Q1.

This question is about displacement reactions.

Iron is extracted from iron oxide by a displacement reaction with carbon.

(a) Balance the equation for the reaction.

$$Fe_2O_3 + 3\ C \rightarrow \_\_\_\_\_Fe + \_\_\_\_\_CO$$

(2)

(b) Iron oxide is reduced in this reaction.

How does the equation show that iron oxide is reduced?

_____

_____

(1)

A student investigated the reactivity of four different metals, **A**, **B**, **C** and **D**.

The student:

- added each metal to aqueous solutions of each of the metal sulfates
- observed whether a reaction took place.

(e) Give **one** observation that would show a reaction took place.

_____

_____

(1)

(f) The table below shows the results.

	Metal sulfate solution			
Metal	**A sulfate**	**B sulfate**	**C sulfate**	**D sulfate**
A	×	×	✓	×
B	✓	×	✓	×
C	×	×	×	×
D	✓	✓	✓	×

✓ shows that a displacement reaction took place.
× shows that a displacement reaction did not take place.

Write metals **A**, **B**, **C** and **D** in order of reactivity.

Give a reason for your order of reactivity.

Most reactive _____

_____

_____

Least reactive _____

Reason _____

_____

(2)

Q2.

This question is about metals.

(a) Platinum is used to make jewellery.

Suggest **one** reason why platinum is used to make jewellery.

_____

_____

(1)

(c) (TRIPLE)Copper is a transition element.

Sodium is a Group 1 element.

What are **two** differences between copper and sodium?

Tick (✓) **two** boxes.

Copper has a lower melting point. ☐

Copper is harder. ☐

Copper is less dense. ☐

Copper is less reactive. ☐

Copper is less strong. ☐

(2)

(d) The metals aluminium and copper can be used to make pans for cooking.

The table below shows information about the two metals.

The higher the value for thermal conductivity, the better the metal conducts thermal energy.

	Aluminium	**Copper**
Thermal conductivity in arbitrary units	250	400
Density in g/cm^3	2.7	8.9
Cost of metal per kg in £	1.50	7.00

Evaluate the use of pans made of aluminium and of copper.

Use the table.

(4)
(Total 9 marks)

Q3.

The table gives information about some metals.

Name of the metal	Cost of one tonne of the metal in December 2003 (£)	Percentage of the metal in the crust of the earth (%)
Aluminium	883	8.2
Platinum	16720000	0.0000001
Iron	216	4.1
Gold	8236800	0.0000001

(a) Use information in the table to suggest why gold and platinum are very expensive metals.

(1)

(b) Aluminium and iron are made by *reduction* of their ores.

(i) Name the element that is removed from the ores when they are *reduced.*

(1)

(ii) Use the reactivity series on the Data Sheet to suggest a metal that would reduce aluminium ore.

(1)

(c) Aluminium is made by the reduction of molten aluminium ore, using a very large amount of electricity.

(i) How is iron ore reduced in a blast furnace to make iron?

_____

_____

_____

_____

(2)

(ii) Suggest why aluminium is more expensive than iron.

_____

_____

(1)

(Total 6 marks)

Q4.

Cassiterite is an ore of the metal tin.

(a) What is an ore?

_____

_____

(2)

(b) Some metals are obtained by removing oxygen from the metal oxide.

What name do we give to this chemical reaction?

_____

(1)

(c) Name **one** metal which must be extracted from its melted ore by electrolysis rather than by using carbon.

_____

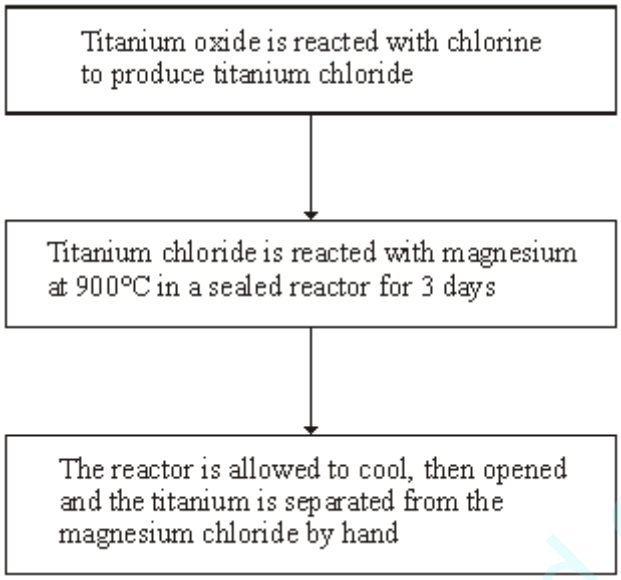
(1)

(Total 4 marks)

Q5.

Titanium is used in aircraft, ships and hip replacement joints. Titanium is as strong as steel but 45% lighter, and is more resistant to acids and alkalis.

Most titanium is produced from its ore, rutile (titanium oxide), by a batch process that takes up to 17 days.



Titanium reactors produce about 1 tonne of the metal per day.
Iron blast furnaces produce about 20 000 tonnes of the metal per hour.

(a) (TRIPLE) Give **one** property of titanium that makes it more useful than steel for hip replacement joints.

_____

(1)

(b) In the reactor magnesium is used to produce titanium. If carbon were used instead of magnesium, no titanium would be produced.

What does this tell you about the relative reactivities of carbon, magnesium and titanium?

_____

_____

_____

_____

(2)

(c) The use of titanium is limited because it is expensive.

Explain why titanium costs more than steel.

(3)

(Total 6 marks)

Q6.

Copper is a widely used metal. The main ore of copper contains copper sulfide. Copper can be extracted from copper sulfide in a three stage process.

$$Cu_2S + \_\_\_\_O_2 \rightarrow \_\_\_\_\_CuO + SO_2$$

(1)

(ii) (INTERLEAVE POLLUTANTS) Explain why there would be an environmental problem if the gas from this reaction were allowed to escape into the atmosphere.

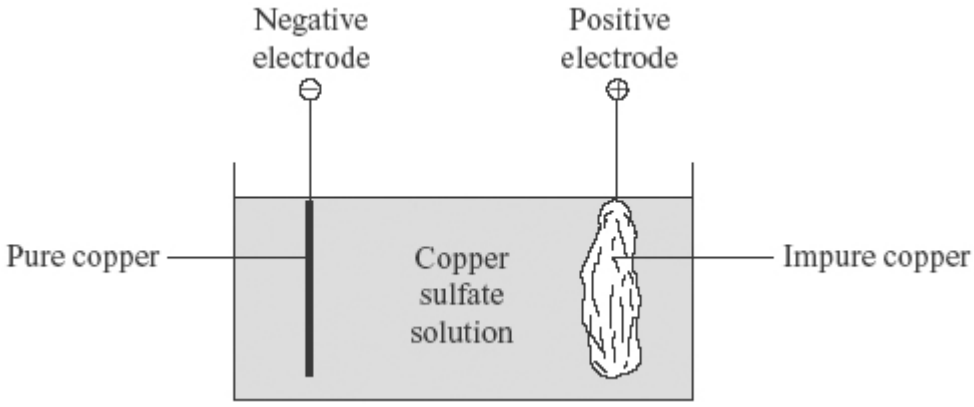
(2)

(b) In the second stage copper oxide, CuO, is reduced using carbon.

Describe and explain what happens during this reaction.

(2)

(c) During the third stage the copper can be purified as shown in the diagram.



(i) What is the name of the type of process used for this purification?

_____

(1)

(ii) Give **one** use of purified copper.

_____

(1)

(d) Copper-rich ores are running out.

New ways of extracting copper from low grade ores are being researched.

Recycling of copper may be better than extracting copper from its ores.

Explain why.

_____

_____

_____

_____

_____

_____

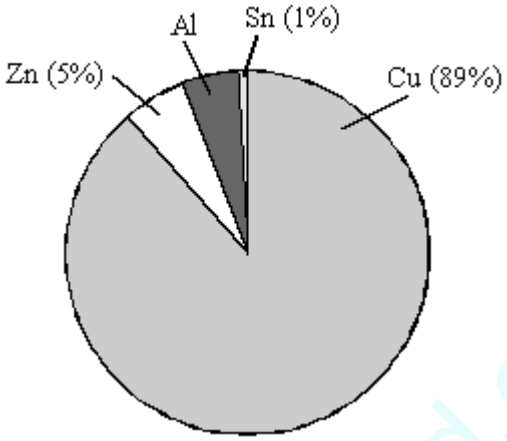
(3)

(Total 10 marks)

Q7.

The 50 Eurocent coin is made from an alloy called 'Nordic Gold'.

The pie chart shows the percentage by mass of each metal in 'Nordic Gold'.



(a) (i) Calculate the percentage of aluminium, Al, in the coin.

_____

(1)

(ii) The 50 Eurocent coin has a mass of 7 grams.
Calculate the mass of zinc, Zn, in this coin.

_____

_____

Mass of zinc = _____ g

(2)

(b) Zinc is extracted by removing oxygen from zinc oxide.

(i) What name is given to a reaction in which oxygen is removed from a substance?

_____

(1)

(ii) Explain how oxygen can be removed from zinc oxide to make zinc. Use the reactivity series on the Data Sheet to help you

_____

_____

_____

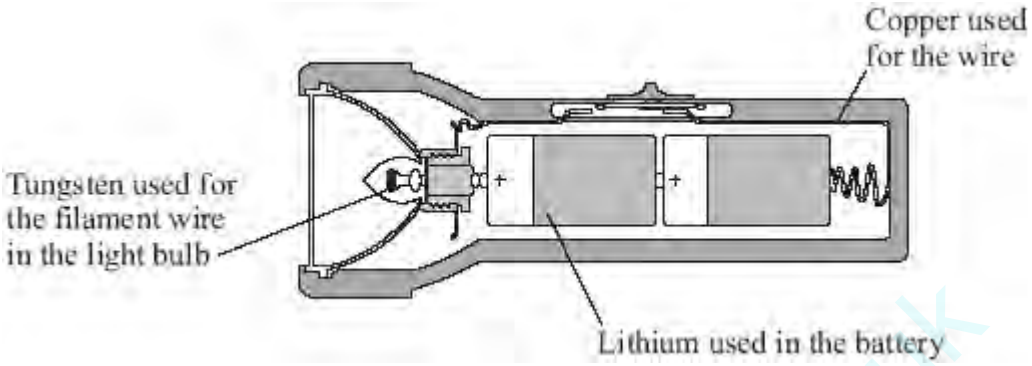
_____

(2)

(Total 6 marks)

Q8.

The diagram shows a circuit that is used in a torch. Electrons flow through this circuit.



(c) The table shows some properties of the metals used in the electrical circuit.

