Q1. (a) The formula for the chemical compound magnesium sulphate is $MgSO_4$.

Calculate the relative formula mass (M_r) of this compound. (Show your working.)

.....

.....

.....

.....

(2)

(b) Magnesium sulphate can be made from magnesium and dilute sulphuric acid.

This is the equation for the reaction.

$$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$$

Calculate the mass of magnesium sulphate that would be obtained from 4g of magnesium.
(Show your working.)

.....

.....

.....

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.....

.....

Answer..... g

(2)

(Total 4 marks)

Q2. (a) Iron powder is used in the manufacture of ammonia. Why is it used?

.....

.....

(1)

(b) Ammonia is manufactured from nitrogen and hydrogen. The equation for the reaction between them is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) Which **two** raw materials are used to make the hydrogen?

..... and .....

(1)

(ii) Why does increasing the pressure increase the chance of molecules of nitrogen reacting with molecules of hydrogen?

.....

.....

(1)

(iii) Calculate the mass, in tonnes, of ammonia which could be produced from 560 tonnes of nitrogen.

The relative atomic masses are: H 1; N 14.

Show clearly how you get to your answer.

.....

.....

.....

Mass of ammonia = ... tonnes

(3)

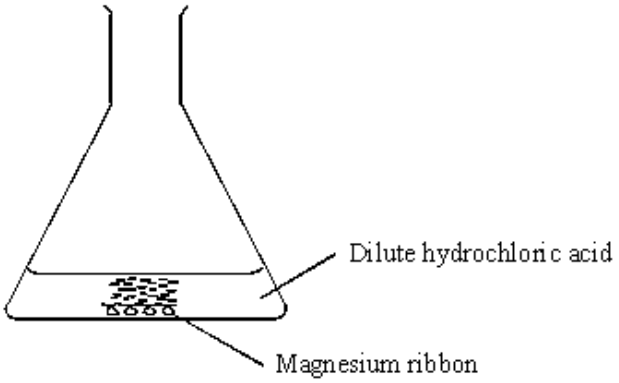
(Total 6 marks)

##

In this question you will need to use the following information:

Relative atomic masses: H 1; O 16; Mg 24. The volume of one mole of any gas is 24 dm^3 at room temperature and atmospheric pressure.

The diagram shows a chemical reaction taking place in a conical flask.



The balanced equation for this reaction is:

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

(a) Write a balanced ionic equation for this reaction.

.....

(2)

(b) Calculate the mass of magnesium required to produce 0.50 g of hydrogen. Show clearly how you work out your final answer and give the unit.

.....

.....

Mass = ...

(2)

(c) (i) Draw a diagram to show how the electrons are arranged in a hydrogen molecule.

(1)

(ii) What is the name of the type of chemical bond between the hydrogen atoms in a hydrogen molecule?

.....

(1)

(d) The chemical formula for hydrogen peroxide is H_2O_2.

Calculate, to the nearest whole number, the percentage, by mass, of hydrogen in hydrogen peroxide. Show clearly how you work out your answer.

.....

.....

Percentage = ... %

(2)

(Total 8 marks)

Q4. The balanced symbol equation for the reaction is

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

Starting with 2 g of hydrogen, what mass of hydrogen chloride would be produced?
(Relative atomic masses: H = 1; Cl = 35.5)

.....

.....

.....

.....

Mass of hydrogen chloride = ... g

(Total 3 marks)

Q5. 'Iron tablets' usually contain iron sulphate ($FeSO_4$).

(a) This salt can be made by reacting iron with sulphuric acid.

$$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$$

Calculate the mass of iron sulphate that could be obtained from 4 g of iron.

(Relative atomic masses: Fe = 56, H = 1, O = 16, S = 32)

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.....

Mass of iron sulphate = ... g

(3)

(b) Under different conditions, another type of iron sulphate may form.
Balance the symbol equation for this reaction.

$$Fe + H_2SO_4 \rightarrow Fe_2(SO_4)_3 + H_2$$

(1)

(Total 4 marks)

Q6. Iron is the most commonly used metal. Iron is extracted in a blast furnace from iron oxide using carbon monoxide.

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

(a) A sample of the ore haematite contains 70% iron oxide.

Calculate the amount of iron oxide in 2000 tonnes of haematite.

.....

.....

Amount of iron oxide = ... tonnes

(1)

(b) Calculate the amount of iron that can be extracted from 2000 tonnes of haematite.
(Relative atomic masses: O = 16; Fe = 56)

.....

.....

.....

.....

.....

.....

Amount of iron = ... tonnes

(4)

(Total 5 marks)

Q7. Bromine can be made from sea water. In 1000 g of sea water there is 0.065 g of bromine. What mass of sea water would be needed to make 1000 g of bromine?

.....

.....

(Total 2 marks)

Q8. Quicklime can be converted to slaked lime. The equation which represents this reaction is shown below.

$$CaO_{(s)} + H_2O_{(l)} \rightarrow Ca(OH)_{2(s)}$$

quickline slaked line

(i) Why do farmers sometimes add slaked lime to acidic soil?

.....

.....

(1)

(ii) Use these relative atomic masses: H = 1; O = 16; Ca = 40
to calculate the relative formula mass (M_r) of

quicklime CaO .....

slaked lime $Ca(OH)_2$ .....

(2)

(iii) Calculate the mass of slaked lime that could be made from 1000 kg of quicklime.

.....

.....

.....

Mass of slaked lime ..... kg

(2)

(Total 5 marks)

Q9. The following passage was taken from a chemistry textbook.

Germanium is a white, shiny, brittle element. It is used in the electronics industry because it is able to conduct a small amount of electricity.

It is made from germanium oxide obtained from flue dusts of zinc and lead smelters.
The impure germanium oxide from the flue dusts is changed into germanium by the process outlined below.

STEP 1 The germanium oxide is reacted with hydrochloric acid to make germanium tetrachloride. This is a volatile liquid in which the germanium and chlorine atoms are joined by covalent bonds.

STEP 2 The germanium tetrachloride is distilled off from the mixture.

STEP 3 The germanium tetrachloride is added to an excess of water to produce germanium oxide and hydrochloric acid.

STEPS 1 to 3 are repeated several times.

STEP 4 The pure germanium oxide is reduced by hydrogen to form germanium.

(a) Balance the equation below which represents the reaction in step 1.

GeO_2 + ... HCl → $GeCl_4$ + ... H_2O

(1)

(b) Write a word equation for the reaction in step 3.

