Chemical Changes

Q1.

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)

Q2.

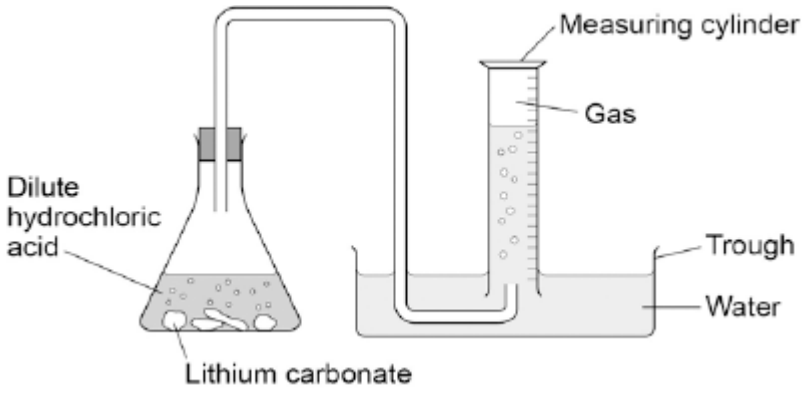
Lithium carbonate reacts with dilute hydrochloric acid.

A group of students investigated the volume of gas produced.

This is the method used.

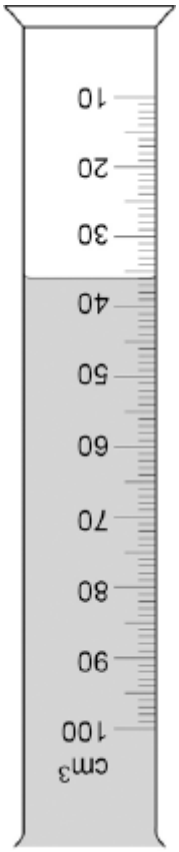
1. Place a known mass of lithium carbonate in a conical flask.
2. Measure 10 cm^3 of dilute hydrochloric acid using a measuring cylinder.
3. Pour the acid into the conical flask.
4. Place a bung in the flask and collect the gas as shown in **Figure 1**.

Figure 1



(a) **Figure 2** shows the measuring cylinder.

Figure 2



What volume of gas has been collected?

Volume = _____ cm^3

(1)

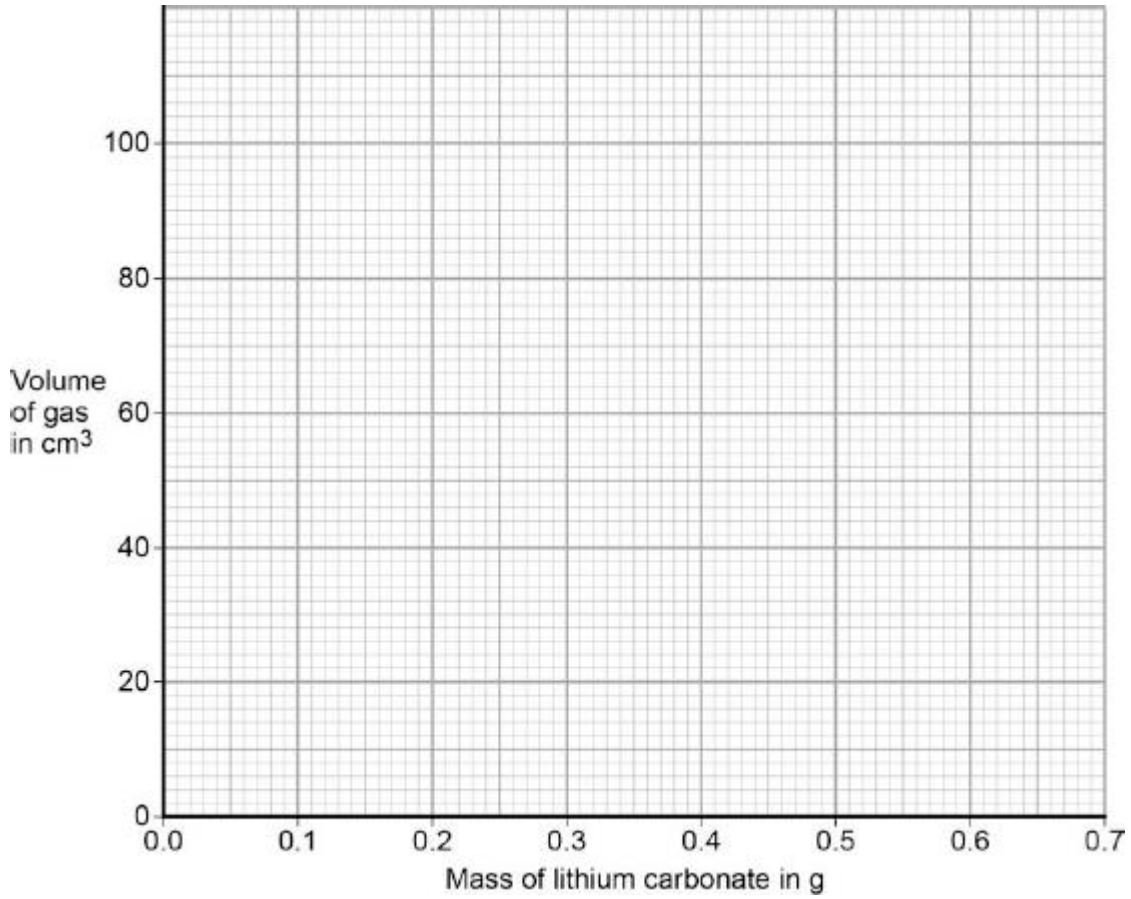
(b) The table below shows the students' results.

Mass of lithium carbonate in g	**Volume of gas in cm^3**
0.0	0
0.1	22
0.2	44
0.3	50
0.4	88
0.5	96
0.6	96
0.7	96

On **Figure 3**:

- Plot these results on the grid.
- Complete the graph by drawing **two** straight lines of best fit.

Figure 3



(4)

(c) What are **two** possible reasons for the anomalous result?

Tick **two** boxes.

Too much lithium carbonate was added.	☐
The bung was not pushed in firmly enough.	☐
There was too much water in the trough.	☐
The measuring cylinder was not completely over the delivery	☐
The conical flask was too small.	☐

(2)

(d) Describe the pattern the graph shows up to 0.4 g of lithium carbonate added.

_____

_____

_____

_____

(2)

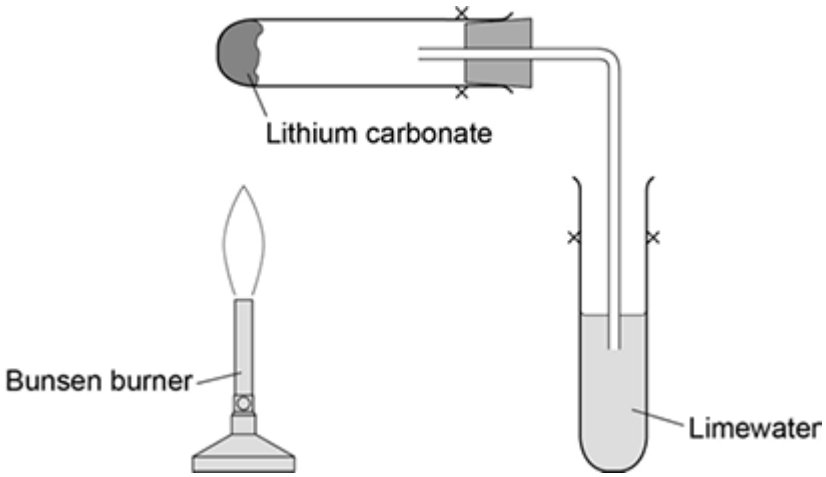
(e) Lithium carbonate decomposes when heated.

The equation shows the decomposition of lithium carbonate.

Li_2CO_3 (s) → Li_2O (s) + CO_2 (g)

Figure 4 shows the apparatus a student used to decompose lithium carbonate.

Figure 4



Why does the limewater bubble?

_____

_____

(1)

(f) The student repeated the experiment with potassium carbonate.
The limewater did not bubble.

Suggest why there were **no** bubbles in the limewater.

_____

_____

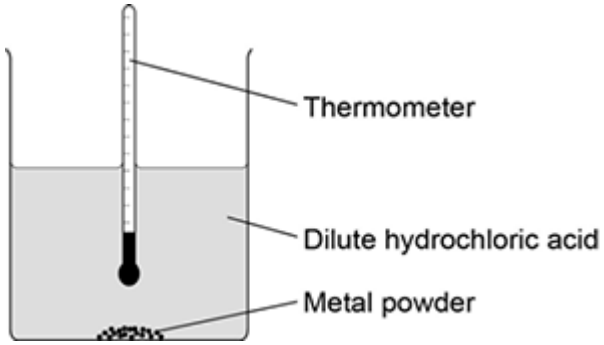
(1)

(Total 11 marks)

Q3.

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)

Q4.

The figure below shows magnesium burning in air.

© Charles D Winters/Science Photo Library

(a) Look at the figure above.

How can you tell that a chemical reaction is taking place?

_____

_____

(1)

(b) Name the product from the reaction of magnesium in the figure.

_____

(1)

(c) The magnesium needed heating before it would react.

What conclusion can you draw from this?

Tick **one** box.

The reaction is reversible ☐

The reaction has a high activation energy ☐

The reaction is exothermic ☐

Magnesium has a high melting point ☐

(1)

(d) A sample of the product from the reaction in the figure above was added to water and shaken.

Universal indicator was added.

The universal indicator turned blue.

What is the pH value of the solution?

Tick **one** box.

1 ☐

4 ☐

7 ☐

9 ☐

(1)

(e) Why are nanoparticles effective in very small quantities?

Tick **one** box.

They are elements ☐

They are highly reactive ☐

They have a low melting point ☐

They have a high surface area to volume ratio ☐

(1)

(f) Give **one** advantage of using nanoparticles in sun creams.

_____

_____

(1)

(g) Give **one** disadvantage of using nanoparticles in sun creams.

_____

_____

(1)

(h) A coarse particle has a diameter of 1×10^{-6} m.
A nanoparticle has a diameter of 1.6×10^{-9} m.

Calculate how many times bigger the diameter of the coarse particle is than the diameter of the nanoparticle.

_____

_____

_____

_____

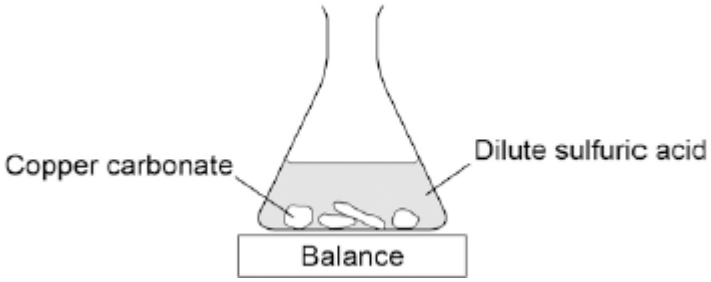
(2)

(Total 9 marks)

Q5.

A student investigated the reaction of copper carbonate with dilute sulfuric acid.

The student used the apparatus shown in the figure below.



(a) Complete the state symbols in the equation.

$$CuCO_3 (\_\_\_) + H_2SO_4 (aq) \rightarrow CuSO_4 (aq) + H_2O (\_\_\_) + CO_2 (g)$$

(2)

(b) Why did the balance reading decrease during the reaction?

Tick **one** box.

The copper carbonate broke down. ☐

A salt was produced in the reaction. ☐

A gas was lost from the flask. ☐

Water was produced in the reaction. ☐

(1)

(c) Describe a safe method for making pure crystals of copper sulfate from copper carbonate and dilute sulfuric acid. Use the information in the figure above to help you.

In your method you should name all of the apparatus you will use.

(6)

(d) The percentage atom economy for a reaction is calculated using:

$$\frac{\text{Relative formula mass of desired product from equation}}{\text{Sum of relative formula masses of all reactants from equation}} \times 100$$

The equation for the reaction of copper carbonate and sulfuric acid is:

$$CuCO_3 + H_2SO_4 \rightarrow CuSO_4 + H_2O + CO_2$$

Relative formula masses : $CuCO_3 = 123.5$; $H_2SO_4 = 98.0$; $CuSO_4 = 159.5$

Calculate the percentage atom economy for making copper sulfate from copper carbonate.

Atom economy = _____ %

(3)

(e) Give **one** reason why is it important for the percentage atom economy of a reaction to be as high as possible.

_____

(1)

(Total 13 marks)

Q6.

Rock salt is a mixture of sand and salt.

Salt dissolves in water. Sand does **not** dissolve in water.

Some students separated rock salt.

This is the method used.

1. Place the rock salt in a beaker.
2. Add 100 cm^3 of cold water.
3. Allow the sand to settle to the bottom of the beaker.
4. Carefully pour the salty water into an evaporating dish.
5. Heat the contents of the evaporating dish with a Bunsen burner until salt crystals start to form.

(a) Suggest **one** improvement to step 2 to make sure all the salt is dissolved in the water.

_____

_____

(1)

(b) The salty water in step 4 still contained very small grains of sand.

Suggest **one** improvement to step 4 to remove all the sand.

_____

_____

(1)

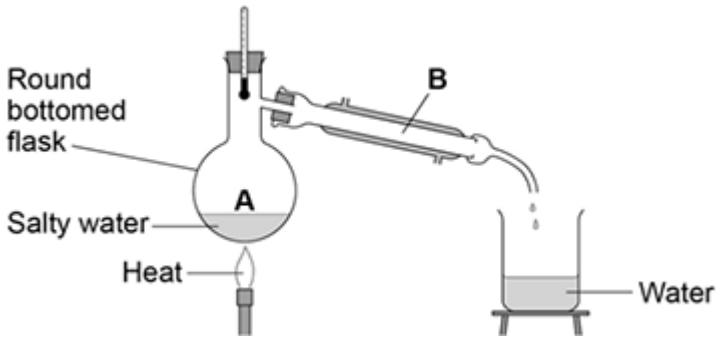
(c) Suggest **one** safety precaution the students should take in step 5.

_____

_____

(1)

(d) Another student removed water from salty water using the apparatus in the figure below.



Describe how this technique works by referring to the processes at **A** and **B**.

_____

_____

_____

_____

(2)

(e) What is the reading on the thermometer during this process?

_____ °C

(1)

(Total 6 marks)

Q7.

This question is about halogens and their compounds.

The table below shows the boiling points and properties of some of the elements in Group 7 of the periodic table.

Element	**Boiling point in °C**	**Colour in aqueous solution**
Fluorine	−188	colourless
Chlorine	−35	pale green
Bromine	X	orange
Iodine	184	brown

(a) Why does iodine have a higher boiling point than chlorine?

Tick **one** box.

Iodine is ionic and chlorine is covalent ☐

Iodine is less reactive than chlorine ☐

The covalent bonds between iodine atoms are stronger ☐

The forces between iodine molecules are stronger ☐

(1)

(b) Predict the boiling point of bromine.

_____

(1)

(c) A redox reaction takes place when aqueous chlorine is added to potassium iodide solution.

The equation for this reaction is:

$$Cl_2(aq) + 2KI(aq) \rightarrow I_2(aq) + 2KCl(aq)$$

Look at table above.

What is the colour of the final solution in this reaction?

Tick **one** box.

Brown ☐

Orange ☐

Pale green ☐

Colourless ☐

(1)

(d) What is the ionic equation for the reaction of chlorine with potassium iodide?

Tick **one** box.

$Cl_2 + 2K \rightarrow 2KCl$ ☐

$2I^- + Cl_2 \rightarrow I_2 + 2Cl^-$ ☐

$I^- + Cl \rightarrow I + Cl^-$ ☐

$I^- + K^+ \rightarrow KI$ ☐

(1)

(e) Why does potassium iodide solution conduct electricity?

Tick **one** box.

It contains a metal ☐

It contains electrons which can move ☐

It contains ions which can move ☐

It contains water ☐

(1)

(f) What are the products of electrolysing potassium iodide solution?

Tick **one** box.

Product at cathode **Product at anode**

hydrogen	iodine	☐
hydrogen	oxygen	☐
potassium	iodine	☐
potassium	oxygen	☐

(1)

(Total 6 marks)

Q8.

A student investigated the reactions of copper carbonate and copper oxide with dilute hydrochloric acid.

In both reactions one of the products is copper chloride.

(a) Describe how a sample of copper chloride crystals could be made from copper carbonate and dilute hydrochloric acid.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(b) A student wanted to make 11.0 g of copper chloride.

The equation for the reaction is:

$$CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$$

Relative atomic masses, A_r: H = 1; C = 12; O = 16; Cl = 35.5; Cu = 63.5

Calculate the mass of copper carbonate the student should react with dilute hydrochloric acid to make 11.0 g of copper chloride.

_____

_____

_____

_____

Mass of copper carbonate = _____ g

(4)

(c) The percentage yield of copper chloride was 79.1 %.

Calculate the mass of copper chloride the student actually produced.

_____

_____

Actual mass of copper chloride produced = _____ g

(2)

(d) Look at the equations for the two reactions:

Reaction 1 $CuCO_3(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l) + CO_2(g)$

Reaction 2 $CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$

Reactive formula masses: CuO = 79.5; HCl = 36.5; $CuCl_2$ = 134.5; H_2O = 18

The percentage atom economy for a reaction is calculated using:

$$\frac{\text{Relative formula mass of desired product from equation}}{\text{Sum of relative formula masses of all reactants from equation}} \times 100$$

Calculate the percentage atom economy for Reaction 2.

_____

_____

_____

_____

_____

_____

Percentage atom economy = _____ %

(3)

(e) The atom economy for Reaction 1 is 68.45 %.
Compare the atom economies of the two reactions for making copper chloride.

Give a reason for the difference.

_____

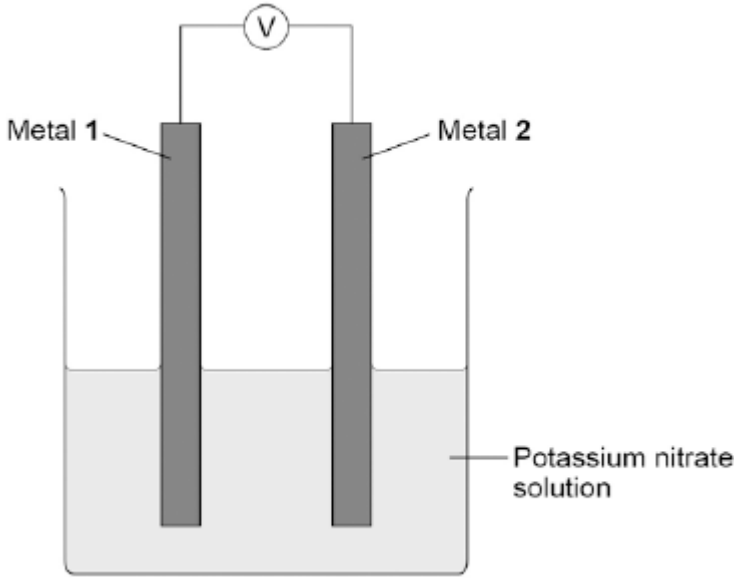
_____

(1)

(Total 14 marks)

Q9.

A student investigated simple cells using the apparatus shown in the figure below.



- If metal **2** is more reactive than metal **1** then the voltage measured is positive.
- If metal **1** is more reactive than metal **2** then the voltage measured is negative.
- The bigger the difference in reactivity of the two metals, the larger the voltage produced.

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

Metal 2 / Metal 1	Chromium	Copper	Iron	Tin	Zinc
Chromium	0.0 V				
Copper	1.2 V	0.0 V			
Iron	0.5 V	not measured	0.0 V		
Tin	0.8 V	-0.4 V	0.3 V	0.0 V	
Zinc	0.2 V	-1.0 V	-0.3 V	-0.6 V	0.0 V

(a) The ionic equation for the reaction occuring at the zinc electrode in the simple cell made using copper and zinc electrodes is:

$$Zn \rightarrow Zn^{2+} + 2e^{-}$$

Zinc is oxidised in this reaction.

