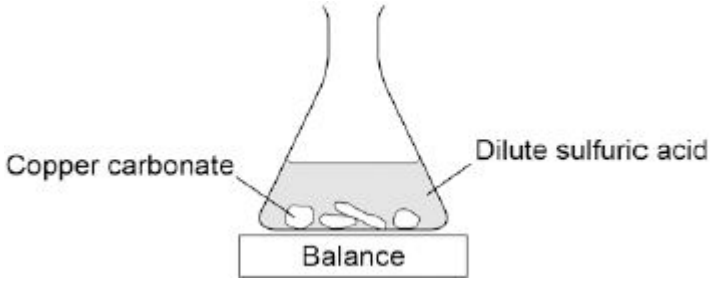
1 A student investigated the reaction of copper carbonate with dilute sulfuric acid.

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.

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(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.

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.....

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.....

.....

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.

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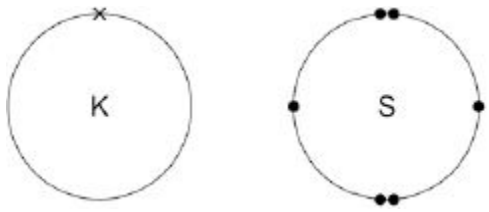
(1)

(Total 13 marks)

2 **Figure 1** shows the outer electrons in an atom of the Group 1 element potassium and in an atom of the Group 6 element sulfur.

Figure 1



(a) Potassium forms an ionic compound with sulfur.

Describe what happens when **two** atoms of potassium react with **one** atom of sulfur.

Give your answer in terms of electron transfer.

Give the formulae of the ions formed.

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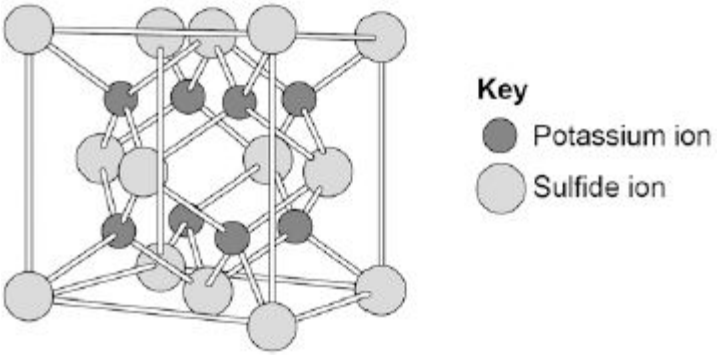
(5)

(b) The structure of potassium sulfide can be represented using the ball and stick model in **Figure 2**.

Figure 2



The ball and stick model is **not** a true representation of the structure of potassium sulfide.

Give **one** reason why.

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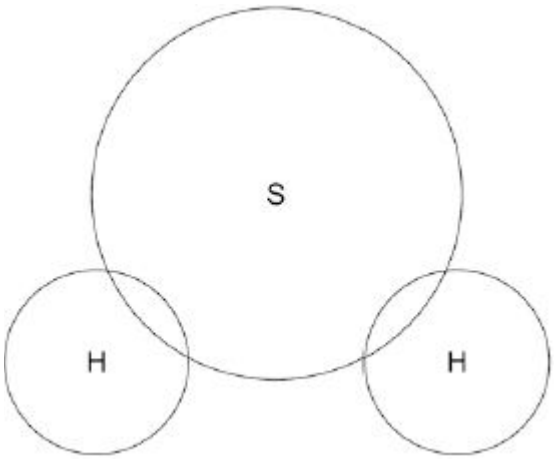
(1)

(c) Sulfur can also form covalent bonds.

Complete the dot and cross diagram to show the covalent bonding in a molecule of hydrogen sulfide.

Show the outer shell electrons only.



(2)

(d) Calculate the relative formula mass (M_r) of aluminium sulfate $Al_2(SO_4)_3$

Relative atomic masses (A_r): oxygen = 16; aluminium = 27; sulfur = 32

.....

.....

.....

Relative formula mass = ...

(2)

(e) Covalent compounds such as hydrogen sulfide have low melting points and do **not** conduct electricity when molten.

Draw **one** line from each property to the explanation of the property.

Property	**Explanation of property**
Low melting point	There are no charged particles free to move
Does not conduct electricity when molten	Weak intermolecular forces of attraction
	Bonds are weak

Electrons are free to move

Ions are free to move

Bonds are strong

(2)

(f) Ionic compounds such as potassium sulfide have high boiling points and conduct electricity when dissolved in water.

Draw **one** line from each property to the explanation of the property.

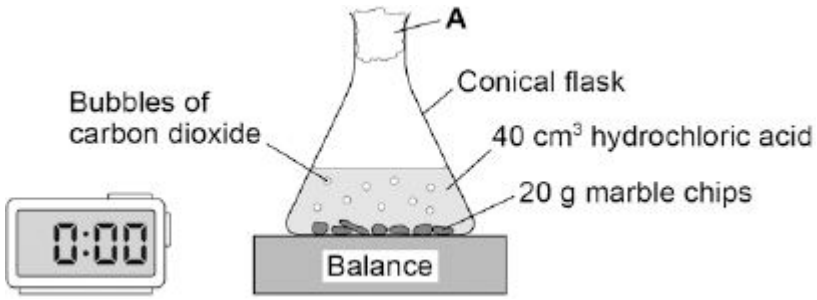
Property	**Explanation of property**
High boiling point	There are no charged particles free to move
Conduct electricity when molten	Ions are free to move
	Weak intermolecular forces of attraction
	Bonds are weak
	Bonds are strong
	Electrons are free to move

(2)
(Total 14 marks)

3 A student investigated the rate of reaction between marble chips and hydrochloric acid.

Figure 1 shows the apparatus the student used.

Figure 1



(a) What is **A**?

Tick **one** box.

cotton wool ☐

limestone ☐

poly(ethene) ☐

rubber bung ☐

(1)

(b) **Table 1** shows the student's results for one investigation.

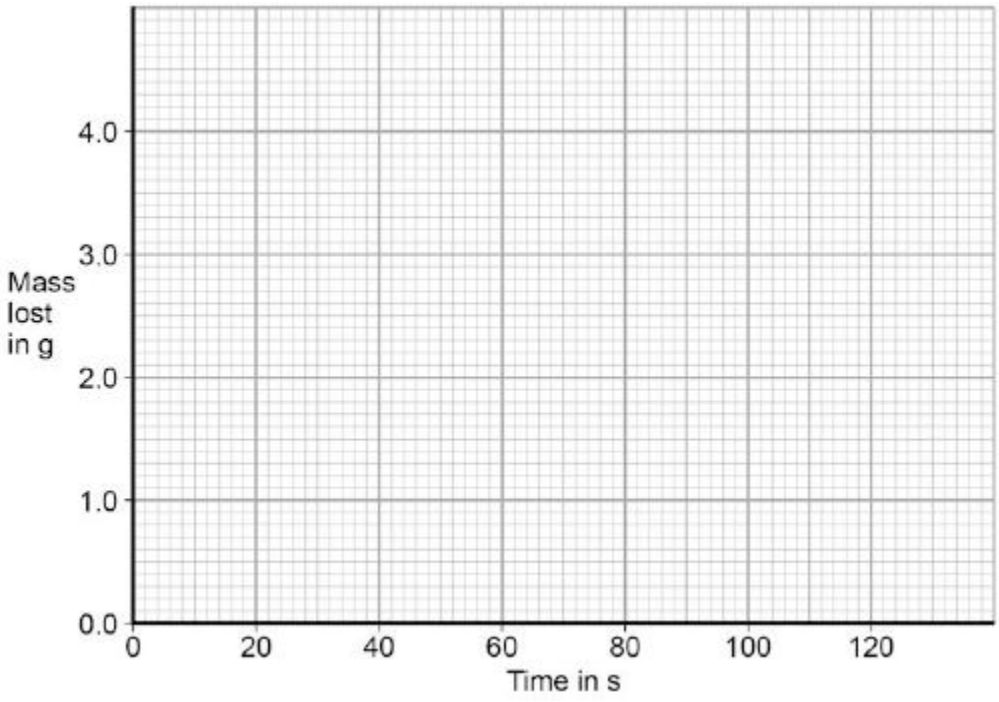
Table 1

Time in s	Mass lost in g
0	0.0
20	1.6
40	2.6
60	2.9
80	3.7
100	4.0
120	4.0

On **Figure 2**:

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

Figure 2



(3)

(c) Use **Figure 2** to complete **Table 2**.

Table 2

Mass lost after 0.5 minutes	..... g
Time taken to complete the reaction	..... s

(2)

(d) The equation for the reaction is:

$2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

Explain why there is a loss in mass in this investigation.

.....

.....

.....

.....

(2)

(e) Another student investigated the rate of a different reaction.

Table 3 shows the results from the different reaction.

Table 3

Mass lost when the reaction was complete	9.85 g
Time taken to complete the reaction	2 minutes 30 seconds

Calculate the mean rate of the reaction using **Table 3** and the equation:

$$\text{mean rate of reaction} = \frac{\text{mass lost in g}}{\text{time taken in s}}$$

Give your answer to two decimal places.