.....

(1)

(c) Suggest why steps 1 to 3 are repeated several times.

.....

.....

(1)

(d) The equation which represents the reaction in step 4 is shown below.

$$GeO_2 + 2H_2 \rightarrow Ge + 2H_2O$$

(i) Explain what is meant by the term 'reduced'.

.....

.....

(1)

(ii) Calculate the mass of germanium which could be made from 525 g of germanium oxide. (Relative atomic masses: Ge = 73; O = 16).

.....

.....

.....

.....

Mass ..... g

(3)

(e) Germanium is difficult to classify as either a metal or a non-metal.

(i) Give as much evidence as you can from the information in this question to support the view that germanium is a metal. Explain your answer as fully as you can.

.....

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.....

(3)

(ii) Give as much evidence as you can from the information in this question to support the view that germanium is a non-metal. Explain your answer as fully as you can.

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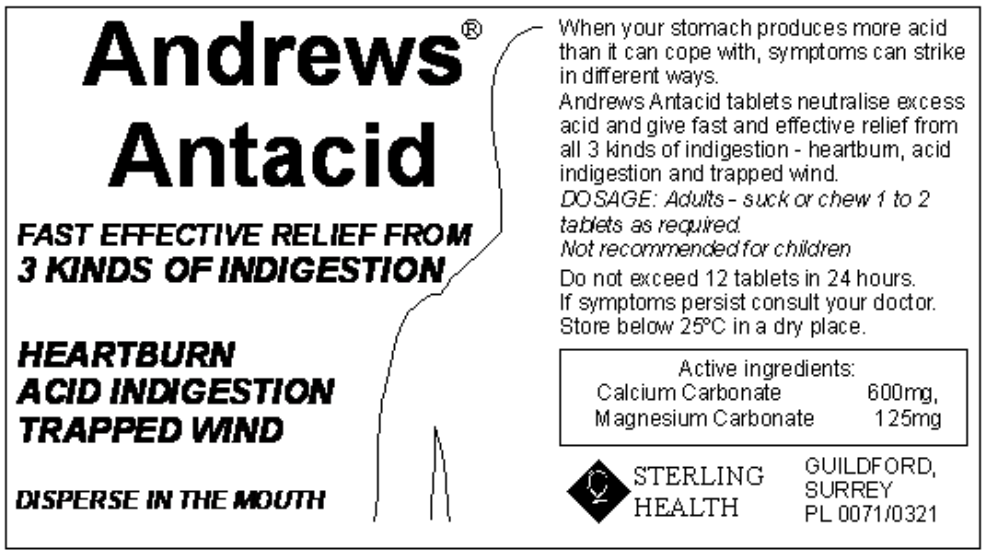
(3)

(Total 13 marks)

Q10. (a) This label has been taken from a packet of *Andrews Antacid*.



(i) Write the simplest ionic equation which represents a neutralisation reaction.

.....

(1)

(ii) Chewing the tablet cures indigestion faster than swallowing the tablet whole. Explain why.

.....

.....

(1)

(iii) Write the formula of the magnesium compound present in *Andrews Antacid*. You may find the Data Sheet helpful.

.....

(1)

(b) The active ingredients in the *Antacid* react with hydrochloric acid in the stomach to give salts, water and carbon dioxide.

A student investigated how quickly the tablets react with **excess** hydrochloric acid.

40 cm^3 of dilute hydrochloric acid were placed in a conical flask. The flask was placed on a direct reading balance. Two *Antacid* tablets were quickly added to the flask. The apparatus was weighed immediately. At the same time, a stop clock was started. The mass was recorded every half minute for 5 minutes.

The results are shown in the table below.

Mass of flask + contents (g)	92.0	90.0	89.0	88.3	87.8	87.5	87.3	87.1	87.0	87.0	87.0
Time (minutes)	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0

The main active ingredient in *Andrews Antacid* is calcium carbonate.

(i) Balance the equation which represents the reaction between calcium carbonate and hydrochloric acid.

$$CaCO_{3(s)} + \text{.....} HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

(1)

(ii) State the meaning of the symbol "(aq)".

.....

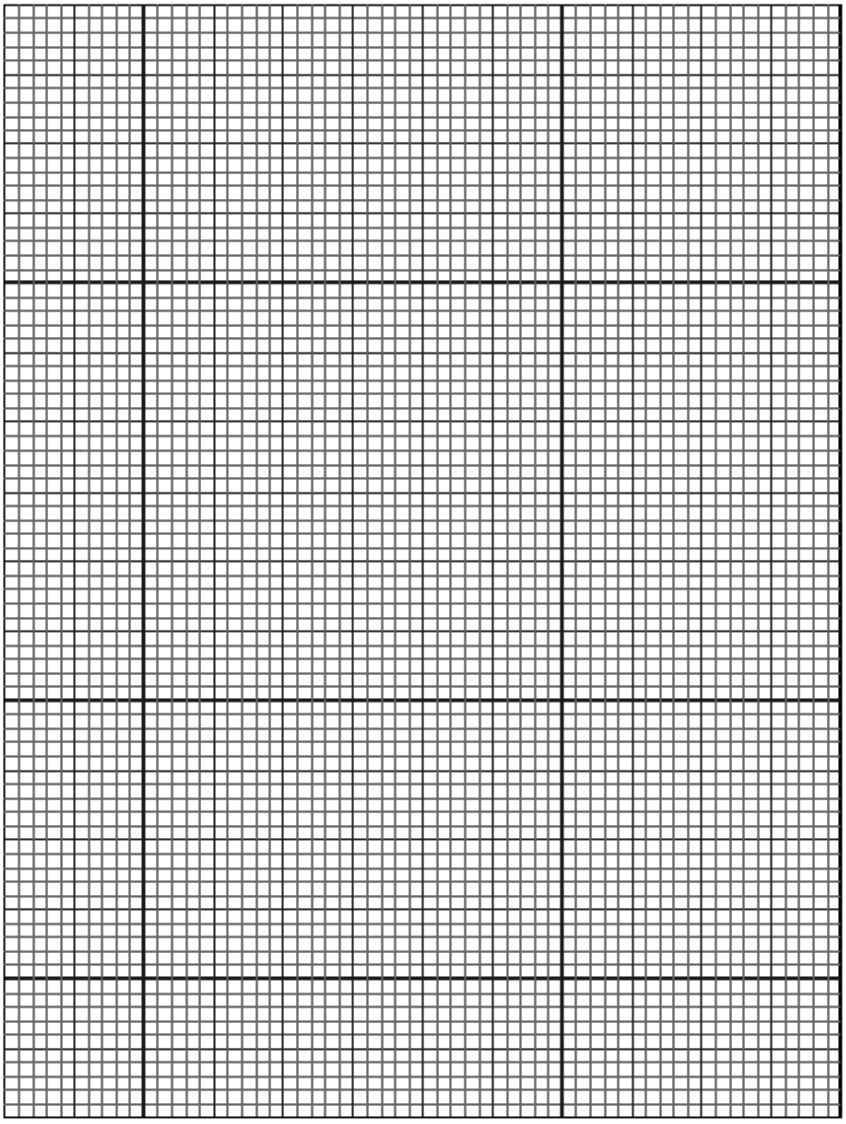
(1)

