be used to prepare a solution of ammonium sulfate.

Pure, dry ammonium sulfate crystals can be made from this solution.

Figure 11 shows some of the equipment that may be used in the experiment.

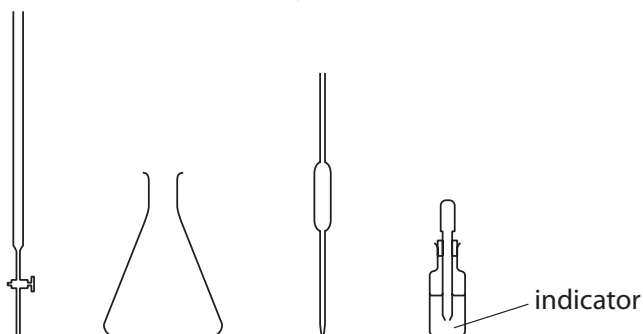


Figure 11

Write a detailed method to make ammonium sulfate crystals starting with ammonia solution and dilute sulfuric acid.

(6)

(Total for Question 7 = 12 marks)

6 Figure 11 shows part of the reactivity series of metals.

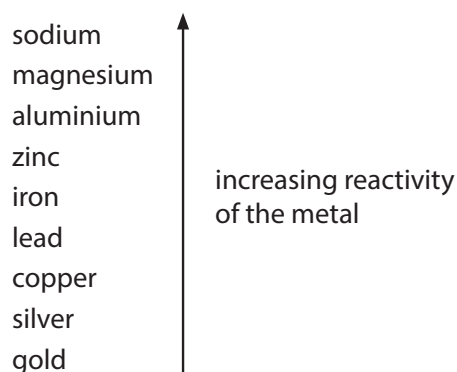


Figure 11

(a) The method used to extract a metal from its ore is related to the metal's position in the reactivity series.

(i) Which metal is found in the Earth's crust as an uncombined element?

(1)

☐ A aluminium

☐ B gold

☐ C lead

☐ D sodium

(ii) Name **one** metal in Figure 11 that is normally extracted by electrolysis.

(1)

(b) 25 000 kg of an ore of iron was found to contain 10 050 kg of iron.

Calculate the percentage of iron in this ore of iron.

$$\text{percentage of metal} = \frac{\text{mass of metal}}{\text{mass of metal ore}} \times 100$$

(2)

percentage of iron in ore = ...

(c) When copper oxide is heated with carbon, the products are copper and carbon dioxide.

(i) Write the word equation for this reaction.

(1)

(ii) In this reaction, copper oxide loses oxygen.

State the type of reaction when copper oxide loses oxygen.

(1)

(iii) In one reaction, 159.0 g of copper oxide was heated with excess carbon to produce 127.0 g of copper.

Use this information to calculate the mass of copper formed, in g, when 238.5 g of copper oxide is reacted with excess carbon.

(2)

mass of copper = ... g

(iv) State why this reaction with copper oxide uses excess carbon.

(1)

(d) A solution of zinc sulfate was made by dissolving 23.8 g of the compound in water and was made up to a total volume of 250 cm³ with water.

Calculate the concentration of this solution in g dm⁻³.

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

Give your answer to 2 significant figures.

(3)

concentration = ... g dm⁻³

(Total for Question 6 = 12 marks)



13-MARK QUESTIONS

2 questions in this booklet



9 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.

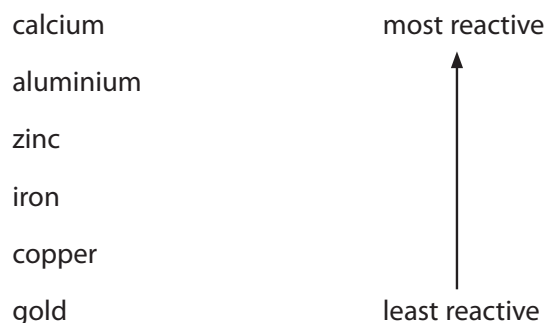
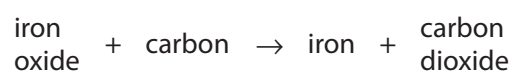


Figure 14

(a) Iron ore contains iron oxide.

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



(i) In this reaction

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

(1)

(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)

.....

.....

.....