Give a reason why this is oxidation.

_____

_____

(1)

(b) Look at the table above.

Which **one** of the metals used was the least reactive?

Give a reason for your answer.

Metal _____

Reason _____

_____

_____

(2)

(c) Predict the voltage that would be obtained for a simple cell that has iron as metal **1** and copper as metal **2**.

Explain your answer.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(d) Hydrogen fuel cells have been developed for cars.

Write a word equation for the overall reaction that takes place in a hydrogen fuel cell.

_____

(1)

(e) Write the **two** half equations for the reactions that occur at the electrodes in a hydrogen fuel cell.

_____

_____

_____

_____

(2)

(Total 9 marks)

Q10.

Sodium carbonate reacts with dilute hydrochloric acid:

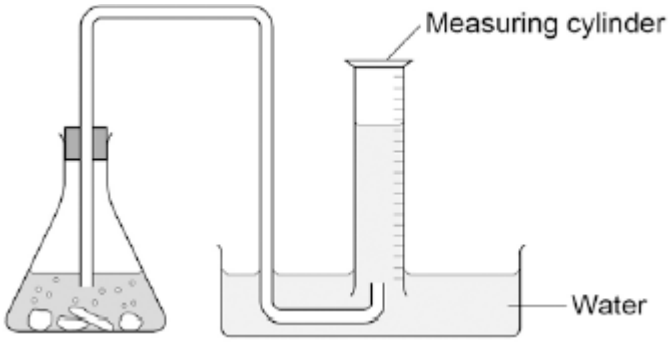
$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

A student investigated the volume of carbon dioxide produced when different masses of sodium carbonate were reacted with dilute hydrochloric acid.

This is the method used.

1. Place a known mass of sodium carbonate in a conical flask.
2. Measure 10 cm^3 of dilute hydrochloric acid using a measuring cylinder.
3. Pour the acid into the conical flask.
4. Place a bung in the flask and collect the gas until the reaction is complete.

(a) The student set up the apparatus as shown in the figure below.



Identify the error in the way the student set up the apparatus.

Describe what would happen if the student used the apparatus shown.

_____

_____

_____

_____

(2)

(b) The student corrected the error.

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

Mass of sodium carbonate in g	**Volume of carbon dioxide gas in cm^3**
0.07	16.0
0.12	27.5
0.23	52.0
0.29	12.5
0.34	77.0
0.54	95.0
0.59	95.0
0.65	95.0

The result for 0.29 g of sodium carbonate is anomalous.

Suggest what may have happened to cause this anomalous result.

_____

_____

(1)

(c) Why does the volume of carbon dioxide collected stop increasing at 95.0 cm^3?

_____

_____

(1)

(d) What further work could the student do to be more certain about the minimum mass of sodium carbonate needed to produce 95.0 cm^3 of carbon dioxide?

_____

_____

(1)

(e) The carbon dioxide was collected at room temperature and pressure.
The volume of one mole of any gas at room temperature and pressure is 24.0 dm^3.

How many moles of carbon dioxide is 95.0 cm^3?

Give your answer in three significant figures.

_____

_____

_____

_____

_____ mol

(2)

(f) Suggest **one** improvement that could be made to the apparatus used that would give more accurate results.

Give a reason for your answer.

_____

_____

_____

_____

(2)

(g) One student said that the results of the experiment were wrong because the first few bubbles of gas collected were air.

A second student said this would make no difference to the results.

Explain why the second student was correct.

(2)

(Total 11 marks)

Q11.

Sodium hydroxide neutralises sulfuric acid.

The equation for the reaction is:

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

(a) Sulfuric acid is a strong acid.

What is meant by a strong acid?

(2)

(b) Write the ionic equation for this neutralisation reaction. Include state symbols.

(2)

(c) A student used a pipette to add 25.0 cm^3 of sodium hydroxide of unknown concentration to a conical flask.

The student carried out a titration to find out the volume of 0.100 mol / dm^3 sulfuric acid needed to neutralise the sodium hydroxide.

Describe how the student would complete the titration.

You should name a suitable indicator and give the colour change that would be seen.

(4)

(d) The student carried out five titrations. Her results are shown in the table below.

	Titration 1	Titration 2	Titration 3	Titration 4	Titration 5
Volume of 0.100 mol / dm^3 sulfuric acid in cm^3	27.40	28.15	27.05	27.15	27.15

Concordant results are within 0.10 cm^3 of each other.

Use the student's concordant results to work out the mean volume of 0.100 mol / dm^3 sulfuric acid added.

Mean volume = _____ cm^3

(2)

(e) The equation for the reaction is:

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

Calculate the concentration of the sodium hydroxide.

Give your answer to three significant figures.

Concentration = _____ mol / dm^3

(4)

(f) The student did another experiment using 20 cm^3 of sodium hydroxide solution with a concentration of 0.18 mol / dm^3.

Relative formula mass (M_r) of NaOH = 40

Calculate the mass of sodium hydroxide in 20 cm^3 of this solution.

_____

_____

_____

_____

Mass = _____ g

(2)

(Total 16 marks)

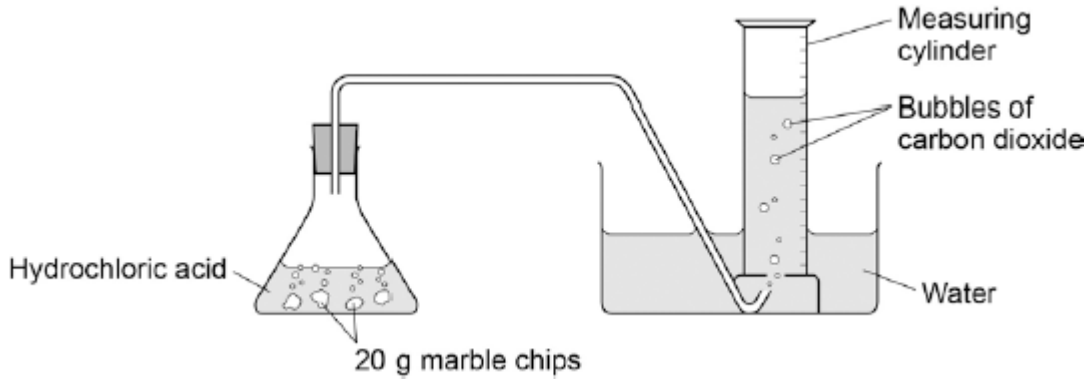
Q12.

Marble chips are mainly calcium carbonate ($CaCO_3$).

A student investigated the rate of reaction between marble chips and hydrochloric acid (HCl).

Figure 1 shows the apparatus the student used.

Figure 1



(a) Complete and balance the equation for the reaction between marble chips and hydrochloric acid.

_____ + _____ → $CaCl_2$ + _____ + _____

(2)

(b) The table below shows the student's results.

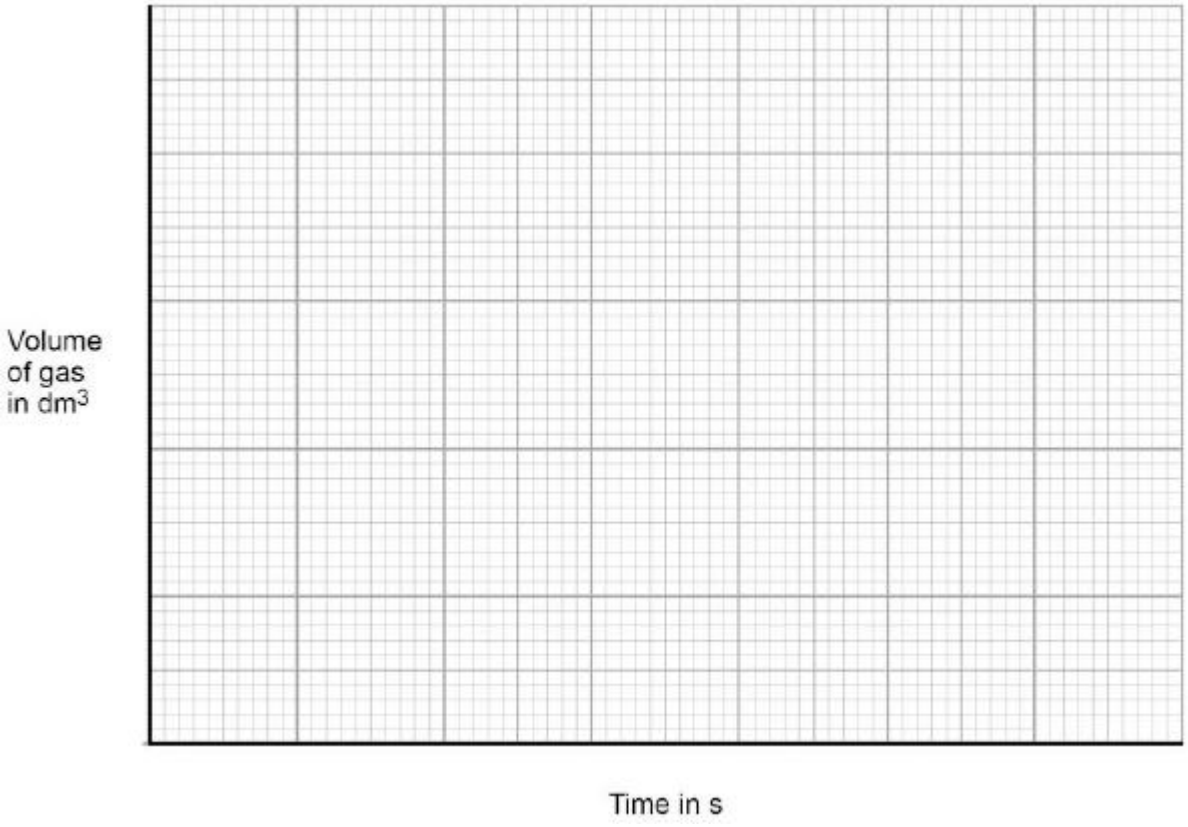
Time in s	Volume of gas in dm^3
0	0.000
30	0.030
60	0.046

90	0.052
120	0.065
150	0.070
180	0.076
210	0.079
240	0.080
270	0.080

On **Figure 2**:

- Plot these results on the grid.
- Draw a line of best fit.

Figure 2



(4)

(c) Sketch a line on the grid in **Figure 2** to show the results you would expect if the experiment was repeated using 20 g of smaller marble chips.

Label this line **A**.

(2)

(d) Explain, in terms of particles, how and why the rate of reaction changes during the reaction of calcium carbonate with hydrochloric acid.

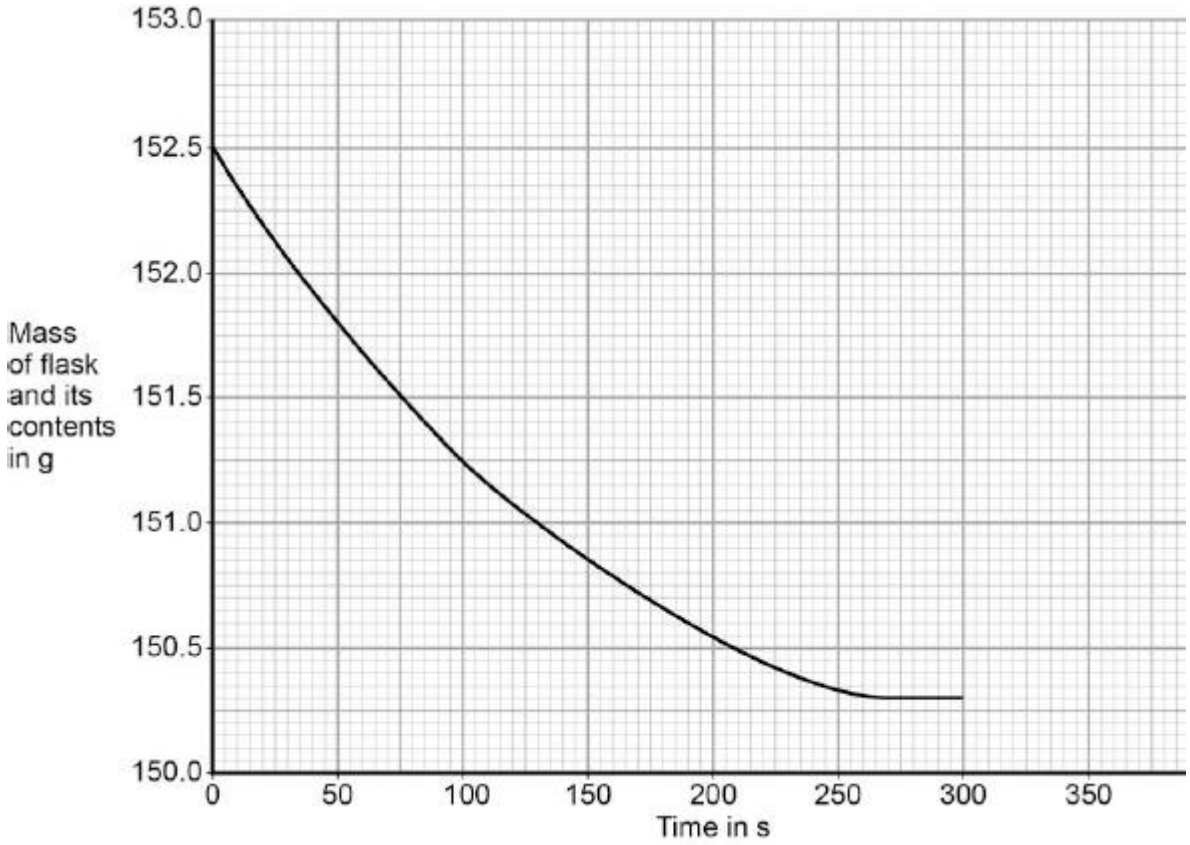
_____

(4)

(e) Another student investigated the rate of reaction by measuring the change in mass.

Figure 3 shows the graph plotted from this student's results.

Figure 3



Use **Figure 3** to calculate the mean rate of the reaction up to the time the reaction is complete.

Give your answer to three significant figures.

_____

_____

Mean rate of reaction = _____ g / s

(4)

(f) Use **Figure 3** to determine the rate of reaction at 150 seconds.

Show your working on **Figure 3**.

Give your answer in standard form.

_____

_____

_____

_____

_____

Rate of reaction at 150 s = _____ g / s

(4)

(Total 20 marks)

Q13.

Metals are extracted from ores in the Earth's crust.

Some ores contain metal carbonates and some ores contain metal oxides.

(a) (i) Name the type of reaction that happens when a metal carbonate is heated.

_____

(1)

(ii) Which solid product is formed when copper carbonate is heated?

Tick (✔) **one** box.

copper ☐

copper nitrate ☐

copper oxide ☐

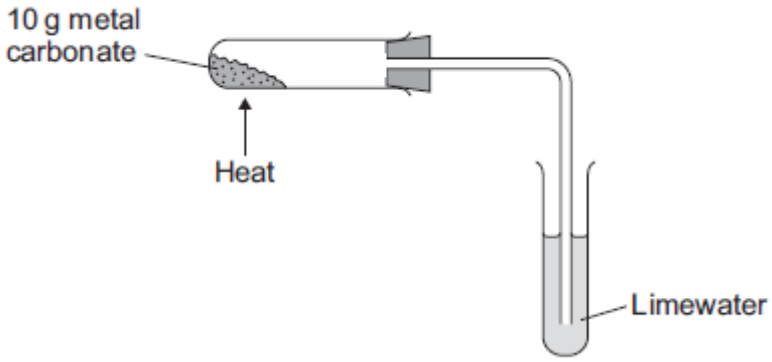
copper sulfide ☐

(1)

(b) A student investigated heating four metal carbonates.

Figure 1 shows the apparatus used.

Figure 1



The student heated each metal carbonate for five minutes.

The table below shows the results.

Metal carbonate	Mass of metal carbonate at start in g	Mass of solid after heating for 5 minutes in g	Observations
Copper carbonate	10.0	6.9	Limewater turns cloudy
Magnesium carbonate	10.0	9.1	Limewater turns cloudy
Potassium carbonate	10.0	10.0	Limewater does not turn cloudy
Zinc carbonate	10.0	8.3	Limewater turns cloudy

(i) Explain the results for potassium carbonate.

(3)

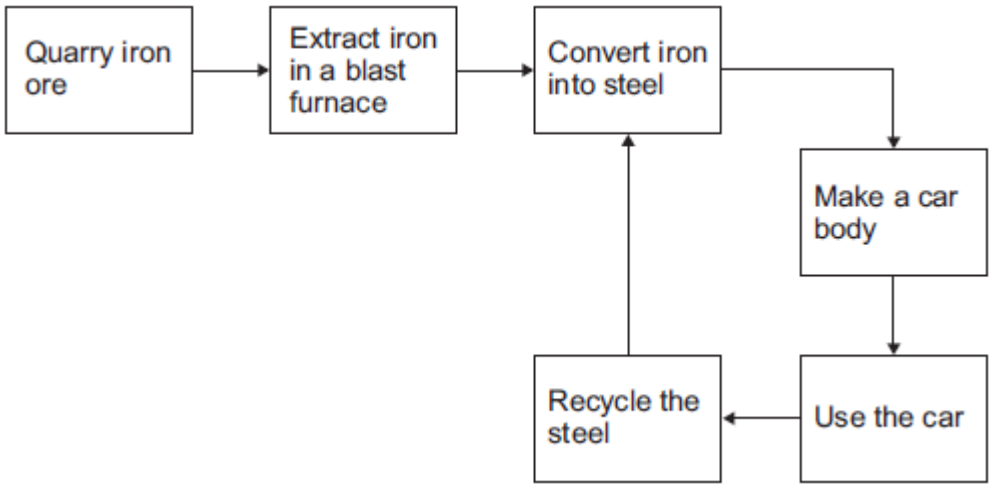
(ii) Suggest how the reactivity series can be used to predict which metal carbonate reacts most easily when heated.

_____

(2)

(c) **Figure 2** shows a simple life cycle of a car body.

Figure 2



(i) Complete the sentence.

Iron ores must contain enough iron to _____

_____

(1)

(ii) Some iron ores contain iron oxide (Fe_2O_3).

Complete and balance the equation for a reaction to produce iron from iron oxide.

_____ Fe_2O_3 + _____ C $\longrightarrow$ _____ + _____ CO_2

(2)

(iii) Give **two** reasons why iron produced in a blast furnace is converted into steel.

_____

_____

_____

_____

(2)

(iv) When a car reaches the end of its useful life, the car body can be:

- recycled
- reused
- sent to landfill.

Give **three** reasons why a steel car body should be recycled and **not** reused or sent to landfill.

_____

_____

_____

_____

_____

_____

(3)

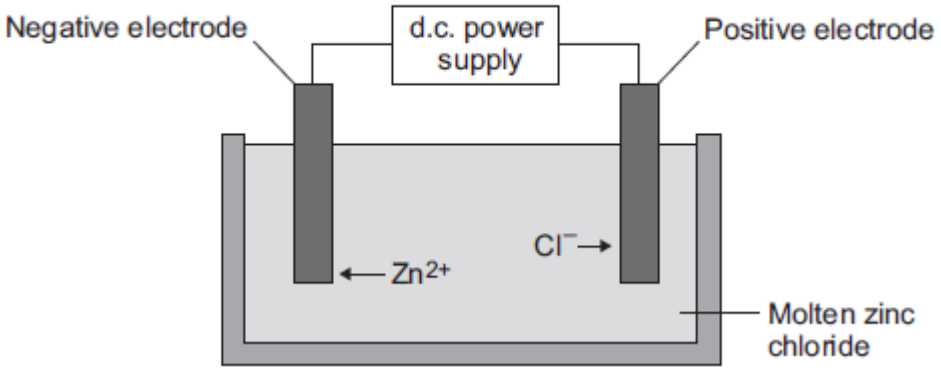
(Total 15 marks)

Q14.

This question is about zinc.

Figure 1 shows the electrolysis of molten zinc chloride.

Figure 1



(a) Zinc chloride is an ionic substance.
Complete the sentence.

When zinc chloride is molten, it will conduct _____ .

(1)

(b) Zinc ions move towards the negative electrode where they gain electrons to produce zinc.