(iii) Why does the mass of the flask and contents decrease?

.....

(1)

(c) (i) Plot the results on the graph below and draw a smooth curve to show how the mass of the flask and its contents changes with time. Label this curve “A”.



(3)

(ii) One of the results does not appear to fit the pattern. Circle this result on the graph.

(1)

(d) The student did a second experiment. The only change was that the acid was twice as concentrated.

On the graph, sketch a second curve to show a possible result for this experiment. Label this curve “B”.

(2)

(Total 12 marks)

Q11. Ammonium nitrate is an important fertiliser. It is made by reacting nitric acid with the alkali ammonia.

(i) State the type of reaction taking place.

.....

(1)

(ii) The equation for this reaction is:

$NH_3 + HNO_3 \rightarrow NH_4NO_3$

Calculate the number of tonnes of ammonium nitrate that can be made from 68 tonnes of ammonia.

(Relative atomic masses: H = 1, N = 14, O = 16)

.....

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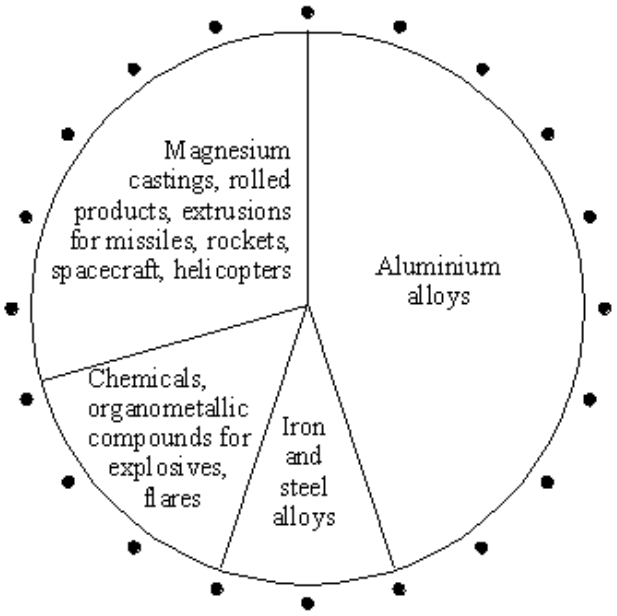
.....

.....

(3)
(Total 4 marks)

Q12. 280 000 tonnes of magnesium are produced in the world each year. The pie chart below shows the ways in which magnesium is used.



(a) (i) Use the pie chart to calculate the percentage of magnesium used to make aluminium alloys.

..... %

(1)

(ii) How many tonnes of magnesium are used to make aluminium alloys each year?

..... tonnes

(1)

(b) Magnesium is produced by the electrolysis of molten magnesium chloride. The reactions which take place at the electrodes are represented by the equations below.

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

$$2Cl^- - 2e^- \rightarrow Cl_2$$

(i) Calculate the mass of chlorine produced when one kilogram of magnesium is made. (Relative atomic masses: Mg = 24, Cl = 35.5)

.....

.....

.....

.....

(3)

(ii) Give a use for chlorine.

.....

(1)

(Total 6 marks)

Q13. Limestone ($CaCO_3$) is a raw material. On strong heating it is converted to calcium oxide which is a very useful substance.

$$CaCO_3 \xrightarrow{\text{heat}} CaO + CO_2$$

(a) Calculate the formula mass (M_r) of calcium carbonate.

.....

M_r of calcium carbonate = ...

(2)

(b) About 60 million tonnes of calcium oxide is made in Britain each year.
Calculate the mass of calcium carbonate needed to make this amount of calcium oxide.

.....

.....

.....

.....

.....

.....

Mass of calcium carbonate needed = ... million tonnes

(4)

(c) Water is added to some of the calcium oxide produced in a process known as 'slaking'.
The product of this reaction is used to make plaster.

$CaO_{(s)} + H_2O_{(1)} \rightarrow Ca(OH)_{2(s)}$

(i) Give the chemical name of $Ca(OH)_2$.

.....

(1)

(ii) What is the physical state of the $Ca(OH)_2$ formed in the reaction?

.....

(1)

(Total 8 marks)

Q14. Titanium is a transition metal used as pins and plates to support badly broken bones. Titanium is extracted from an ore that contains the mineral titanium oxide. This oxide is converted into titanium chloride. Titanium chloride is heated with sodium to form titanium metal. This reaction takes place in an atmosphere of a noble gas, such as argon.

$$4Na(s) + TiCl_4(l) \rightarrow Ti(s) + 4NaCl(s)$$

Calculate the mass of titanium that can be extracted from 570 kg of titanium chloride.

Relative atomic masses: Cl 35.5; Ti 48.

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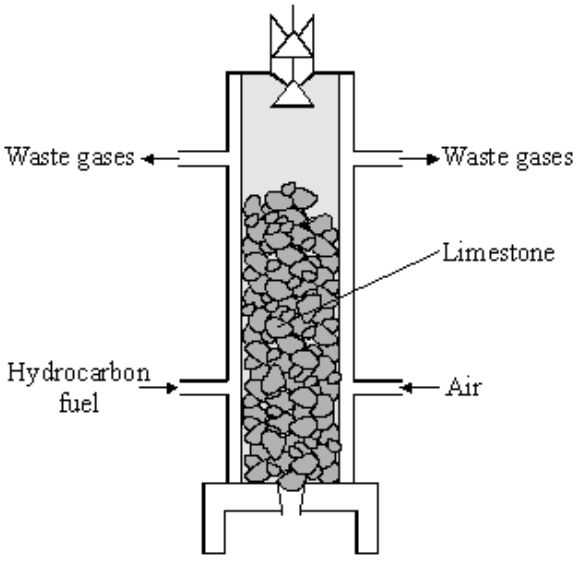
.....