.....

.....

.....

mass of iron = ... tonnes

(b) Aluminium cannot be extracted by heating its oxide with carbon.
Aluminium has to be extracted from its oxide by electrolysis.

Explain why.

(2)

.....

.....

.....

.....

(c) Predict the method that will have to be used to extract calcium from its ore.

(1)

.....



*(d) Aluminium is extracted from its ore by electrolysis.
Iron is extracted from its ore by heating with carbon.
Both metals can also be obtained by recycling.

Explain the advantages of recycling aluminium and iron rather than extracting them from their ores.

(6)



(Total for Question 9 = 13 marks)



9 Figure 13 shows part of the reactivity series of metals.

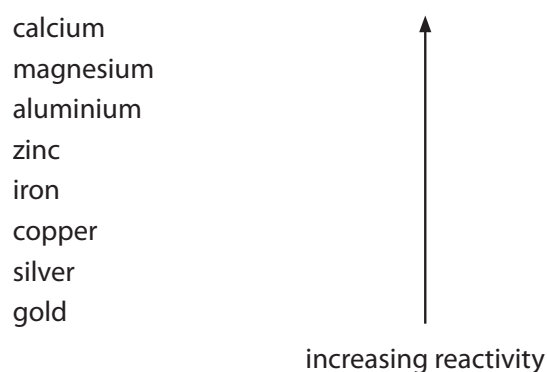


Figure 13

(a) Which metal reacts when added to cold water?

(1)

- ☐ **A** calcium
- ☐ **B** copper
- ☐ **C** gold
- ☐ **D** silver

(b) A student investigates the reactivity of four different metals.

The student adds an equal-sized piece of each metal to separate test tubes containing dilute hydrochloric acid.

The student's observations for zinc and copper are recorded in Figure 14.

metal	observations
magnesium	
zinc	bubbles produced at a steady rate test tube feels slightly warm
iron	
copper	no reaction

Figure 14

- (i) Use the information in Figure 13 and in Figure 14 to predict the observations for the reactions of magnesium and of iron with dilute hydrochloric acid.

(2)

magnesium

.....

.....

iron

.....

.....

- (ii) When metals react with acids, hydrogen gas is produced.

Describe the test to show that the gas is hydrogen.

(2)

.....

.....

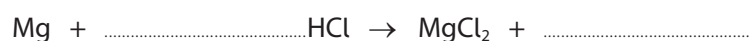
.....

.....

- (iii) When magnesium reacts with hydrochloric acid, magnesium chloride and hydrogen are formed.

Complete the balanced equation for the reaction.

(2)



*(c) There are **three** common methods of obtaining metals from the Earth's crust:

- mine the pure metal
- mine the metal ore and heat it with carbon
- mine the metal ore and electrolyse the molten compound.

The method used to obtain a metal is linked to its position in the reactivity series of metals.

Aluminium, gold, iron, and silver are some commonly used metals.

Use the reactivity series in Figure 13 to state and explain the method chosen to obtain each of these four metals.

(6)

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(Total for Question 9 = 13 marks)



MARK SCHEMES

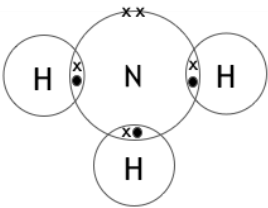
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Question number	Answer	Additional guidance	Mark
1(a)	phosphorous (1) potassium (1)	allow phonetic spelling	(2) A01-1

Question number	Answer	Mark
1(b)(i)	Haber (1)	(1) A01-1

Question number	Answer	Additional guidance	Mark
1(b)(ii)	(reaction is) {reversible / can go both ways / can go backwards and forwards}	allow (dynamic) equilibrium ignore 'reversed' alone	(1) A01-1

Question number	Answer	Mark
1(b)(iii)	B is the only correct answer  A is incorrect as there are no shared pairs and the nitrogen atom shown only has 3 electrons C is incorrect as there are no shared pairs D is incorrect as the nitrogen atom shown only has 3 electrons	(1) A02-1

Question number	Answer	Additional guidance	Mark
1(c)	ammonia + nitric acid (1) ammonium nitrate (1)	allow reactants in either order if symbol equation given, formulae must be fully correct if both word and symbol equations are given, ignore symbols	(2) A02-1