(i) Name the product formed at the positive electrode.

_____

(1)

(ii) Explain why zinc ions move towards the negative electrode.

_____

_____

_____

_____

(2)

(iii) What type of reaction occurs when the zinc ions gain electrons?

Tick (✔) **one** box.

Neutralisation ☐

Oxidation ☐

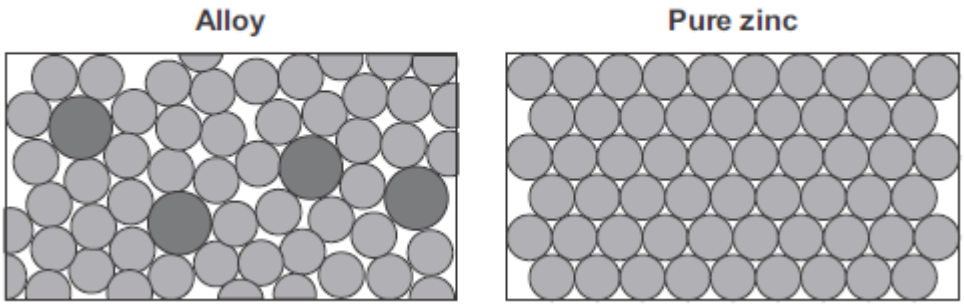
Reduction ☐

(1)

(c) Zinc is mixed with copper to make an alloy.

(i) **Figure 2** shows the particles in the alloy and in pure zinc.

Figure 2



Use **Figure 2** to explain why the alloy is harder than pure zinc.

_____

_____

_____

_____

(2)

(ii) Alloys can be bent. Some alloys return to their original shape when heated.

What name is used for these alloys?

_____

(1)

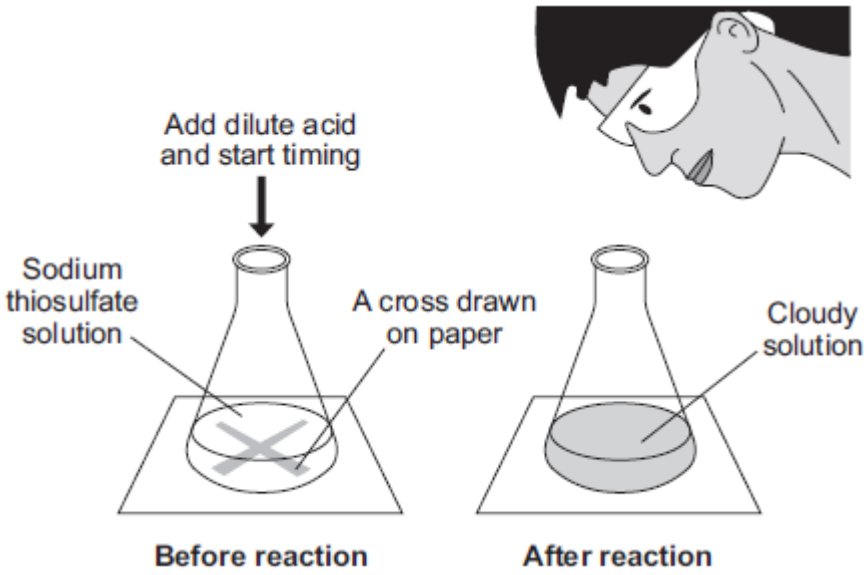
(Total 8 marks)

Q15.

A student investigated the effect of temperature on the rate of a reaction.

Figure 1 shows an experiment.

Figure 1



The student:

- put 50 cm^3 sodium thiosulfate solution into a conical flask
- heated the sodium thiosulfate solution to the required temperature
- put the flask on a cross drawn on a piece of paper
- added 5 cm^3 dilute hydrochloric acid and started a stopclock
- stopped the stopclock when the cross could no longer be seen
- repeated the experiment at different temperatures.

The equation for the reaction is:

$$\underset{\text{sodium thiosulfate}}{Na_2S_2O_3(aq)} + \underset{\text{hydrochloric acid}}{2HCl(aq)} \longrightarrow \underset{\text{sodium chloride}}{2NaCl(aq)} + \underset{\text{water}}{H_2O(l)} + \underset{\text{sulfur dioxide}}{SO_2(g)} + \underset{\text{sulfur}}{S(s)}$$

(a) Which product is a gas?

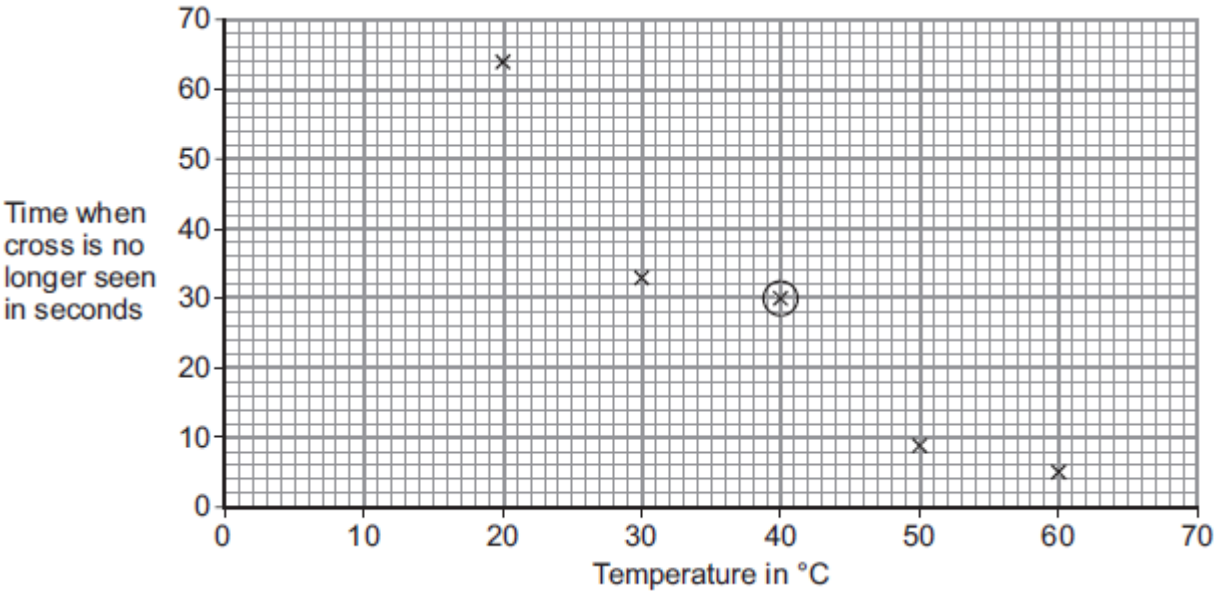
_____

(1)

(b) **Figure 2** shows the results of this experiment at five different temperatures.

The circled result point is anomalous.

Figure 2



(i) Draw a line of best fit on **Figure 2** to show how the reaction time varied with reaction temperature.

(1)

(ii) Give a possible reason for the anomalous result at 40 °C.

_____

_____

(1)

(iii) The reaction at 20 °C produced 0.32 g of sulfur in 64 seconds.

Calculate the rate of the reaction at 20 °C using the equation:

$$\text{Rate of reaction} = \frac{\text{mass of sulfur}}{\text{time}}$$

_____

_____

_____

_____

Rate of reaction = _____ grams per second

(2)

(iv) Give **two** reasons why the rate of the reaction increases as the temperature increases.

Tick (✔) **two** boxes.

The particles move faster. ☐

The particles collide less often. ☐

All the particles have the same energy.	☐
The particles collide with more energy.	☐
The number of particles increases.	☐

(2)

(v) Use the correct answer from the box to complete the sentence.

activation	**collision**	**exothermic**

The minimum amount of energy particles must have to react is called

the _____ energy.

(1)

(Total 8 marks)

Q16.

This question is about ammonia and fertilisers.

(a) Ammonia is produced by a reversible reaction.

The equation for the reaction is:

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

Complete the sentence.

The forward reaction is exothermic, so the reverse reaction

is _____

(1)

(b) Calculate the percentage by mass of nitrogen in ammonia (NH_3).
Relative atomic masses (A_r): H = 1; N = 14
You **must** show how you work out your answer.

_____

_____

_____

_____

_____

_____

Percentage by mass of nitrogen = _____ %

(3)

(c) A neutral solution can be produced when ammonia reacts with an acid.

(i) Give the pH of a neutral solution.

pH _____

(1)

(ii) Which of these ionic equations shows a neutralisation reaction?

Tick (✔) **one** box.

$H^+ + OH^- \longrightarrow H_2O$ ☐

$NH_4^+ + OH^- \longrightarrow NH_4OH$ ☐

$H^+ + Cl^- \longrightarrow HCl$ ☐

$H^+ + H_2O \longrightarrow H_3O^+$ ☐

(1)

(iii) Name the salt produced when ammonia reacts with hydrochloric acid.

_____

(1)

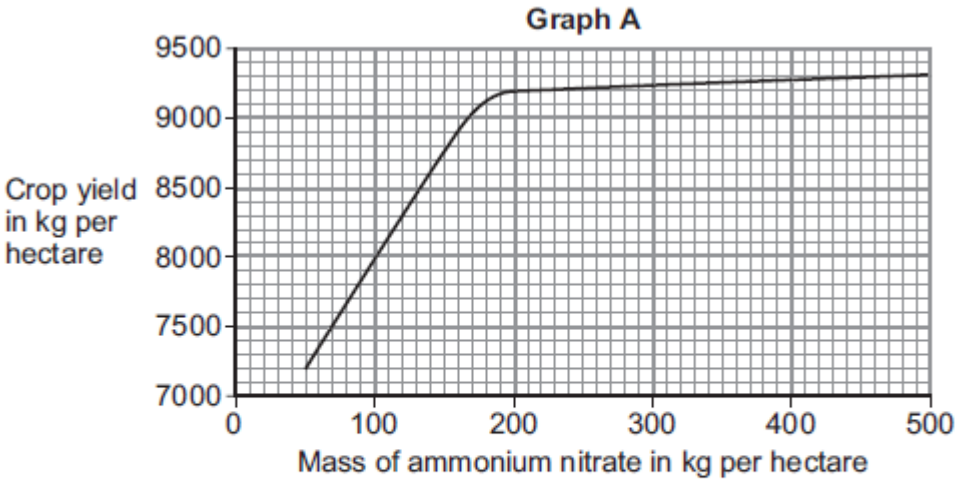
(d) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

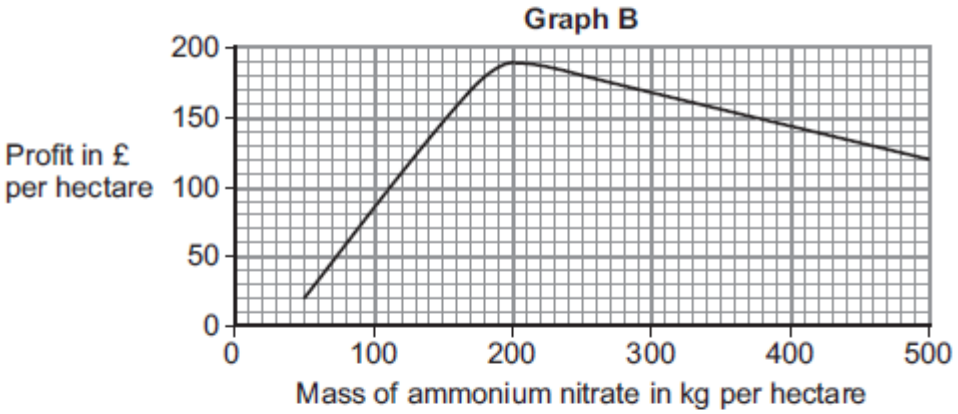
Farmers use ammonium nitrate as a fertiliser for crops.

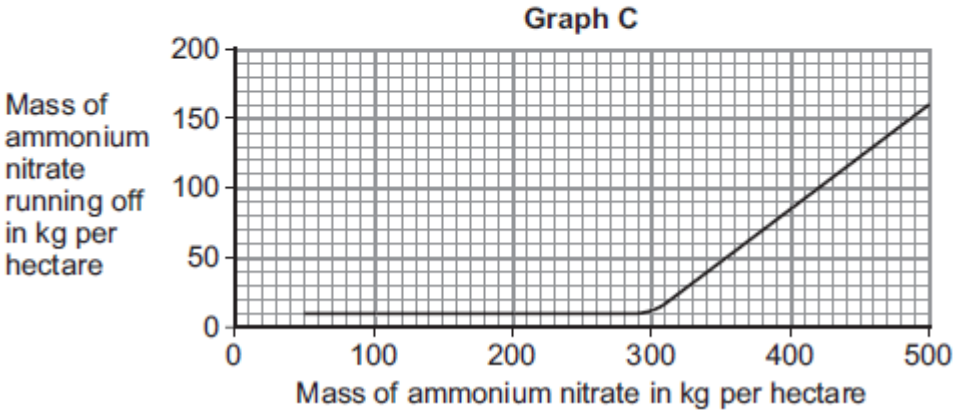
Rainwater dissolves ammonium nitrate in the soil.

Some of the dissolved ammonium nitrate runs off into rivers and lakes.

The graphs **A**, **B** and **C** below show information about the use of ammonium nitrate as a fertiliser. A hectare is a measurement of an area of land.







Suggest how much ammonium nitrate farmers should use per hectare.

Give reasons for your answer.

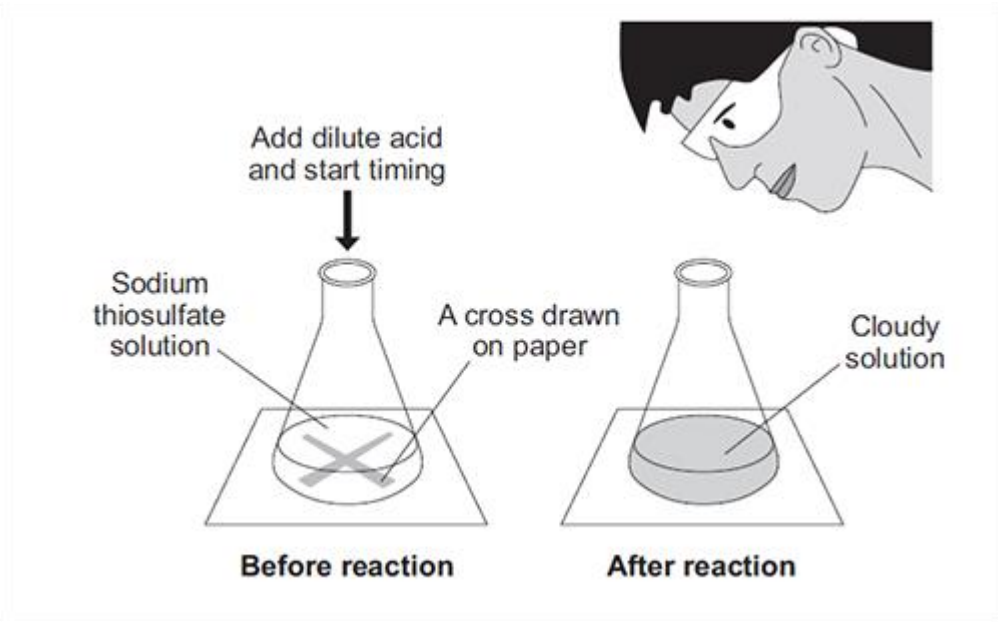
Use information from graphs **A**, **B** and **C**.

(6)

(Total 13 marks)

Q17.

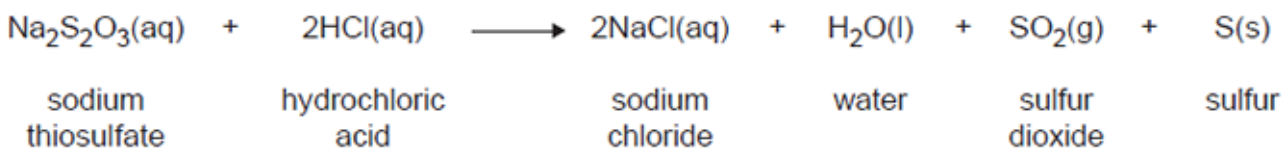
A student investigated the effect of temperature on the rate of a reaction.
The picture below shows an experiment.



The student:

- put sodium thiosulfate solution into a conical flask
- heated the sodium thiosulfate solution to the required temperature
- put the flask on a cross drawn on a piece of paper
- added dilute hydrochloric acid and started a stopclock
- stopped the stopclock when the cross could no longer be seen
- repeated the experiment at different temperatures.

The equation for the reaction is:



(a) Explain why the solution goes cloudy.

(2)

(b) Give **two** variables the student must control to make the investigation a fair test.

1. _____

2. _____

(2)

(c) State the effect that increasing the temperature of the sodium thiosulfate solution has on the rate of the reaction.
Explain this effect in terms of particles and collisions.

(4)

(d) Suggest how the student should change the method to investigate the rate of reaction at 5°C.

(1)

(Total 9 marks)

Q18.

This question is about magnesium and magnesium chloride.

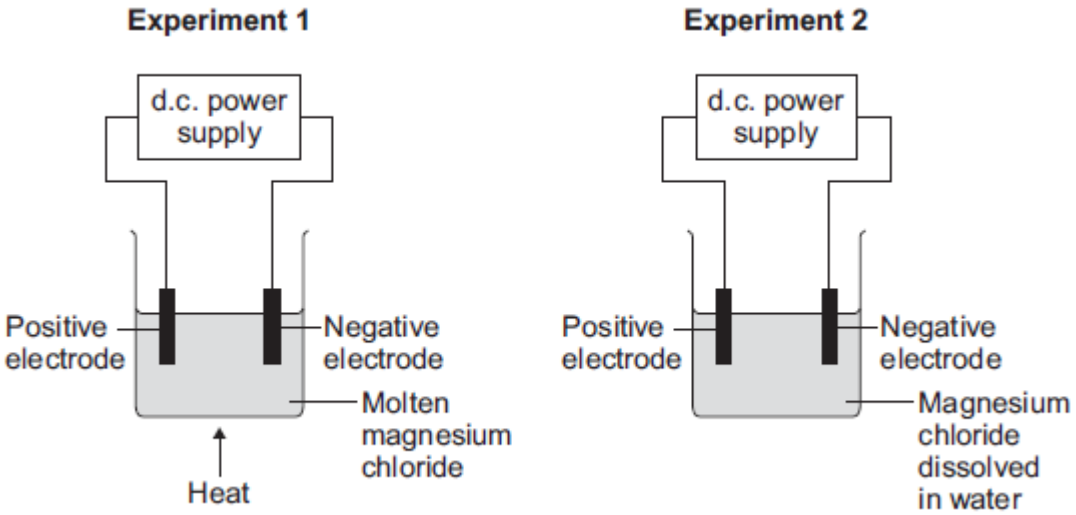
(a) Magnesium chloride contains magnesium ions (Mg^{2+}) and chloride ions (Cl^-).

Describe, in terms of electrons, what happens when a magnesium atom reacts with chlorine atoms to produce magnesium chloride.

(4)

(b) Magnesium chloride can be electrolysed.

The diagram below shows two experiments for electrolysing magnesium chloride.



(i) Explain why magnesium chloride must be molten or dissolved in water to be electrolysed.

(2)

(ii) Explain how magnesium is produced at the negative electrode in **Experiment**

1.

_____

_____

_____

_____

_____

_____

(3)

(iii) In **Experiment 2** a gas is produced at the negative electrode.
Name the gas produced at the negative electrode.

_____

(1)

(iv) Suggest why magnesium is **not** produced at the negative electrode in **Experiment 2**.

_____

_____

(1)

(v) Complete and balance the half equation for the reaction at the positive electrode.

_____ Cl^- $\longrightarrow$ Cl_2 + _____

(1)

(c) Magnesium is a metal.

Explain why metals can be bent and shaped.