Mass of titanium = ... kg

(Total 3 marks)

Q15. Limestone is a useful mineral. Every day, large amounts of limestone are heated in limekilns to produce lime. Lime is used in the manufacture of iron, cement and glass and for neutralising acidic soils.



$$CaCO_3 \rightleftharpoons CaO + CO_2$$

(i) The decomposition of limestone is a *reversible* reaction. Explain what this means.

.....

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.....

.....

(2)

(ii) Calculate the mass of lime, CaO, that would be produced from 250 tonnes of limestone, $CaCO_3$.

Relative atomic masses: C 12; O 16; Ca 40.

.....

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.....

.....

Mass of lime = ... tonnes

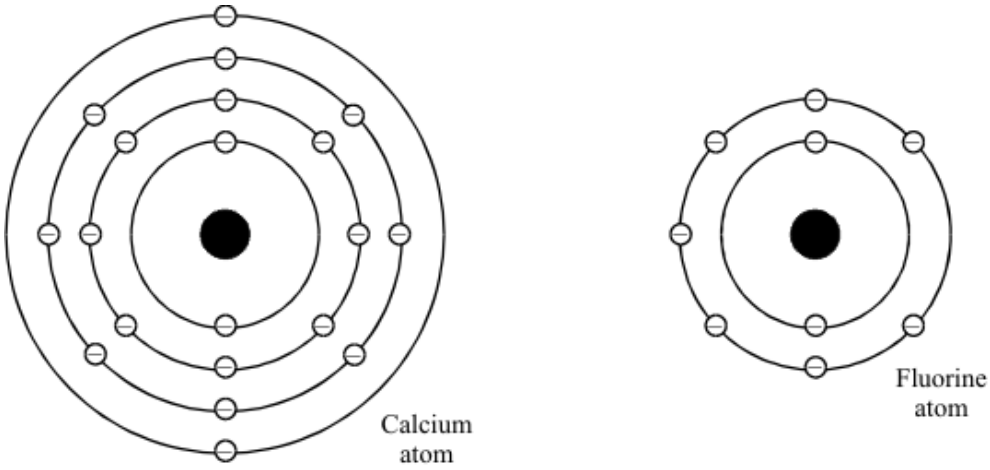
(3)

(Total 5 marks)

Q16. Uranium metal can be produced by reacting uranium hexafluoride with calcium.

$UF_6 + 3Ca \rightarrow 3CaF_2 + U$

(a) Describe how calcium and fluorine bond together to form calcium fluoride. The electron arrangement of each atom is shown.



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(5)

(b) Uranium has two main isotopes, $^{235}_{92}U$ and $^{238}_{92}U$. Use these as examples to explain what is meant by the word isotope.

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(4)

(c) At the start of a reaction there was 174.5 g of uranium hexafluoride, UF_6.

Relative atomic masses: F 19; U 235

(i) Calculate the relative formula mass of uranium hexafluoride, UF_6.

.....

.....

.....

Relative formula mass UF_6 = ... g

(1)

(ii) Calculate the mass of uranium that would be produced from 134.5 g of uranium hexafluoride.

.....

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.....

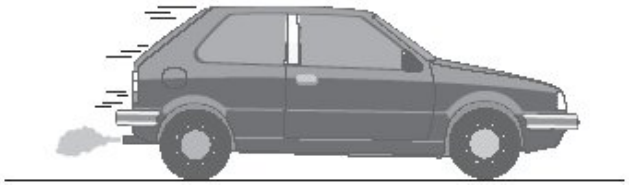
Mass of uranium = ... g

(2)

(Total 12 marks)

Q17. Petrol is a mixture of hydrocarbons such as octane, C_8H_{18}

When petrol is burned in a car engine, a large amount of carbon dioxide is produced.



This car uses 114 g of petrol to travel one mile.

Calculate the mass of carbon dioxide produced when this car travels one mile.

Assume that petrol is octane and that combustion is complete.

(Relative atomic masses: H = 1; C = 12; O = 16)

The combustion of octane can be represented by this equation.

$$C_8H_{18} + 12\tfrac{1}{2}\ O_2 \rightarrow 8CO_2 + 9H_2O$$

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.....

Mass of carbon dioxide = ... g

(Total 3 marks)

Q18. Silicon is an important element used in the electronics industry.

(a) Silicon can be made by heating a mixture of sand (silicon dioxide) with magnesium powder.

The equation for this reaction is shown below.

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

Calculate the mass of silicon dioxide needed to make 1 g of silicon.

Relative atomic masses: O = 16; Si = 28

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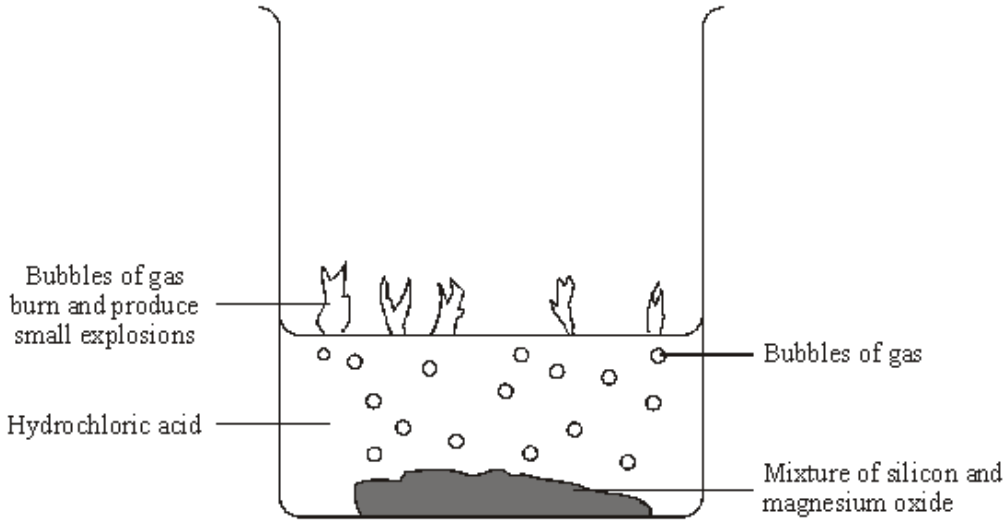
Mass = ...g

(3)

(b) The resulting mixture of magnesium oxide and silicon is added to a beaker containing hydrochloric acid. The silicon is then filtered from the solution.