Question number	Answer	Additional guidance	Mark
3(a)(i)	Haber	ignore spelling	(1)

Question number	Answer	Additional guidance	Mark
3(a)(ii)	nitrogen + hydrogen = ammonia (3) reactants {= / →}(1) {= / →} product (1) = (1)	allow reactant either way round nitrogen + hydrogen → ammonia (2) $N_2 + 3H_2 = 2NH_3$ (3) incorrectly balanced equation scores 2 max allow: correct formulae (1) reversible sign (1) balancing (1)	(3)

Question number	Answer	Additional guidance	Mark
3(b)	one nitrogen (atom) and three hydrogen (atoms) (1)	allow 1 N and 3 H (atoms) (1)	(1)

Question number	Answer	Additional guidance	Mark
3(c)(i)	C ammonium nitrate A, B, D are incorrect names		(1)

Question number	Answer	Additional guidance	Mark
3(c)(ii)	An explanation linking any two from - crops require fertilisers to grow (1) - fertilisers contain N / P / K compounds (1) - promote plant growth (1) - increased yield (means greater profits) (1)		(2)

Total for Question 3 = 8 marks



Question number	Answer	Mark
1(a)(i)	to make plants grow more/ faster/ bigger	(1) AO1

Question number	Answer	Mark
1(a)(ii)	K: potassium N: nitrogen P: phosphorus all three correct (2); one or two correct (1)	(2) AO2

Question number	Answer	Mark
1(b)(i)	P: burette (1) Q: pipette (1)	(2) AO1

Question number	Answer	Mark
1(b)(ii)	P / burette	(1) AO1

Question number	Answer		Mark
1(b)(iii)	A description including - heat (1) and any one from - use of Bunsen burner (1) - until all water evaporates/ disappears (1) - until some water evaporates then leave (1) - leave in warm place/ windowsill (1)	ignore filtering	(2) AO1

Question number	Answer	Mark
5(a)	gas hydrogen nitrogen substance air natural gas sea water if two lines leave from a gas, no mark scored for that gas	(2) AO1

Question number	Answer	Mark
5(b)	backward (1) equal (1)	(2) AO1

Question number	Answer	Additional guidance	Mark
5(c)	20265000 with or without working scores 2 101325 x 200 (1) = 20265000 (Pascals) (1)	allow 20270000 / 20300000 for 2 506.625/ 506.63/ 506.6/ 507 scores 1	(2) AO2

Question number	Answer	Mark
5(d)(i)	hydrogen row: 10 4 -6	(1) AO2

Question number	Answer	Additional guidance	Mark
5(d)(ii)	$\text{N}_2 + 3 \text{H}_2 \rightleftharpoons 2 \text{NH}_3$ (2) Formulae of nitrogen and hydrogen (1)	balancing mark only if formulae correct	(2) AO2

Question number	Answer	Additional guidance	Mark										
4(a)	<table><tr><td>phosphorus, P</td><td></td></tr><tr><td>rubidium, Rb</td><td>✓</td></tr><tr><td>rhodium, Rh</td><td>✓</td></tr><tr><td>Strontium, Sr</td><td>✓</td></tr><tr><td>Tellurium, Te</td><td></td></tr></table>	phosphorus, P		rubidium, Rb	✓	rhodium, Rh	✓	Strontium, Sr	✓	Tellurium, Te		0 or 1 tick - scores 0 2 ticks – must be both correct to score 1 3 ticks – all correct scores 2 3 ticks – two correct scores 1 3 ticks – one correct scores 0 4 ticks – must have three correct ticks to score 1 5 ticks - scores 0	(2) AO1-1
	phosphorus, P												
	rubidium, Rb	✓											
	rhodium, Rh	✓											
	Strontium, Sr	✓											
	Tellurium, Te												

Question number	Answer	Additional guidance	Mark					
4(b)(i)	<table><tr><td>metal</td></tr><tr><td>H</td></tr><tr><td>E</td></tr><tr><td>F</td></tr><tr><td>G</td></tr></table> (2)	metal	H	E	F	G	score 1 for H F E G all other combinations score 0	(2) AO3-2
metal								
H								
E								
F								
G								