.....

.....

Mean rate of reaction = ... g / s

(2)

(f) The student measured the change in mass of the reactants.

Describe another method, other than measuring the change in mass of the reactions, that the student could have used to find the rate of the reaction between marble chips and hydrochloric acid.

.....

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.....

(2)

(g) Another student planned to investigate the effect of temperature on the rate of reaction. The student predicted that the rate of reaction would increase as the temperature was increased.

Give **two** reasons why the student's prediction is correct.

Tick **two** boxes.

The particles are more concentrated. ☐

The particles have a greater mass. ☐

The particles have a larger surface area. ☐

The particles have more energy. ☐

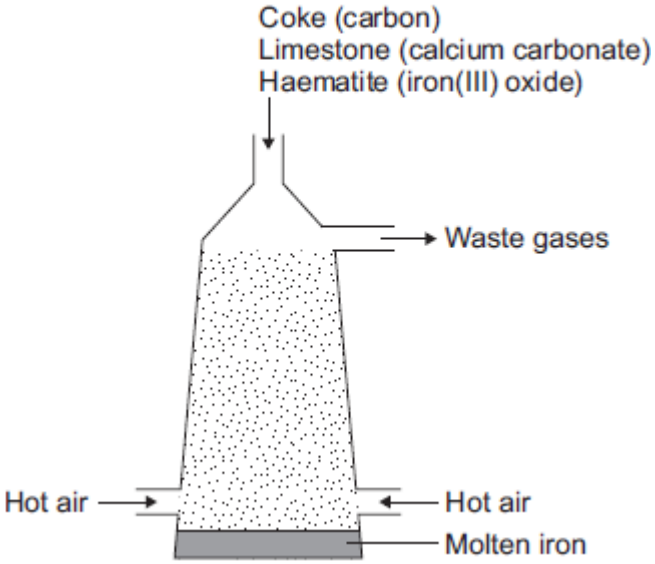
The particles move faster. ☐

(2)
(Total 14 marks)

4 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.

$$C(s) + CO_2(g) \longrightarrow \text{.....} CO(g)$$

(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

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.....

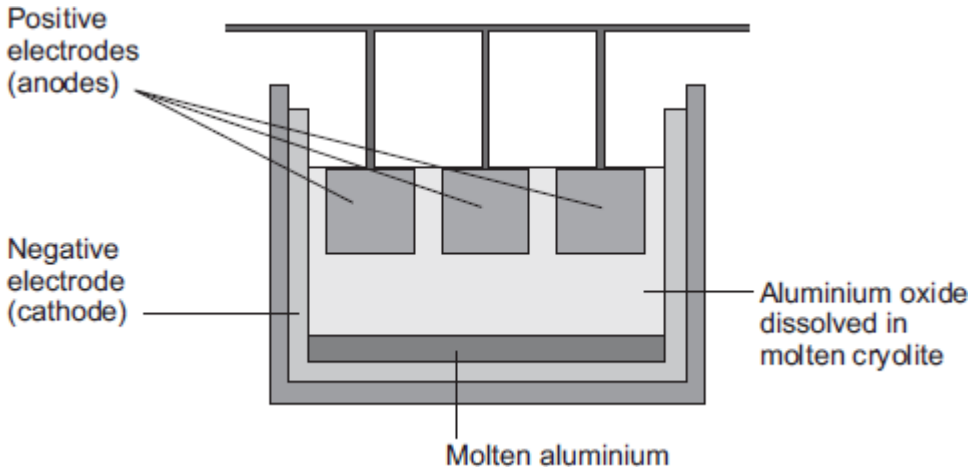
.....

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?

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(1)

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

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(3)

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

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(3)
(Total 13 marks)

5 Copper is a transition metal.

(a) (i) Where is copper in the periodic table?

Tick (✓) **one** box.

in the central block ☐

in Group 1 ☐

in the noble gas group ☐

(1)

(ii) What is a property of copper?

Tick (✓) **one** box.

breaks easily ☐

conducts electricity ☐

does not conduct heat ☐

(1)

(b) Copper ores are quarried by digging large holes in the ground, as shown in **Figure 1**.

Figure 1

© photllurg/iStock/Thinkstock

Give **two** reasons why quarrying is bad for the environment.

.....

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.....

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(2)

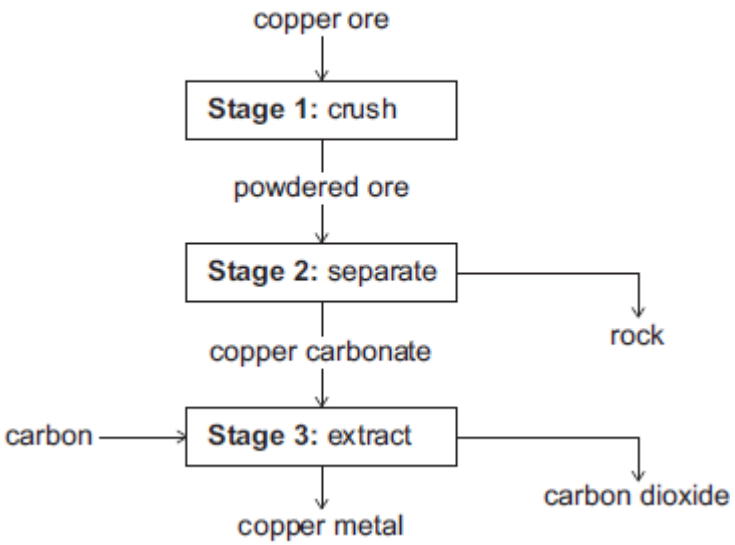
(c) Some copper ores contain only 2% copper.

Most of the ore is rock that is not needed.

In one ore, the main compound is copper carbonate ($CuCO_3$).

Figure 2 shows the stages used in the extraction of copper from this ore.

Figure 2



(i) Why is **Stage 2** important?

.....

.....

(1)

(ii) The equation for the reaction in **Stage 3** is:

$$2\ CuCO_3 + C \longrightarrow 2\ Cu + 3\ CO_2$$

From the symbol equation, a company calculated that 247 tonnes of copper carbonate are needed to produce 127 tonnes of copper and 132 tonnes of carbon dioxide are released.

Calculate the mass of carbon needed to make 127 tonnes of copper.

copper carbonate	+	carbon	⟶	copper	+	carbon dioxide
247 tonnes		..... tonnes		127 tonnes		132 tonnes

.....

.....

(2)

(iii) Suggest **one** reason why it is important for the company to calculate the mass of reactants in **Stage 3**.

.....

.....

(1)

(Total 8 marks)

6 This question is about carbon and gases in the air.

(a) Carbon atoms have protons, neutrons and electrons.

Complete the table by writing the relative mass of a neutron and an electron.

Name of particle	**Relative mass**
proton	1
neutron	
electron	

(2)

(b) What is the total number of protons and neutrons in an atom called?

Tick (✓) **one** box.

The atomic number ☐

The mass number ☐

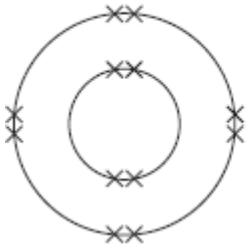
One mole of the atom ☐

(1)

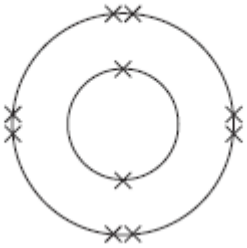
(c) An atom of carbon has six electrons.

Which structure, **A, B** or **C**, represents the electronic structure of the carbon atom?

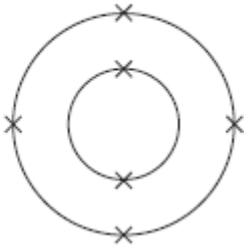
Structure A



Structure B



Structure C



The carbon atom is structure ☐

(1)

(d) Carbon reacts with oxygen to produce carbon dioxide (CO_2).

(i) How many different elements are in one molecule of carbon dioxide?

.....

(1)

(ii) What is the total number of atoms in one molecule of carbon dioxide?

.....

(1)

(e) Sometimes carbon reacts with oxygen to produce carbon monoxide (CO).

(i) Calculate the relative formula mass (M_r) of carbon monoxide.

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

.....

.....

M_r of carbon monoxide = ...

(1)

(ii) Calculate the percentage by mass of carbon in carbon monoxide.

.....