Metal	Melting point in °C	Boiling point in °C	Reaction with oxygen
Copper	1083	2582	Reacts **slowly** to form a thin oxide layer on surface
Lithium	179	1317	Reacts **rapidly** to form oxide
Tungsten	3370	5930	Reacts **only** when very hot to form oxide

(i) Use information from the table to suggest the order of reactivity for copper, lithium and tungsten.

most reactive _____

_____

least reactive _____

(2)

(ii) The filament wire glows because it gets very hot.

Use information from the table to suggest **one** reason why tungsten is used for the filament wire in the light bulb.

_____

_____

(1)

(d) The gas used in the light bulb is argon.

Draw a ring around the correct word in the box to complete the sentence.

Argon is used in the light bulb because it is

dense.
solid.
unreactive.

.

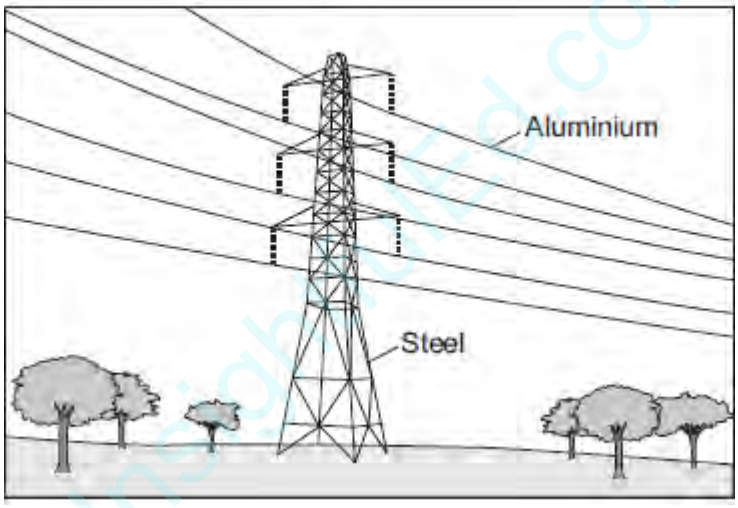
(1)

Q9.

This question is about metals.

Figure 1 shows the metals used to make pylons and the wires of overhead cables.

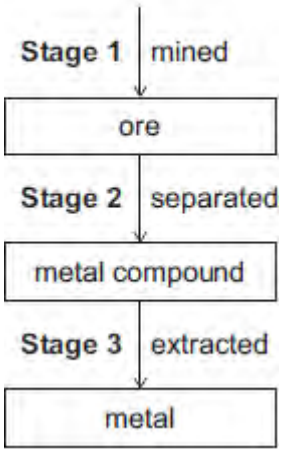
Figure 1



(a) An ore contains a metal compound.

A metal is extracted from its ore in three main stages, as shown in **Figure 2**.

Figure 2



Explain why **Stage 2** needs to be done.

_____

_____

_____

_____

(2)

(b) Cast iron from a blast furnace contains 96% iron and 4% carbon.

(i) Cast iron is not suitable for the manufacture of pylons.

Give **one** reason why.

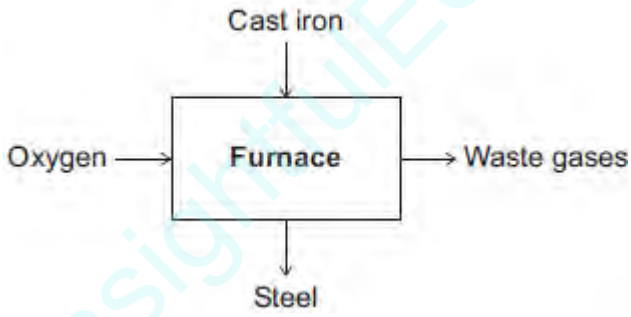
_____

_____

(1)

(ii) Most cast iron is converted into steel, as shown in **Figure 3**.

Figure 3



Describe how cast iron is converted into steel.

Use **Figure 3** to help you to answer this question.

_____

_____

_____

_____

(2)

(c) Aluminium and copper are good conductors of electricity.

(i) State **one** property that makes aluminium more suitable than copper for overhead cables.

_____

_____

(1)

(ii) (TRIPLE) How can you tell that copper is a transition metal and aluminium is **not** a transition metal from the position of each metal in the periodic table?

_____

_____

_____

_____

(2)

(iii) Copper can be extracted from solutions of copper salts by adding iron.

Explain why.

_____

_____

_____

_____

(2)

(Total 10 marks)

Q10.

Where copper ore has been mined there are areas of land that contain very low percentages of copper compounds.

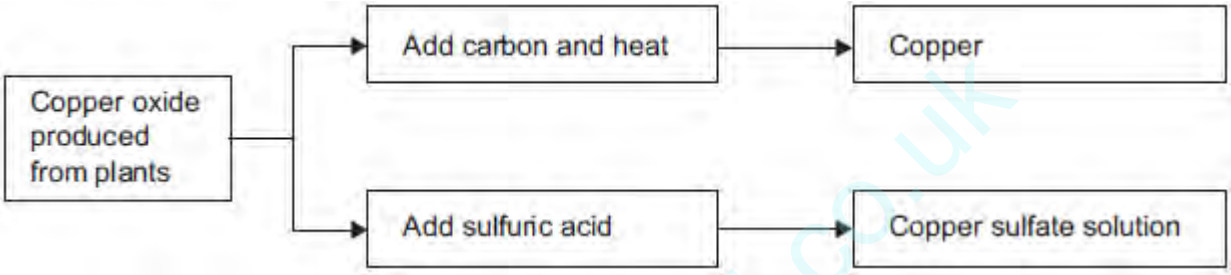
One way to extract the copper is to grow plants on the land.

The plants absorb copper compounds through their roots.

The plants are burned to produce copper oxide.

The copper oxide produced from plants can be reacted to produce copper or copper sulfate solution, as shown in **Figure 1**.

Figure 1



(a) Draw a ring around the correct answer to complete each sentence.

(i) Copper ores contain enough copper to make extraction of the metal

carbon neutral.

economical.

reversible.

(1)

(ii) Using plants to extract metals is called

photosynthesis.

phytomining.

polymerisation.

(1)

(iii) Copper oxide reacts with carbon to produce copper and

carbon dioxide.

oxygen.

sulfur dioxide.

(1)

(b) Copper is produced from copper sulfate solution by displacement using iron or by electrolysis.

(i) Complete the word equation.

copper sulfate + iron ⟶ _____ + _____

(2)

(c) Suggest **two** reasons why copper should **not** be disposed of in landfill sites.

_____

_____

_____

_____

(2)

Q11.

Cans for food and drinks are made from steel or aluminium.
The main metal in steel is iron.

By Sun Ladder (Own work) [CC-BY-SA-3.0 or GFDL],
via Wikimedia Commons

(a) Iron is extracted by heating a mixture of iron oxide and carbon in a blast furnace.

(i) Name this type of reaction.

_____

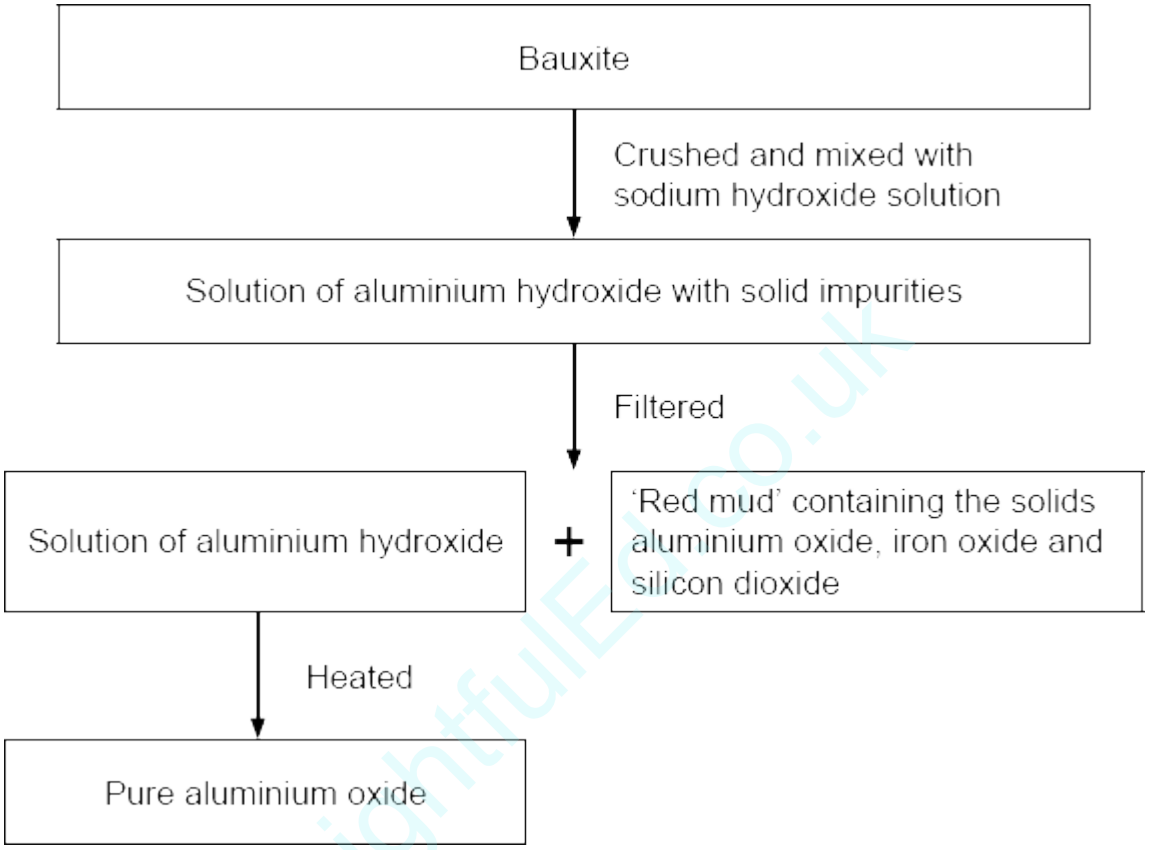
(1)

(ii) Balance the symbol equation for this reaction.

$2Fe_2O_3$ + _____ C → _____ Fe + _____ CO_2

(1)

(b) Aluminium ore, bauxite, contains aluminium oxide, iron oxide and silicon dioxide. Aluminium is extracted by electrolysis of aluminium oxide.



The 'red mud' which is dumped in very large ponds contains:

Name of solid	Percentage (%)
Aluminium oxide	10
Iron oxide	65
Silicon dioxide	25

(i) 100 tonnes of bauxite produced 50 tonnes of pure aluminium oxide and 50 tonnes of 'red mud'.

What percentage of aluminium oxide did the bauxite contain?

_____

Answer = _____ %

(1)

(ii) Apart from the solids shown in the table, name **one** other substance that would be in the 'red mud'.

_____

(1)

(iii) The purification of the aluminium oxide is usually done near to the bauxite quarries.