Question number	Answer	Mark
4(b)(ii)	B put a lighted splint into the gas – the gas ignites with a squeaky pop is the only correct answer A, C and D are not correct because they are not the test for hydrogen	(1) AO1-2



Question number	Answer	Additional guidance	Mark
4(c)(i)	189 with or without working scores 2 $65 + (14 \times 2) + (16 \times 6) = (1)$ $= 189 (1)$	one error (i.e. incorrect Ar / one error in x2 or x3) in expression, but correctly evaluated scores 1 examples (working needed if not 189) $65 + (14 + 16) \times 2 = 125 (1)$ $65 + 14 + 6 \times 16 = 175 (1)$ $64 + (14 \times 2) + (16 \times 6) = 188 (1)$ $(65 \times 2) + (14 \times 2) + (16 \times 6) = 254 (1)$	(2) AO2-1
Question number	Answer	Additional guidance	Mark
4(c)(ii)	a description including any 2 from - no change in mass / mass remains constant / (reading on) balance stays the same (1) - no {bubbles / effervescence / fizzing} (1) {metal / solid / named reactive metal} has gone (1)	allow weight for mass allow stops decreasing ignore mass has decreased allow no (more) {gas / hydrogen} allow has 'dissolved' allow <u>all of the metal</u> has reacted ignore the metal has melted	(2) AO2-2

Total for Question 4 = 9 marks



Question number	Answer	Mark
6(a)	B gold A, C, D – these metals too reactive to exist as uncombined elements	(1)

Question number	Answer	Additional guidance	Mark
6(b)	Any two from preserves ore reserves / reduces waste / reduces energy needed for metal extraction / preserves {habitats/ landscape / resources}	allow reduces carbon emissions ignore cheaper	(2)

Question number	Answer	Mark
6(c)	$2\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 4\text{Fe} + 3\text{CO}_2$	(1)

Question number	Answer	Additional guidance	Mark
6(d)	$\frac{42.5}{5000} (1) \times 100 (1) (= 0.85)$	0.85 alone scores 2	(2)

Question number	Answer	Additional guidance	Mark
6(e)	An explanation linking - carbon / C (1) - gained oxygen (to form carbon dioxide) (1)	reject other elements for MP1 allow oxidation is gain of oxygen / oxidation is loss of electrons (1)	(2)

Question number	Answer	Additional guidance	Mark
6(f)	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 1 st step with no simplest ratio	(3)

Total for Question 6 = 11 marks

Question number	Answer	Additional guidance	Mark
7(a)(i)	phosphorus / P	reject phosphorus oxide, P ₂ O ₅	A03-2 (1)

Question number	Answer	Mark
7(a)(ii)	C nitric acid is the only correct answer A is incorrect because ethanoic acid makes ethanoate salts. B is incorrect because hydrochloric acid makes chloride salts. D is incorrect because sulfuric acid makes sulfate salts	A01-1 (1)

Question number	Answer	Additional guidance	Mark
7(a)(iii) Group B	to promote plant growth / increase (crop) yield / provide nutrients to plants	allow plants / crops grow faster ignore 'food' reject references to killing pests / weeds	A01-1 (1)

Question number	Answer	Additional guidance	Mark
7(b)(i) Group A	LHS: ammonia + sulfuric acid → (1) RHS: → ammonium sulfate (1)	allow words in either order reject additional reagents and products do not allow ammonium on LHS or ammonia on RHS	A02-1 (2)

Question number	Answer	Additional guidance	Mark
7(b)(ii) Group A	products needed on a larger scale than can be obtained in titration / owtte	ignore references to cost allow batch process allow yield in terms of quantity produced allow takes longer to produce	A01-2 (1)



Question number	Indicative content	Mark
*7(c) Group A	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlines in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 (6 marks) • pipette to measure out the sulfuric acid • into a suitable container, e.g. conical flask • add few drops of (suitable) indicator • put flask on a white tile • fill burette with ammonia solution • read level of liquid in burette • add ammonia solution from the burette • swirl flask gently / mix • add drop-wise near end-point • until indicator just changes colour • read level on burette • repeat experiment until concordant results CRYSTALLISATION • mix the same volumes of sulfuric acid and ammonia solution (determined from the titration experiment) • but leaving out the indicator • pour solution into an evaporating dish • heat the solution to point of crystallisation • leave to cool • filter off / decant crystals • leave to dry / pat dry with filter paper	AO1-2 (6)



Level	Mark	Descriptor
	0	No awardable content.
Level 1	1–2	- Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas, enquiry, techniques and procedures lacks detail. - Presents a description which is not logically ordered and with significant gaps.
Level 2	3–4	- Demonstrates chemical understanding which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. - Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing.
Level 3	5–6	- Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. - Presents a description that has a well developed structure which is clear, coherent and logical.