(i) The magnesium oxide reacts with the hydrochloric acid and forms magnesium chloride ($MgCl_2$) solution and water.

magnesium oxide + hydrochloric acid → magnesium chloride solution + water

Write a balanced symbol equation for this reaction, including state symbols.

.....

(2)

(ii) The gases produced are a mixture of several silicon hydrides.

One of the gases produced in the reaction is the silicon hydride with the formula SiH_4. The structure of this molecule is similar to methane, CH_4.

Draw a diagram to show the bonding in a molecule of SiH_4. Represent the electrons as dots and crosses and only show the outer shell (energy level) electrons.

(1)

(iii) A sample of a different silicon hydride was found to contain 1.4 g of silicon and 0.15 g of hydrogen.

Calculate the formula of this silicon hydride. You must show all your working to gain full marks.

Relative atomic masses: H = 1; Si = 28

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(4)

(iv) The silicon hydrides react immediately they come into contact with oxygen in the air. They burst into flames with a small explosion and give out energy.

Which letter, **A** to **H**, best describes this reaction?

Energy involved in breaking and forming bonds	Activation energy	Rate of reaction	Letter
The energy released from forming new bonds is greater than the energy needed to break existing bonds	high	fast	**A**
		slow	**B**
	low	fast	**C**
		slow	**D**
The energy needed to break existing bonds is greater than the energy released from forming new bonds	high	fast	**E**
		slow	**F**
	low	fast	**G**
		slow	**H**

Letter .....

(1)

(c) The structure of silicon is similar to the structure of diamond.

Describe the structure of silicon and explain why it has a high melting point. You may draw a diagram if this helps.

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(4)
(Total 15 marks)

Q19. This cake recipe is taken from a cookery book.

Soda Cake

- Mix the flour and butter and add the sugar, currants and flavouring.
- Then add the beaten egg.
- Add a little milk with a teaspoonful of **baking soda (sodium hydrogencarbonate)** and mix it in well.
- Bake in a moderate oven for about 30 minutes.

When sodium hydrogencarbonate is heated in an oven, it forms carbon dioxide gas.

$$2\ NaHCO_3 \xrightarrow{Heat} Na_2CO_3 + H_2O + CO_2$$

A teaspoonful of baking soda contains a mass of 11 g of sodium hydrogencarbonate. Calculate the mass of carbon dioxide that could be made from 11 g of sodium hydrogencarbonate. Show clearly how you work out your final answer.

Relative atomic masses: H = 1; C = 12; O = 16; Na = 23.

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Mass of carbon dioxide = ... g

(Total 3 marks)

Q20. Cosmetic powders were widely used in ancient Egypt.

Cosmetic powders that may have been used in face paints have been analysed. These powders contained compounds that are rare in nature. The compounds must have been made by the ancient Egyptians using chemical reactions.

One of these compounds is called phosgenite.

Analysis of this compound shows that it contains:

76.0% lead (Pb) 13.0% chlorine (Cl) 2.2% carbon (C) 8.8% oxygen (O)

Calculate the empirical formula of this compound.

To gain full marks you must show all your working.

Relative atomic masses: C = 12 ; O = 16 ; Cl = 35.5 ; Pb = 207

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(Total 4 marks)

Q21. Perfumes contain a mixture of chemicals.

The main ingredients of perfumes are a solvent and a mixture of fragrances.

(a) A sample of the solvent used in one perfume contained 0.60 g of carbon, 0.15 g of hydrogen and 0.40 g of oxygen.

Relative atomic masses: H = l; C = 12; O = 16.

Calculate the empirical (simplest) formula of the solvent.

You must show all of your working to gain full marks for this question.

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(4)

(b) Solvent molecules evaporate easily.

Explain why substances made of simple molecules evaporate easily.

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(2)

(c) Most companies claim that their perfumes have been tested on skin. A study was made of the tests they used. The study found that each company used different tests.

The perfumes were tested in the companies' own laboratories and **not** by independent scientists.

Some companies did not give any information about the tests that they had used.

(i) Suggest why companies test their perfumes on skin.

.....

.....

.....

(1)

(ii) Did the study show that the tests made by the different companies were valid and reliable?

Explain your answer.

.....

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(2)

(Total 9 marks)

Q22. Liquefied petroleum gases such as propane and butane are used as heating fuels for caravans, boats and barbecues.

(a) Propane and butane have no smell, so for safety reasons a very small amount of thioethanol – the smelliest substance known – is added, even though it is toxic in large concentrations.

Suggest **one** safety reason why thioethanol is added to propane and butane.

.....

.....

(1)

(b) Suggest how mass spectrometry could be used to distinguish between propane (C_3H_8) and butane (C_4H_{10}).

.....

.....

(1)

(c) When 0.4 g of a hydrocarbon gas was completely burned in oxygen, 1.1 g of carbon dioxide and 0.9 g of water were the only products.

Relative formula masses: CO_2 = 44; H_2O = 18.

Use this information to calculate the number of moles of carbon dioxide and of water produced in this reaction. Use your answers to calculate the empirical formula of this hydrocarbon.

You must show all your working to gain full marks.

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Empirical formula is .....

(4)

(Total 6 marks)

Q23. Aspirin tablets have important medical uses.

A student carried out an experiment to make aspirin. The method is given below.

1. Weigh 2.00 g of salicylic acid.
2. Add 4 cm^3 of ethanoic anhydride (an excess).
3. Add 5 drops of concentrated sulfuric acid.
4. Warm the mixture for 15 minutes.
5. Add ice cold water to remove the excess ethanoic anhydride.
6. Cool the mixture until a precipitate of aspirin is formed.
7. Collect the precipitate and wash it with cold water.
8. The precipitate of aspirin is dried and weighed.

(a) The equation for this reaction is shown below.

$$\underset{\text{salicylic acid}}{C_7H_6O_3} + C_4H_6O_3 \rightarrow \underset{\text{aspirin}}{C_9H_8O_4} + CH_3COOH$$

Calculate the maximum mass of aspirin that could be made from 2.00 g of salicylic acid.