Suggest **one** reason why.

_____

(1)

(c) Aluminium is used to make many things including cans.

During one year in the USA:

- 100 billion aluminium cans were sold
- 55 billion aluminium cans were recycled.

Give **one** environmental impact of recycling aluminium cans and **one** ethical or social impact of recycling aluminium cans.

Environmental _____

_____

Ethical or social _____

_____

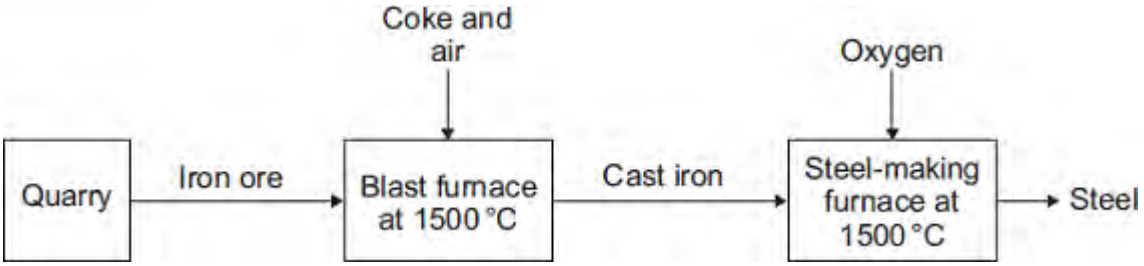
(2)

(Total 7 marks)

Q12.

The iron produced from iron ore in a blast furnace is called cast iron.

Cast iron is converted into steel in a furnace.



Iron ore contains iron oxide.
Coke contains carbon.

(a) Quarrying iron ore will have an impact on everything near to the quarry.

(i) Describe **one** positive impact and **one** negative impact of quarrying iron ore.

positive impact _____

_____

negative impact _____

_____

(2)

(ii) Draw a ring around the correct answer to complete the sentence.

Ores contain enough metal to make extraction of the metal

carbon neutral.
economical.
reversible.

(1)

(b) Many chemical reactions take place in a blast furnace.
Use the flow diagram to help you to answer this question.

Suggest how the blast furnace is heated.

_____

_____

(1)

(c) A chemical reaction for the extraction of iron is:

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

(i) Complete the word equation for this chemical reaction.

_____ + carbon monoxide → iron + _____

(2)

(ii) Draw a ring around the correct answer to complete the sentence.

Iron is extracted from its ore by

- decomposition.
- oxidation.
- reduction.

(1)

(d) Cast iron contains about 4% carbon.
Cast iron is converted into low-carbon steels.

(i) Low-carbon steel is produced by blowing oxygen into molten cast iron.

Suggest how oxygen removes most of the carbon.

_____

_____

_____

_____

(2)

(ii) Draw a ring around the correct answer to complete the sentence.

Metals, such as nickel, are added to low-carbon steels to make

the steel

- corrode easily.
- easy to shape.
- much harder.

(1)

(e) Recycling steel uses less energy than producing steel from iron ore.Tick (✓) **one** advantage and Tick (✓) **one** disadvantage of recycling steel.

Statement	**Advantage Tick (✓)**	**Disadvantage Tick (✓)**
Iron is the second most common metal in the Earth's crust.		
Less carbon dioxide is produced.		
More iron ore needs to be mined.		
There are different types of steel which must be sorted.		

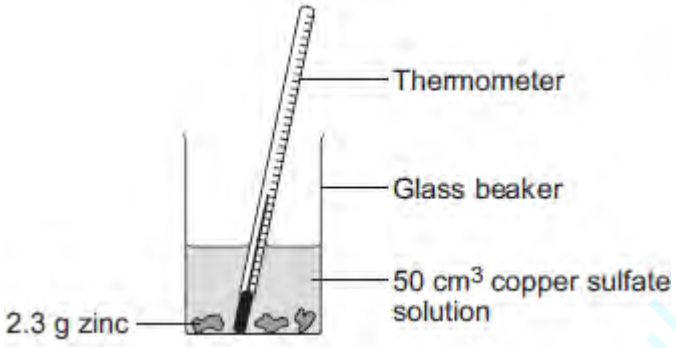
(2)(Total 12 marks)

Q14.

A student investigated the temperature change when zinc reacts with copper sulfate solution.

The student used a different concentration of copper sulfate solution for each experiment.

The student used the apparatus shown below.



The student:

- measured 50 cm^3 copper sulfate solution into a glass beaker
- measured the temperature of the copper sulfate solution
- added 2.3 g zinc
- measured the highest temperature
- repeated the experiment using copper sulfate solution with different concentrations.

The equation for the reaction is:

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

zinc + copper sulfate solution $\longrightarrow$ copper + zinc sulfate solution

(a) The thermometer reading changes during the reaction.

Give **one** other change the student could **see** during the reaction.

_____

_____

(1)

(b) Suggest **one** improvement the student could make to the apparatus.

Give a reason why this improves the investigation.

Improvement _____

_____

Reason _____

_____

(2)

(c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

The student's results are shown in the table below.

Experiment number	Concentration of copper sulfate in moles per dm^3	Increase in temperature in °C
1	0.1	5
2	0.2	10
3	0.3	12
4	0.4	20
5	0.5	25
6	0.6	30
7	0.7	35
8	0.8	35
9	0.9	35
10	1.0	35

Describe **and** explain the trends shown in the student's results.

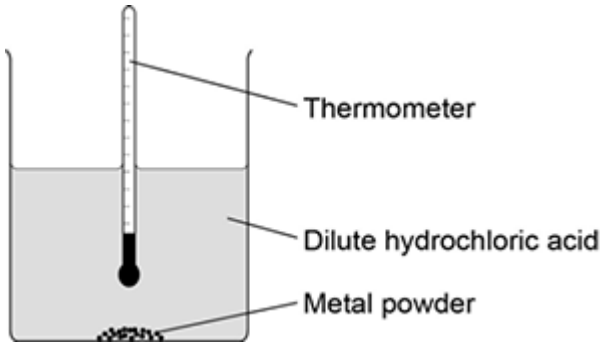
(6)

(Total 9 marks)

Q15.

A student investigated the reactivity of different metals.

The student used the apparatus shown in the figure below.



The student used four different metals.

The student measured the temperature rise for each metal three times.

The student's results are shown in the table below.

Metal	**Temperature rise in °C**			**Mean temperature rise in °C**
	Test 1	Test 2	Test 3	
Calcium	17.8	16.9	17.5	
Iron	6.2	6.0	6.1	6.1
Magnesium	12.5	4.2	12.3	12.4
Zinc	7.8	8.0	7.6	7.8

(a) Give **two** variables the student should control so that the investigation is a fair test.

1. _____

_____

2. _____

_____

(2)

(b) One of the results for magnesium is anomalous.

Which result is anomalous?

Suggest **one** reason why this anomalous result was obtained.

Result _____

Reason _____

_____

(2)

(c) Calculate the mean temperature rise for calcium.

_____

Mean temperature rise = _____ °C

(1)

(d) The temperature rose when the metals were added to sulfuric acid.

Give **one** other observation that might be made when the metal was added to sulfuric acid.
How would this observation be different for the different metals?

_____

_____

_____

_____

(2)

(e) Aluminium is more reactive than iron and zinc but less reactive than calcium and magnesium.

Predict the temperature rise when aluminium is reacted with dilute hydrochloric acid.

_____

Temperature rise = _____ °C

(1)

(Total 8 marks)

Q16.

A student investigated the reactivity of three different metals.

This is the method used.

1. Place 1 g of metal powder in a test tube.
2. Add 10 cm^3 of metal sulfate.
3. Wait 1 minute and observe.
4. Repeat using the other metals and metal sulfates.

The student placed a tick in the table below if there was a reaction and a cross if there was no reaction.

	Zinc	**Copper**	**Magnesium**
Copper sulfate	✓	x	✓
Magnesium sulfate	x	x	x
Zinc sulfate	x	x	✓

(a) What is the dependent variable in the investigation?

Tick **one** box.

Time taken ☐

Type of metal ☐

Volume of metal sulfate ☐

Whether there was a reaction or not ☐

(1)

(b) Give **one** observation the student could make that shows there is a reaction between zinc and copper sulfate.

_____

_____

(1)

(c) The student used measuring instruments to measure some of the variables.

Draw **one** line from each variable to the measuring instrument used to measure the variable.

Variable	**Measuring instrument**
	Balance
	Measuring cylinder
Mass of metal powder	
	Ruler
	Burette
Volume of metal sulfate	
	Theromometer
	Test tube

(2)

(d) Use the results shown in table above to place zinc, copper and magnesium in order of reactivity.

Most reactive _____

_____

Least reactive _____

(1)

(e) Suggest **one** reason why the student should **not** use sodium in this investigation.

_____

_____

(1)

(f) Which metal is found in the Earth as the metal itself?

Tick **one** box.

Calcium ☐

Gold ☐

Lithium ☐

Potassium ☐

(1)

(g) Iron is found in the Earth as iron oxide (Fe_2O_3).

Iron oxide is reduced to produce iron.

Balance the equation for the reaction.

___Fe_2O_3 + ___C → ___Fe + ___CO_2

(1)

(h) Name the element used to reduce iron oxide.

_____

(1)

(i) What is meant by reduction?

Tick **one** box.

Gain of iron ☐

Gain of oxide ☐

Loss of iron ☐

Loss of oxygen ☐

(1)

(Total 10 marks)

Q17.

This question is about metal oxides.

When sodium is heated in oxygen, sodium oxide is produced.

(a) Balance the equation for the reaction.

_____ Na + O_2 → 2 Na_2O

(1)

(b) Why is this an oxidation reaction?

_____

_____

(1)

(c) Sodium oxide is added to water and shaken.
Universal indicator is added.
The pH of the solution is 14

What is the colour of the universal indicator?

Tick (✓) **one** box.

Green ☐

Purple ☐

Red ☐

Yellow ☐

(1)

(d) Aluminium oxide reacts with hydrochloric acid to produce a salt.

What is the name of the salt produced?

Tick (✓) **one** box.

Aluminium chloride ☐

Aluminium nitrate ☐

Aluminium sulfate ☐

Aluminium sulfide ☐

(1)

A student investigates the solubility of four metal oxides and four non-metal oxides in water.

The student tests the pH of the solutions formed.

The table shows the student's results.

Type of oxide	Oxide	Solubility in water	pH of solution
Metal oxides	Sodium oxide	Soluble	14
	Calcium oxide	Soluble	10
	Magnesium oxide	Slightly soluble	9
	Zinc oxide	Insoluble	No solution formed
Non-metal oxides	Carbon dioxide	Soluble	5
	Sulfur dioxide	Soluble	2
	Phosphorus oxide	Soluble	1
	Silicon dioxide	Insoluble	No solution formed

The student makes two conclusions.