Level	Mark	Descriptor	Additional Guidance
	0	No rewardable material.	Read whole answer and ignore all incorrect material/ discard any contradictory material then:
Level 1	1–2	<u>Additional Guidance</u> Gives a description including limited details of the titration OR the crystallisation.	<u>Possible candidate response</u> - using a pipette, measure out some ammonia solution and add acid from the burette (ORA for chemicals) (2) - add indicator to conical flask (1) - heat the neutral solution (1) until crystals start to form (1)
Level 2	3–4	<u>Additional Guidance</u> Gives a description of carrying out the titration with some detail. OR Gives a description of carrying out the crystallisation with some detail. OR Gives a description including limited detail of the titration AND the crystallisation	<u>Possible candidate response</u> - use a pipette to measure out the acid and add to the conical flask along with a few drops of indicator. Put the flask onto a white tile. Add ammonia from the burette until the indicator changes colour, swirling the flask. (4) - heat the ammonium sulfate solution using a Bunsen burner until crystals start to form, then turn off the Bunsen and allow the mixture to cool. Filter off the crystals and pat them dry with some filter paper. (4) - use a pipette to measure out the ammonia solution. Add some indicator and add acid from the burette. Leave the ammonium sulfate solution on the windowsill to crystallise. (3)
Level 3	5–6	<u>Additional Guidance</u> Gives a detailed description of the titration and some detail about crystallisation OR Gives a detailed description of the crystallisation and some detail about carrying out a titration	<u>Possible candidate response</u> - use a pipette to measure out the acid and add to conical flask along with a few drops of indicator. Add the ammonia solution from the burette until the solution is neutral. Repeat the procedure but add the acid drop by drop near the neutralisation point. Then repeat the procedure with the known volumes but without indicator. This solution should then be heated until crystals start to form.(6) - measure out the ammonia solution using a pipette and add acid until it has been neutralised. Pour the solution into an evaporating basin and heat gently until crystals have started to form. Allow the solution to cool and crystallise by leaving it in a warm place such as on a windowsill. (6)

Total for Question 7 = 12 marks

Question number	Answer	Mark
6(a)(i)	B gold is the only correct answer A , C and D are incorrect because these metals are too high in reactivity to be found as the uncombined element	(1) AO1-1

Question number	Answer	Additional guidance	Mark
6(a)(ii)	sodium / magnesium / aluminium / zinc	reject answer including any <u>other</u> metals allow Na / Mg / Al / Zn	(1) AO1-1

Question number	Answer	Additional guidance	Mark
6(b)	40.2 / 40 with or without working scores 2 $\frac{10\ 050}{25\ 000} \times 100$ (1) = 40.2 (%) (1)	no ecf in this question 0.402 / 0.40 / 0.4 / $\frac{201}{5}$ / 59.8 scores 1 with or without working	(2) AO1-1

Question number	Answer	Additional guidance	Mark
6(c)(i)	copper oxide + carbon → copper + carbon dioxide	allow $2\text{CuO} + \text{C} \rightarrow 2\text{Cu} + \text{CO}_2$ (1) incorrectly balanced equation scores 0 allow = for → ignore heat	(1) AO2-1



Question number	Answer	Additional guidance	Mark
6(c)(ii)	reduction / redox	Reject deoxidation	(1) AO2-1

Question number	Answer	Additional guidance	Mark
6(c)(iii)	190.5 with or without working scores 2 mass = $\frac{238.5 \times 127.0}{159.0} = 190.5$ (2)	allow ECF $\frac{159.0}{127.0} = 1.25196\dots$ (1) [$\frac{238.5}{1.25196} = 190.5$ (2)] $\frac{238.5}{159.0} = 1.5$ (1) [$\times 127 = 190.5$ (2)] $\frac{127.0}{159.0} = 0.79874\dots$ (1) [$\times 238.5 = 190.5$ (2)] if fractions are evaluated they must be correctly rounded to score, but can use ECF to score MP2 e.g $127/159 = 0.799 \times 238.5 = 190.6$ (2) $127/159 = 0.798 \times 238.5 = 190.3$ (1)	(2) AO2-1