The relative formula mass (M_r) of salicylic acid, $C_7H_6O_3$, is 138

The relative formula mass (M_r) of aspirin, $C_9H_8O_4$, is 180

.....

.....

.....

.....

Maximum mass of aspirin = ... g

(2)

(b) The student made 1.10 g of aspirin from 2.00 g of salicylic acid.

Calculate the percentage yield of aspirin for this experiment.

(If you did not answer part (a), assume that the maximum mass of aspirin that can be made from 2.00 g of salicylic acid is 2.50 g. This is **not** the correct answer to part (a).)

.....

.....

.....

.....

Percentage yield of aspirin = ... %

(2)

(c) Suggest **one** possible reason why this method does **not** give the maximum amount of aspirin.

.....

.....

(1)

(d) Concentrated sulfuric acid is a catalyst in this reaction.

Suggest how the use of a catalyst might reduce costs in the industrial production of aspirin.

.....

.....

(1)

(Total 6 marks)

Q24. Aspirin tablets have important medical uses.

(a) Aspirin is made when salicylic acid reacts with ethanoic anhydride.

The equation for this reaction is:

$$\underset{\text{salicylic acid}}{C_7H_6O_3} + C_4H_6O_3 \rightarrow \underset{\text{aspirin}}{C_9H_8O_4} + CH_3COOH$$

Calculate the maximum mass of aspirin that could be made from 100 g of salicylic acid.

Show clearly how you work out your answer.

The relative formula mass (M_r) of salicylic acid ($C_7H_6O_3$) is 138.
The relative formula mass (M_r) of aspirin ($C_9H_8O_4$) is 180.

.....

.....

.....

.....

Maximum mass of aspirin = ... g

(2)

(b) (i) In an experiment a chemist calculated that the maximum yield of aspirin is 400 g.

The chemist did the experiment but only made 250 g of aspirin.

Calculate the percentage yield of aspirin for this experiment.

Show clearly how you work out your answer.

.....

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.....

Percentage yield of aspirin = ... %

(2)

(ii) Suggest **one** possible reason why the chemist did **not** have a percentage yield of 100%.

.....

.....

(1)

(c) The use of a catalyst might reduce costs in the industrial production of aspirin.

Suggest how.

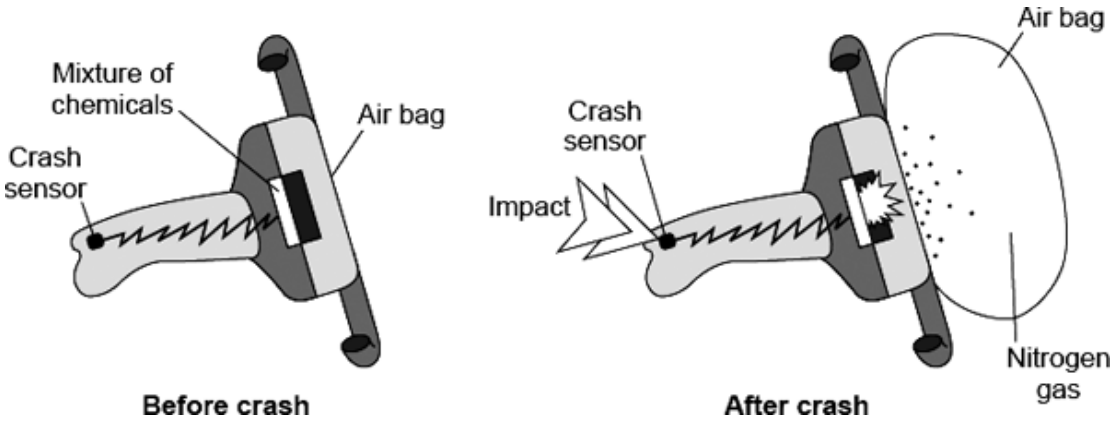
.....

.....

(1)

(Total 6 marks)

Q25. Air bags are used to protect the passengers in a car during an accident. When the crash sensor detects an impact it causes a mixture of chemicals to be heated to a high temperature. Reactions take place which produce nitrogen gas. The nitrogen fills the air bag.



(a) The mixture of chemicals contains sodium azide (NaN_3) which decomposes on heating to form sodium and nitrogen.

$$2NaN_3 \rightarrow 2Na + 3N_2$$

A typical air bag contains 130 g of sodium azide.

(i) Calculate the mass of nitrogen that would be produced when 130 g of sodium azide decomposes.

Relative atomic masses (A_r): N = 14; Na = 23

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Mass of nitrogen = ... g

(3)

(ii) 1 g of nitrogen has a volume of 0.86 litres at room temperature and pressure.

What volume of nitrogen would be produced from 130 g of sodium azide?

(If you did not answer part (a)(i), assume that the mass of nitrogen produced from 130 g of sodium azide is 80 g. This is **not** the correct answer to part (a)(i).)

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Volume = ... litres

(1)

(b) The sodium produced when the sodium azide decomposes is dangerous.
The mixture of chemicals contains potassium nitrate and silicon dioxide which help to make the sodium safe.

(i) Sodium reacts with potassium nitrate to make sodium oxide, potassium oxide and nitrogen. Complete the balancing of the equation for this reaction.

$10Na + ...KNO_3 \rightarrow Na_2O + K_2O + N_2$

(1)

(ii) The silicon dioxide reacts with the sodium oxide and potassium oxide to form silicates.

Suggest why sodium oxide and potassium oxide are dangerous in contact with the skin.

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(1)
(Total 6 marks)

Q26. Lead compounds have been used for thousands of years as colours in paint.

Johannes Vermeer [Public domain], via Wikimedia Commons

(a) A sample of a red oxide used in paint was found to contain 6.21 g of lead and 0.64 g of oxygen.

Calculate the empirical (simplest) formula of this compound.

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

Relative atomic masses: O = 16; Pb = 207.

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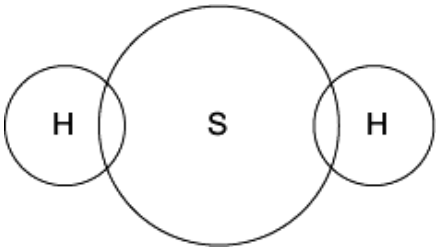
(4)

(b) A problem with lead compounds is that they slowly react with hydrogen sulfide in the air. This produces lead sulfide which is black.