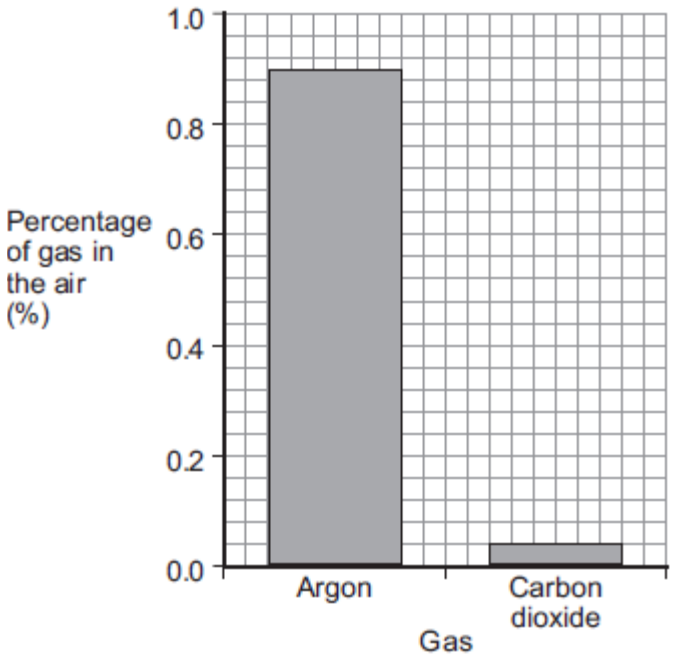
.....

Percentage by mass of carbon in carbon monoxide = ...%

(1)

(f) Carbon dioxide is one of the gases in the air.

(i) The graph shows the percentage of argon and the percentage of carbon dioxide in the air.



What is the percentage of argon in the air?

Percentage of argon = ... %

(1)

(ii) An instrumental method is used to measure the amount of carbon dioxide in the air.

Give **one** reason for using an instrumental method.

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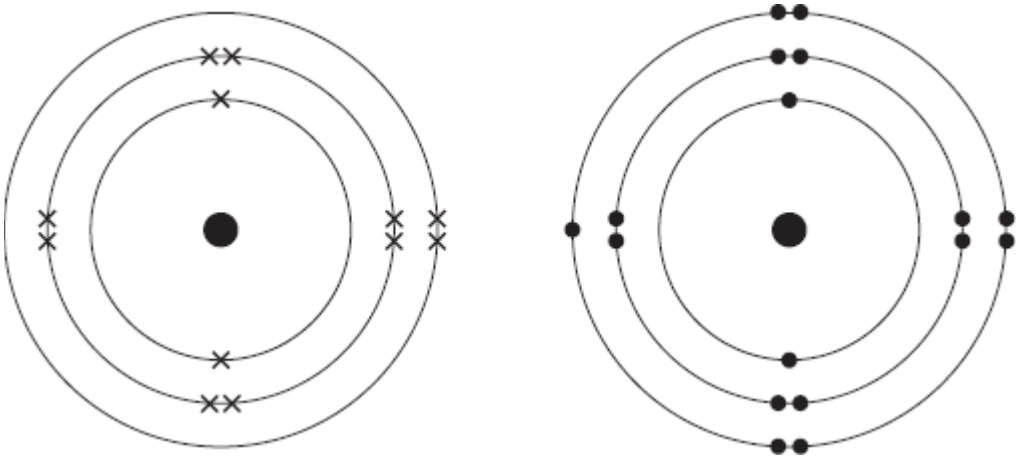
(1)
(Total 10 marks)

7 (a) The diagram shows an atom of magnesium and an atom of chlorine.



Magnesium **Chlorine**

Describe, in terms of electrons, how magnesium atoms and chlorine atoms change into ions to produce magnesium chloride ($MgCl_2$).

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(4)

(b) Calculate the relative formula mass (M_r) of magnesium chloride ($MgCl_2$).

Relative atomic masses (A_r): magnesium = 24; chlorine = 35.5

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.....

.....

Relative formula mass (M_r) = ...

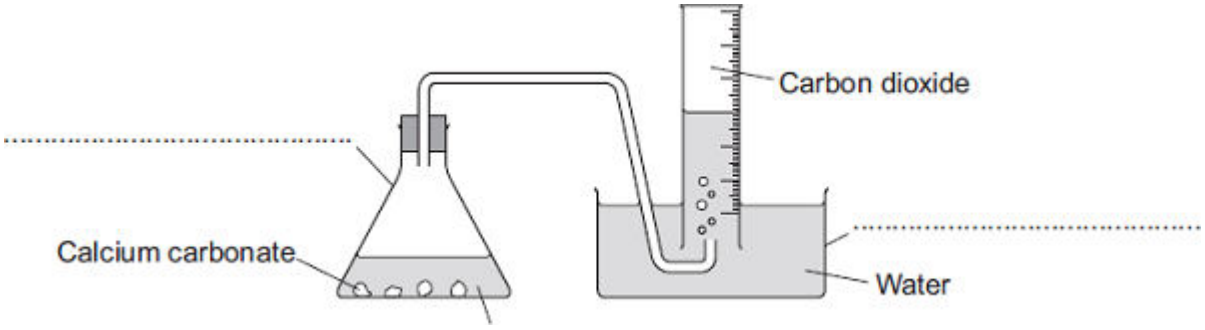
(2)
(Total 6 marks)

8 Some students were investigating the rate at which carbon dioxide gas is produced when metal carbonates react with an acid.

One student reacted 1.00 g of calcium carbonate with 50 cm^3, an excess, of dilute hydrochloric acid.

The apparatus used is shown in **Diagram 1**.

Diagram 1



(a) Complete the **two** labels for the apparatus on the diagram.

(2)

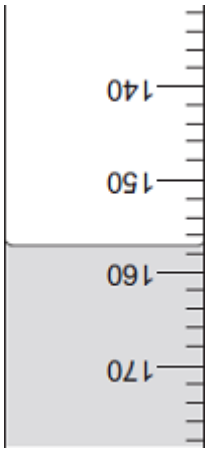
(b) The student measured the volume of gas collected every 30 seconds.

The table shows the student's results.

Time in seconds	Volume of carbon dioxide collected in cm^3
30	104
60	
90	198
120	221
150	232
180	238
210	240
240	240

(i) **Diagram 2** shows what the student saw at 60 seconds.

Diagram 2



What is the volume of gas collected?

Volume of gas = ... cm^3

(1)

(ii) Why did the volume of gas stop changing after 210 seconds?

.....

.....

(1)

(c) Another student placed a conical flask containing 1.00 g of a Group 1 carbonate (M_2CO_3) on a balance.

He then added 50 cm^3, an excess, of dilute hydrochloric acid to the flask and measured the mass of carbon dioxide given off.

The equation for the reaction is:

$$M_2CO_3 + 2HCl \longrightarrow 2MCl + H_2O + CO_2$$

The final mass of carbon dioxide given off was 0.32 g.

(i) Calculate the amount, in moles, of carbon dioxide in 0.32 g carbon dioxide.

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

.....

.....

.....

Moles of carbon dioxide = ... moles

(2)

(ii) How many moles of the metal carbonate are needed to make this number of moles of carbon dioxide?

.....

.....

Moles of metal carbonate = ... moles

(1)

(iii) The mass of metal carbonate used was 1.00 g.

Use this information, and your answer to part **(c) (ii)**, to calculate the relative formula mass (M_r) of the metal carbonate.

If you could not answer part **(c) (ii)**, use 0.00943 as the number of moles of metal carbonate. This is **not** the answer to part **(c) (ii)**.

.....

.....

Relative formula mass (M_r) of metal carbonate = ...

(1)

(iv) Use your answer to part **(c) (iii)** to calculate the relative atomic mass (A_r) of the metal in the metal carbonate (M_2CO_3) and so identify the Group 1 metal in the metal carbonate.

If you could not answer part **(c) (iii)**, use 230 as the relative formula mass of the metal carbonate. This is **not** the answer to part **(c) (iii)**.

To gain full marks, you must show your working.

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.....

.....

.....

Relative atomic mass of metal is .....

Identity of metal .....

(3)

(d) Two other students repeated the experiment in part **(c)**.

(i) When the first student did the experiment some acid sprayed out of the flask as the metal carbonate reacted.

Explain the effect this mistake would have on the calculated relative atomic mass of the metal.

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(3)

(ii) The second student used 100 cm^3 of dilute hydrochloric acid instead of 50 cm^3.

Explain the effect, if any, this mistake would have on the calculated relative atomic mass of the metal.

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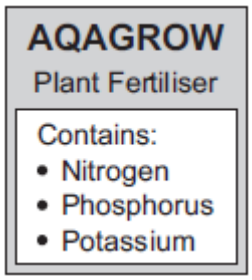
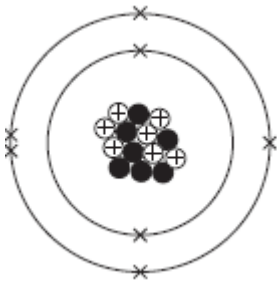
(3)
(Total 17 marks)

9 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)

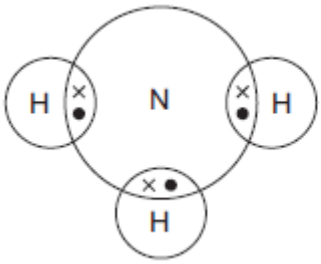
(iii) Compared with a proton, the mass of an electron is ..... .

(1)

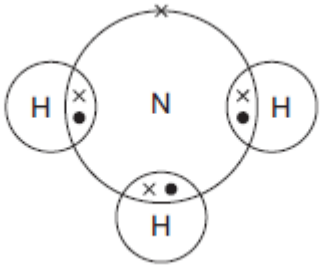
(b) Fertilisers can be made from ammonia.