Conclusion 1: 'All metal oxides produce alkaline solutions.'

Conclusion 2: 'All non-metal oxides produce acidic solutions.'

(e) Explain why the student's conclusions are only partly correct.

Use information from the table above.

(4)

(f) Give an improved conclusion for metal oxides.

Use the table above.

_____

_____

_____

_____

_____

_____

_____

_____

(2)

(Total 9 marks)

Q18.

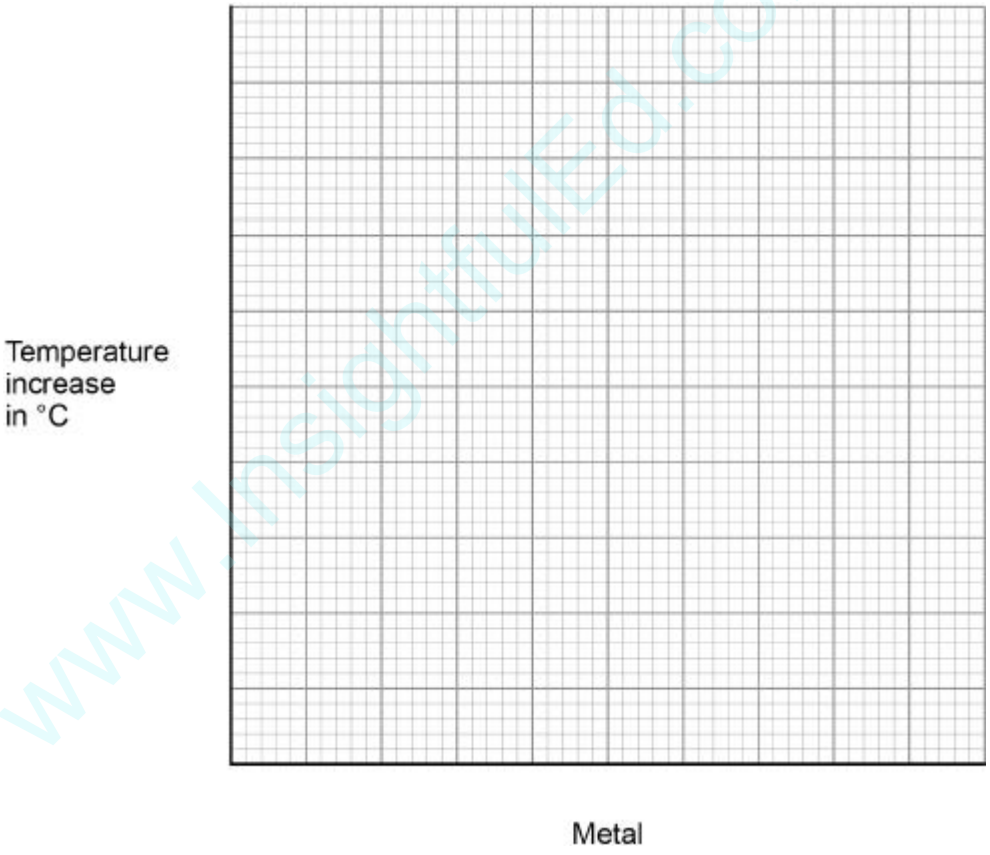
A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

The table below shows the student's results.

Metal	Temperature increase in °C
Copper	0
Iron	13
Magnesium	43
Zinc	17

(a) Plot the data from the table above on **Figure 1** as a bar chart.

Figure 1



(2)

(b) The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give **one** reason why this conclusion is **not** correct.

_____

_____

(1)

(c) The temperature change depends on the reactivity of the metal.

The student's results are used to place copper, iron, magnesium and zinc in order of their reactivity.

Describe a method to find the position of an unknown metal in this reactivity series.

Your method should give valid results.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

Q19.

This question is about displacement reactions.

Magnesium displaces zinc from zinc sulfate solution.

(c) Complete the ionic equation for the reaction.

You should include state symbols.

$$Mg(s) + Zn^{2+}(aq) \rightarrow \_\_\_\_\_ + \_\_\_\_\_$$

(2)

(d) Explain why the reaction between magnesium atoms and zinc ions is both oxidation and reduction.

_____

_____

_____

_____

(2)

Q20.

A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

This is the method used.

1. Measure 50 cm^3 of the copper sulfate solution into a polystyrene cup.
2. Record the starting temperature of the copper sulfate solution.
3. Add the metal and stir the solution.
4. Record the highest temperature the mixture reaches.
5. Calculate the temperature increase for the reaction.
6. Repeat steps 1-5 with different metals.

(a) Draw **one** line from each type of variable to the name of the variable in the investigation.

Type of variable	Name of variable in the investigation
	Concentration of solution
Dependent variable	Particle size of solid
	Temperature change
Independent variable	Type of metal
	Volume of solution

(2)

(b) The student used a polystyrene cup and not a glass beaker.

Why did this make the investigation more accurate?

Tick **one** box.

Glass is breakable ☐

Glass is transparent ☐

Polystyrene is a better insulator ☐

Polystyrene is less dense ☐

(1)

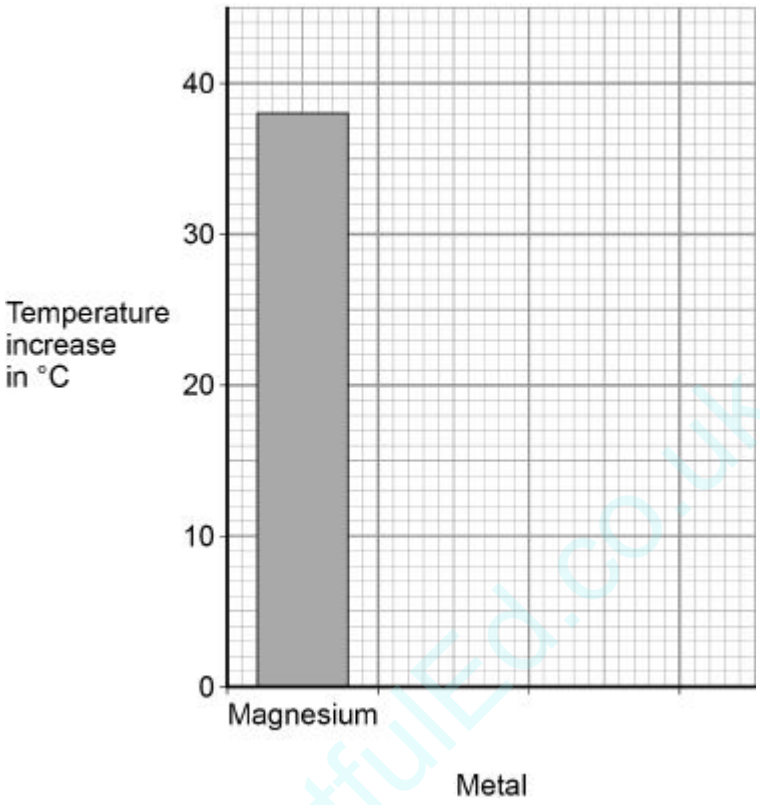
The table below shows the student's results.

Metal	**Temperature increase in °C**
Magnesium	38
Nickel	8
Zinc	16

(c) Complete **Figure 1**.

Use data from the table above.

Figure 1



(2)

(d) The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give **one** reason why this conclusion is **not** correct.

_____

_____

(1)

(e) The temperature increase depends on the reactivity of the metal.

Write the metals magnesium, nickel and zinc in order of reactivity.

Use the table above.

Most reactive _____

_____

Less reactive _____

(1)

(f) **Y** is an unknown metal.

Describe a method to find the position of **Y** in the reactivity series in Question **(e)**

_____

_____

_____

_____

_____

_____

_____

_____

(3)

Q21.

This question is about metals and the reactivity series.

(a) Which **two** statements are properties of most transition metals?

Tick (✓) **two** boxes.

They are soft metals. ☐

They form colourless compounds. ☐

They form ions with different charges. ☐

They have high melting points. ☐

They have low densities. ☐

(2)

(b) A student added copper metal to colourless silver nitrate solution.

The student observed:

- pale grey crystals forming
- the solution turning blue.

Explain how these observations show that silver is less reactive than copper.

(3)

(c) A student is given three metals, **X**, **Y** and **Z** to identify.

The metals are magnesium, iron and copper.

Plan an investigation to identify the three metals by comparing their reactions with dilute hydrochloric acid.

Your plan should give valid results.

(4)

Q22.

This question is about salts.

(a) Name the salt produced by the neutralisation of hydrochloric acid with potassium hydroxide.

_____

(1)

(b) Write an ionic equation for the neutralisation of hydrochloric acid with potassium hydroxide.

_____ + _____ → _____

(1)

(c) Soluble salts can be produced by reacting dilute hydrochloric acid with an insoluble solid.

Copper, copper carbonate and copper oxide are insoluble solids.

Which of these insoluble solids can be used to make a copper salt by reacting the solid with dilute hydrochloric acid?

Tick (✓) **one** box.

Copper and copper carbonate only	☐
Copper and copper oxide only	☐
Copper carbonate and copper oxide only	☐
Copper, copper carbonate and copper oxide	☐

(1)

A student makes crystals of magnesium sulfate.

This is the method used.

1. Add sulfuric acid to a beaker.
2. Warm the sulfuric acid.
3. Add a spatula of magnesium oxide to the beaker.
4. Stir the mixture.
5. Repeat steps 3 and 4 until there is magnesium oxide remaining in the beaker.
6. Filter the mixture.
7. Evaporate the filtrate gently until crystals start to form.
8. Leave the solution to finish crystallising.

(d) Give **one** reason for:

- step 2
- step 5
- step 6.

Step 2 _____

_____

Step 5 _____

_____

Step 6 _____

_____

(3)

(e) How should the filtrate be evaporated gently in **step 7**?

_____

_____

(1)

Q23.

This question is about metals.

(a) The table below shows information about four substances.

Substance	Melting point in °C	Boiling point in °C	Does it conduct electricity in the solid state?	Does it conduct electricity in the liquid state?
A	–117	79	No	No
B	801	1413	No	Yes
C	1535	2750	Yes	Yes
D	1610	2230	No	No

Which substance could be a metal?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(b) Explain why alloys are harder than pure metals.

_____

_____

_____

_____

_____

_____

(3)

(c) A student wants to compare the reactivity of an unknown metal, **Q**, with that of zinc.

Both metals are more reactive than silver.

The student is provided with:

- silver nitrate solution
- metal **Q** powder
- zinc powder
- a thermometer
- normal laboratory equipment.

No other chemicals are available.

Describe a method the student could use to compare the reactivity of metal **Q** with that of zinc.

Your method should give valid results.

(4)

(Total 8 marks)

Q24.

This question is about elements in the periodic table**.**

(a) Argon has the atomic number 18

Explain why argon does **not** form compounds.