(i) Hydrogen sulfide has the formula H_2S. The bonding in a molecule of hydrogen sulfide can be represented as:

H–S–H

Complete the diagram below to show the arrangement of the outer electrons of the hydrogen and sulfur atoms in hydrogen sulfide.
Use dots (●) and crosses (x) to represent the electrons.
You need only show the outer shell electrons.
(Atomic numbers: H = 1; S = 16.)



(1)

(ii) Hydrogen sulfide has a low boiling point.

Explain why.

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(2)

(iii) Lead white is also used in paint. The white colour slowly darkens when lead sulfide is produced.

The painting can be restored with hydrogen peroxide. This converts the black lead sulfide into white lead sulfate.

Balance the equation for the reaction between lead sulfide and hydrogen peroxide (H_2O_2).

$$PbS(s) + ...H_2O_2(aq) \rightarrow PbSO_4(s) + 4H_2O(l)$$

(1)
(Total 8 marks)

Q27. This question is about calcium hydroxide.

Ancient artworks and monuments can be protected from acid rain if the surface is sprayed with calcium hydroxide nanoparticles.

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

(a) Calcium hydroxide has the formula $Ca(OH)_2$

Why are there two hydroxide ions for each calcium ion in the formula?

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(1)

(b) The calcium hydroxide is used in the form of *nanoparticles*.

What are *nanoparticles*?

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(1)

(c) A student added water to calcium oxide to make calcium hydroxide.

The equation for the reaction is shown below.

$$CaO + H_2O \rightarrow Ca(OH)_2$$

Calculate the maximum mass of calcium hydroxide which could be made from 2.00 g of calcium oxide.

Relative atomic masses (A_r): H = 1; O = 16; Ca = 40.

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Maximum mass of calcium hydroxide = ... g

(3)

(Total 5 marks)

Q28. Aluminium is extracted from aluminium oxide.

(a) The formula of aluminium oxide is Al_2O_3

The relative formula mass (M_r) of aluminium oxide is 102.

Calculate the percentage of aluminium in aluminium oxide.

Relative atomic masses (A_r): O = 16; Al = 27.

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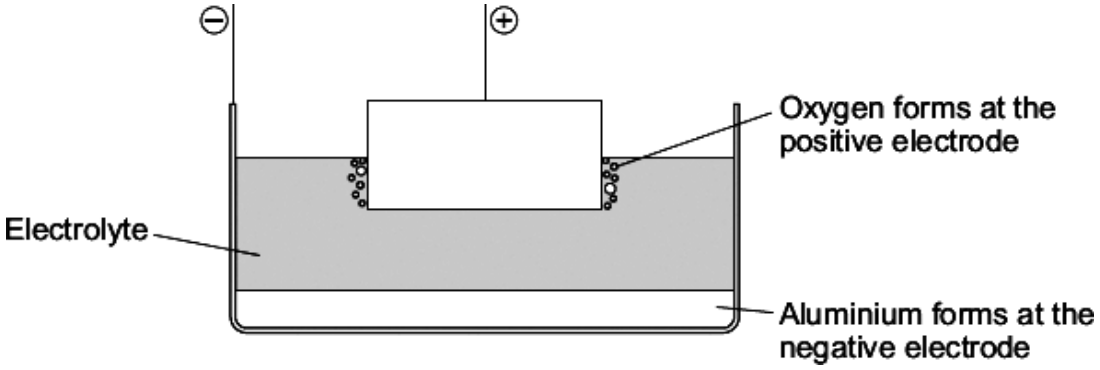
Percentage of aluminium = ... %

(2)

(b) Aluminium is extracted from aluminium oxide using electrolysis.

The diagram shows a cell used for the extraction of aluminium.



(i) The electrolyte contains cryolite.

Explain why.

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(2)

(ii) Oxygen is formed at the positive electrode. Complete and balance the equation for this reaction.

$$\ldots\ O^{2-} \rightarrow O_2 + \ldots\ldots$$

(2)

(iii) The positive electrode in the cell is used up during the process.

Explain why.

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(2)

(Total 8 marks)

Q29. The picture shows a painting which was painted in a cave in France about 17 000 years ago.

By Carla Hufstedler [CC-BY-SA-2.0], via Wikimedia Commons

One of the pigments in this painting contains:

70 % of iron (Fe) and 30 % of oxygen (O)

Calculate the simplest (empirical) formula of this substance.

Relative atomic masses: O = 16; Fe = 56.

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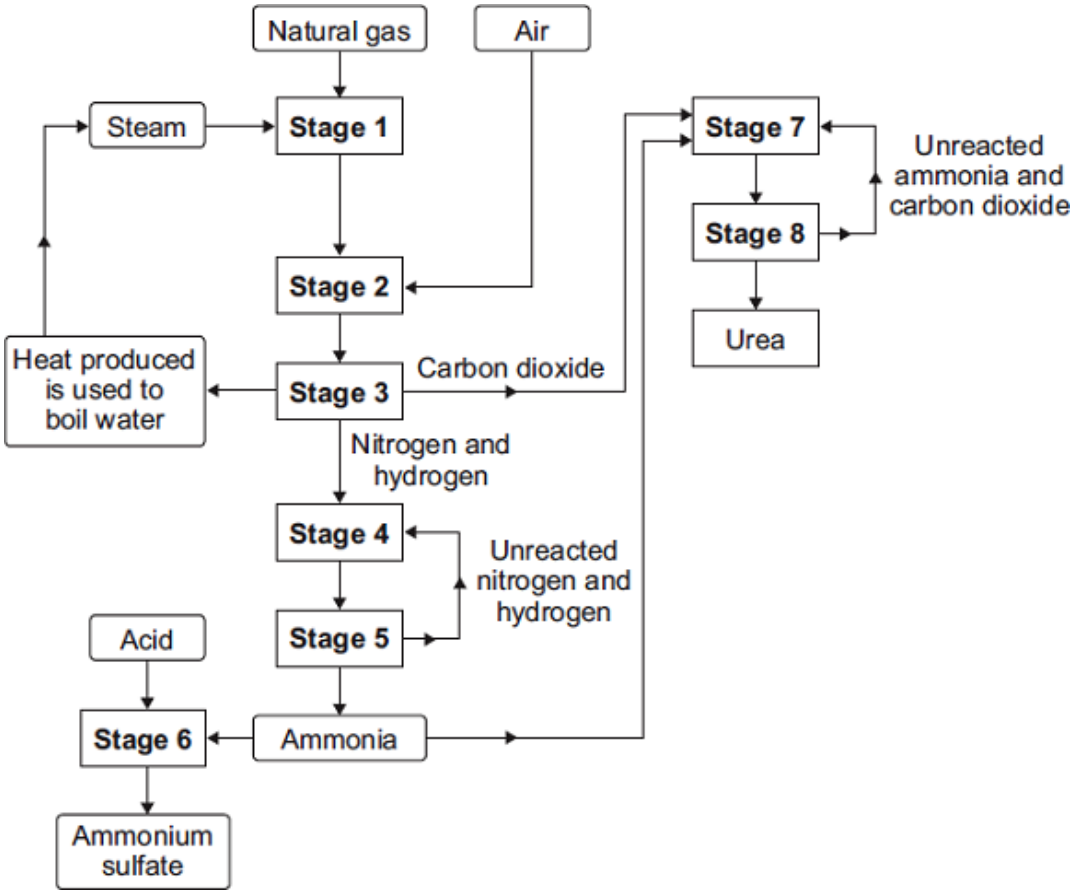
(4)
(Total 4 marks)