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

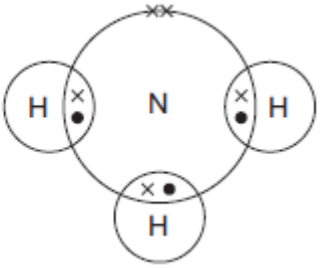
A



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.

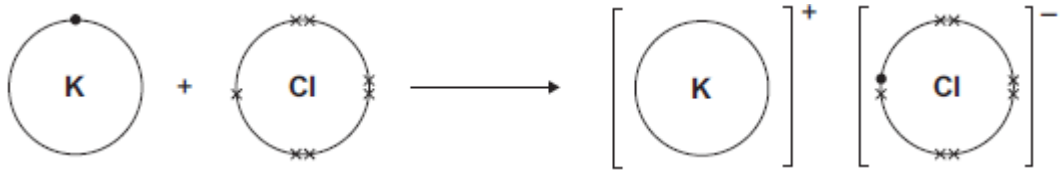
Potassium reacts with chlorine to produce potassium chloride.

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.

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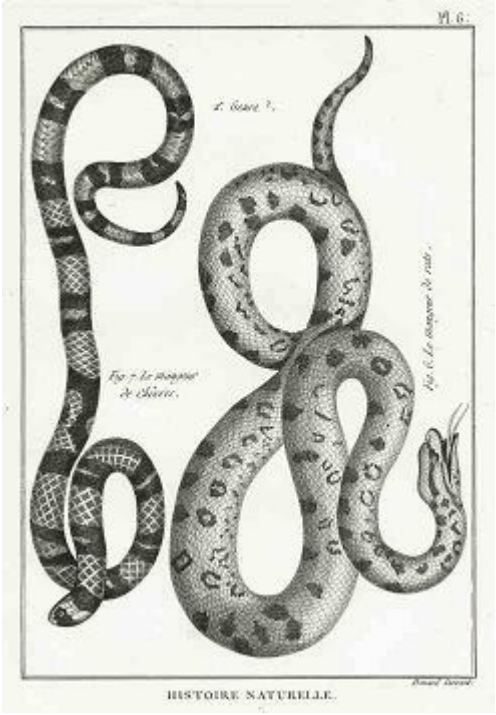
(4)
(Total 13 marks)

10 Printed pictures can be made using etchings.



© Eduardo Jose Bernardino/iStock

An etching can be made when a sheet of brass reacts with iron chloride solution.

(a) Brass is a mixture of two metals, copper and zinc.

(i) A mixture of two metals is called ..... .

(1)

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

Copper and zinc atoms are different sizes.

This makes brass

harder
more flexible
softer

than the pure metals.

(1)

(b) Iron chloride has the formula $FeCl_3$

Relative atomic masses (A_r): Cl = 35.5; Fe = 56.

(i) Calculate the relative formula mass (M_r) of iron chloride ($FeCl_3$).

.....

.....

.....

Relative formula mass (M_r) of iron chloride = ...

(2)

(ii) Calculate the percentage of iron in iron chloride ($FeCl_3$).

.....

.....

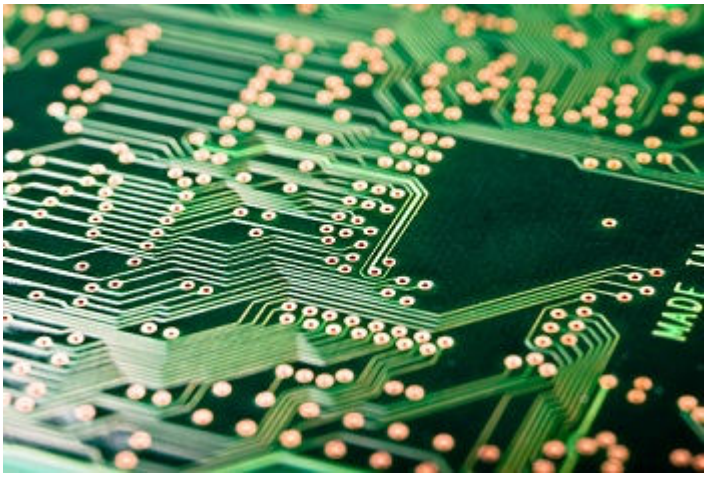
.....

Percentage of iron in iron chloride = ...%

(2)

(Total 6 marks)

11 Etching is a way of making printed circuit boards for computers.



© Dario Lo Presti/Shutterstock

Printed circuit boards are made when copper sheets are etched using iron(III) chloride solution. Where the copper has been etched, only plastic remains.

(a) Copper is a good conductor of electricity.

Explain why.

.....

.....

.....

.....

(2)

(b) Iron(III) chloride can be produced by the reaction shown in the equation:

$$2\ Fe + 3\ Cl_2 \rightarrow 2\ FeCl_3$$

(i) Calculate the maximum mass of iron(III) chloride ($FeCl_3$) that can be produced from 11.20 g of iron.

Relative atomic masses (A_r): Cl = 35.5; Fe = 56.

.....

.....

.....

.....

.....

Maximum mass of iron(III) chloride = ... g

(3)

(ii) The actual mass of iron(III) chloride ($FeCl_3$) produced was 24.3 g.

Calculate the percentage yield.

(If you did not answer part (b)(i) assume that the maximum theoretical mass of iron(III) chloride ($FeCl_3$) is 28.0 g. This is **not** the correct answer to part (b)(i).)

.....

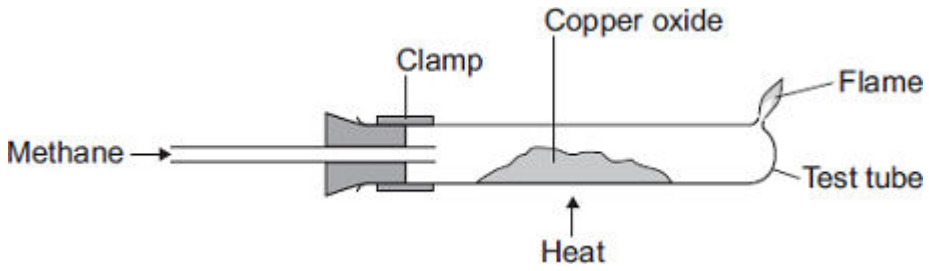
.....

Percentage yield = ...%

(1)

(Total 6 marks)

12 This apparatus is used for the reaction of copper oxide (CuO) with methane (CH_4).



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

$$4\ CuO(s) + CH_4(g) \longrightarrow 4\ Cu(s) + 2\ H_2O(g) + CO_2(g)$$

The water and carbon dioxide produced escape from the test tube.

Use information from the equation to explain why.

.....

.....

(1)

(b) (i) Calculate the relative formula mass (M_r) of copper oxide (CuO).

Relative atomic masses (A_r): O = 16, Cu = 64

.....

.....

.....

Relative formula mass (M_r) = ...

(2)

(ii) Calculate the percentage of copper in copper oxide.

.....

.....

.....

Percentage of copper = ... %

(2)

(iii) Calculate the maximum mass of copper that could be produced from 4.0 g of copper oxide.

.....

.....

Mass of copper produced = ... g

(1)

(c) The experiment was done three times.

The mass of copper oxide used and the mass of copper produced were measured each time.

The results are shown in the table.

	Experiment		
	1	**2**	**3**
Mass of copper oxide used in g	4.0	4.0	4.0
Mass of copper produced in g	3.3	3.5	3.2

(i) Calculate the mean mass of copper produced in these experiments.

.....

.....

Mean mass of copper produced = ... g

(1)

(ii) Suggest how the results of the experiment could be made more precise.

.....

.....

(1)

(iii) The three experiments gave different results for the amount of copper produced.

This was caused by experimental error.

Suggest two causes of experimental error in these experiments.

1 .....

.....

2 .....

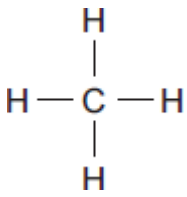
.....

(2)

(Total 10 marks)

13 Saturated hydrocarbons, for example methane and octane, are often used as fuels.

(a) Methane can be represented as:



(i) The formula of methane is ..... .

(1)

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

In a saturated hydrocarbon molecule all of the bonds are

double.
ionic.
single.

(1)

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

The homologous series that contains methane and octane is called the

alcohols.
alkanes.
alkenes.

(1)

(b) (i) The complete combustion of petrol produces carbon dioxide, water vapour and sulfur dioxide.

Name **three** elements petrol must contain.

1 .....

2 .....

3 .....

(3)

(ii) The exhaust gases from cars can contain oxides of nitrogen.

Complete the sentence.

Nitrogen in the oxides of nitrogen comes from ..... .

(1)

(iii) The sulfur dioxide and oxides of nitrogen from cars cause an environmental problem.

Name the problem and describe **one** effect of the problem.

Name of problem .....

Effect of problem .....

.....

(2)

(c) When a fuel burns without enough oxygen, there is incomplete combustion.

One gaseous product of incomplete combustion is carbon monoxide.