_____

_____

_____

_____

(2)

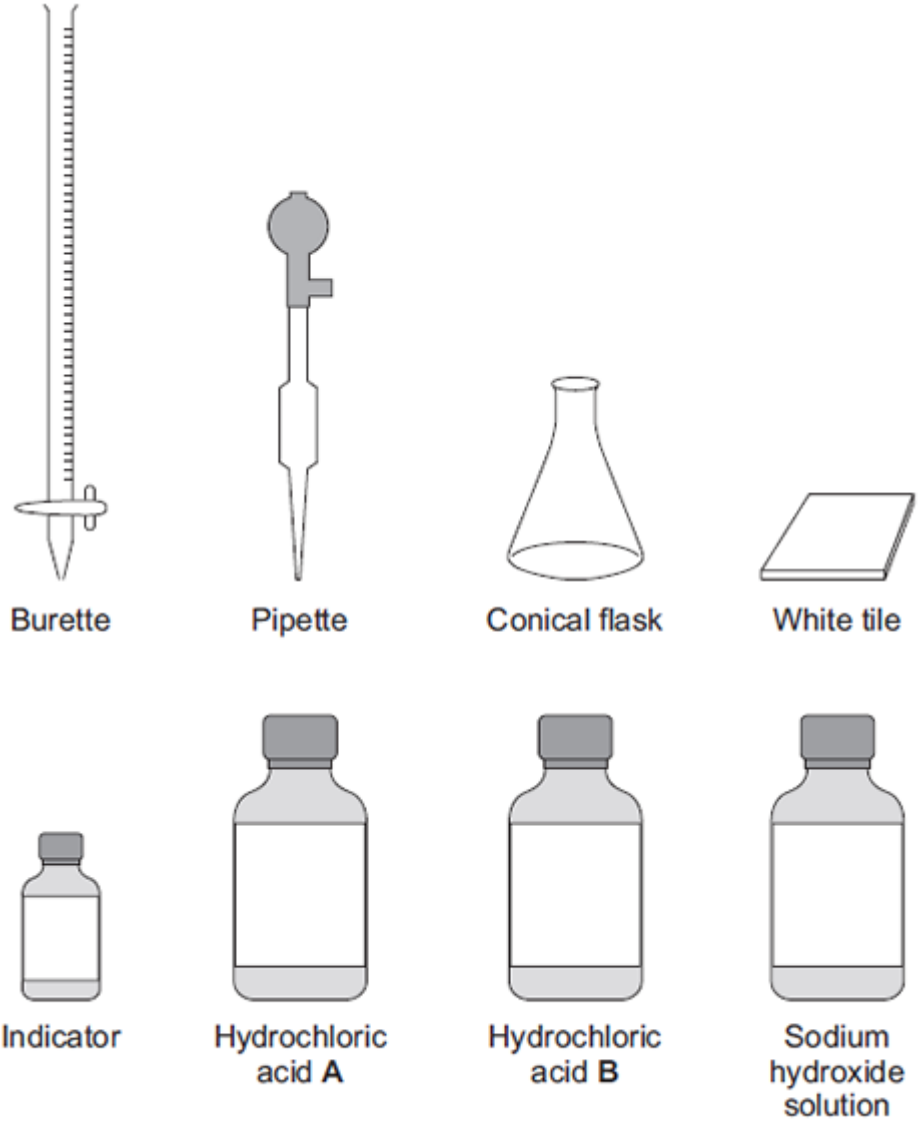
(Total 14 marks)

Q19.

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

A student has to check if two samples of hydrochloric acid, **A** and **B**, are the same concentration.

Describe how the student could use the apparatus and the solutions in the diagram below to carry out titrations.

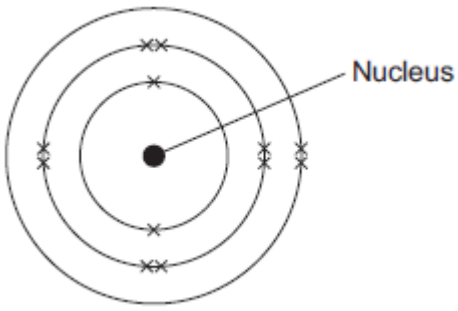


(Total 6 marks)

Q20.

This question is about magnesium.

(a) (i) The electronic structure of a magnesium atom is shown below.



Use the correct answer from the box to complete each sentence.

electrons	**neutrons**	**protons**	**shells**

The nucleus contains protons and _____

The particles with the smallest relative mass that move around the nucleus are called

_____

Atoms of magnesium are neutral because they contain the same number of

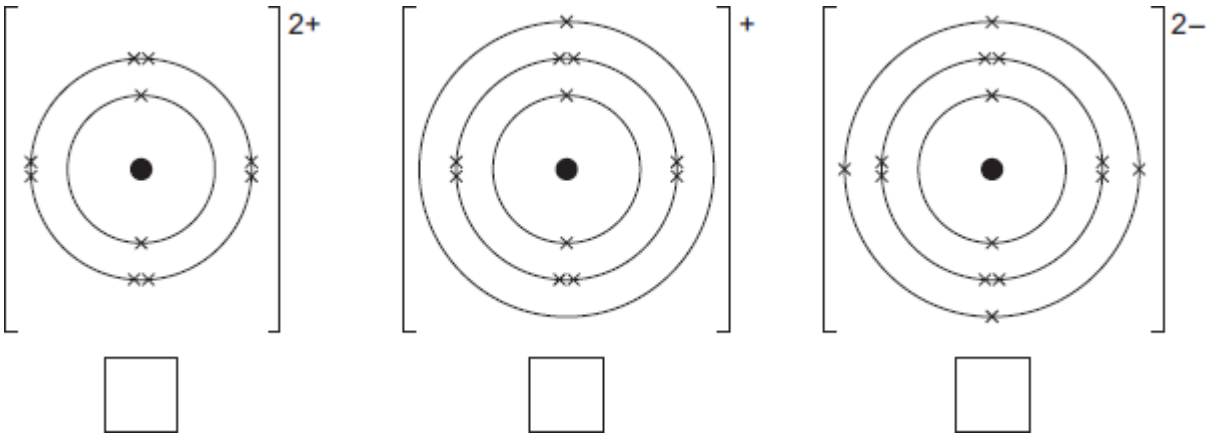
electrons and _____

(3)

(ii) A magnesium atom reacts to produce a magnesium ion.

Which diagram shows a magnesium ion?

Tick (✓) **one** box.



(1)

(b) Magnesium and dilute hydrochloric acid react to produce magnesium chloride solution and hydrogen.

$$Mg(s) + 2\ HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

(i) State **two** observations that could be made during the reaction.

1. _____

_____

2. _____

_____

(2)

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

Describe a method for making pure crystals of magnesium chloride from magnesium and dilute hydrochloric acid.

In your method you should name the apparatus you will use.

You do **not** need to mention safety.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(6)

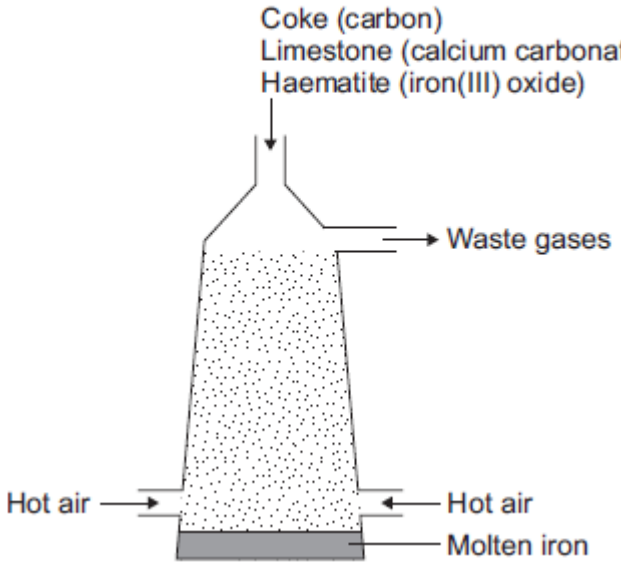
(Total 12 marks)

Q21.

This question is about iron and aluminium.

(a) Iron is extracted in a blast furnace. **Figure 1** is a diagram of a blast furnace.

Figure 1



(i) Calcium carbonate decomposes at high temperatures.

Complete the word equation for the decomposition of calcium carbonate.

calcium carbonate ⟶ _____ +

_____

(2)

(ii) Carbon burns to produce carbon dioxide.

The carbon dioxide produced reacts with more carbon to produce carbon monoxide.

Balance the equation.

$$C(s) + CO_2(g) \longrightarrow \_\_\_\_\_ CO(g)$$

(1)

(iii) Carbon monoxide reduces iron(III) oxide:

$$Fe_2O_3(s) + 3\,CO(g) \longrightarrow 2\,Fe(s) + 3\,CO_2(g)$$

Calculate the maximum mass of iron that can be produced from 300 tonnes of iron(III) oxide.

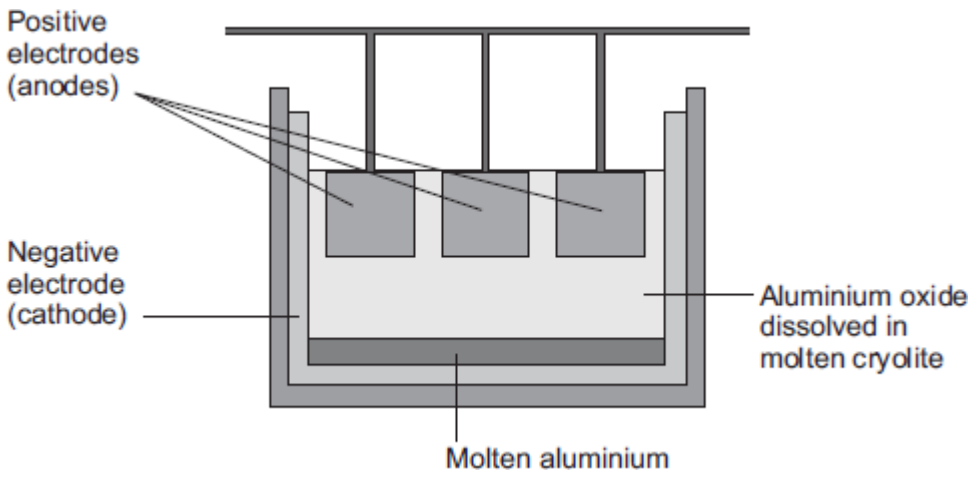
Relative atomic masses (A_r): O = 16; Fe = 56

Maximum mass = _____ tonnes

(3)

(b) Aluminium is extracted by electrolysis, as shown in **Figure 2**.

Figure 2



(i) Why can aluminium **not** be extracted by heating aluminium oxide with carbon?

(1)

(ii) Explain why aluminium forms at the negative electrode during electrolysis.

_____

_____

_____

_____

(3)

(iii) Explain how carbon dioxide forms at the positive electrodes during electrolysis.

_____

_____

_____

_____

_____

_____

(3)

(Total 13 marks)

Q22.

Dilute nitric acid reacts with potassium hydroxide solution.

The equation for the reaction is:

$$HNO_3 + KOH \longrightarrow KNO_3 + H_2O$$

A student investigated the temperature change in this reaction.

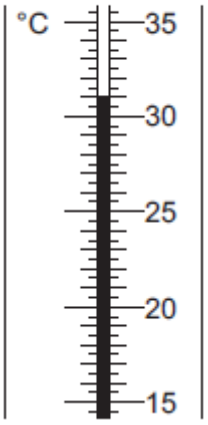
This is the method the student used.

Step 1 Put 25 cm^3 of dilute nitric acid in a polystyrene cup.
Step 2 Use a thermometer to measure the temperature of the dilute nitric acid.
Step 3 Use a burette to add 4 cm^3 of potassium hydroxide solution to the dilute nitric acid and stir the mixture.
Step 4 Use a thermometer to measure the highest temperature of the mixture.
Step 5 Repeat steps 3 and 4 until 40 cm^3 of potassium hydroxide solution have been added.

The dilute nitric acid and the potassium hydroxide solution were both at room temperature.

(a) **Figure 1** shows part of the thermometer after some potassium hydroxide solution had been added to the dilute nitric acid.

Figure 1



What is the temperature shown on the thermometer?

The temperature shown is _____ °C

(1)

(b) Errors are possible in this experiment.

(i) Suggest **two** causes of random error in the experiment.

_____

_____

_____

_____

(2)

(ii) Another student used a glass beaker instead of a polystyrene cup.

This caused a systematic error.

Why does using a glass beaker instead of a polystyrene cup cause a systematic error?

_____

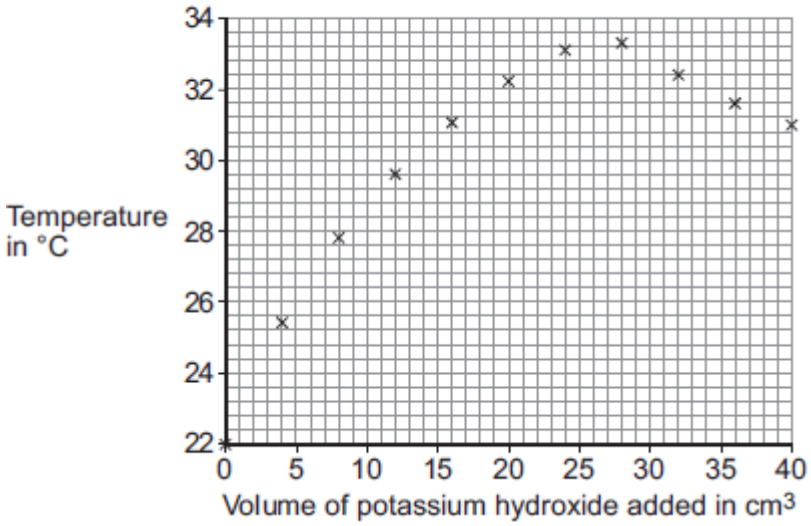
_____

_____

(1)

(c) The results of the student using the polystyrene cup are shown in **Figure 2**.

Figure 2



(i) How do the results in **Figure 2** show that the reaction between dilute nitric acid and potassium hydroxide solution is exothermic?

_____

_____

(1)

(ii) Explain why the temperature readings decrease between 28 cm^3 and 40 cm^3 of potassium hydroxide solution added.

_____

_____

_____

(2)

(iii) It is difficult to use the data in **Figure 2** to find the exact volume of potassium hydroxide solution that would give the maximum temperature.

Suggest further experimental work that the student should do to make it easier to find the exact volume of potassium hydroxide solution that would give the maximum temperature

_____

_____

_____

_____

(2)

(d) The student did further experimental work and found that 31.0 cm^3 of potassium hydroxide solution neutralised 25.0 cm^3 of dilute nitric acid.

The concentration of the dilute nitric acid was 2.0 moles per dm^3.

$$HNO_3 + KOH \longrightarrow KNO_3 + H_2O$$

Calculate the concentration of the potassium hydroxide solution in moles per dm^3.

Concentration = _____ moles per dm^3

(3)

(e) The student repeated the original experiment using 25 cm^3 of dilute nitric acid in a polystyrene cup and potassium hydroxide solution that was twice the original concentration.

She found that:

- a smaller volume of potassium hydroxide solution was required to reach the maximum temperature
- the maximum temperature recorded was higher.

Explain why the maximum temperature recorded was higher.

(2)

(Total 14 marks)

Q23.

This question is about metals.

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

Tick (✓) **one** box.

aluminium ☐

gold ☐

magnesium ☐

(1)

(b) Complete the sentence.

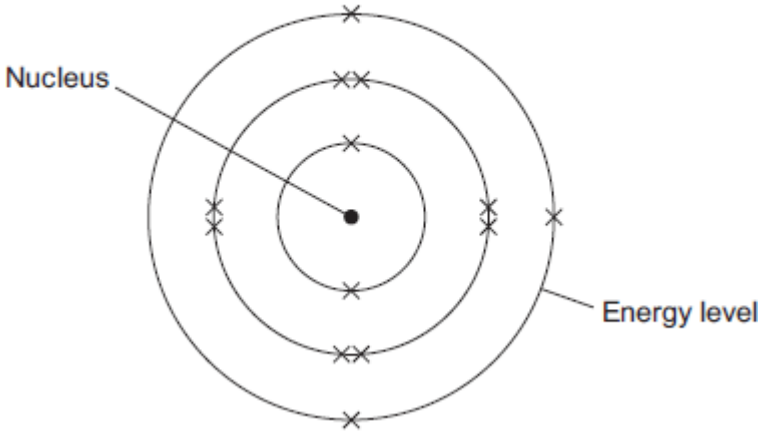
Aluminium is an element because aluminium is made of

only one type of _____ .

(1)

(c) **Figure 1** shows the electronic structure of an aluminium atom.

Figure 1



(i) Use the correct words from the box to complete the sentence.

electrons	**ions**	**protons**	**neutrons**	**shells**

The nucleus of an aluminium atom contains _____ and

_____ .

(2)

(ii) Complete the sentence.

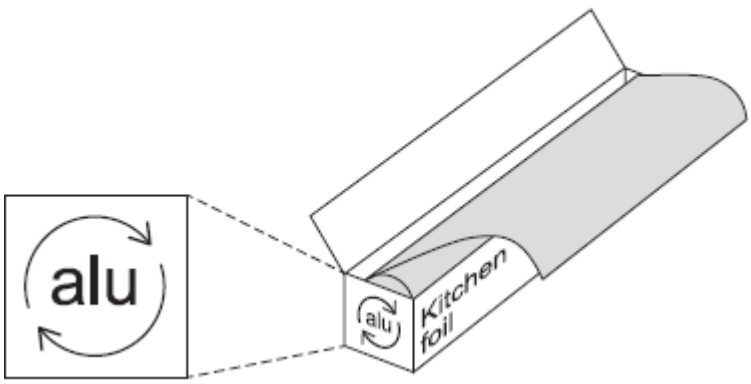
In the periodic table, aluminium is in Group _____ .

(1)

(d) Aluminium is used for kitchen foil.

Figure 2 shows a symbol on a box of kitchen foil.

Figure 2



The symbol means that aluminium can be recycled. It does not show the correct chemical symbol for aluminium.

(i) What is the correct chemical symbol for aluminium?

_____ .

(1)

(ii) Give **two** reasons why aluminium should be recycled.

_____

_____

_____

_____

(2)

(e) Aluminium has a low density, conducts electricity and is resistant to corrosion.

Which **one** of these properties makes aluminium suitable to use as kitchen foil? Give a reason for your answer.

_____

_____

_____

_____

(2)

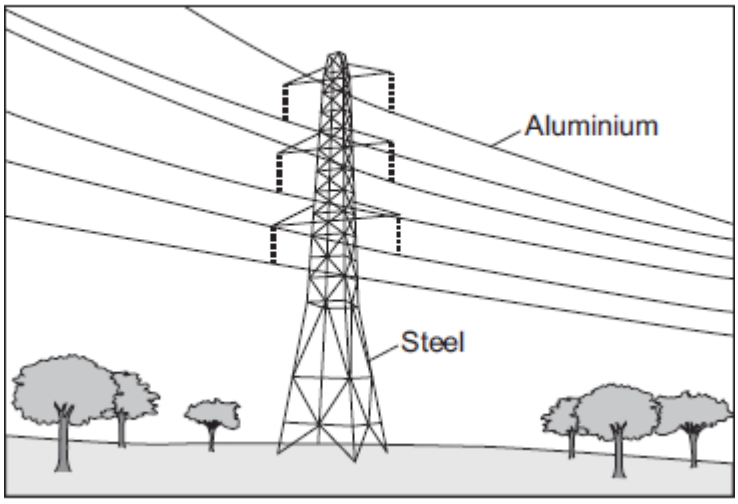
(Total 10 marks)

Q24.

This question is about metals.

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

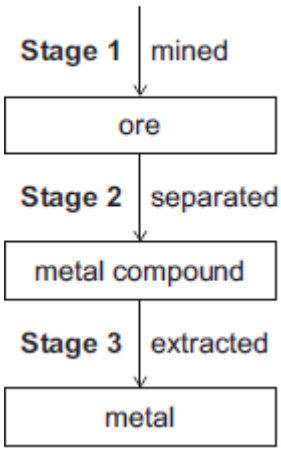
Figure 1



(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.