Question number	Answer	Additional guidance	Mark
6(c)(iv)	so the copper oxide completely reacts / to get maximum yield (of copper)	allow so it completely reacts allow 'so all the { <u>metal/ copper</u> } is extracted' allow so that <u>all</u> of the oxygen is removed (from the copper) / so that copper oxide is fully reduced allow 'so the reaction is complete', ignore 'so there is enough carbon' reject so the carbon completely reacts	(1) AO3-2



Question number	Answer	Additional guidance	Mark
6(d)	95 with or without working scores 3 volume of solution = $\frac{250}{1000} = 0.25$ (1) concentration = $\frac{23.8}{0.25}$ (1) = 95 (to 2 sig figs) (1) OR concentration = $\frac{23.8}{250}$ (1) = $0.0952 \times 1000 = 95.2$ (1) = 95 (to 2 sig figs) (1)	95.2 with or without working scores 2 0.095 with or without working scores 2 allow ecf for incorrect volume conversion allow correct rounding to 2 sig fig of a calculation using all the data in the question (23.8 and 250) 95.2 to any power of 10 scores 1 e.g 0.00952 / 95200 95 to any power of 10 score 2 e.g 0.95 / 9.5	(3) AO2-1

Total for Question 6 = 12 marks



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

Question Number	Answer		Mark
9(a)(ii)	final answer of 168 (tonnes) with or without working (3) OR relative formula mass $\text{Fe}_2\text{O}_3 = 2 \times 56 + 3 \times 16 (= 160)$ (1) 160 tonnes Fe_2O_3 produces $\{2 \times 56 / 112\}$ tonnes Fe (1) 240 tonnes Fe_2O_3 produces $\frac{2 \times 56}{160} \times 240$ (1) = 168 (tonnes) OR relative formula mass $\text{Fe}_2\text{O}_3 = 2 \times 56 + 3 \times 16 (= 160)$ (1) $\frac{240}{160}$ (1) = 1.5 1.5 x 112 (1) = 168 (tonnes) OR relative formula mass $\text{Fe}_2\text{O}_3 = 2 \times 56 + 3 \times 16 (= 160)$ (1) $\frac{112}{160}$ (1) = 0.7 0.7 x 240 (1) = 168 (tonnes)	allow ECF throughout $M_r [\text{Fe}_2\text{O}_3] = 160$ 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

Question Number	Answer	Additional guidance	Mark
9(b)	An explanation linking the following points - aluminium is high in reactivity / aluminium oxide is (very) stable (1) - aluminium (oxide) cannot be reduced by carbon (1)	allow carbon is less reactive than aluminium / ORA / aluminium is very reactive ignore 'aluminium is more reactive' (alone) allow carbon cannot displace aluminium / aluminium oxide does not react with carbon ignore aluminium extracted by electrolysis	(2) AO 1 1

Question Number	Answer	Mark
9(c)	electrolysis	(1) AO 3 2a

Question Number	Indicative content		Mark
9(d)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlines in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • recycling conserves raw materials/natural resources • less power/energy used • therefore conserves fossil fuels • reduces waste in landfill sites • mining for ores avoided • less damage to habitats/landscape • less energy required to melt and reform metals than to extract them • produces less carbon dioxide than extracting/ reduces carbon footprint • carbon dioxide is a greenhouse gas • greenhouse gases cause global warming • avoids use of large amounts of electricity to extract aluminium from its ore • electricity is expensive • avoids release of carbon dioxide when carbon burns • avoids use of large amounts of heat energy needed to extract iron from its ore IGNORE: • environmentally friendly • cheaper • faster • employment		(6) AO 1 1 AO 2 1
Level	Mark	Descriptor	
	0	• No awardable content	
Level 1	1-2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)	



Level 2	3-4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5-6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

(Total for question 9 = 13 marks)