Name **one** solid product of incomplete combustion.

.....

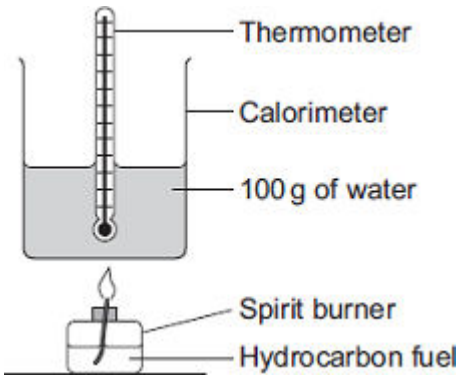
(1)

(d) A student investigated how well different hydrocarbon fuels would heat up 100 g of water.

Her hypothesis was:

The more carbon atoms there are in a molecule of any fuel, the better the fuel is.

The apparatus the student used is shown in the diagram.



She burned each hydrocarbon fuel for 2 minutes.

Her results are shown in the table.

Name of hydrocarbon fuel	Number of carbon atoms in a molecule of hydrocarbon fuel	Temperature change of water in °C after 2 minutes	Temperature change per g of fuel burned	Observations
Pentane	5	30	60	no smoke
Hexane	6	40	57	very small amount of smoke
Octane	8	55	55	small amount of smoke
Decane	10	57	52	large amount of smoke
Dodecane	12	60	43	very large amount of smoke

The student investigated only hydrocarbons.

Look carefully at her results.

How well do the student's results support her hypothesis?

The more carbon atoms there are in a molecule of any fuel, the better the fuel is.

Give reasons for your answer.

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(4)

(e) A 0.050 mol sample of a hydrocarbon was burned in excess oxygen.

The products were 3.60 g of water and 6.60 g of carbon dioxide.

(i) Calculate the number of moles of carbon dioxide produced.

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

.....

.....

Moles of carbon dioxide = ...

(2)

(ii) When the hydrocarbon was burned 0.20 mol of water were produced.

How many moles of hydrogen atoms are there in 0.20 mol of water?

.....

Moles of hydrogen atoms = ...

(1)

(iii) The amount of hydrocarbon burned was 0.050 mol.

Use this information and your answers to parts **(e) (i)** and **(e) (ii)** to calculate the molecular formula of the hydrocarbon.

If you could not answer parts **(e) (i)** or **(e) (ii)** use the values of 0.20 moles carbon dioxide and 0.50 moles hydrogen. These are **not** the answers to parts **(e) (i)** and **(e) (ii)**.

.....

.....

.....

.....

Formula = ...

(2)

(Total 19 marks)

14 This question is about lithium and sodium.

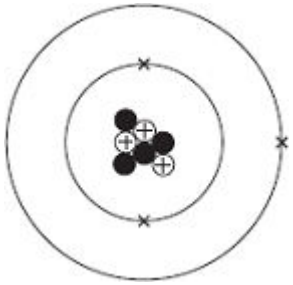
(a) Use the Chemistry Data Sheet to help you to answer this question.

In which group of the periodic table are lithium and sodium? Group ☐

(1)

(b) A lithium atom can be represented as $^{7}_{3}Li$

The diagram represents the lithium atom.



(i) Some particles in the nucleus have a positive charge.

What is the name of these particles? .....

(1)

(ii) Some particles in the nucleus have no charge.

What is the name of these particles? .....

(1)

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

3	4	7

The mass number of this atom of lithium is ☐

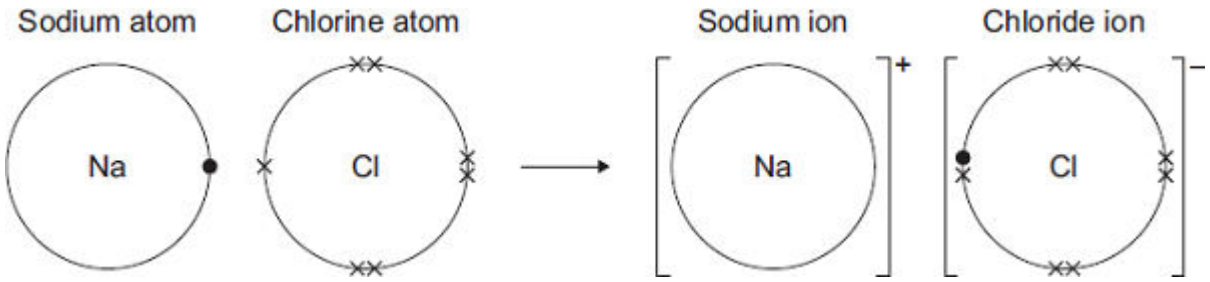
(1)

(c) Sodium reacts with chlorine to produce sodium chloride.

sodium + chlorine ⟶ sodium chloride

The diagram shows how the reaction happens.

Only the outer electrons are shown.



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

(i) A sodium atom changes into a sodium ion by

gaining
losing
sharing

an electron.

(1)

(ii) A sodium ion has

a negative
no
a positive

charge.

(1)

(iii) The ions in sodium chloride are held together by strong

covalent
electrostatic
magnetic

forces.

(1)

(d) Sodium chloride is an ionic compound.

Tick (✓) **two** properties of ionic compounds.

Property	Tick (✓)
Do **not** dissolve in water	
High melting points	
Low boiling points	
Strong bonds	

(2)

(e) (i) The formula of sodium chloride is NaCl

Calculate the relative formula mass of sodium chloride.

Relative atomic masses: Na = 23; Cl = 35.5

.....

.....

Relative formula mass = ...

(1)

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

The relative formula mass of a substance, in grams, is one | ion / isotope / mole | of the substance.

(1)

(f) Nanoparticles of sodium chloride (salt) are used to flavour crisps.

What are nanoparticles?

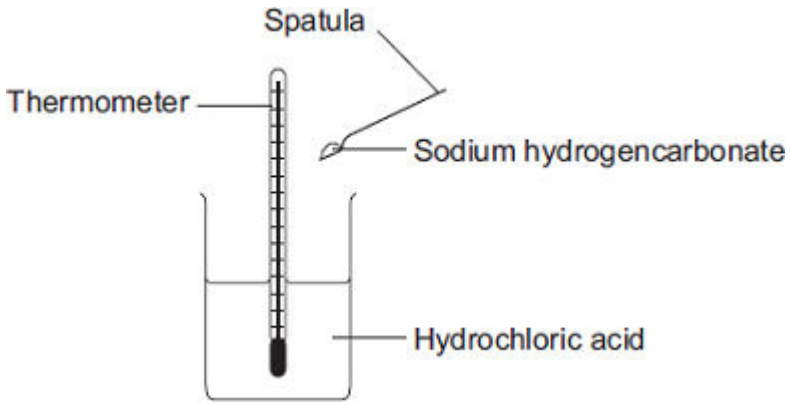
.....

.....

(1)

(Total 12 marks)

15 (a) Some students did an experiment to find the temperature change when hydrochloric acid reacts with sodium hydrogencarbonate.



The results are in the table.

Number of spatula measures of sodium hydrogencarbonate	Start temperature in °C	Final temperature in °C	Change in temperature in °C
2	20	16	4
4	20	14	6
6	19	11	8
8	20	10	10
10	19	9	10
12	20	10	10

(i) Describe, as fully as you can, the trends shown in the students' results.

.....

.....

.....

.....

.....

.....

.....

.....

(3)

(ii) State the type of energy transfer for this reaction.

.....

.....

(1)

(b) Sodium hydrogencarbonate is used as baking powder for making cakes.

When the cake mixture is baked the sodium hydrogencarbonate decomposes.

The equation for the reaction is:

$$2\,NaHCO_3(s) \xrightarrow{Heat} Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

(i) The cake mixture rises when baked.

© Michael Valdez/iStock

Use the equation to suggest why.

.....

.....

(1)

(ii) The same reaction can be reversed to produce sodium hydrogencarbonate from sodium carbonate.

$$Na_2CO_3 + H_2O + CO_2 \longrightarrow 2NaHCO_3$$

Do the reactants need to be heated?

Give a reason for your answer.

.....

.....

(1)

www.tutorzone.co.uk

(c) (i) Calculate the relative formula mass of sodium hydrogencarbonate ($NaHCO_3$).

Relative atomic masses (A_r): H=1; C=12; O=16; Na=23

.....

.....

.....

Relative formula mass (M_r) = ...

(2)

(ii) Calculate the percentage by mass of carbon in sodium hydrogencarbonate.

.....

.....

Percentage of carbon = ... %

(1)

(Total 9 marks)

16 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

.....

.....

.....

.....

.....

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.

.....

.....

Percentage yield of ammonia = ... %

(2)

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

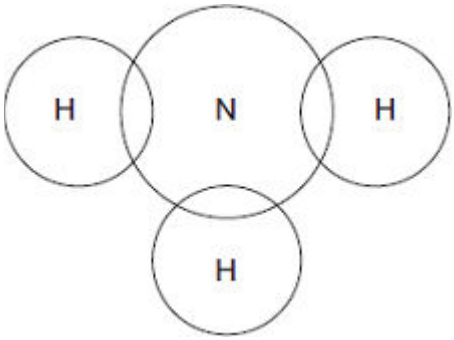
.....