Answer in terms of electrons.

_____

_____

_____

_____

(2)

(b) Phosphorus (P) is the element below nitrogen in the periodic table.

Predict the formula of the compound formed between phosphorus and hydrogen.

Formula = _____

(1)

(c) Tellurium is the element with atomic number 52

Predict whether tellurium reacts with metals.

Explain your answer.

Answer in terms of the position of tellurium in the periodic table.

_____

_____

_____

_____

(2)

Barium (Ba) is an element in Group 2 of the periodic table.

Barium reacts with hydrochloric acid.

(d) Suggest **two** observations that could be made when barium reacts with hydrochloric acid.

1 _____

_____

2 _____

_____

(2)

(e) Write a balanced symbol equation for the reaction between barium and hydrochloric acid.

_____ + _____ → _____ + _____

(3)

(Total 10 marks)

Q25.

A student investigated the reactivity of metals with hydrochloric acid.

This is the method used.

1. Measure 50 cm^3 of hydrochloric acid into a polystyrene cup.
2. Measure the temperature of the hydrochloric acid.
3. Add one spatula of metal powder to the hydrochloric acid and stir.
4. Measure the highest temperature the mixture reaches.
5. Calculate the temperature increase for the reaction.
6. Repeat steps 1 to 5 three more times.
7. Repeat steps 1 to 6 with different metals.

The table below shows the student's results.

Metal	**Temperature increase in °C**				**Mean temperature increase in °C**
	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	
Cobalt	6	7	5	9	7
Magnesium	54	50	37	55	**X**
Zinc	18	16	18	20	18

(a) Calculate the mean temperature increase **X** for magnesium in the table above.

Do **not** include the anomalous result in your calculation.

_____

_____

_____

_____

X = _____ °C

(2)

(b) Determine the order of reactivity for the metals cobalt, magnesium and zinc.

Use the table above.

Most reactive _____

_____

Least reactive _____

(1)

(c) The range of measurements either side of the mean shows the uncertainty in the mean temperature increase.

Complete the sentence.

Use the table above.

The mean temperature increase for zinc is 18 ± _____ °C

(1)

(d) What type of variable is the volume of hydrochloric acid in this investigation?

Tick (✓) **one** box.

Control ☐

Dependent ☐

Independent ☐

(1)

(e) Suggest **one** way of improving **step 3** in the method to give results which are more repeatable.

_____

_____

_____

_____

(1)

Q26.

This question is about silicon and compounds of silicon.

(a) The reactivity series sometimes includes non-metals such as carbon, hydrogen and silicon.

Silicon can be extracted by reducing silicon dioxide with different substances.

The equation for one possible reaction is:

$$2\ C(s) + SiO_2(s) \rightarrow Si(s) + 2\ CO(g)$$

Explain what this reaction shows about the position of silicon in the reactivity series.

_____

_____

_____

_____

(2)

(b) Aluminium also reduces silicon dioxide.

Carbon is used rather than aluminium to reduce silicon dioxide because carbon is cheaper than aluminium.

Carbon can be obtained by heating coal.

Aluminium is obtained from aluminium oxide.

Explain why aluminium is more expensive than carbon.

_____

_____

_____

_____

(2)

Magnesium also reduces silicon dioxide.

The equation for the reaction is:

$$2\ Mg(s) + SiO_2(s) \rightarrow Si(s) + 2\ MgO(s)$$

(c) Give **one** reason why the products are difficult to separate if magnesium is used to reduce silicon dioxide.

_____

_____

(1)

Q27.

This question is about displacement reactions.

Iron is extracted from iron oxide by a displacement reaction with carbon.

The equation for the reaction is:

$$Fe_2O_3 + 3\ C \rightarrow 2\ Fe + 3\ CO$$

(a) Which substance in the equation is reduced?

Give **one** reason for your answer.

Answer in terms of oxygen.

Substance reduced _____

Reason _____

_____

(2)

(b) Which expression shows how to calculate the mass of carbon needed to produce 1 mole of iron from iron oxide?

Relative atomic mass (A_r): C = 12

Tick (✓) **one** box.

$\frac{1}{3} \times 12\ g$ ☐

$\frac{3}{2} \times 12\ g$ ☐

$1 \times 12\ g$ ☐

$3 \times 12\ g$ ☐

(1)

A student investigated displacement reactions of four different metals represented by **A**, **B**, **C** and **D**.

A, **B**, **C** and **D** are **not** the actual chemical symbols for the metals.

The student:

- added each metal to aqueous solutions of the metal nitrates
- observed whether a reaction took place.

The table below shows information about three of the reaction mixtures.

Reaction	Metal	Metal nitrate solution	Equation
1	**A**	**B**NO_3	**A** + 2**B**NO_3 → 2**B** + **A**$(NO_3)_2$
2	**C**	**A**$(NO_3)_2$	2**C** + 3**A**$(NO_3)_2$ → 3**A** + 2**C**$(NO_3)_3$
3	**C**	**D**$(NO_3)_2$	no reaction

(c) The ionic equation for **Reaction 1** is:

$$\mathbf{A} + 2\ \mathbf{B}^{+} \rightarrow 2\ \mathbf{B} + \mathbf{A}^{2+}$$

Why is this a redox reaction?

Tick (✓) **one** box.

A gains electrons and $\mathbf{B}^{+}$ loses electrons. ☐

A loses electrons and $\mathbf{B}^{+}$ gains electrons. ☐

Both **A** and $\mathbf{B}^{+}$ gain electrons. ☐

Both **A** and $\mathbf{B}^{+}$ lose electrons. ☐

(1)

(d) Which of the four metals has the greatest tendency to form positive ions?

Use the table above.

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(e) The nitrate ion has the formula NO_3^-

Which of the four metals could be aluminium?

Explain your answer.

Use the table above.

Metal _____

Explanation _____

_____

_____

_____

(3)

Q28.

This question is about groups in the periodic table.

The elements in Group 1 become more reactive going down the group.

Rubidium is below potassium in Group 1.

(a) Rubidium and potassium are added to water.

Predict **one** observation you would see that shows that rubidium is more reactive than potassium.

_____

_____

(1)

(b) (GRP 1 INTERLEAVE) Explain why rubidium is more reactive than potassium.

_____

_____

_____

_____

_____

_____

(3)

(c) Complete the equation for the reaction of rubidium with water.

You should balance the equation.

$$Rb + H_2O \rightarrow \quad +$$

(3)

The noble gases are in Group 0.

(d) Which is a correct statement about the noble gases?

Tick (✓) **one** box.

The noble gases all have atoms with eight electrons in the outer shell.	☐
The noble gases have boiling points that increase going down the group.	☐
The noble gases have molecules with two atoms.	☐
The noble gases react with metals to form ionic compounds.	☐

(1)

Q29.

This question is about zinc and compounds of zinc.

A student produces pure crystals of zinc chloride by reacting zinc oxide with hydrochloric acid.

The equation for the reaction is:

$$ZnO(s) + 2\ HCl(aq) \rightarrow ZnCl_2(aq) + H_2O(l)$$

(a) The student adds zinc oxide to hydrochloric acid until the zinc oxide is in excess.

Give **one** observation that the student could make to show that the zinc oxide is in excess.

_____

_____

(1)

(b) Why is excess zinc oxide used rather than excess hydrochloric acid?

_____

_____

(1)

(c) Name **one other** compound that the student could add to hydrochloric acid to produce zinc chloride.

_____

_____

(1)

(d) Describe how the student should obtain crystals of zinc chloride from a solution of zinc chloride.

_____

_____

_____

_____

(2)

Zinc chloride is also produced in a displacement reaction between zinc and copper chloride solution.

The equation for the reaction is:

$$Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$$

(e) Complete the ionic equation for this reaction.

$$Zn + \_\_\_\_\_ \rightarrow Zn^{2+} + \_\_\_\_\_$$

(1)

(f) Why is zinc described as being oxidised in this reaction?

_____

_____

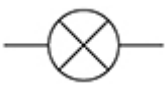
(1)

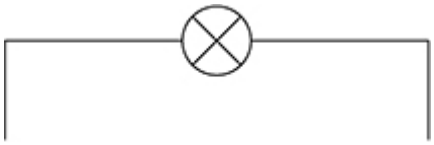
(g) (INTERLEAVE) Zinc and copper can be used with another substance to produce electricity.

Complete the figure below to show how zinc, copper and another substance can be used to light a lamp.

Label:

- zinc
- copper
- the other substance used.

The symbol  represents the lamp.



(3)

(Total 10 marks)

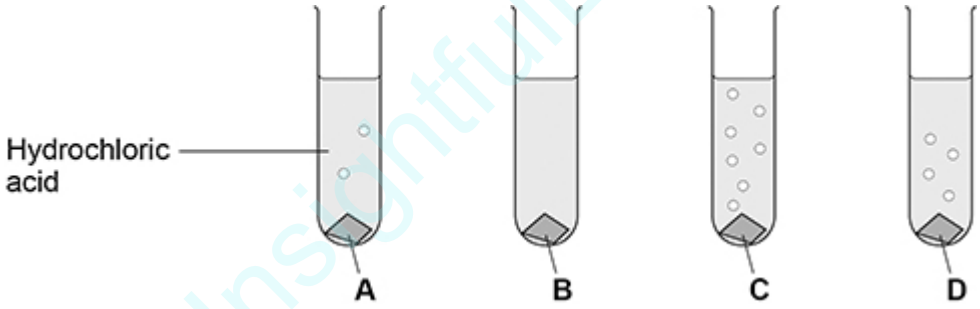
Q30.

This question is about acids.

A student added four metals, **A**, **B**, **C** and **D** to hydrochloric acid.

Figure 1 shows the rate of bubbling in each tube.

Figure 1



Use **Figure 1** to answer parts (a) and (b).

(a) Which metal is copper?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(b) Which metal is the most reactive?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(c) A metal oxide reacts with an acid to produce zinc sulfate and water.

Name the metal oxide and the acid used in this reaction.

Name of metal oxide _____

Name of acid _____

(2)

(d) Universal indicator is used to measure the pH of a solution.

Draw **one** line from each pH to the colour of universal indicator in a solution with that pH.

pH	**Colour of universal indicator**
	Blue
1	Green
	Purple
7	Red
	Yellow

(2)

A student reacts an acid with an alkali in a titration.

(e) What is the type of reaction when an acid reacts with an alkali?

Tick (✓) **one** box.

Combustion	☐
Decomposition	☐
Neutralisation	☐

(1)

(f) **Figure 2** shows a piece of equipment used to measure the volume of the acid in the titration.

Figure 2

What is the name of this piece of equipment?

Tick (✓) **one** box.

Burette ☐

Pipette ☐

Syringe ☐

Tube ☐

(1)

(Total 8 marks)

Mark schemes

Q1.