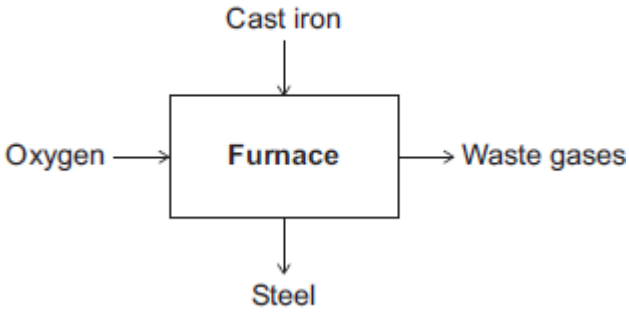
_____

_____

(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) 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)

Q25.

This question is about salts.

(a) Salt (sodium chloride) is added to many types of food.

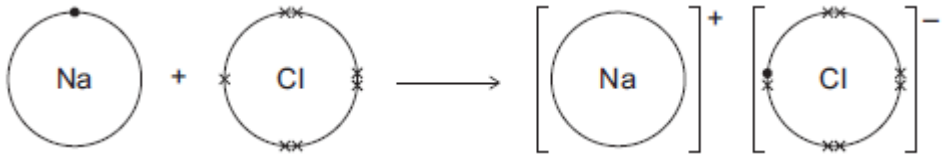
Sodium chloride is produced by reacting sodium with chlorine.

sodium + chlorine $\longrightarrow$ sodium chloride

The diagram shows what happens to atoms of sodium and chlorine in this reaction.

The dots (•) and crosses (×) represent electrons.

Only the outer electrons are shown.



Describe, in terms of electrons, what happens when a sodium atom reacts with a chlorine atom to produce sodium chloride.

(3)

(b) Lack of iodine can affect the learning ability of children.

One idea is that salt (sodium chloride) should have iodine added.

(i) Iodine consists of simple molecules.

What is a property of substances that have simple molecules?

Tick (✓) **one** box.

Have no overall electric charge	☐
Have high boiling points	☐
Have giant covalent structures	☐

(1)

(ii) Which one of the following questions cannot be answered by science alone?

Tick (✓) **one** box.

How much sodium chloride is in food?	☐
What harm does a lack of iodine do?	☐

Should iodine be added to salt in food? ☐

Give **one** reason why this question cannot be answered by science alone.

_____

_____

(2)

(c) A student produced the salt ammonium nitrate by adding an acid to ammonia solution.

(i) Name the acid used.

_____

(1)

(ii) Use the correct answer from the box to complete the sentence.

an acid	**an alkali**	**a salt**

Ammonia solution (ammonium hydroxide) is _____ .

(1)

(iii) The student added a few drops of a solution which changed colour when the reaction was complete.

Complete the sentence.

The solution added is an _____ .

(1)

(d) Farmers buy solid ammonium nitrate in poly(ethene) sacks.

(i) How is solid ammonium nitrate made from a solution of ammonium nitrate?

Tick (✓) **one** box.

Crystallisation ☐

Decomposition ☐

Electrolysis ☐

(1)

(ii) Why do farmers use ammonium nitrate on their fields?

_____

_____

(1)

(iii) The properties of poly(ethene) depend on the reaction conditions when it is made.

State **one** reaction condition that can be changed when making poly(ethene).

_____

_____

(1)

(Total 12 marks)

Q26.

This question is about electrolysis.

(a) Metal spoons can be coated with silver.
This is called electroplating.

Suggest **one** reason why spoons are electroplated.

_____

_____

(1)

(b) When sodium chloride solution is electrolysed the products are hydrogen and chlorine.

(i) What is made from chlorine?

Tick (✓) **one** box.

Bleach ☐

Fertiliser ☐

Soap ☐

(1)

(ii) Sodium chloride solution contains two types of positive ions, hydrogen ions (H^+) and sodium ions (Na^+).

Why is hydrogen produced at the negative electrode and **not** sodium?

Tick (✓) **one** box.

Hydrogen is a gas. ☐

Hydrogen is less reactive than sodium. ☐

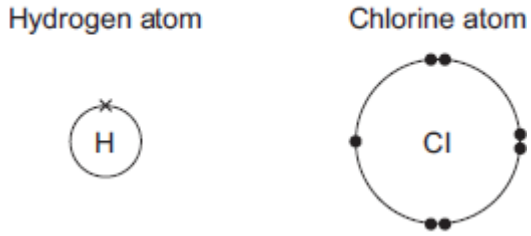
Hydrogen ions move faster than sodium ions. ☐

(1)

(iii) Hydrogen and chlorine can be used to produce hydrogen chloride.

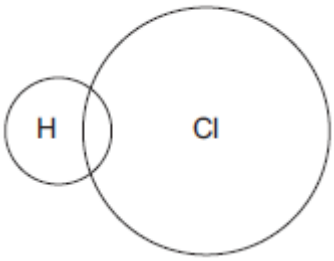
The diagrams in **Figure 1** show how the outer electrons are arranged in an atom of hydrogen and an atom of chlorine.

Figure 1



Complete **Figure 2** to show how the outer electrons are arranged in a molecule of hydrogen chloride (HCl).

Figure 2



(1)

(iv) What is the type of bond in a molecule of hydrogen chloride?

Tick (✓) **one** box.

Covalent ☐

Ionic ☐

Metallic ☐

(1)

(v) Why is hydrogen chloride a gas at room temperature (20 °C)?

Tick (✓) **two** boxes.

Hydrogen chloride has a low boiling point. ☐

Hydrogen chloride has a high melting point. ☐

Hydrogen chloride is made of simple molecules. ☐

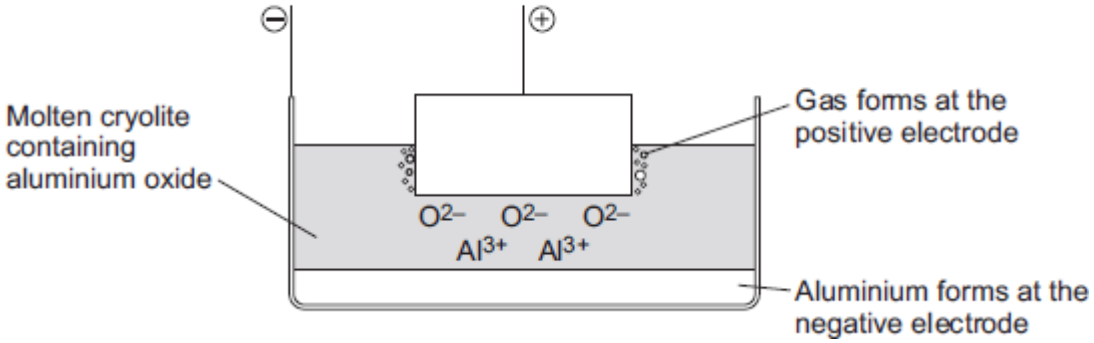
Hydrogen chloride does not conduct electricity. ☐

Hydrogen chloride has a giant structure. ☐

(2)

(c) Aluminium is produced by electrolysis of a molten mixture of aluminium oxide and cryolite.
This is shown in **Figure 3**.

Figure 3



(i) Name a gas produced at the positive electrode.

_____

(1)

(ii) Aluminium ions move to the negative electrode.

Explain why.

_____

_____

_____

_____

(2)

(iii) At the negative electrode, the aluminium ions gain electrons to produce

aluminium.

What is this type of reaction called?

Tick (✓) **one** box.

Combustion ☐

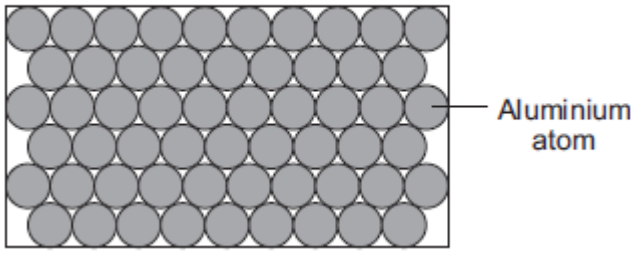
Oxidation ☐

Reduction ☐

(1)

(iv) Aluminium has layers of atoms, as shown in **Figure 4**.

Figure 4



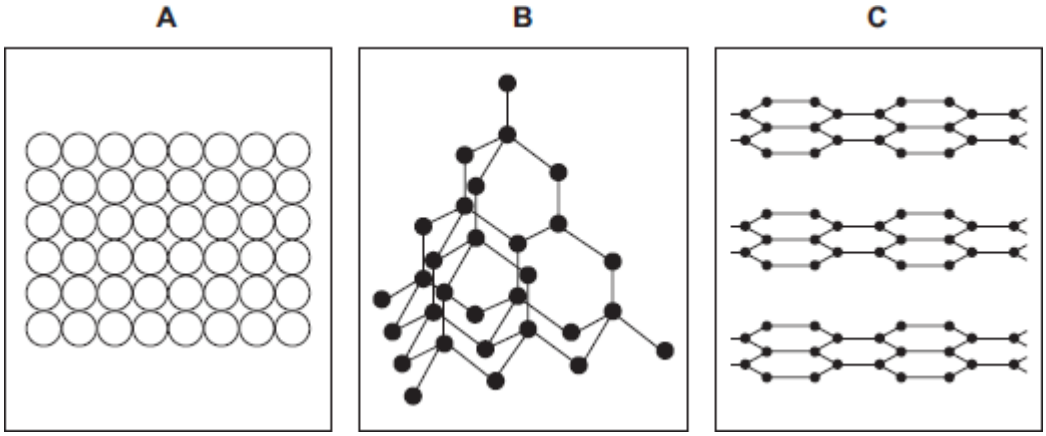
Complete the sentence.

Metals can be bent and shaped because the layers of atoms can ___

(1)

(d) Electrodes used in the production of aluminium are made from graphite.

(i) Which diagram, **A, B** or **C**, shows the structure of graphite?



The structure of graphite is shown in diagram ☐

(1)

(ii) The temperature for the electrolysis is 950 °C.

Use the correct answer from the box to complete the sentence.

cross links	**a giant ionic lattice**	**strong covalent bonds**

The graphite does not melt at 950 °C because

graphite has _____ .

(1)

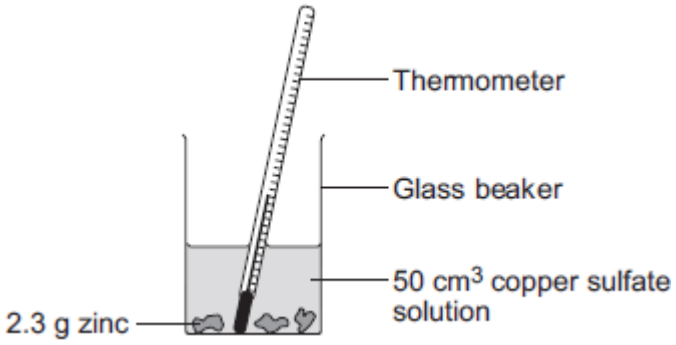
(Total 14 marks)

Q27.

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 ⟶ 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.

Table

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)

Q28.

This question is about metals and alloys.

(a) Explain how electricity is conducted in a metal.

To gain full marks you must include a description of the structure and bonding of a metal.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(b) Describe how the structure of an alloy is different from the structure of a pure metal.

_____

_____

_____

_____

(2)

(c) Alloys are used to make dental braces and coins.

(i) Nitinol is an alloy used in dental braces.

Why is Nitinol used in dental braces?

_____

_____

(1)

(ii) Suggest **one** reason why coins are not made of pure copper.

Do **not** give cost as a reason.

_____

_____

(1)

(iii) Some coins are made from an alloy of aluminium.

Complete the sentence.

Aluminium is manufactured by the electrolysis of a molten mixture of cryolite and

_____

(1)

(iv) Banks keep coins in poly(ethene) bags. These bags are made from low density poly(ethene).

High density poly(ethene) can also be made from the same monomer.

How can the same reaction produce two different products?

_____

_____

(1)

(d) Give **two** reasons why instrumental methods of analysis are used to detect impurities in metals.

_____

_____

_____

(1)

(Total 11 marks)

Q29.

This question is about compounds.

(a) The table gives information about the solubility of some compounds.

Soluble compounds
All potassium and sodium salts
All nitrates
Chlorides, bromides and iodides, except those of silver and lead

Use information from the table to answer these questions.

(i) Name a soluble compound that contains silver ions.

_____

(1)

(ii) Name a soluble compound that contains carbonate ions.

_____

(1)

(b) Metal oxides react with acids to make salts.

What type of compound is a metal oxide?

_____

(1)

(c) Lead nitrate solution is produced by reacting lead oxide with nitric acid.

(i) State how solid lead nitrate can be obtained from lead nitrate solution.

_____

_____

(1)

(ii) Balance the equation for the reaction.

$PbO \quad + \quad HNO_3 \longrightarrow Pb(NO_3)_2 \quad + \quad H_2O$

(1)

(iii) Give the total number of atoms in the formula $Pb(NO_3)_2$

_____

(1)

(d) An oxide of lead that does **not** have the formula PbO contains 6.21 g of lead and 0.72 g of oxygen.

Calculate the empirical formula of this lead oxide.

Relative atomic masses (A_r): O = 16; Pb = 207

You must show your working to gain full marks.

_____

_____

_____

_____

_____

_____

Empirical formula = _____

(4)

(Total 10 marks)

Q30.

This question is about sodium chloride and iodine.

(a) Describe the structure and bonding in sodium chloride.

_____

_____

(4)

(b) When sodium chloride solution is electrolysed, one product is chlorine.

Name the **two** other products from the electrolysis of sodium chloride solution.

(2)

(c) Many people do not have enough iodine in their diet.

Sodium chloride is added to many types of food. Some scientists recommend that sodium chloride should have a compound of iodine added.

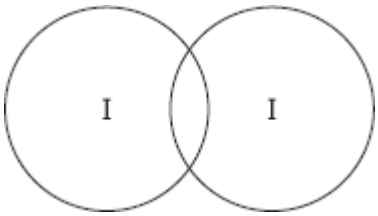
Give **one** ethical reason why a compound of iodine should **not** be added to sodium chloride used in food.

(1)

(d) The bonding in iodine is similar to the bonding in chlorine.

(i) Complete the diagram below to show the bonding in iodine.

Show the outer electrons only.



(2)

(ii) Explain why iodine has a low melting point.

_____

(3)

(iii) Explain, in terms of particles, why liquid iodine does not conduct electricity.

_____

_____

_____

_____

(2)

(Total 14 marks)

Q31.

Some pollutants cause acid rain.

A student tested 25.0 cm^3 samples of three types of rainwater, **P, Q** and **R**.
The student titrated the samples with sodium hydroxide solution (an alkali).

The student recorded the volume of sodium hydroxide solution needed to neutralise the rainwater. The student's results are shown in **Table 1**.

Table 1

	Volume of sodium hydroxide needed to neutralise the rainwater in cm^3				
Type of rainwater	**Titration 1**	**Titration 2**	**Titration 3**	**Titration 4**	**Titration 5**
P	18.0	15.5	14.5	15.0	15.0
Q	13.0	10.0	11.0	10.5	10.5
R	23.0	19.5	18.5	19.0	19.0

(a) (i) The student calculated the mean value for rainwater **R** as 19.0 cm^3.

Show how the student calculated the mean value for rainwater **R**.

_____

_____

_____

_____

(2)

(ii) Write down **P, Q** and **R** in order of their acidity.

Most acidic _____

_____

Least acidic _____

(2)

(b) A second student repeated the experiment and recorded the results in **Table 2**.

Table 2

	Volume of sodium hydroxide needed to neutralise the rainwater in cm^3	
Type of rainwater	**Titration 1**	**Titration 2**
P	17	15
Q	11	9
R	20	18

Use **Table 1** and **Table 2** to suggest **two** improvements the second student could make to obtain more accurate results.

_____

_____

_____

_____

(2)

(c) The results of the two students show that the experiment is reproducible.

Give the reason why.

_____

_____

(1)

(Total 7 marks)

Q32.

This question is about organic compounds.

(a) Ethanol is an alcohol.
One use of ethanol is in alcoholic drinks.

Give **two** other uses of ethanol.

_____

_____

(2)

(b) Which gas is produced when sodium reacts with ethanol?

Tick (✓) **one** box.

Carbon dioxide ☐

Carbon monoxide ☐

Hydrogen ☐

Oxygen ☐

(1)

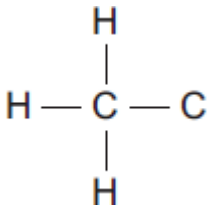
(c) Ethanoic acid (CH_3COOH) can be produced from ethanol (CH_3CH_2OH).

(i) What type of reaction produces ethanoic acid from ethanol?

_____

(1)

(ii) Complete the displayed structure of ethanoic acid.



(1)

(iii) Solutions of ethanoic acid and hydrochloric acid with the same concentration have different pH values.

Explain why the solution of ethanoic acid has a higher pH than the solution of hydrochloric acid.

_____

_____

_____

_____

(2)

(d) Ethanol and ethanoic acid react in the presence of a catalyst to form an ester.

(i) Name the ester made from ethanol and ethanoic acid.

_____

(1)

(ii) What type of chemical is used as a catalyst in this reaction?

_____

(1)

(iii) Esters are used in perfumes because they smell pleasant and are volatile.

What does volatile mean?

_____

(1)

(Total 10 marks)

Q33.

This question is about chemical analysis.

(a) A student has solutions of three compounds, **X, Y** and **Z**.

The student uses tests to identify the ions in the three compounds.

The student records the results of the tests in the table.

	Test			
Compound	**Flame test**	**Add sodium hydroxide solution**	**Add hydrochloric acid and barium chloride solution**	**Add nitric acid and silver nitrate solution**
X	no colour	green precipitate	white precipitate	no reaction
Y	yellow flame	no reaction	no reaction	yellow precipitate
Z	no colour	brown precipitate	no reaction	cream precipitate

Identify the **two** ions present in each compound, **X, Y** and **Z**.

X _____

Y _____

Z _____

(3)

(b) A chemist needs to find the concentration of a solution of barium hydroxide. Barium hydroxide solution is an alkali.

The chemist could find the concentration of the barium hydroxide solution using two different methods.

Method 1

- An excess of sodium sulfate solution is added to 25 cm^3 of the barium hydroxide solution. A precipitate of barium sulfate is formed.
- The precipitate of barium sulfate is filtered, dried and weighed.

- The concentration of the barium hydroxide solution is calculated from the mass of barium sulfate produced.

Method 2

- 25 cm^3 of the barium hydroxide solution is titrated with hydrochloric acid of known concentration.

- The concentration of the barium hydroxide solution is calculated from the result of the titration.

Compare the advantages and disadvantages of the two methods.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5)

(Total 8 marks)

Q34.

Iron is extracted from iron oxide in the blast furnace.

(a) The equation for one of the reactions in the blast furnace is:

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

(i) Complete the word equation for this reaction.

iron oxide + carbon monoxide ⟶ _____ + _____

(2)

(ii) Oxygen is removed from iron oxide in the blast furnace.

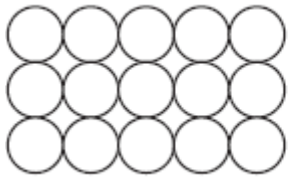
Draw a ring around the correct answer to complete the sentence.

The iron oxide is

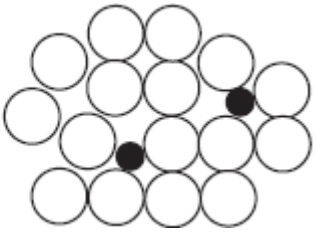
neutralised.
oxidised.
reduced.

(1)

(b) The diagrams represent pure iron and iron from the blast furnace.



Pure iron



Iron from the blast furnace

(i) Draw **one** line from each statement to the correct explanation.

Statement	Explanation
Pure iron is an element because	it is made of one sort of atom only.
	it contains two elements not chemically combined.
Iron from the blast furnace is a mixture because	every atom has the same number of neutrons.
	it contains two elements chemically combined.

(2)

(ii) Explain why iron from the blast furnace is harder than pure iron.

Use the diagrams on page 4 to help you.