.....

(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?

.....

(1)

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

.....

(1)

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

.....

(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.

.....

(1)

(Total 12 marks)

17 Some students investigated magnesium oxide.

(a) Magnesium oxide has the formula MgO.

(i) Calculate the relative formula mass (M_r) of magnesium oxide.

Relative atomic masses: O = 16; Mg = 24.

.....

.....

Relative formula mass = ...

(2)

(ii) Calculate the percentage by mass of magnesium in magnesium oxide.

.....

.....

Percentage by mass of magnesium in magnesium oxide = ...%

(2)

(iii) Calculate the mass of magnesium needed to make 25 g of magnesium oxide.

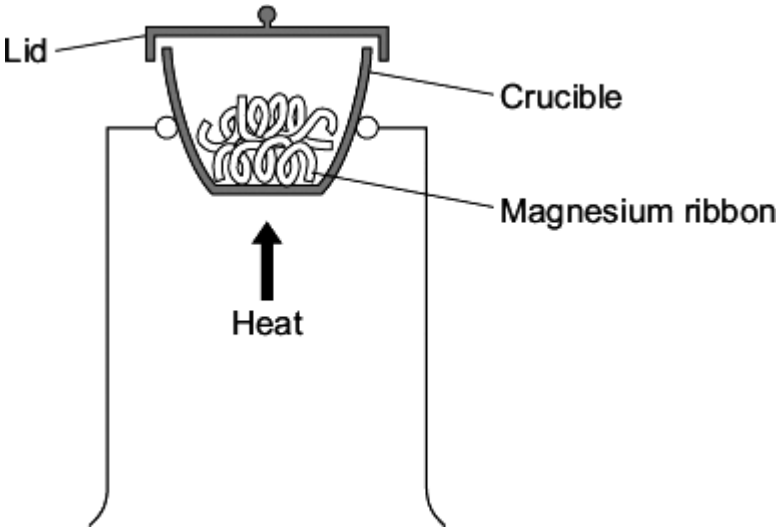
.....

Mass of magnesium = ... g

(1)

(b) The students calculated that if they used 0.12 g of magnesium they should make 0.20 g of magnesium oxide.

They did this experiment to find out if this was correct.



- The students weighed 0.12 g of magnesium ribbon into a crucible.
- They heated the magnesium ribbon.
- They lifted the lid of the crucible slightly from time to time to allow air into the crucible.
- The students tried to avoid lifting the lid too much in case some of the magnesium oxide escaped.
- When all of the magnesium appeared to have reacted, the students weighed the magnesium oxide produced.

The results of the experiment are shown below.

Mass of magnesium used in grams	0.12
Mass of magnesium oxide produced in grams	0.18

(i) The mass of magnesium oxide produced was lower than the students had calculated. They thought that this was caused by experimental error.

Suggest **two** experimental errors that the students had made.

.....

.....

.....

.....

(2)

(ii) The students only did the experiment once.

Give **two** reasons why they should have repeated the experiment.

.....

.....

.....

.....

(2)
(Total 9 marks)

18 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.

.....

.....

.....

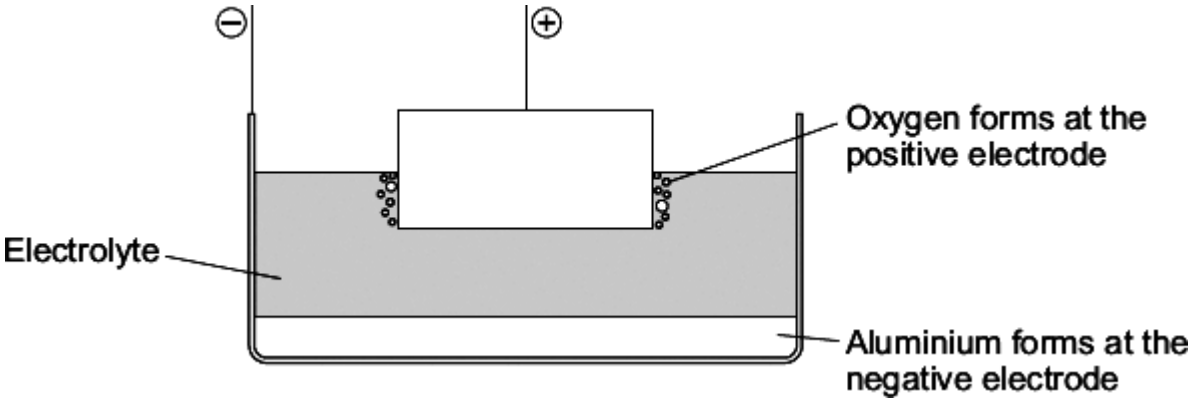
.....

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.

.....

.....

.....

.....

(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.

.....

.....

.....

.....

.....

.....

(2)
(Total 8 marks)

19 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?

.....

.....

.....

(1)

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

What are *nanoparticles*?

.....

.....

(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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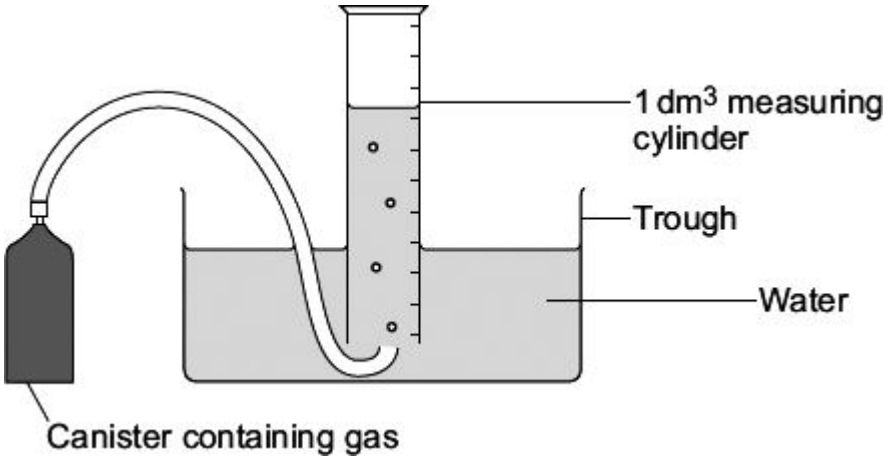
Maximum mass of calcium hydroxide = ... g

(3)

(Total 5 marks)

20 Some students did an experiment to find the relative formula mass (M_r) of a gas.



This is the method they used.

- The mass of the canister of gas was measured using a balance, which weighed to two decimal places.
- The measuring cylinder was filled with 1 dm^3 of the gas from the canister.
- The mass of the canister of gas was measured again.
- The temperature of the laboratory was measured.
- The air pressure in the laboratory was measured.

The students repeated the experiment three times.

(a) The results for one of the experiments are shown in the table below.

Mass of the canister of gas before filling the measuring cylinder	53.07 g
Mass of the canister of gas after filling the measuring cylinder	51.21 g

Calculate the mass of the 1 dm^3 of gas in the measuring cylinder.

.....

Mass = ... g

(1)

(b) How could the results be made more precise?

.....

.....

(1)

(c) The students used their results to calculate values for the relative formula mass (M_r) of this gas.
The results are shown in the table below.

Experiment	**1**	**2**	**3**	**4**
Relative formula mass (M_r)	45.4	51.5	46.3	45.8

(i) Calculate the mean value for these results.

.....

Mean = ...

(2)

(ii) The four results are different.
The students thought this was because of experimental error.

Suggest **two** causes of experimental error in this experiment.

.....

.....

.....

.....

(2)

(iii) It was important for the students to repeat the experiment.
Suggest why.

.....

.....

(1)

(d) The teacher told the students that the formula of the gas is C_3H_8

Calculate the relative formula mass (M_r) of this gas. You should show your working.

Relative atomic masses: H = 1; C = 12.

.....

.....

Relative formula mass = ...

(2)
(Total 9 marks)

21 Calamine lotion is used to treat itching. The main ingredients are two metal oxides.

(a) One of the metal oxides has a relative formula mass (M_r) of 81.

The formula of this metal oxide is MO.
(M is **not** the correct symbol for the metal.)

The relative atomic mass (A_r) of oxygen is 16.

(i) Calculate the relative atomic mass (A_r) of metal M.

.....

.....

.....

Relative atomic mass (A_r) = ...

(2)

(ii) Use your answer to part (a)(i) and the periodic table on the Data Sheet to name metal M.

The name of metal M is ..... .

(1)

(b) The other metal oxide is iron(III) oxide.

This contains iron(III) ions (Fe^{3+}) and oxide ions (O^{2-}).

(i) Explain in terms of electrons how an iron atom (Fe) can change into an iron(III) ion (Fe^{3+}).

.....

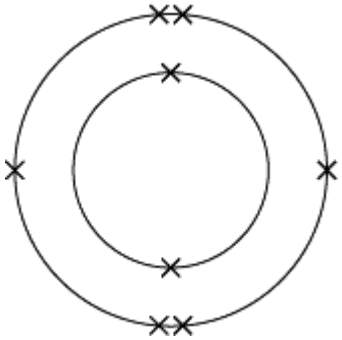
.....