(a) Fe_2O_3 + 3 C → **2** Fe + **3** CO

allow multiples

*allow **1** mark for 2 Fe*

or

*allow **1** mark for 3 CO*

2

(b) (iron oxide) loses oxygen

ignore references to gain of electrons

1

(e) any **one** from:

- colour change (in solution)
- colour change (in metal)
- change of temperature

allow bubbles

1

(f) (most reactive) **D**

B

A

(least reactive) **C**

1

(reason) more reactive (metals) displace less reactive (metals)

*allow **D** has most (displacement) reactions*

***and C** does not react*

allow the more reactive metals have more (displacement) reactions

1

Q2.

(a) any **one** from:

- unreactive

  allow does not react with air / water / skin

  allow does not tarnish
- appearance

  allow aesthetic reasons
- easily shaped

  allow malleable

  allow easily moulded

  ignore references to cost

  ignore references to hardness / strength

  ignore references to melting / boiling point

1

(c) copper is harder

1

copper is less reactive

1

(d) **Level 2:** Some logically linked reasons are given. There may also be a simple judgement.

3-4

Level 1: Relevant points are made. They are not logically linked.

1-2

No relevant content

0

Indicative content

- copper is the better conductor
- so heats food more quickly

- copper has the higher density
- so the pan is heavier

- copper costs more per kilogram
- so the pan is more expensive to buy

- simple judgement

Q3.

(a) (very) small percentage / amount (in the Earth's crust)

any indication that there is a small amount, eg not much (left)
accept rare (elements) / rarer
accept not commonly found
ignore cannot find easily
ignore hard to extract

1

(b) (i) oxygen / O^{2-} / O

*do **not** accept* O^{2}

1

(ii) any **one** from:

- potassium / K
- sodium / Na
- calcium / Ca
- magnesium / Mg

symbols must be correct
write name and incorrect symbol, ignore symbol

1

(c) (i) heating (with) **or** hot air blown into furnace

accept high temperatures or (very) hot

1

carbon / carbon monoxide / coke / coking coal

*do **not** accept coal / charcoal accept balanced equation only*

or

carbon reacts with O_2 **or** carbon / coke burning (1)

accept balanced equation only CO / CO_2

CO reacts with the ore (1)

for naming the reducing agent

1

(ii) cost of melting ore / electricity
makes aluminium expensive (owtte)
or (large amount of) electricity used
or because you have to use electrolysis
or aluminium is higher in the reactivity series
or aluminium is harder to reduce
or unable to reduce with carbon
or the cost of purifying the bauxite

*do **not** accept harder to extract / produce*
*more energy is **not** enough*

1

[6]

Q4.

(a) *ideas that it is a*

- compound of metal/metal oxide/combined (NOT mixed) cpd/ named cpd O^{2-}/S^{2-}/CO_3^{2-} etc
- found naturally/in rocks/in Earth's Crust

for 1 mark each

2

(b) reduction (accept smelting/refining but not electrolysis)

for 1 mark

1

(c) One example. Al or above in Reactivity Series
ie Group I or II metals NOT Pb/Cu or compounds

for 1 mark

1

[4]

Q5.

(a) any **one** from:

- light(er) / less dense
  ignore stronger
- resistant to acids / alkalis / chemical
  accept resistant to corrosion

1

(b) any **two** from:

it must be clear
list principle applies
allow reverse argument
ignore reference to temperature

- magnesium is <u>more</u> reactive than titanium
  magnesium is above titanium in the reactivity series
- titanium is <u>more</u> reactive than carbon
- magnesium is <u>more</u> reactive than carbon
- magnesium is <u>most</u> reactive
- carbon is <u>least</u> reactive

2

(c) any **three** from:

it = titanium
*ignore references to cost / easier / usefulness alone **or** references to incorrect processes*

- takes a long time to process
- low abundance (of ore)
- small amount produced
- batch process used **or** blast furnace is continuous
- more stages used to manufacture titanium
  allow ≥ 3 / many / several
- more energy used (per tonne of titanium)
  allow high energy requirement
  ignore references to temperature
- magnesium / chlorine is expensive
- labour intensive

3

[6]

Q6.

(a) (i) $Cu_2S + 2O_2 \rightarrow 2CuO + SO_2$

accept fractions and multiple

1

(ii) any **two** from:

- sulfur dioxide

  accept sulphur dioxide / sulphur oxide / SO_2

- causes acid rain

  ignore other comments eg global warming / ozone / global dimming / greenhouse effect

- consequence of acid rain eg kills fish / plants

2

(b) any **two** from:

- heat (copper oxide with carbon)
- oxygen is removed by carbon

  accept copper (oxide) loses oxygen

  or

  carbon gains oxygen

  accept carbon oxide

  or

  carbon monoxide / carbon dioxide is produced

  or

  carbon displaces copper

  accept a correct word or balanced symbol equation

- because carbon is more reactive than copper

  allow a correct comparison of reactivity

2

(c) (i) electrolysis

accept electroplating

1

(ii) (electrical) wiring / appliances / coins / pipes / cladding for buildings / jewellery / <u>making</u> alloys

1

or

named alloys

(d) any **three** explanations from:

for recycling

- less acid rain (pollution)
- copper reserves last longer / conserved

or

do not run out

- energy for extraction (saved)

or

less energy required

- less mining / quarrying
- less waste (copper) / electrical appliances dumped

or

less landfill

against recycling

- collection problems
- transport problems
- difficult to separate copper from appliances
- energy used to melt the collected copper

ignore electrolysis / pollution
ignore ideas about less machinery / plant
ignore idea of cost

3

[10]

Q7.

(a) (i) 5(%)

1

(ii) 0.35

$$\frac{5}{10} \times 7$$

for 1 mark

2

(b) (i) reduction

accept (it's) reduced
*do **not** accept redox / deoxidation*

1

(ii) heat with / reduce / react with **or** (chemical) reaction

1

with a metal / element / substance higher in reactivity

ignore displace
*accept higher <u>named</u> elements **or** symbol*
accept carbon monoxide / coal / coke

*correct word equation for **2** marks*
*correct formulas for **1** mark*
*correct <u>balanced</u> symbol equation for **2** marks*

1

or

electrolysis:
molten (1)
electrolysis (1)

[6]

Q8.

(c) (i) lithium>copper>tungsten **or**

Li>Cu>W

all correct
*allow **1** mark for one metal in the correct position*

2

(ii) has high / highest melting point

accept has high / highest boiling point

or

can withstand the highest temperature

1

(d) unreactive

1

[6]

Q9.

(a) The ore is not pure or contains impurities or the ore does not contain 100% of the metal compound

allow to concentrate the metal or metal compound

1

rock / other compounds need to be removed / separated

1

(b) (i) (cast iron is) brittle

allow not strong
ignore weak

1

(ii) the oxygen reacts with carbon

allow carbon burns in oxygen or is oxidised

1

reducing the percentage of carbon in the mixture
or producing carbon dioxide

1

(c) (i) aluminium has a low density

1

(ii) (because copper) is in the central / middle (block of the periodic table)

1

whereas aluminium is in Group 3 (of the periodic table)

1

(iii) iron is more reactive (than copper)
ignore cost

1

so copper is displaced / reduced

1

[10]

Q10.

(a) (i) economical

1

(ii) phytomining

1

(iii) carbon dioxide

1

(b) (i) copper / Cu

1

iron sulfate / $FeSO_4$

1

(c) any **two** from:
ignore not biodegradable or does not decay

- copper ores are limited / running out
  allow copper is running out
- copper can be recycled
- copper can be reused
- copper is expensive
- landfill sites are filling up
- copper compounds are toxic
  allow copper is toxic

2

[8]

Q11.

(a) (i) reduction

accept redox / smelting

1

(ii) 3 4 3

1

(b) (i) 55

ignore other units

(ii) Water

accept sodium hydroxide

accept correct formulae H_2O or NaOH

1

(iii) any **one** from:

- save energy / fuel for transporting the ore

  accept less (cost of) transport allow transported quickly

- (old) quarries nearby for waste/red mud

1

(c) **Environmental**

any **one** from:

- less mining / quarrying (of bauxite)

  allow loss of habitat / less qualified noise pollution

- less landfill space needed / used

  allow less red mud / waste

- less use of fossil fuels / energy

- less carbon dioxide produced

1

Ethical or social

any **one** from:

- saves resources

  allow using resources more than once

- creates (local) employment

  *if answers reversed and both correct award **1** mark*

- more people aware of the need for recycling

  allow less qualified noise pollution if not given in environmental

1

[7]

Q12.

(a) (i) Positive impact

any **one** from:

- provides employment **or**
- improves local economy
- improved transport - new roads are built, new rail links
- after use the quarry could provide recreation facilities

1

Negative impact

any **one** from:

- destruction of animal habitats
- fewer plants and trees to absorb carbon dioxide
- visual pollution **or** noise pollution **or** atmospheric / air pollution
  allow dust pollution
- more traffic
- uses non-renewable resources
  allow pollutants from burning diesel

1

(ii) economical

1

(b) carbon / coke burns (in oxygen / air)
accept carbon / coke reacts with oxygen / air

1

(c) (i) iron oxide (reactant)
must be words

1

carbon dioxide (product)

1

(ii) reduction

1

(d) (i) oxygen <u>reacts with</u> carbon

1

or

oxygen and carbon produce carbon dioxide / carbon monoxide

carbon dioxide / carbon monoxide is a <u>gas</u>

or

the carbon is removed as a gas

1

(ii) much harder

1

(e) Advantage:

less carbon dioxide is produced

1

Disadvantage:

there are different types of steel which must be sorted

1

[12]

Q14.

(a) any **one** from:

- solution becomes colourless or colour fades
- zinc becomes bronze / copper coloured
  allow copper (forms) or a solid (forms)
- zinc gets smaller
  allow zinc dissolves
- bubbles or fizzing.
  ignore precipitate

1

(b) improvement:
use a plastic / polystyrene cup or add a lid
accept use lagging / insulation

1

reason - must be linked
reduce / stop heat loss
OR
improvement:

use a digital thermometer
allow use a data logger

reason - must be linked

more accurate or easy to read or stores data
allow more precise or more sensitive
ignore more reliable
ignore improvements to method, eg take more readings

1

(c) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking Guidance and apply a 'best–fit' approach to the marking.

0 marks

No relevant content

Level 1 (1−2 marks)

There is a statement about the results.

Level 2 (3−4 marks)

There are statements about the results. These statements may be linked or may include data.

Level 3 (5−6 marks)

There are statements about the results with at least one link and an attempt at an explanation.