Question number	Answer	Mark
9(a)	A calcium is the only correct answer B , C and D are incorrect because copper, silver and gold do not react with cold water	A01-1 (1)

Question number	Answer	Additional guidance	Mark
9(b)(i) Group B	MAGNESIUM many bubbles / bubbles produced quickly / bubbles vigorously OR test tube feels hot / warm / warmer than with zinc (1) IRON few bubbles / bubbles produced slowly / some bubbles OR test tube feels <u>very</u> slightly warm (1)	Mark answer lines first, if blank or only contain statements that can be ignored, then look at the table. Ignore hydrogen / gas / reactivity of metal reject incorrect additional observations for each metal allow 'magnesium disappears/ dissolves' ignore steady bubbling / slightly warm ignore steady bubbling / no bubbling allow does not feel warm ignore test tube feels slightly warm	A03-2 (2)

Question number	Answer	Additional guidance	Mark
9(b)(ii) Group B	a description to include the following points • apply lighted splint (to the gas) (1) • (squeaky) pop (1)	allow apply flame / ignite ignore 'squeaky pop test' reject glowing splint MP2 depends on MP1	A01-2 (2)

Question number	Answer	Additional guidance	Mark
9(b)(iii)	$\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$ H_2 (1) 2 (1)	reject H_2 , H^2 , 2H , 2h , h_2 , h^2	A02-1 (2)

Question number	Indicative content	Mark
*9(c) Group B	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlines in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. ALUMINIUM • extracted by electrolysis • aluminium is more reactive than carbon / ORA • aluminium compound is reduced / redox reaction • as heating with carbon will not work • a more powerful method / more energy is needed • electrolysis is expensive IRON • heating with carbon • iron is less reactive than carbon • iron compound is reduced / redox reaction • method cheaper than electrolysis SILVER • found uncombined / native state / often just mined • low reactivity • so reduction not needed or • silver is less reactive than carbon • heating with carbon • silver compound is reduced / redox reaction • method cheaper than electrolysis GOLD • found uncombined / native state / often just mined • least reactive / low reactivity • so reduction not needed	A02-1 (6)



Level	Mark	Descriptor
	0	No awardable content.
Level 1	1–2	- The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. - Lines of reasoning are unsupported or unclear.
Level 2	3–4	- The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. - Lines of reasoning mostly supported through the application of relevant evidence.
Level 3	5–6	- The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. - Lines of reasoning are supported by sustained application of relevant evidence.



Level	Mark	Descriptor	Additional Guidance
	0	No rewardable material.	Read whole answer and ignore all incorrect material and any references to other metals / discard any contradictory material then:
Level 1	1–2	<u>Additional Guidance</u> Correctly identifies method to obtain 1 named metal Correctly identifies method to obtain 2 named metals Correctly identified method to obtain 1 named metal with a part explanation	<u>Possible candidate response</u> (all examples, not a definitive list) Aluminium is obtained using electrolysis (1) Gold and silver are obtained as the pure metal (2) Aluminium is obtained using electrolysis because it is very reactive (2)
Level 2	3–4	<u>Additional Guidance</u> Correctly identifies methods for all four metals (with no explanation) Correctly identified method to extract at least 1 named metal with a full explanation Correctly identifies method to extract at least 2 named metals with part explanations for one (3) or two (4).	<u>Possible candidate response</u> Aluminium extracted using electrolysis, iron obtained by heating with carbon, gold and silver are found as pure metals (3) Iron is extracted by heating (the ore) with carbon as iron is less reactive than carbon and is cheaper than electrolysis (3) Silver and gold are obtained as the {pure/unreacted} metals as they are {unreactive/low in reactivity} (3)
Level 3	5–6	<u>Additional Guidance</u> Correctly identifies method to extract at least 2 metals with full explanations Correctly identifies method to extract at least 3 metals with a full explanation for one metal	<u>Possible candidate response</u> Iron is extracted by heating (the ore) with carbon as iron is less reactive than carbon and is cheaper than electrolysis, and aluminium is obtained using electrolysis because it is very reactive and heating with carbon will not work Aluminium is extracted by electrolysis, iron by heating (the ore) with carbon and silver is found as the unreacted metal as it is very unreactive and reduction is not needed

Total for Question 9 = 13 marks