.....

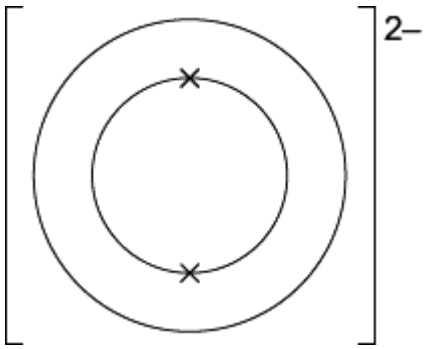
.....

(2)

(ii) The diagram below represents the electronic structure of an oxygen atom (O).

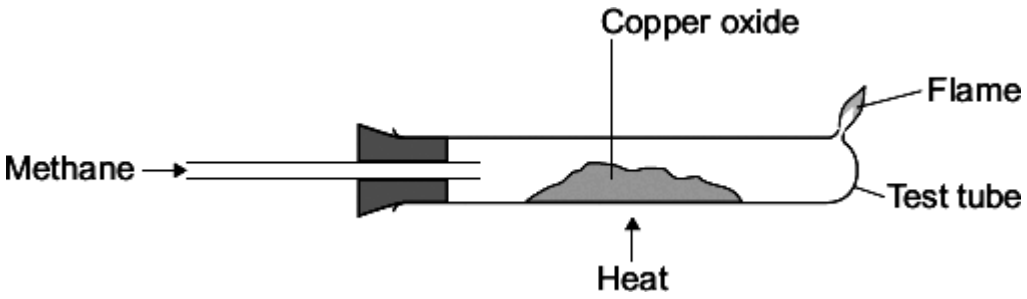


Complete the diagram below to show the electronic structure of an oxide ion (O^{2-}).



(1)
(Total 6 marks)

22 An experiment was done on the reaction of copper oxide (CuO) with methane (CH_4).



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

$$4CuO(s) + CH_4(g) \rightarrow 4Cu(s) + 2H_2O(g) + CO_2(g)$$

The water and carbon dioxide produced escapes from the test tube.

Use information from the equation to explain why.

.....

(1)

(b) (i) Calculate the relative formula mass (M_r) of copper oxide (CuO).

Relative atomic masses (A_r): O = 16; Cu = 64.

.....

.....

.....

Relative formula mass (M_r) = ...

(2)

(ii) Calculate the percentage of copper in copper oxide.

.....

.....

.....

Percentage of copper = ... %

(2)

(iii) Calculate the mass of copper that could be made from 4.0 g of copper oxide.

.....

.....

Mass of copper = ... g

(1)

(c) The experiment was done three times.
The mass of copper oxide used and the mass of copper made was measured each time.
The results are shown in the table.

	Experiment		
	1	**2**	**3**
Mass of copper oxide used in g	4.0	4.0	4.0
Mass of copper made in g	3.3	3.5	3.2

(i) Calculate the mean mass of copper made in these experiments.

.....

.....

Mean mass of copper made = ... g

(1)

(ii) Suggest how the results of these experiments could be made more precise.

.....

.....

(1)

(iii) The three experiments gave slightly different results for the mass of copper made.
This was caused by experimental error.

Suggest **two** causes of experimental error in these experiments.

1 .....

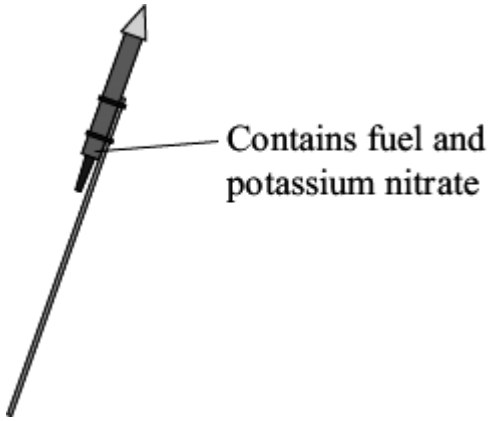
.....

2 .....

.....

(2)
(Total 10 marks)

23 Firework rockets contain fuel and potassium nitrate.



The potassium nitrate provides oxygen for the fuel to react.

(a) The table shows how a student worked out the relative formula mass (M_r) of potassium nitrate.

Some of the numbers are missing.

Relative atomic masses (A_r): N = 14; O = 16; K = 39.

Name of atom (symbol)	**Number of atoms**	**A_r**	**Mass**
potassium (K)	1	39	39
nitrogen (N)	1	14	14
oxygen (O)		16	
		The M_r of potassium nitrate =	101

(i) The mass of oxygen is not shown in the table.

Draw a ring around the correct mass of oxygen.

16 **32** **48**

(1)

(ii) Draw a ring around the number of oxygen atoms in the formula of potassium nitrate.

1 **2** **3**

(1)

(b) When the fuel reacts with the oxygen an *exothermic* reaction takes place.

What does *exothermic* mean?

.....

.....

.....

.....

(2)

(c) The fuel contains carbon. Carbon reacts with oxygen to make carbon dioxide.

Which **two** statements in the table explain why carbon dioxide is a gas at room temperature?

Tick (✓) the **two** statements.

Statement	**Tick (✓)**
It has a giant structure	
It has a low boiling point.	
It is made of small molecules.	
It is made of ions.	

(2)
(Total 6 marks)

24 (a) The table gives information about two isotopes of hydrogen, hydrogen-1 and hydrogen-2.

	Hydrogen-1	**Hydrogen-2**
Atomic number	1	1
Mass number	1	2

An atom of hydrogen-1 is represented as: $^{1}_{1}\mathrm{H}$

Show how an atom of hydrogen-2 is represented.

(1)

(b) (i) Calculate the relative formula mass (M_r) of water, H_2O

Relative atomic masses: H = 1; O = 16.

.....

.....

Relative formula mass (M_r) = ...

(1)

(ii) Simple molecules like water have low boiling points.

Explain why, in terms of molecules.

.....

.....

.....

.....

(2)

(c) Molecules of heavy water contain two atoms of hydrogen-2 instead of two atoms of hydrogen-1.

Explain why a molecule of heavy water has more mass than a normal water molecule.
You should refer to the particles in the nucleus of the two different hydrogen atoms in your answer.

.....

.....

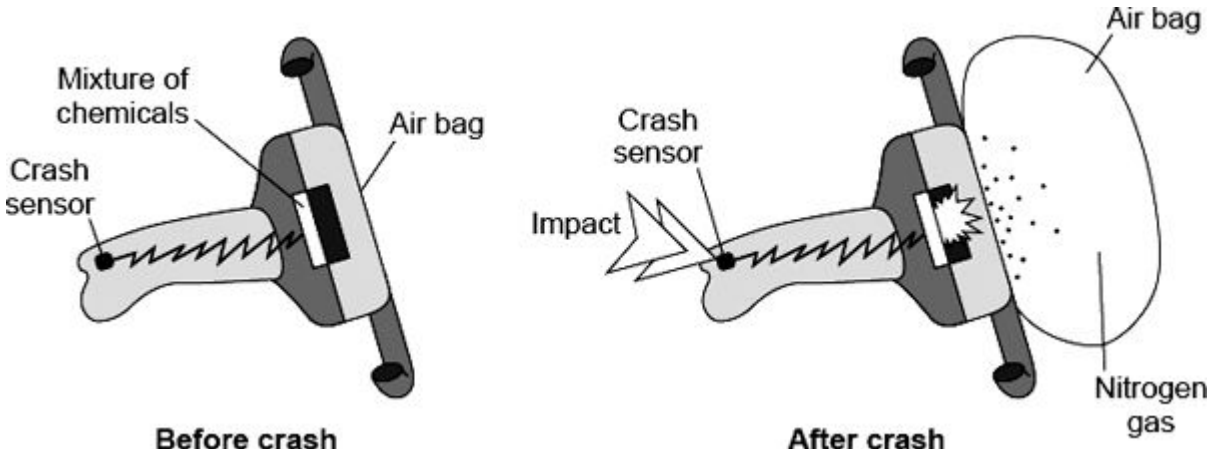
.....

.....

.....

(2)
(Total 6 marks)

25 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

.....

.....

.....

.....

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).)

.....

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.

.....

.....

(1)
(Total 6 marks)

26 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.

$C_7H_6O_3$ + $C_4H_6O_3$ → $C_9H_8O_4$ + CH_3COOH
salicylic acid aspirin

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)

27 This question is about methods of treating water.

(a) Chlorine is used to kill microorganisms in water. When chlorine is added to water a chemical reaction takes place. The equation for this reaction is shown below.

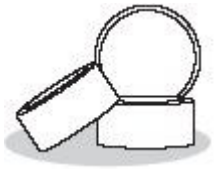
$$Cl_2(g) + H_2O(l) \rightleftharpoons 2H^+(aq) + OCl^-(aq) + Cl^-(aq)$$

An acidic solution is produced when chlorine reacts with water.