_____

_____

_____

_____

(2)

(Total 7 marks)

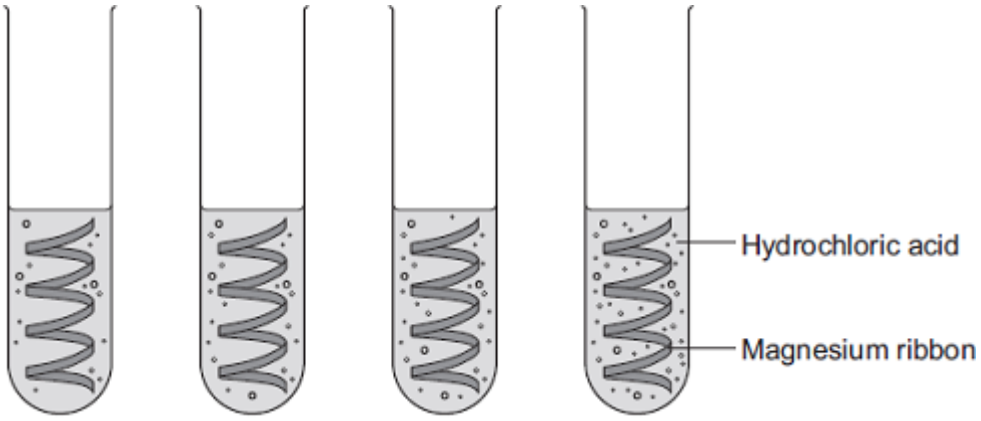
Q35.

A student investigated the rate of reaction of magnesium and hydrochloric acid.

$$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

The student studied the effect of changing the concentration of the hydrochloric acid.

She measured the time for the magnesium to stop reacting.



Concentration of hydrochloric acid in moles per dm^3	0.5	1.0	1.5	2.0

(a) The student changed the concentration of the hydrochloric acid.

Give **two** variables that the student should control.

1. _____

2. _____

(2)

(b) (i) The rate of reaction increased as the concentration of hydrochloric acid increased.

Explain why.

_____

_____

_____

_____

(2)

(ii) Explain why increasing the temperature would increase the rate of reaction.

_____

_____

_____

_____

_____

(3)

(c) (i) The student had a solution of sodium hydroxide with a concentration of 0.100 moles per dm^3.

She wanted to check the concentration of a solution of hydrochloric acid.

She used a pipette to transfer 5.00 cm^3 of the hydrochloric acid into a conical flask.

She filled a burette with the 0.100 moles per dm^3 sodium hydroxide solution.

Describe how she should use titration to obtain accurate results.

(4)

(ii) Sodium hydroxide neutralises hydrochloric acid as shown in the equation:

$$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$$

The student found that 27.20 cm^3 of 0.100 moles per dm^3 sodium hydroxide neutralised 5.00 cm^3 of hydrochloric acid.

Calculate the concentration of the hydrochloric acid in moles per dm^3.

Give your answer to three significant figures.

Concentration of hydrochloric acid = _____ moles per dm^3

(3)

(Total 14 marks)

Q36.

Sulfur is a non-metal.

Sulfur burns in the air to produce sulfur dioxide, SO_2

(a) Why is it important that sulfur dioxide is **not** released into the atmosphere?

Tick (✔) **one** box.

Sulfur dioxide causes acid rain. ☐

Sulfur dioxide causes global dimming. ☐

Sulfur dioxide causes global warming. ☐

(1)

(b) Sulfur dioxide dissolves in water.

What colour is universal indicator in a solution of sulfur dioxide?
Give a reason for your answer.

_____

_____

_____

_____

(2)

(c) Sulfur dioxide is a gas at room temperature.

The bonding in sulfur dioxide is covalent.

Explain, in terms of its structure and bonding, why sulfur dioxide has a low boiling point.

_____

_____

_____

_____

_____

_____

(3)

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

Sulfur dioxide is produced when fossil fuels are burned.

It is important that sulfur dioxide is not released into the atmosphere.

Three of the methods used to remove sulfur dioxide from gases produced when fossil fuels are burned are:

- wet gas desulfurisation (**W**)
- dry gas desulfurisation (**D**)
- seawater gas desulfurisation (**S**).

Information about the three methods is given in the bar chart and in **Table 1** and **Table 2**.

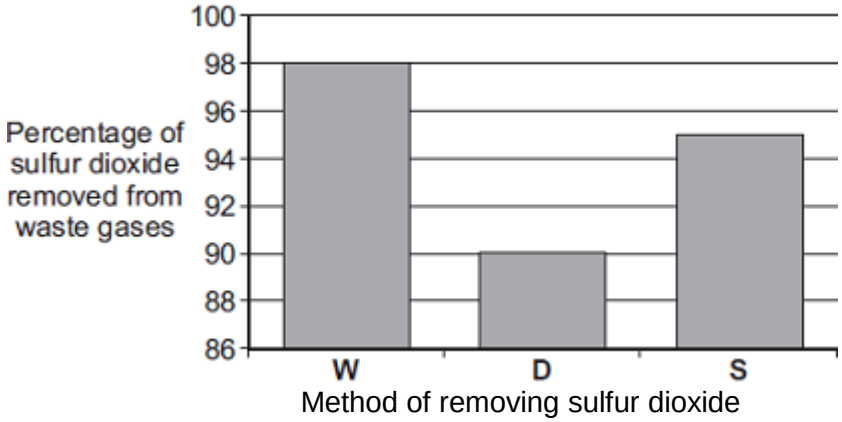


Table 1

Method	Material used	How material is obtained
W	Calcium carbonate, $CaCO_3$	Quarrying
D	Calcium oxide, CaO	Thermal decomposition of calcium carbonate: $CaCO_3 \longrightarrow CaO + CO_2$
S	Seawater	From the sea

Table 2

Method	What is done with waste material
W	Solid waste is sold for use in buildings. Carbon dioxide is released into the atmosphere.
D	Solid waste is sent to landfill.
S	Liquid waste is returned to the sea.

Evaluate the three methods of removing sulfur dioxide from waste gases.

Compare the three methods and give a justified conclusion.

(6)

(Total 12 marks)

Q37.

Lead nitrate solution reacts with potassium iodide solution.

The reaction produces a solid.

Figure 1 shows the reaction occurring.

Figure 1

Lead Iodide By Der Kreole (own work) (CC-BY-3.0) via Wikimedia Commons

(a) (i) Give the name of this type of reaction.

Tick (✓) **one** box.

Combustion ☐

Neutralisation ☐

Precipitation ☐

(1)

(ii) Write the missing state symbols in the chemical equation.

$Pb(NO_3)_2$(aq) + 2KI(___) ⟶ PbI_2(___) + $2KNO_3$(aq)

(2)

(iii) Complete the word equation for the reaction.

lead nitrate + _____ ⟶ lead iodide + _____

(2)

(iv) How is solid lead iodide separated from the solution?

Draw a ring around the correct answer.

Distillation **Electrolysis** **Filtration**

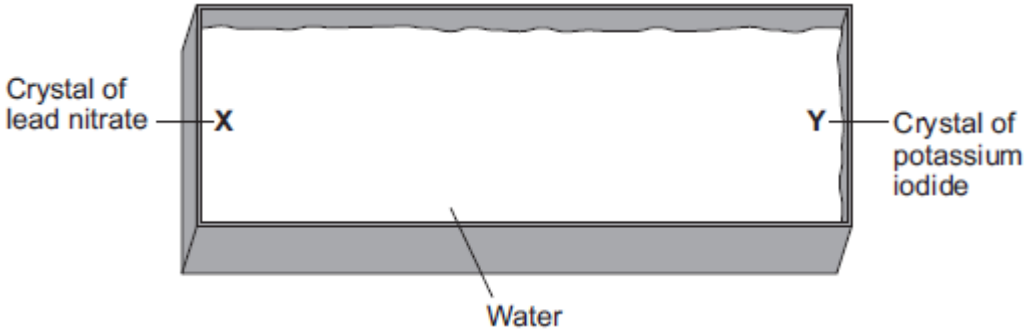
(1)

(b) A group of students investigated the movement of particles.

The students filled a container with water.

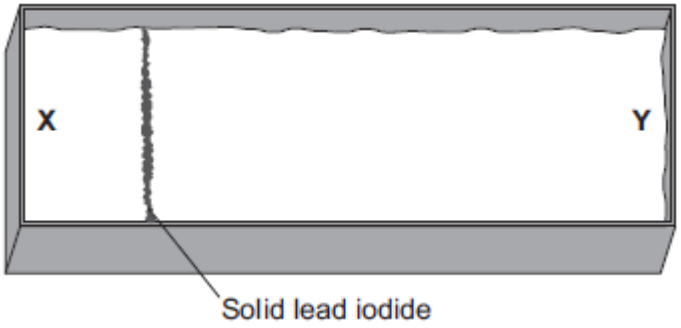
The students added a crystal of lead nitrate at position **X** and a crystal of potassium iodide at position **Y**, as shown in **Figure 2**.

Figure 2 – view from above



After 3 minutes solid lead iodide started to form at the position shown in **Figure 3**.

Figure 3 – view from above



(i) Tick (✓) the correct box to complete the sentence.

Lead ions and iodide ions move through the water by

diffusion. ☐

evaporation. ☐

neutralisation. ☐

(1)

(ii) What conclusion can you make about the speed of movement of lead ions compared with iodide ions?

Give a reason for your answer.

_____

_____

_____

_____

(2)

(iii) The students repeated the experiment at a higher temperature.

The solid lead iodide formed after a shorter period of time.

Explain why, in terms of particles.

_____

_____

_____

_____

(2)

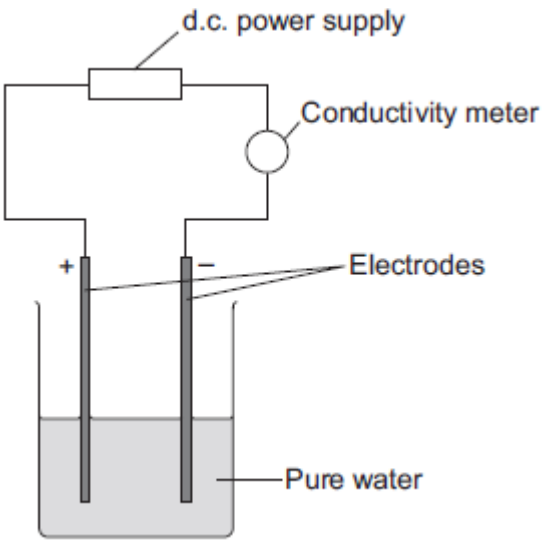
(Total 11 marks)

Q38.

A student investigated the conductivity of different concentrations of sodium chloride solution.

The student set the apparatus up as shown in **Figure 1**.

Figure 1



The student measured the conductivity of the pure water with a conductivity meter.

The reading on the conductivity meter was zero.

(a) The student:

- added sodium chloride solution one drop at a time
- stirred the solution
- recorded the reading on the conductivity meter.

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

Number of drops of sodium chloride solution added	Relative conductivity of solution
0	0
1	100
2	120

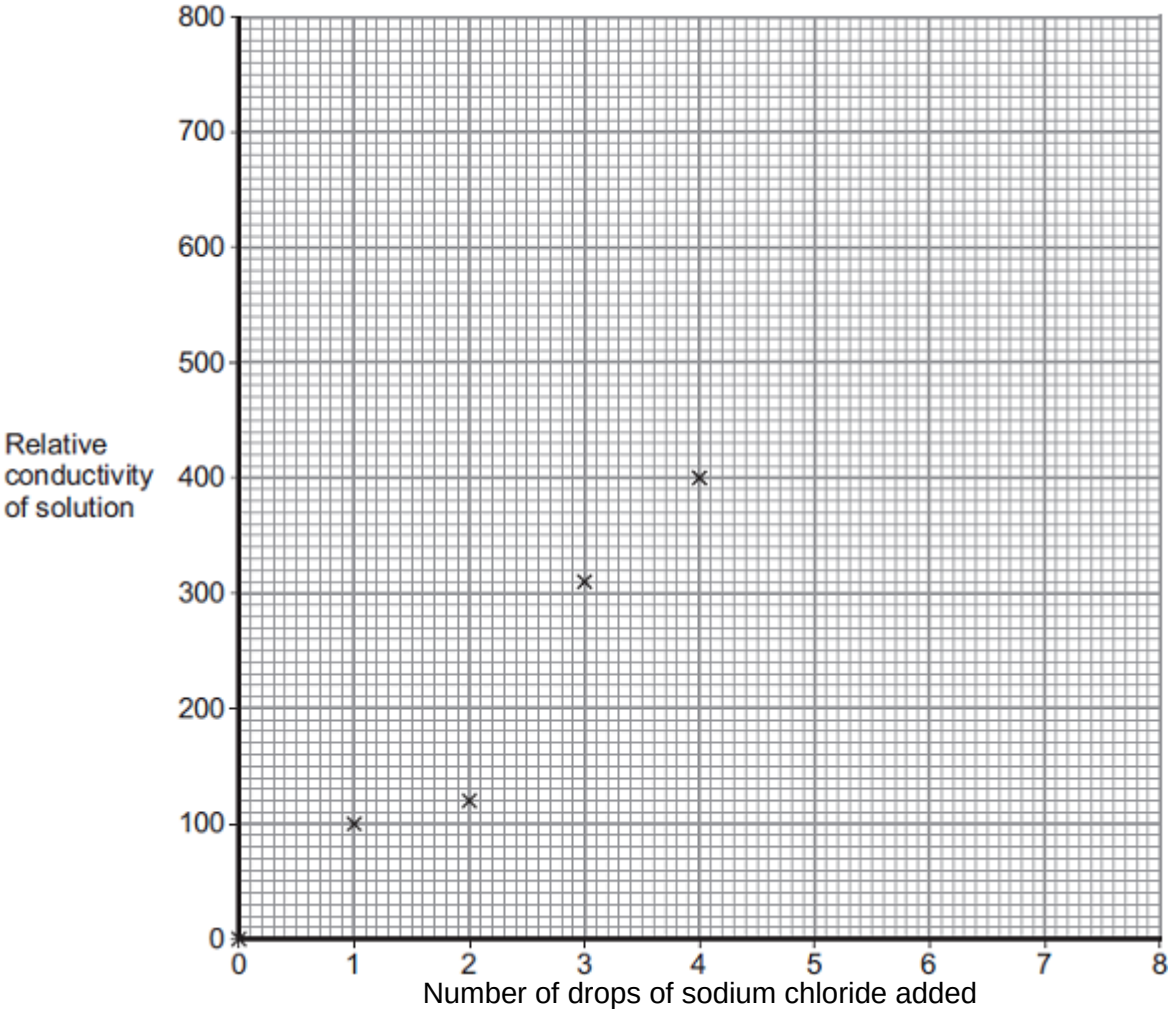
3	310
4	400
5	510
6	590
7	710
8	800

(i) The student plotted the results on the grid shown in **Figure 2**.

Plot the four remaining results.

Draw a line of best fit, ignoring the anomalous result.

Figure 2



(3)

(ii) One of the points is anomalous.

Suggest **one** error that the student may have made to cause the anomalous result.

_____

_____

(1)

(iii) The student wanted to compare the conductivity of sodium chloride solution with the conductivity of potassium chloride solution.

State **one** variable he should keep constant when measuring the conductivity of the two solutions.

_____

(1)

(b) (i) Explain, in terms of bonding, why pure water does **not** conduct electricity.

_____

_____

_____

_____

(2)

(ii) Explain why sodium chloride solution conducts electricity.

_____

_____

_____

_____

(2)

(iii) After he had added sodium chloride solution, the student noticed bubbles of gas at the negative electrode.

Complete the sentence.

The gas produced at the negative electrode is _____

(1)

(Total 10 marks)

Q39.

Use the periodic table and the information in the table below to help you to answer the questions.

The table shows part of an early version of the periodic table.

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
H						
Li	Be	B	C	N	O	F
Na	Mg	Al	Si	P	S	Cl

(a) Hydrogen was placed at the top of Group 1 in the early version of the periodic table.

The modern periodic table does **not** show hydrogen in Group 1.

(i) State one **similarity** between hydrogen and the elements in Group 1.

_____

_____

(1)

(ii) State one **difference** between hydrogen and the elements in Group 1.

_____

_____

(1)

(b) Fluorine, chlorine, bromine and iodine are in Group 7, the halogens.

The reactivity of the halogens decreases down the group.

Bromine reacts with a solution of potassium iodide to produce iodine.

$$Br_2 + 2KI \longrightarrow 2KBr + I_2$$

(i) In the reaction between bromine and potassium iodide, there is a reduction of bromine to bromide ions.

In terms of electrons, what is meant by reduction?

_____

_____

(1)

(ii) Complete the half equation for the oxidation of iodide ions to iodine molecules.

$$2I^- \longrightarrow$$

(2)

(iii) Explain, in terms of electronic structure, why fluorine is the most reactive element in Group 7.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

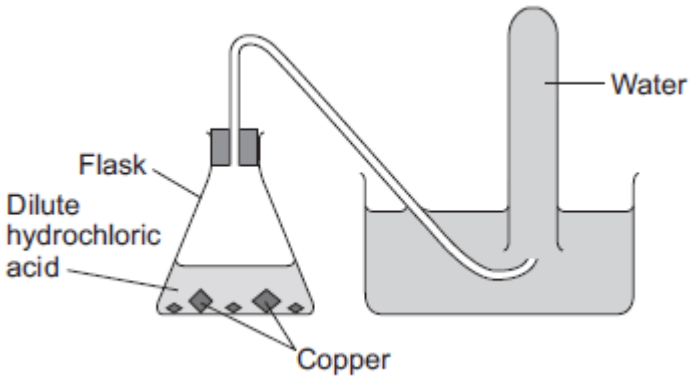
(Total 8 marks)

Q40.

A student was trying to produce hydrogen gas.

Figure 1 shows the apparatus she used.

Figure 1



(a) No gas was produced.

The student's teacher said that this was because the substances in the flask did **not** react.

(i) Suggest why the substances in the flask did **not** react.

_____

_____

_____

(1)

(ii) Which two substances could the student have put in the flask to produce hydrogen safely?

Tick (✓) **one** box.

Gold and dilute hydrochloric acid ☐

Potassium and dilute hydrochloric acid ☐

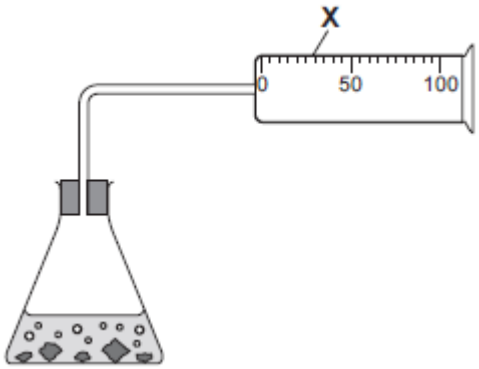
Zinc and dilute hydrochloric acid ☐

(1)

(b) Another student did produce hydrogen from two substances.

Figure 2 shows the apparatus the student used to collect and measure the volume of the hydrogen gas.

Figure 2



Give the name of the apparatus labelled **X**.

_____

(1)

(c) The student did the experiment four times. Her results are shown in the table below.

Experiment	**Volume of hydrogen collected in one minute in cm^3**
1	49
2	50
3	35
4	48

(i) One of the results is anomalous.

Which result is anomalous? Write your answer in the box. ☐

Give a reason for your choice.

_____

(2)

(ii) Calculate the mean volume of hydrogen collected in one minute.

_____

_____

Mean volume = _____ cm^3

(2)

(iii) Give a reason why the experiment should be repeated several times.

_____

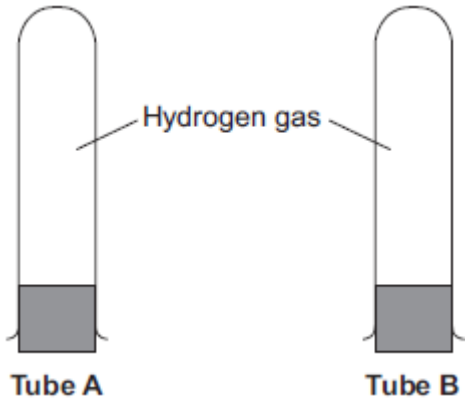
_____

_____

(1)

(d) A teacher collected two tubes full of hydrogen gas, as shown in **Figure 3**.