Q30. Ammonium sulfate and urea are made from ammonia. These compounds are used by farmers.

The flow diagram shows the stages to make ammonium sulfate and urea.



(a) Give **two** examples from the flow diagram of the efficient use of energy and raw materials.

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(2)

(b) The equation for the reaction in Stage **4** is shown below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The forward reaction is exothermic.

State **and** explain:

(i) how a **decrease** in temperature would affect the yield of ammonia at equilibrium

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(2)

(ii) how an **increase** in pressure would affect the yield of ammonia at equilibrium.

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(2)

(c) The equation for the reaction in Stage **7** is shown below.

$$\underset{\text{ammonia}}{2\,NH_3} + CO_2 \rightleftharpoons \underset{\text{urea}}{NH_2CONH_2} + H_2O$$

The table gives the relative formula masses (M_r) of the reactants and the products for this reaction.

Formula of reactant or product	**Relative formula masses (M_r)**
NH_3	17
CO_2	44
NH_2CONH_2	60
H_2O	18

Percentage atom economy can be calculated using:

$$\text{Percentage atom economy} = \frac{M_r \text{ of useful product}}{\text{total } M_r \text{ of all reactants added together}} \times 100\%$$

Calculate the percentage atom economy for the reaction in Stage **7**.

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Percentage atom economy = ... %

(2)

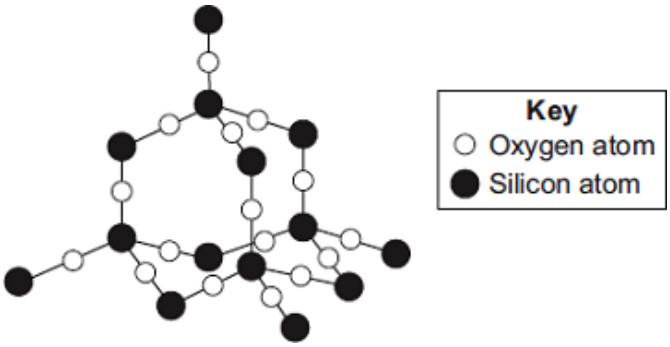
(Total 8 marks)

Q31. Silicon dioxide is used as a lining for furnaces.

Furnaces can be used to melt iron for recycling.

© Oleksiy Mark/iStock

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



Explain why silicon dioxide is a suitable material for lining furnaces.

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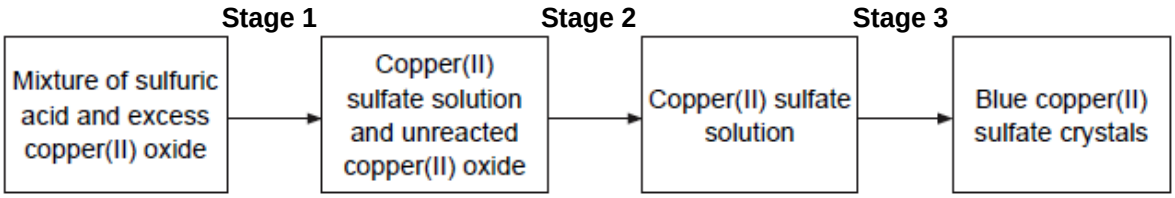
(Total 4 marks)

Q32. 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.

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(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**?

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(1)

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

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(1)

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

Suggest **one** reason why.

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(1)

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

The word equation for the reaction is shown below.

hydrated copper(II) sulfate ⇌ anhydrous copper(II) sulfate + water

blue white

(i) What does the symbol ⇌ mean ?

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(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?

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(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.

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Empirical formula = ...

(4)

(Total 13 marks)

Q33. Ammonia is produced from nitrogen and hydrogen.

The equation for this reaction is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(a) (i) A company wants to make 6.8 tonnes of ammonia.

Calculate the mass of nitrogen needed.

Relative atomic masses (A_r): H = 1; N = 14

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Mass of nitrogen = ... tonnes

(3)

(ii) The company expected to make 6.8 tonnes of ammonia.

The yield of ammonia was only 4.2 tonnes.

Calculate the percentage yield of ammonia.

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Percentage yield of ammonia = ... %

(2)

(iii) Use the equation above to explain why the percentage yield of ammonia was less than expected.

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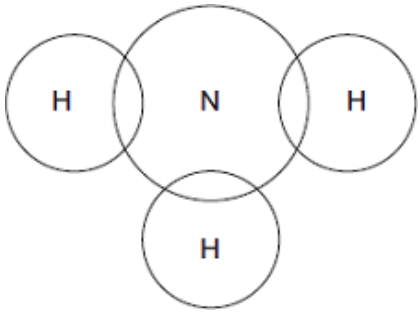
(1)

(b) Complete the diagram to show the arrangement of the outer shell electrons of the nitrogen and hydrogen atoms in ammonia.

Use dots (●) and crosses (x) to represent the electrons.



(2)

(c) Ammonia dissolves in water to produce an alkaline solution.

(i) Which ion makes ammonia solution alkaline?

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(1)

(ii) Name the type of reaction between aqueous ammonia solution and an acid.

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(1)

(iii) Name the acid needed to produce ammonium nitrate.

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(1)

(iv) The reaction of ammonia with sulfuric acid produces ammonium sulfate.

Use the formulae of the ions on the Chemistry Data Sheet.

Write the formula of ammonium sulfate.

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(1)

(Total 12 marks)