Examples of chemistry points made in the response:

Description:

Statements

Concentration of copper sulfate increases

Temperature change increases

There is an anomalous result

The temperature change levels off

Reaction is exothermic

Linked Statements

Temperature change increases as concentration of copper sulfate increases

The temperature change increases, and then remains constant

After experiment 7 the temperature change remains constant

Statements including data

The trend changes at experiment 7

Experiment 3 is anomalous

Attempted Explanation

Temperature change increases because rate increases

Temperature change levels off because the reaction is complete

Explanation

As more copper sulfate reacts, more heat energy is given off

Once copper sulfate is in excess, no further heat energy produced

6

[9]

Q15.

(a) any **two** from:

- concentration / volume of dilute hydrochloric acid
- mass of metal powder
- surface area of metal powder
- stirring (of any) / rate of stirring

allow reacted for the same length of time

2

(b) 4.2 °C

allow Magnesium Test 2

1

and any **one** from:

- lower mass of magnesium added
- surface area of magnesium too low
- magnesium coated in magnesium oxide (so took a while to start reacting)
- not stirred
- not stirred as quickly as the other metals
- not reacted for as long a time as the other metals

allow reason for break in circuit

1

(c) 17.4(°C)

1

(d) bubbles of gas

1

more (bubbles) seen with calcium than other metals

allow any correct comparison between two metals

1

(e) any value between 7.9 °C and 12.3 °C

1

[8]

Q16.

(a) Whether there was a reaction or not

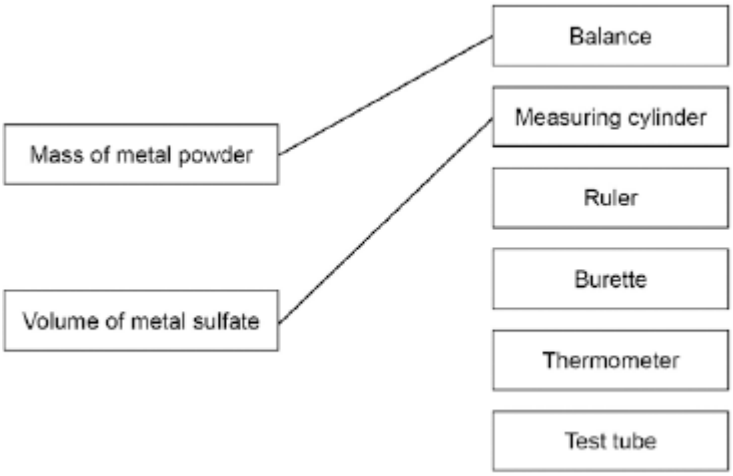
1

(b) brown / orange / dark deposit on zinc
or
blue solution turns colourless / paler

1

(c)

Variable	**Measuring instrument**



more than one line drawn from a variable negates the mark

2

(d) (Most reactive) **Magnesium**
Zinc
(Least reactive) **Copper**
must all be correct

1

(e) would not be safe **or**

too reactive
allow too dangerous

1

(f) Gold

1

(g) $2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$
allow multiples

1

(h) carbon

1

(i) Loss of oxygen

1

[10]

Q17.

(a) $4\ Na + O_2 \rightarrow 2Na_2O$
allow multiples

1

(b) (sodium) gains oxygen

1

(c) purple

1

(d) aluminium chloride

1

(e) **Level 2 (3-4 marks):**
Relevant reasons are identified, given in detail and logically linked to form a clear account.

Level 1 (1-2 marks):
Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

Level 0
No relevant content

Indicative content

conclusion 1
- pH values above 7 are alkaline
- sodium oxide, calcium oxide and magnesium oxide do form alkaline solutions (so correct for those)
- not all metal oxides form solutions (so incorrect for zinc oxide)

conclusion 2
- pH values below 7 are acidic
- carbon dioxide, sulfur dioxide and phosphorus oxide do form acidic solutions (so correct for those)
- not all non-metal oxides form solutions (so incorrect for silicon oxide)]

4

(f) metal oxides produce alkaline solutions if they dissolve in water

*allow **1** mark for most metal oxides produce alkaline solutions*

2

[10]

Q18.

(a) all 4 metals labelled and suitable scale on *y*-axis

magnesium value must be at least half the height of the grid

1

all bars correctly plotted

allow a tolerance of ±½ a small square

ignore width and spacing of bars

*allow **1** mark if copper not included and other 3 bars plotted correctly*

1

(b) temperature increases

allow (because) energy / 'heat' is transferred to the surroundings
allow energy / 'heat' is given out

or

temperature does not decrease

allow energy / 'heat' is not taken in (from the surroundings)

allow the energy of the products is less than the energy of the reactants

1

ignore because it is exothermic
ignore references to copper

(c) suitable method described

1

the observations / measurements required to place in order

dependent on a suitable method

1

an indication of how results would be used to place the unknown metal in the reactivity series

1

a control variable to give a valid result

1

approaches that could be used

approach 1:
add the unknown metal to copper sulfate solution (1)

measure temperature change (1)

place the metals in order of temperature change (1)

any **one** from (1):
- same volume of solution
- same concentration of solution
- same mass / moles of metal
- same state of division of metal

approach 2:
add the metal to salt solutions of the other metals
or
heat the metal with oxides of the other metals (1)

measure temperature change (only if salt solutions used)
or
observe whether a chemical change occurs (1)

place the metals in order of temperature change **or**
compare whether there is a reaction to place in correct order (1)

any **one** from (1):
- same volume of salt solutions
- same concentration of salt solutions
- same (initial) temperature of salt solutions
- same mass / moles of metal **or** metal oxide
- same state of division of metal **or** metal oxide

approach 3:
add all of the metals to an acid (1)

measure temperature change or means of comparing rate of reaction (1)

place the metals in order of temperature change or rate of reaction (1)

any **one** from (1):
- same volume of acid
- same concentration of acid
- same (initial) temperature of acid
- same mass / moles of metal
- same state of division of metal

approach 4:
set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1)

measure the voltage of the cell (1)

place the metals in order of voltage (1)

any **one** from (1):
- same electrolyte
- same concentration of electrolyte
- same (initial) temperature of acid
- same temperature of electrolyte

Q19.

(c) $Mg(s) + Zn^{2+}(aq) \rightarrow Mg^{2+}(aq) + Zn(s)$

allow multiples

*allow **1** mark for Mg^{2+} + Zn with missing or incorrect state symbols*

2

(d) magnesium (atoms) are oxidised because they lose electrons

1

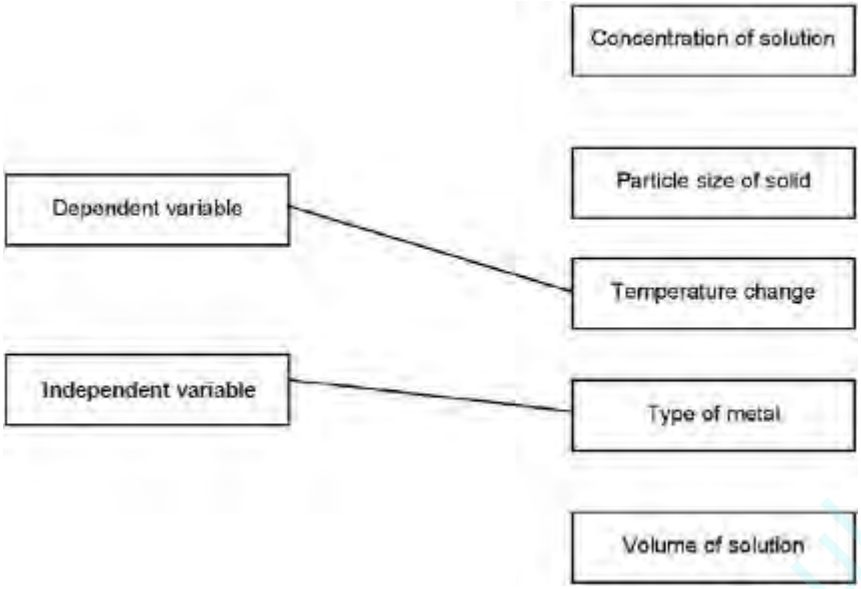
(and) zinc (ions) are reduced because they gain electrons

*if no other marks awarded allow **1** mark for magnesium (atoms) lose electrons and zinc (ions) gain electrons 1*

1

Q20.

(a)



*allow **one** mark if answers are reversed*

1
1

(b) polystyrene is a better insulator

1

(c) both bars labelled

1

both bars correctly plotted

allow tolerance of ±½ small square

ignore width and spacing of bars

*if no other mark scored, allow **1** mark for any one bar correctly plotted and labelled*

1

(d) temperature increases

allow (because) energy / 'heat' is transferred to the surroundings

or

temperature does not decrease

energy / 'heat' is not taken in from the surroundings

allow the energy of the products is less than the energy of the reactants

1

(e) (most reactive)

magnesium

(zinc)

nickel

this order only

1

(f) suitable method described

1

the observations / measurements required to place in order

1

an indication of how results would be used to place the unknown metal in the reactivity series

1

approaches that could be used:

approach 1:
add the unknown metal to copper sulfate solution (1)

measure temperature change (1)

place the metals in order of temperature change (1)

approach 2:
add the metal to salt solutions of the other metals
or
heat the metal with oxides of the other metals (1)

measure temperature change (only if salt solutions used)
or
observe whether a chemical change occurs (1)

compare temperature change or whether there is a reaction to place in correct order (1)

approach 3:
add all of the metals to an acid (1)

measure temperature change or means of comparing rate of reaction (1)

place the metals in order of temperature change or rate of reaction (1)

approach 4:
set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1)

measure the voltage of the cell (1)

place the metals in order of voltage (1)

Q21.

(a) they form ions with different charges

1

they have high melting points

1

(b) the (grey) crystals are silver

1

the copper ions (produced) are blue

allow the copper nitrate / compound (produced) is blue

1

(because) copper displaces silver

1

(c) **Level 2:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.

3–4

Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content

Key steps

- add the metals to (dilute) hydrochloric acid
- measure temperature change
  or
  compare rate of bubbling
  or
  compare colour of resulting solution

for copper:

- no reaction
- shown by no temperature change
  or
  shown by no bubbles

for magnesium and iron:

- magnesium increases in temperature more than iron
  or
  magnesium bubbles faster than iron
  or
  magnesium forms a colourless solution and iron forms a coloured solution

Control variables

- same concentration / volume of hydrochloric acid
- same mass / moles of metal
- same particle size of metal
- same temperature (of acid if comparing rate of bubbling)

Q22.

(a) potassium chloride

allow KCl

1

(b) $H^+ + OH^- \rightarrow H_2O$

ignore state symbols

1

(c) copper carbonate and copper oxide only

1

(d) (Step 2) to speed up the reaction

1

(Step 5) to make sure all the (hydrochloric) acid reacts

1

(Step 6) to remove the excess magnesium oxide

ignore to remove impurities

1

(e) using a (boiling) water bath
or
using an electric heater

1

Q23.