Figure 3



She tested tube **A** with a lighted splint as soon as she took the bung out.

She tested tube **B** with a lighted splint a few seconds after taking the bung out.

(i) Suggest why tube **B** gave a much louder pop than tube **A**.

_____

_____

_____

_____

(1)

(ii) Complete and balance the chemical equation for the reaction that takes place when the hydrogen reacts in this test.

$$H_2 \quad + \quad O_2 \longrightarrow$$

(2)

(Total 11 marks)

Q41.

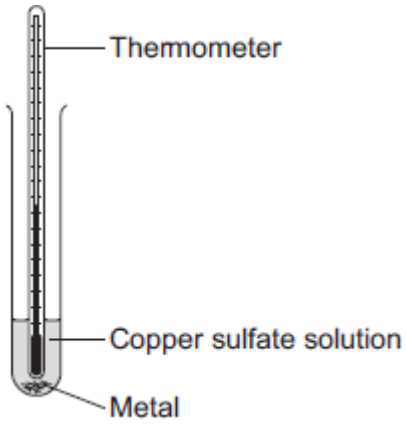
A student investigated displacement reactions of metals.

The student added different metals to copper sulfate solution and measured the temperature change.

The more reactive the metal is compared with copper, the bigger the temperature change.

The apparatus the student used is shown in **Figure 1**.

Figure 1



(a) State **three** variables that the student must control to make his investigation a fair test.

1. _____

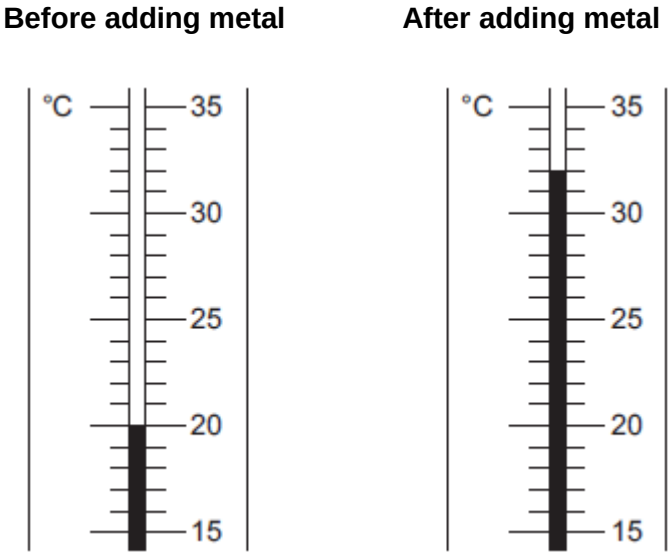
2. _____

3. _____

(3)

(b) **Figure 2** shows the thermometer in one experiment before and after the student added a metal to the copper sulfate solution.

Figure 2



Use **Figure 2** to complete **Table 1**.

Table 1

Temperature before adding metal in °C	_____
Temperature after adding metal in °C	_____
Change in temperature in °C	_____

(3)

(c) The student repeated the experiment three times with each metal.

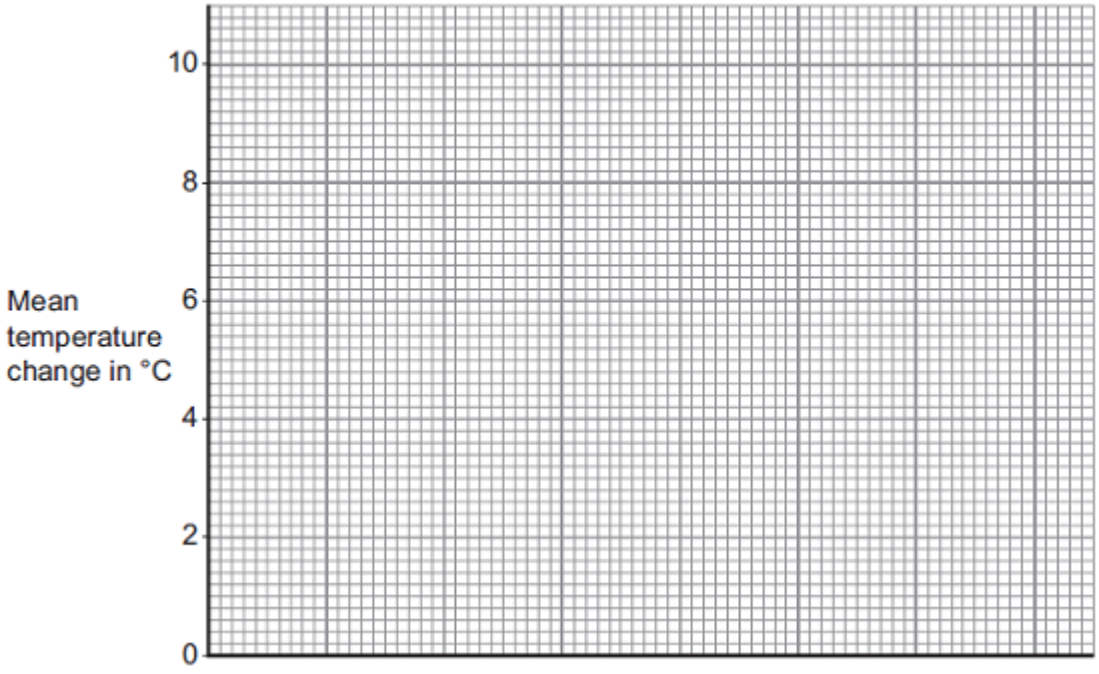
Table 2 shows the mean temperature change for each metal.

Table 2

Metal	**Mean temperature change in °C**
Cobalt	4.5
Gold	0.0
Magnesium	10.0
Nickel	3.0
Silver	0.0
Tin	1.5

(i) On **Figure 3**, draw a bar chart to show the results.

Figure 3



(3)

(ii) Why is a line graph **not** a suitable way of showing the results?

_____

_____

(1)

(iii) Use the results to work out which metal is the most reactive.

Give a reason for your answer.

Most reactive metal _____

Reason _____

_____

(2)

(iv) Explain why there was no temperature change when silver metal was added to the copper sulfate solution.

_____

_____

_____

_____

(2)

(v) It is **not** possible to put all six metals in order of reactivity using these results.

Suggest how you could change the experiment to be able to put all six metals into order of reactivity.

_____

_____

_____

_____

_____

(2)

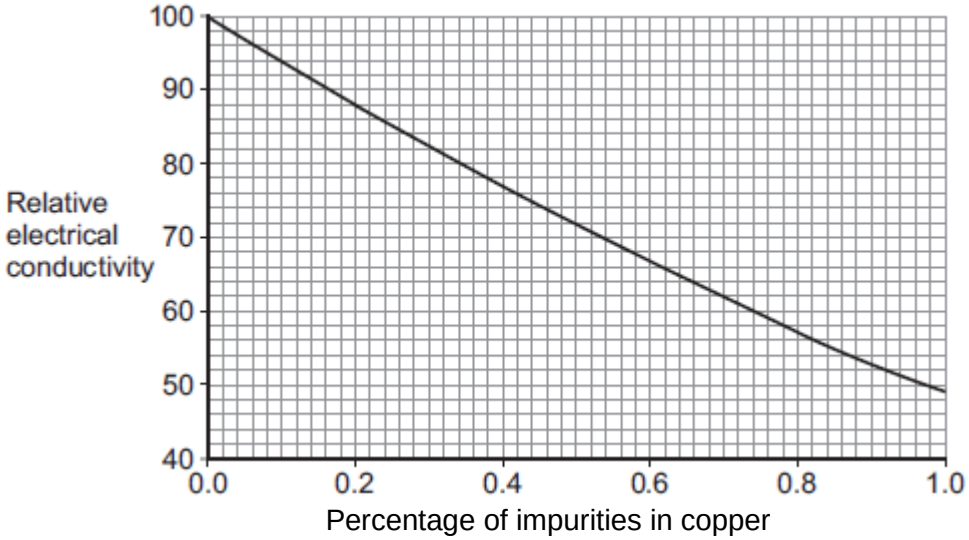
(Total 16 marks)

Q42.

This question is about copper.

(a) Most of the copper extracted is used in electric circuits.

The figure below shows how impurities change the electrical conductivity of copper.



Copper extracted by smelting is about 99% pure.

The 99% pure copper produced by smelting is purified to 99.9999% pure copper by electrolysis.

Use values from the graph to explain why copper is purified to 99.9999%.

(2)

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

Read the information in the box.

Copper extraction

World demand for copper for the year 2011 was about 20 million tonnes.

World reserves of copper are estimated to be 700 million tonnes.

Most of the copper used is obtained from copper ores, which are mined.

The copper ore chalcopyrite is heated in a furnace to produce copper sulfide, CuS

The furnace is heated by burning fossil fuels.

Air is then blown through the hot copper sulfide, to produce copper and sulfur dioxide.

$$CuS + O_2 \rightarrow Cu + SO_2$$

A scientist made the statement: 'Copper should be recycled'.

Use the information in the box and your own knowledge and understanding to justify the scientist's statement.

Extra space

(6)

(c) Phytomining is used to obtain copper from land that contains very low percentages of copper compounds.

Describe how copper compounds are obtained by phytomining.

(3)

(Total 11 marks)

Q43.

Calcium chloride ($CaCl_2$) is a soluble salt.

Calcium chloride can be made by reacting dilute hydrochloric acid with either solid calcium oxide or solid calcium carbonate.

(a) Name the type of reaction that takes place when dilute hydrochloric acid reacts with calcium oxide.

_____

(1)

(b) Write a balanced symbol equation for the reaction of dilute hydrochloric acid with calcium oxide.

_____

(2)

(c) A student added solid calcium oxide to dilute hydrochloric acid in a beaker.

The student added solid calcium carbonate to dilute hydrochloric acid in another beaker.

Describe **one** difference between the two reactions that the student would **see**.

_____

_____

(1)

(d) Describe how crystals of calcium chloride can be made from calcium carbonate and dilute hydrochloric acid.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(e) A student dissolved some crystals of a salt in water.

The student added sodium hydroxide solution to the salt solution.

The student added sodium hydroxide solution until it was in excess.

(i) Describe what the student would **see** if the salt contained calcium ions.

_____

_____

_____

(2)

(ii) Why does the result you have described in part (e)(i) **not** prove that the salt contains calcium ions?

_____

_____

(1)

(iii) Describe an additional test the student could do that would prove the salt contains calcium ions.

_____

_____

_____

(2)

(Total 13 marks)

Q44.

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

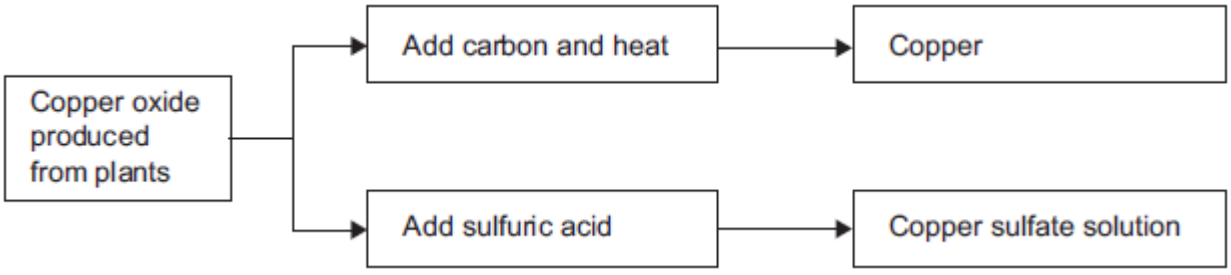
One way to extract the copper is to grow plants on the land.

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.

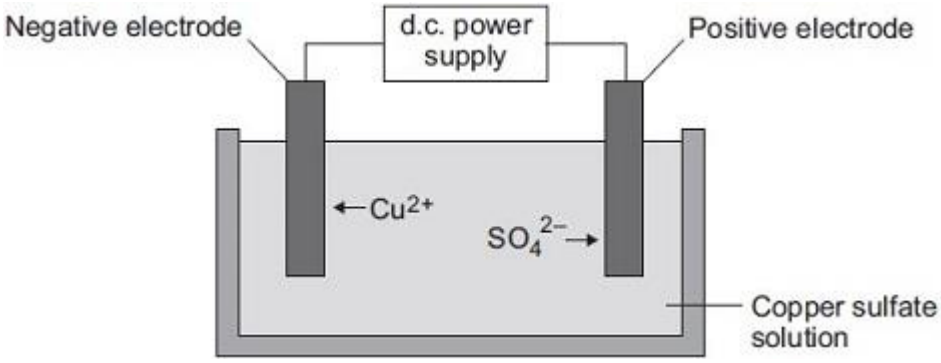
(i) Complete the word equation.

copper sulfate + iron ⟶ _____ + _____

(2)

(ii) **Figure 2** shows the electrolysis of copper sulfate solution.

Figure 2



Why do copper ions go to the negative electrode?

_____

_____

(1)

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

_____

_____

_____

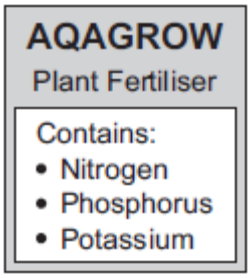
_____

(2)

(Total 8 marks)

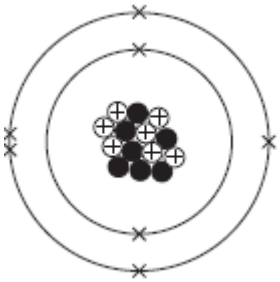
Q45.

Fertilisers contain elements that plants need.



(a) **Figure 1** represents a nitrogen atom.

Figure 1



Complete each sentence.

(i) The mass number of this nitrogen atom is _____ .

(1)

(ii) Atoms of nitrogen with different numbers of neutrons are called

_____ .

(1)

(iii) Compared with a proton, the mass of an electron is

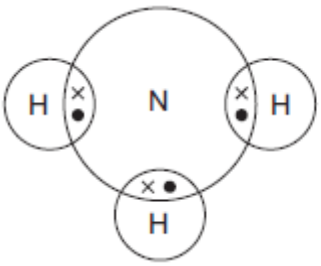
_____ .

(1)

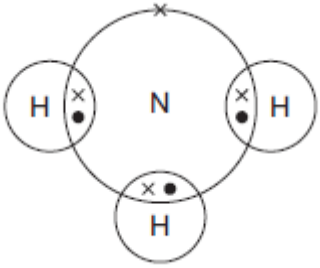
(b) Fertilisers can be made from ammonia.

(i) Which diagram, **A**, **B**, or **C**, represents the electronic structure of an ammonia molecule?

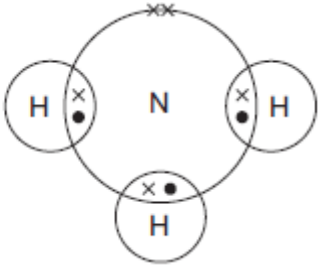
A



B



C



(1)

The electronic structure of an ammonia molecule is shown in diagram

(ii) What is the correct formula of ammonia?

Draw a ring around the correct answer.

N_3H **NH_3** **NH^3**

(1)

(c) A student made ammonium nitrate by reacting ammonia solution with an acid.

(i) Name the acid used to make ammonium nitrate.

_____

(1)

(ii) Complete the sentence.

The student added a few drops of _____, which changed colour

when the ammonia solution had neutralised the acid.

(1)

(iii) The student added charcoal and filtered the mixture.

This produced a colourless solution of ammonium nitrate.

How is solid ammonium nitrate obtained from the solution?

_____

(1)

(iv) A farmer put ammonium nitrate fertiliser onto a field of grass.

Suggest what would happen to the grass.

_____

_____

(1)

(d) Some fertilisers contain potassium chloride.

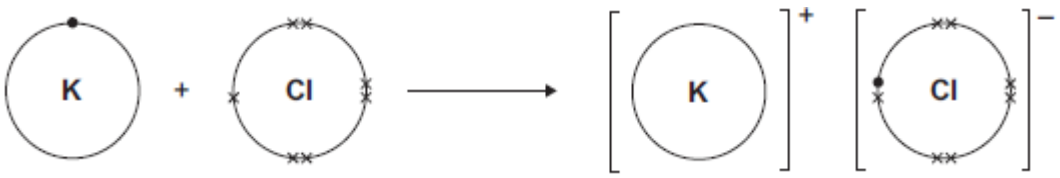
Potassium reacts with chlorine to produce potassium chloride.

Figure 2 shows how this happens.

The dots (•) and crosses (x) represent electrons.

Only the outer shell is shown.

Figure 2



Use **Figure 2** to help you answer this question.

Describe, as fully as you can, what happens when potassium reacts with chlorine to produce potassium chloride.

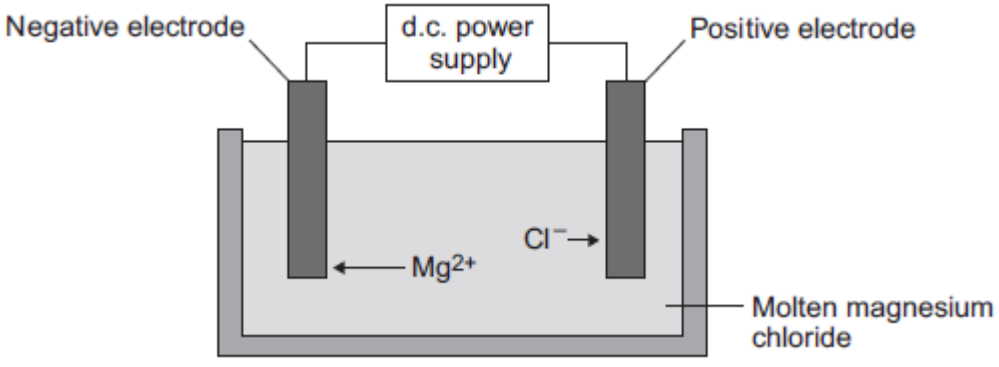
(4)

(Total 13 marks)

Q46.

Some students investigated reactions to produce magnesium.

(a) The students used electrolysis to produce magnesium from magnesium chloride, as shown in the figure below.



(i) Magnesium chloride contains magnesium ions and chloride ions.

Why does solid magnesium chloride **not** conduct electricity?

(1)

(ii) One of the products of the electrolysis of molten magnesium chloride is magnesium.

Name the other product.

_____

(1)

(iii) Why do magnesium ions (Mg^{2+}) move to the negative electrode?

_____

_____

(1)

(iv) At the negative electrode, the magnesium ions (Mg^{2+}) gain electrons to become magnesium atoms.

How many electrons does each magnesium ion gain?

_____

(1)

(b) The students did the experiment four times and weighed the magnesium produced.

The table below shows their results.

Experiment	Mass of magnesium produced in grams
1	1.13
2	0.63
3	1.11
4	1.09

(i) There is an anomalous result.

Suggest **one** possible reason for the anomalous result.

_____

_____

(1)

(ii) Calculate the mean mass of magnesium produced, taking account of the anomalous result.

_____

_____

_____

Mean mass = _____ g

(2)

(c) The formula of magnesium chloride is $MgCl_2$

The relative formula mass of magnesium chloride is 95.

The relative atomic mass of magnesium is 24.

(i) Use the equation to calculate the percentage mass of magnesium in magnesium chloride.

$$\text{Percentage mass of magnesium} = \frac{\text{mass of magnesium}}{\text{mass of magnesium chloride}} \times 100\%$$

_____

_____

_____

Percentage mass of magnesium in magnesium chloride = _____ %

(2)

(ii) Draw a ring around the relative mass of chlorine in $MgCl_2$

71 **95** **119**

(1)

(d) Magnesium is also produced from the reaction of magnesium oxide with silicon.

(i) The equation for the reaction is:

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

What is the meaning of this symbol $\rightleftharpoons$?

Draw a ring around the correct answer.

neutralisation reaction **precipitation reaction** **reversible reaction**

(1)

(ii) The forward reaction is endothermic.

Draw a ring around the correct answer to complete the sentence.

In an endothermic reaction the temperature of the surroundings

decreases.
increases.
stays the same.

(1)

(Total 12 marks)

Q47.

The label shows the ingredients in a drink called Cola.

Cola

Ingredients:

Carbonated water
Sugar
Colouring
Phosphoric acid
Flavouring
Caffeine

(a) (i) The pH of carbonated water is 4.5.

The pH of Cola is 2.9.

Name the ingredient on the label that lowers the pH of Cola to 2.9.

_____

(1)

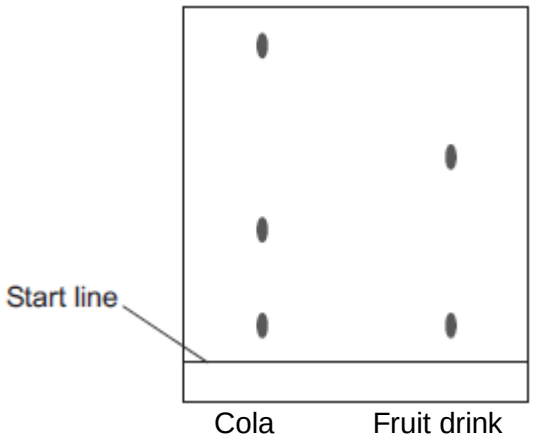
(ii) Which ion causes the pH to be 2.9?

_____

(1)

(b) A student investigated the food colouring in Cola and in a fruit drink using paper chromatography.

The chromatogram in the figure below shows the student's results.



(i) Complete the sentence.

The start line should be drawn with a ruler and _____ .

Give a reason for your answer.

_____

_____

(2)

(ii) Suggest **three** conclusions you can make from the student's results.

_____

_____

_____

_____

_____

_____

(3)

(c) Caffeine can be separated from the other compounds in the drink by gas chromatography.

Why do different compounds separate in a gas chromatography column?

_____

_____

(1)

(d) Caffeine is a stimulant.

Large amounts of caffeine can be harmful.

(i) Only **one** of the questions in the table **can** be answered by science alone.

Tick (✓) **one** question.

Question	Tick (✓)
Should caffeine be an ingredient in drinks?	
Is there caffeine in a certain brand of drink?	
How much caffeine should people drink?	

(1)

(ii) Give **two** reasons why the other questions **cannot** be answered by science alone.

Reason 1 _____

_____

Reason 2 _____

_____

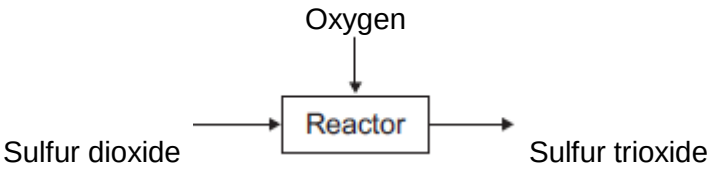
(2)

(Total 11 marks)

Q48.

Figure 1 represents a reaction in the production of sulfuric acid.

Figure 1



(a) Complete and balance the equation for the reaction.

_____ $SO_2(g)$ + _____ (g) ⇌ _____ $SO_3(g)$

(2)

(b) The conditions can affect the rate of the reaction.

(i) The pressure of the reacting gases was increased.

State the effect of increasing the pressure on the rate of reaction.

Explain your answer in terms of particles.

_____

_____

_____

_____

_____

_____

(3)

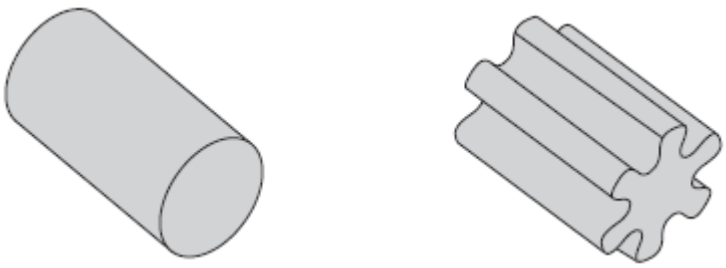
(ii) A catalyst is used for the reaction.

The gases pass through a layer containing pieces of the catalyst.

Figure 2 shows the shapes of pieces of catalyst.

Figure 2

A **B**



Suggest and explain why shape **B** is more effective as a catalyst than shape **A**.

_____

_____

_____

_____

(2)

(c) The reaction is carried out at a high temperature to provide the reactants with the **activation energy**.

What is meant by the **activation energy**?

_____

_____

_____

(1)

(d) Sulfuric acid reacts with metals to produce salts.

(i) A student concluded that potassium would **not** be a suitable metal to react with sulfuric acid.

Explain why.

_____

_____

_____

_____

(2)

(ii) A student reacted zinc metal with sulfuric acid to produce a salt and another product.

Complete the equation for this reaction.

$Zn + H_2SO_4 \longrightarrow$ _____ + _____

(2)

(iii) The student wanted to increase the rate of the reaction between the zinc and sulfuric acid.

State **one** way, other than using a catalyst, that the student could increase the rate of the reaction.

_____

_____

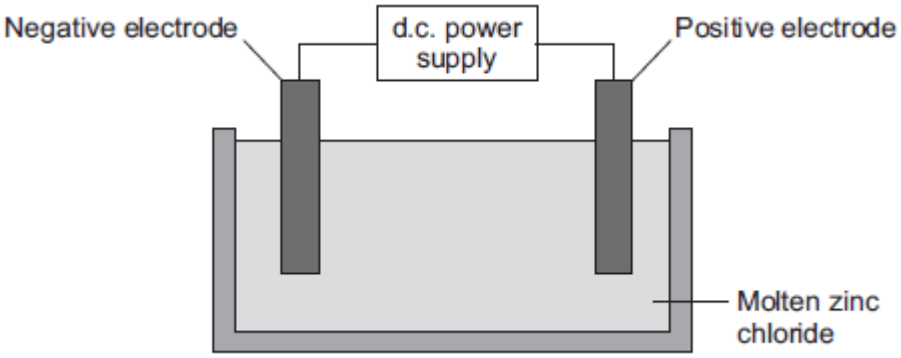
(1)

(Total 13 marks)

Q49.

This question is about zinc and magnesium.

Zinc is produced by electrolysis of molten zinc chloride, as shown in the figure below.



(a) (i) Why must the zinc chloride be molten for electrolysis?

_____

_____

(1)

(ii) Describe what happens at the negative electrode.

_____

_____

_____

_____

_____

_____

(3)

(iii) Complete the half equation for the reaction at the positive electrode.

_____ ⟶ Cl_2 + _____ e^-

(1)

(b) Magnesium can be produced from magnesium oxide.

The equation for the reaction is:

$$Si(s) + 2\,MgO(s) \longrightarrow SiO_2(s) + 2\,Mg(g)$$

(i) How can you tell from the equation that the reaction is done at a high temperature?

_____

_____

(1)

(ii) This reaction to produce magnesium from magnesium oxide is **endothermic**.

What is meant by an **endothermic** reaction?

_____

_____

(1)

(iii) A company made magnesium using this reaction.

Calculate the mass of magnesium oxide needed to produce 1.2 tonnes of magnesium.

Relative atomic masses (A_r): O = 16; Mg = 24

_____

_____

_____

_____

Mass of magnesium oxide needed = _____ tonnes

(3)

(iv) The company calculated that they would produce 1.2 tonnes of magnesium, but only 0.9 tonnes was produced.

Calculate the percentage yield.

_____

_____

Percentage yield = _____ %

(1)

(v) Give **one** reason why the calculated yield of magnesium might not be obtained.

_____

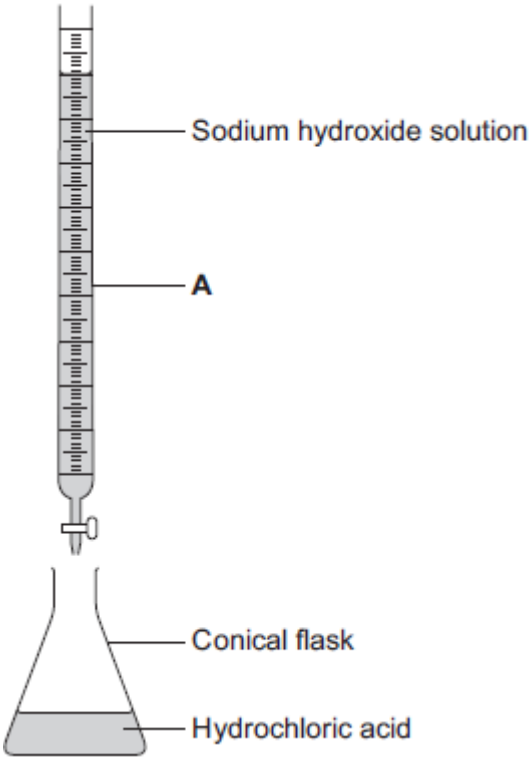
_____

(1)

(Total 12 marks)

Q50.

(a) A student used the apparatus in the figure below to do a titration.



(i) What is the name of the piece of apparatus labelled **A**?

Draw a ring around the correct answer.

burette **measuring cylinder** **test tube**

(1)

(ii) What should the student add to the acid in the conical flask?

Draw a ring around the correct answer.

catalyst **indicator** **water**

(1)

(iii) What would the student see when the end point of the titration has been reached?

_____

(1)

(b) The student does the titration three times.

(i) State **one** variable that the student needs to keep the same to make it a fair test.

_____

(1)

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

Titration	**Volume of sodium hydroxide solution added in cm^3**

1	22.40
2	22.20
3	22.30

Calculate the mean volume of sodium hydroxide solution added.

_____ cm^3

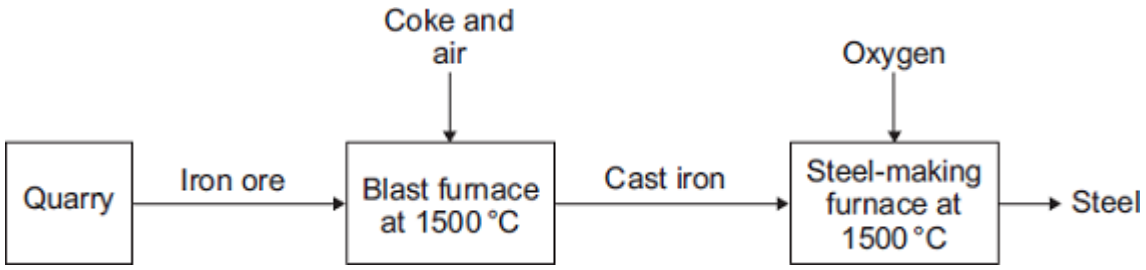
(1)

(Total 5 marks)

Q51.

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 → 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 (✓)**

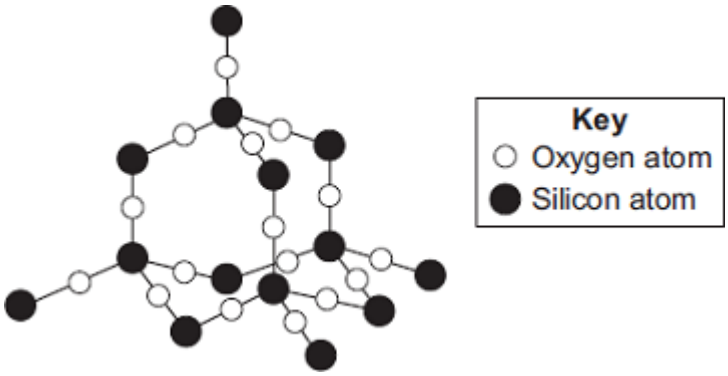
Iron is the second most common metal in the Earth's crust.		
Less carbon dioxide is produced.		
More iron ore needs to be mined.		
There are different types of steel which must be sorted.		

(2)

(Total 12 marks)

Q52.

The diagram shows a small part of the structure of silicon dioxide.



(a) Use the diagram above to answer the question.

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

In silicon dioxide, each silicon atom is bonded with

two
three
four

oxygen atoms.

The bonds in silicon dioxide are

ionic.
covalent.
metallic.

(2)

(b)

Silicon dioxide is used as the inside layer of furnaces.

Suggest why.

_____

_____

(1)

(c) Nanowires can be made from silicon dioxide.

Draw a ring around the correct answer to complete the sentence.

The word 'nano' means the wires are very

brittle.
thick.
thin.

(1)

(Total 4 marks)

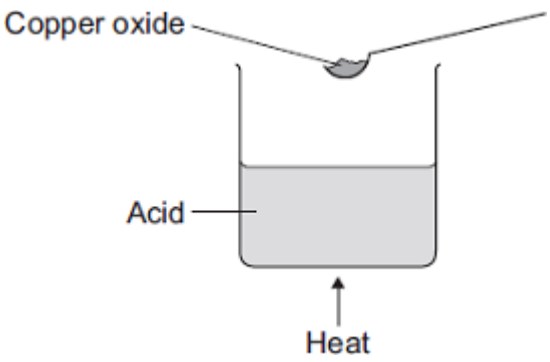
Q53.

A student added copper oxide to an acid to make copper sulfate.

The student heated the acid.

The student added copper oxide until no more reacted.

(a) The diagram shows the first stage in the experiment.



(i) Complete the word equation.

Copper oxide + _____ acid → copper sulfate + water

(1)

(ii) Which **one** of these values could be the pH of the acid?

Draw a ring around the correct answer.

1 **7** **11**

(1)

(iii) Why is the acid heated?

_____

_____

(1)

(b) After the reaction is complete, some solid copper oxide remains.
Why?

_____

_____

(1)

(c) The student removed the solid copper oxide from the solution.

Suggest what the student should do to the solution to form copper sulfate crystals.

_____

_____

(1)

(d) The mass of copper sulfate crystals was less than the student expected.

Tick (✓) the **one** statement that explains why the mass of copper sulfate crystals was less than expected.

Statement	Tick (✓)
Some copper sulfate may have been lost during the experiment.	
The student added too much copper oxide.	
The copper sulfate crystals were wet when they were weighed.	

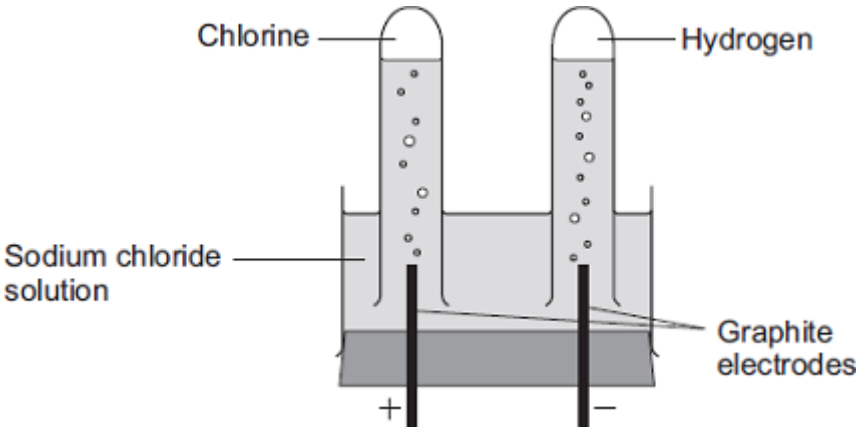
(1)

(Total 6 marks)

Q54.

The electrolysis of sodium chloride solution is an industrial process.

The diagram shows the apparatus used in a school experiment.



(a) One of the products of the electrolysis of sodium chloride solution is hydrogen.

(i) Why do hydrogen ions move to the negative electrode?

_____

_____

(1)

(ii) How does a hydrogen ion change into a hydrogen atom?

_____

_____

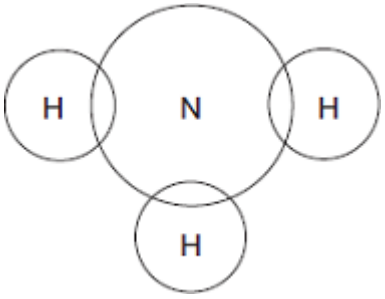
(1)

(b) Hydrogen is used to make ammonia (NH_3).

Complete the diagram to show the bonding in ammonia.

Use dots (●) and crosses (x) to show electrons.

Show only outer shell electrons.



(2)

(c) The table shows the ions in sodium chloride solution.

Positive ions	**Negative ions**
hydrogen	chloride
sodium	hydroxide

In industry, some of the waste from the electrolysis of sodium chloride solution is alkaline and has to be neutralised.

(i) Which ion makes the waste alkaline?

_____

(1)

(ii) This waste must be neutralised.

Write the ionic equation for the neutralisation reaction.

_____

(1)

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

The electrolysis of sodium chloride solution also produces chlorine and sodium hydroxide.

In industry, the electrolysis of sodium chloride solution can be done in several types of electrolysis cell.

Some information about two different types of electrolysis cell is given below.

	Mercury cell	**Membrane cell**
Cost of construction	Expensive	Relatively cheap
Additional substances used	Mercury, which is recycled. Mercury is toxic so any traces of mercury must be removed from the waste	Membrane, which is made of a polymer. The membrane must be replaced every 3 years.
Amount of electricity used for each tonne of chlorine produced in kWh	3400	2950
Quality of chlorine produced	Pure	Needs to be liquefied and distilled to make it pure.
Quality of sodium hydroxide solution produced	50% concentration. Steam is used to concentrate the sodium hydroxide solution produced.	30% concentration. Steam is used to concentrate the sodium hydroxide solution produced.

Use the information and your knowledge and understanding to compare the environmental and economic advantages and disadvantages of these **two** types of electrolysis cell.

_____

_____

(6)

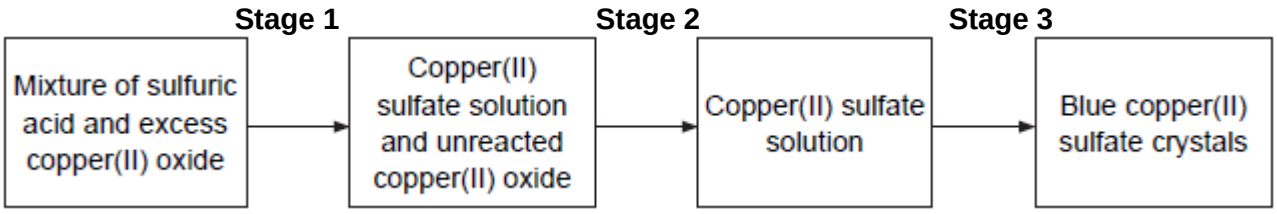
(Total 12 marks)

Q55.

This question is about compounds of copper.

(a) A student made some copper(II) sulfate crystals.

The flow diagram shows the stages of the preparation of copper(II) sulfate crystals.



(i) The reaction mixture is heated in **Stage 1**.

Suggest why.

(1)

(ii) Complete the equation for this reaction.

CuO + _____ → $CuSO_4$ + _____

(2)

(iii) How would the student remove the unreacted copper(II) oxide in **Stage 2**?

_____

_____

(1)

(iv) How would the student obtain copper(II) sulfate crystals from the copper(II) sulfate solution in **Stage 3**?

_____

(1)

(v) The mass of crystals obtained was less than the student had calculated.

Suggest **one** reason why.

_____

_____

(1)

(b) The student heated the blue copper(II) sulfate crystals.

The word equation for the reaction is shown below.

hydrated copper(II) sulfate $\rightleftharpoons$ anhydrous copper(II) sulfate + water

blue white

(i) What does the symbol $\rightleftharpoons$ mean ?

_____

(1)

(ii) 300 J of energy are taken in when some blue copper(II) sulfate crystals are heated.

What is the energy change when an excess of water is added to the anhydrous copper(II) sulfate produced?

_____

_____

(2)

(c) A sample of copper nitride contains 3.81 g of copper and 0.28 g of nitrogen.

Calculate the empirical formula.

You **must** show all your working to get full marks.

Relative atomic masses (A_r): N = 14; Cu = 63.5.

_____

_____

_____

_____

Empirical formula = _____

(4)

(Total 13 marks)