(a) C

1

(b) (in an alloy) the atoms are of different sizes

1

(so) the layers (of atoms in an alloy) are distorted

1

(so in an alloy) the layers slide over each other less easily (than in a pure metal)

1

(c) measure temperature change

*allow measure the temperature before **and** after the reaction*

1

when each metal is added to silver nitrate solution

1

same concentration / volume of solution
or
same mass / moles of metal

allow same initial temperature (of silver nitrate solution)

1

the greater the temperature change the more reactive

1[8]

Q24.

(a) (atoms of) argon have a stable arrangement of electrons

allow (atoms of) argon have a full outer shell (of electrons)

1

(so) argon (atoms) do not share / transfer electrons

1

(b) PH_3

allow H_3P

1

(c) yes, because tellurium is towards the right of the periodic table

allow yes, because tellurium is in Group 6

1

(so) tellurium is a non-metal

allow (so) tellurium will gain electrons (from a metal)

1

MP2 is dependent upon MP1 being awarded

OR

yes, because tellurium is in the same group as oxygen / sulfur (1)

(and) oxygen / sulfur will react with metals (1)

allow (so) tellurium is a non-metal

allow (so) tellurium will gain electrons (from a metal)

OR

no, because tellurium is towards the bottom of the periodic table (1)

(so) tellurium is a metal (1)

allow (so) difficult for tellurium to gain electrons (from a metal) (1)

OR

cannot predict as tellurium is towards the bottom and to the right of the periodic table (1)

(so) don't know whether tellurium is a metal or non-metal (1)

allow (so) don't know whether tellurium will gain electrons

(d) any **two** from:

- effervescence / fizzing / bubbles

  ignore produces a gas
- barium disappears

  allow barium gets smaller
- forms a colourless solution
- temperature increases

allow barium moves around

2

ignore references to floating / flames

(e) $Ba + 2\ HCl \rightarrow BaCl_2 + H_2$

allow multiples

3

*allow **1** mark for $BaCl_2$*
*allow **1** mark for H_2*

ignore state symbols

[10]

Q25.

(a) $\frac{54 + 50 + 55}{3}$

1

= 53 (°C)

*if no other mark awarded allow **1** mark for* $\frac{54 + 50 + 37 + 55}{4}$ *= 49 (°C)*

1

(b) (most reactive) magnesium zinc
(least reactive) cobalt

*allow ecf from question **(a)***

1

(c) (18 ±) 2 (°C)

1

(d) control

1

(e) use the same mass of metal / powder

1

Q26.

(a) silicon is less reactive than carbon

allow converse
allow silicon is below carbon (in the reactivity series)

1

(because) carbon displaces silicon (from silicon dioxide)

ignore (because) carbon reduces silicon dioxide

1

ignore references to hydrogen

(b) more energy is needed (to obtain aluminium)

ignore references to electricity

1

(because) aluminium is obtained (from aluminium oxide) by electrolysis

1

(c) both products are solid

1

Q27.

(a) (substance reduced) Fe_2O_3

allow iron oxide

1

(reason)
(Fe_2O_3) loses oxygen

MP2 is dependent upon MP1 being awarded

ignore Fe^{3+} gains electrons

1

(b) $\frac{3}{2} \times 12g$

1

(c) **A** loses electrons and $\mathbf{B}^+$ gains electrons

1

(d) **D**

1

(e) (metal) **C**

1

(explanation) aluminium forms ions with a charge 3+

allow aluminium forms Al^{3+} (ions)

1

(so) 3 nitrate ions are needed for 1 aluminium ion

allow (so) 3 nitrate ions are needed to balance the 3+ charge on 1 aluminium (ion)

1

(f) (percentage atom economy =)

$$\frac{A_r\mathbf{X}}{A_r\mathbf{X} + 54} \times 100 = 77.3$$

1

100 $A_r\mathbf{X}$ = 77.3 ($A_r\mathbf{X}$ + 54)

allow $A_r\mathbf{X}$ = 0.773 ($A_r\mathbf{X}$ + 54)

allow correct use of an incorrectly determined value of the M_r of the non-useful reactant atoms

1

22.7 $A_r\mathbf{X}$ = 4174.2

allow 0.227 $A_r\mathbf{X}$ = 41.742

1

$A_r\mathbf{X}$ = 184

allow 183.8854626 correctly rounded to at least three significant figures

1

alternative approach 1:

($3M_r$ H_2O = (3 × 16) + (6 × 1) =) 54
and (percentage = 100 - 77.3 =) 22.7% (1)

(total M_r of reactants =)
$\frac{100}{22.7} \times 54$ (1)

allow correct use of an incorrectly determined value for $3M_r$ H_2O and/or percentage of unwanted products

= 238 (1)

(A_r**X** = 238 - 54)
or
$\left(A_r\mathbf{X} = 238 \times \frac{77.3}{100}\right)$
= 184 (1)

allow correct use of an incorrectly determined value of total M_r of reactants and/or value for $3M_r$ H_2O

allow 183.8854626 correctly rounded to at least three significant figures

alternative approach 2:

($3M_r$ H_2O = (3 × 16) + (6 × 1) =) 54
and (percentage = 100 - 77.3 =) 22.7% (1)

$\left(\frac{1}{22.7} \times 54 =\right) 2.3788546$ (1)

allow correct use of an incorrectly determined value for $3M_r$ H_2O and/or percentage of unwanted products

2.3788546 × 77.3 (1)

allow correct use of an incorrectly determined value for 1% of the total M_r of reactants

= 184 (1)

allow 183.8854626 correctly rounded to at least three significant figures

[12]

Q28.

(a) any **one** from:

- more vigorous bubbling (for rubidium)
- bigger / brighter flame (for rubidium)

allow converse statements for potassium

allow (rubidium) catches fire more quickly

allow (rubidium) moves around more quickly

allow (rubidium) explodes

allow (rubidium) disappears more quickly

allow (rubidium) melts more quickly

1

(b) (rubidium's) outer shell / electron is further from the nucleus

allow the (rubidium) atom is larger

allow (rubidium) has more shells

1

(so) there is less (electrostatic) attraction between the nucleus and the outer electron (in rubidium)

allow (so) there is more shielding between the outer electron and the nucleus (in rubidium)

1

(so) the outer electron (in rubidium) is more easily lost

allow (so) less energy is needed to remove the (outer) electron (in rubidium)

1

allow energy level for shell throughout

allow converse argument in terms of potassium

(c) $2\ Rb + 2\ H_2O \rightarrow 2\ RbOH + H_2$

ignore state symbols

allow multiples

*allow **1** mark for H_2*

*allow **1** mark for RbOH*

3

(d) the noble gases have boiling points that increase going down the group

1

(e) (relative atomic mass =) $\frac{(90.48 \times 20)+(0.27 \times 21)+(9.25 \times 22)}{100}$

allow (relative atomic mass =) $\frac{1809.6 + 5.67 + 203.5}{100}$

allow (relative atomic mass =) 18.096 + 0.0567 + 2.035

1

= 20.1877

1

= 20.2

allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses all of the values in the table

ignore units

1

[11]

Q29.

(a) (zinc oxide) solid remaining

allow (zinc oxide) solid no longer disappears

ignore references to colour / effervescence

1

(b) (excess) zinc oxide can be filtered off

allow converse statement for hydrochloric acid

allow separation / removal of (excess) zinc oxide is easier

ignore to ensure all the (hydrochloric) acid is used up

1

(c) any **one** from:

- zinc hydroxide

  allow $Zn(OH_2)$

- zinc carbonate

  allow $ZnCO_3$

1

(d) heat (the solution) until crystallisation point is reached

allow heat (the solution) until crystals start to form

allow heat (the solution) to reduce the volume

allow heat (the solution) to evaporate (some of the water)

1

leave the solution (to cool / crystallise)

1

*if no other mark is awarded allow **1** mark for heat the solution to dryness*

(e) $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$

ignore state symbols

1

(f) zinc (atoms) lose (2) electrons

*do **not** accept references to oxygen*

1

(g) (a diagram showing)

solution in a container

ignore labels

1

zinc electrode
and
copper electrode
both inserted into solution

ignore polarities on electrodes

1

complete circuit that would function as an electrochemical cell including a labelled electrolyte

allow a named electrolyte in solution

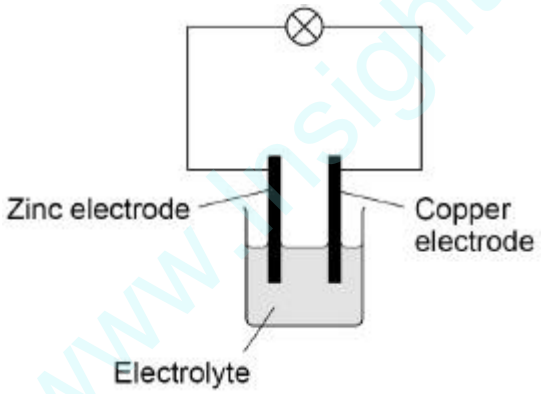
allow a named molten electrolyte

*do **not** accept cell / battery in external circuit*

*do **not** accept a wire between the electrodes*

1

an answer of



scores **3** marks

ignore voltmeter / ammeter regardless of location

[10]

Q30.

(a) **B**

1

(b) **C**

1

(c) zinc (oxide)

allow ZnO

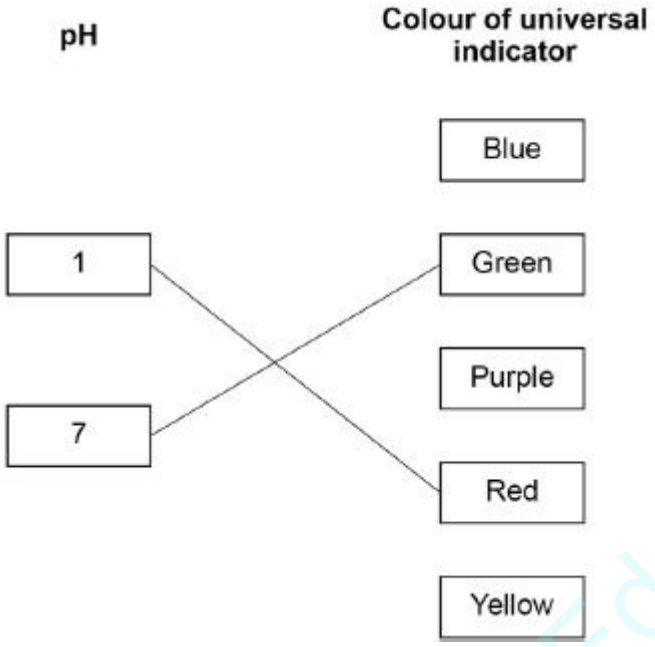
1

sulfuric (acid)

allow H_2SO_4

1

(d)



*do **not** accept more than one line from a box on the left*

2

(e) neutralisation

1

(f) burette

1

[8]