Which ion, shown in the equation, makes the solution acidic? .....

(1)

(b) Calcium hypochlorite tablets are added to water in some swimming pools to kill microorganisms.



The formula of calcium hypochlorite is $CaCl_2O_2$

(i) Calculate the relative formula mass (M_r) of calcium hypochlorite.

Relative atomic masses: O = 16; Cl = 35.5; Ca = 40.

.....

.....

Relative formula mass (M_r) of calcium hypochlorite = ...

(2)

(ii) Calculate the percentage by mass of chlorine in calcium hypochlorite.

.....

.....

Percentage by mass of chlorine in calcium hypochlorite = ... %

(2)

(iii) Calculate the mass of chlorine in a 20 g tablet of calcium hypochlorite.

.....

.....

Mass of chlorine = ... g

(1)

(c) Waste water from some industrial processes sometimes contains harmful metal ions, such as chromium ions. These ions must be removed from the water before it can be returned to a river.

A method of removing chromium ions (Cr^{3+}) from water is represented by this equation.

$$Cr^{3+}(aq) + 3OH^{-}(aq) \rightarrow Cr(OH)_3(s)$$

(i) What type of substance would be added to the water to provide the OH^- ions?

.....

.....

(1)

(ii) A *precipitate* is formed in this reaction.

What is a *precipitate*?

.....

.....

(1)

(iii) What method could be used to separate the precipitate from the solution?

.....

.....

(1)

(Total 9 marks)

28 (a) A chemist was asked to identify a nitrogen compound. The chemist carried out an experiment to find the relative formula mass (M_r) of the compound.

The M_r of the compound was **44**.

Relative atomic masses: N = 14, O = 16

Draw a ring around the formula of the compound.

NO **NO_2** **N_2O_4** **N_2O**

(1)

(b) Potassium nitrate is another nitrogen compound. It is used in fertilisers. It has the formula **KNO_3**.

The **M_r** of potassium nitrate is **101**.

Calculate the percentage of **nitrogen** by mass in potassium nitrate.

Relative atomic mass: N = 14.

.....

.....

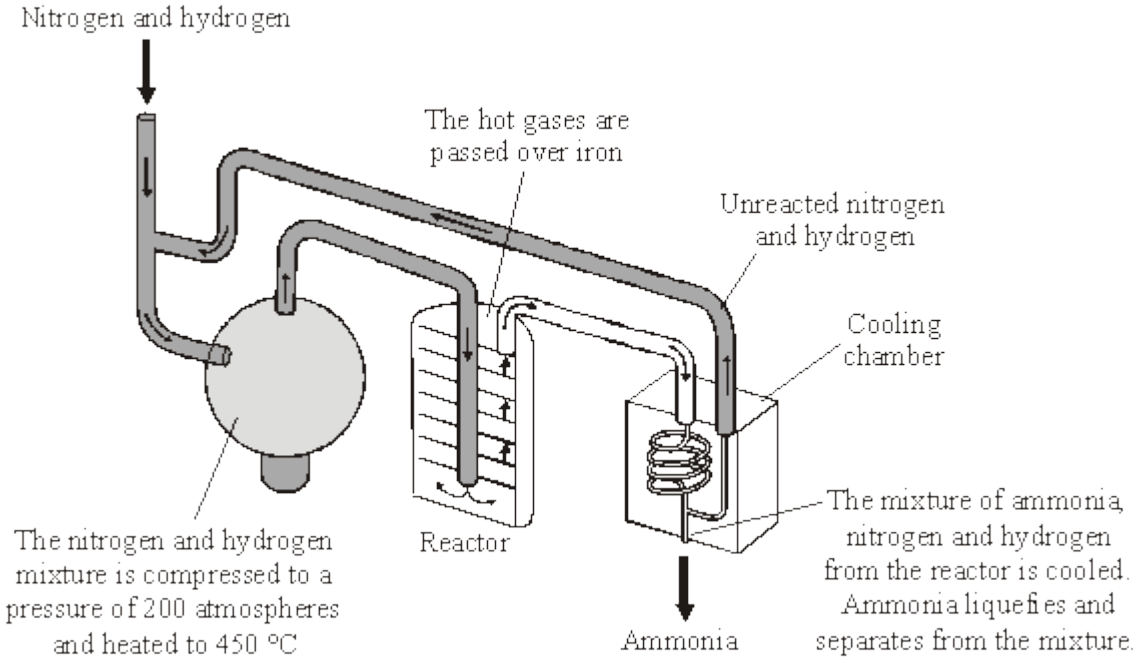
Percentage of nitrogen = ... %

(2)

(Total 3 marks)

29 The Haber process is named after the German chemist, Fritz Haber.

The diagram shows the main stages in the Haber process.



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An exothermic reaction takes place when nitrogen reacts with hydrogen to make ammonia.

The reaction can be represented by this equation.

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

(a) Calculate the maximum mass of ammonia that could be made from 1000 g of nitrogen.

Relative atomic masses: H = 1; N = 14

.....

.....

.....

.....

Mass .....g

(3)

(b) At a temperature of 450 °C and 200 atmospheres the actual mass of ammonia produced when 1000 g of nitrogen is passed through the reactor is 304 g.

Calculate the percentage yield of ammonia produced in the reactor.

(If you did not answer part (a), then assume that the maximum mass of ammonia that can be made from 1000 g of nitrogen is 1100 g. This is **not** the correct answer to part (a).)

.....

.....

.....

.....

.....

Percentage yield of ammonia = ... %

(2)

(c) State **and** explain:

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

.....

.....

.....

.....

(2)

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

.....

.....

.....

.....

(2)

(d) Factories that make ammonia are often near to large towns.

Discuss the economic, safety and environmental factors to be considered when there is an ammonia factory near a town.

.....

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.....

.....

(3)
(Total 12 marks)

30 Toothpastes often contain fluoride ions to help protect teeth from attack by bacteria.

Some toothpastes contain tin(II) fluoride.

This compound has the formula SnF_2 .

(a) Calculate the relative formula mass (M_r) of SnF_2.

Relative atomic masses: F = 19; Sn = 119

.....

.....

.....

.....

Relative formula mass (M_r) = ...

(2)

(b) Calculate the percentage by mass of fluorine in SnF_2.

.....

.....

.....

.....

Percentage by mass of fluorine = ... %

(2)

(c) A tube of toothpaste contains 1.2 g of SnF_2.

Calculate the mass of fluorine in this tube of toothpaste.

.....

.....

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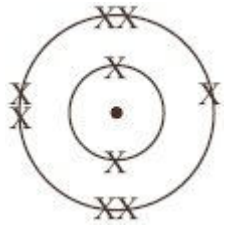
.....

Mass of fluorine = ... g

(1)

(d) The diagram represents the electron arrangement of a fluorine atom.



Explain how a fluorine atom can change into a fluoride ion, F^-.

.....

.....

.....

.....

(2)

(Total 7 marks)

31 Iron ore contains iron oxide.

(i) Calculate the relative formula mass of iron oxide, Fe_2O_3.

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

.....

.....

Answer = ...

(2)

(ii) Calculate the percentage by mass of iron in iron oxide.

.....

Percentage of iron = ... %

(2)

(iii) Calculate the mass of iron that could be extracted from 1000 kg of iron oxide.

Use your answer to part (c) (ii) to help you with this calculation.

.....

Mass of iron = ... kg

(1)

(Total 5 marks)

32 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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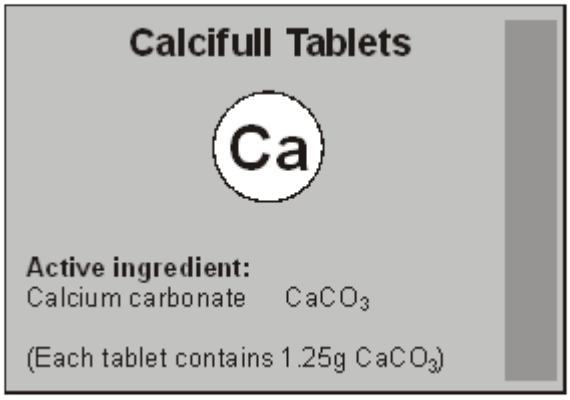
Mass of carbon dioxide = ... g

(Total 3 marks)

33 Calcium carbonate tablets are used to treat people with calcium deficiency.



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

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

.....

.....

Relative formula mass = ...

(2)

(b) Calculate the percentage of calcium in calcium carbonate, $CaCO_3$.

.....

.....

Percentage of calcium = ... %

(2)

(c) Calculate the mass of calcium in each tablet.

.....

.....

Mass of calcium = ... g

(2)

(d) An unwanted side effect of this medicine is that it can cause the patient to have 'wind' (too much gas in the intestine).

The equation below represents the reaction between calcium carbonate and hydrochloric acid (the acid present in the stomach).

$$CaCO_3\ (s) + 2HCl\ (aq) \rightarrow CaCl_2\ (aq) + H_2O\ (l) + CO_2\ (g)$$

Suggest why the patient may suffer from 'wind'.

.....

.....

(1)

(Total 7 marks)

34 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

.....

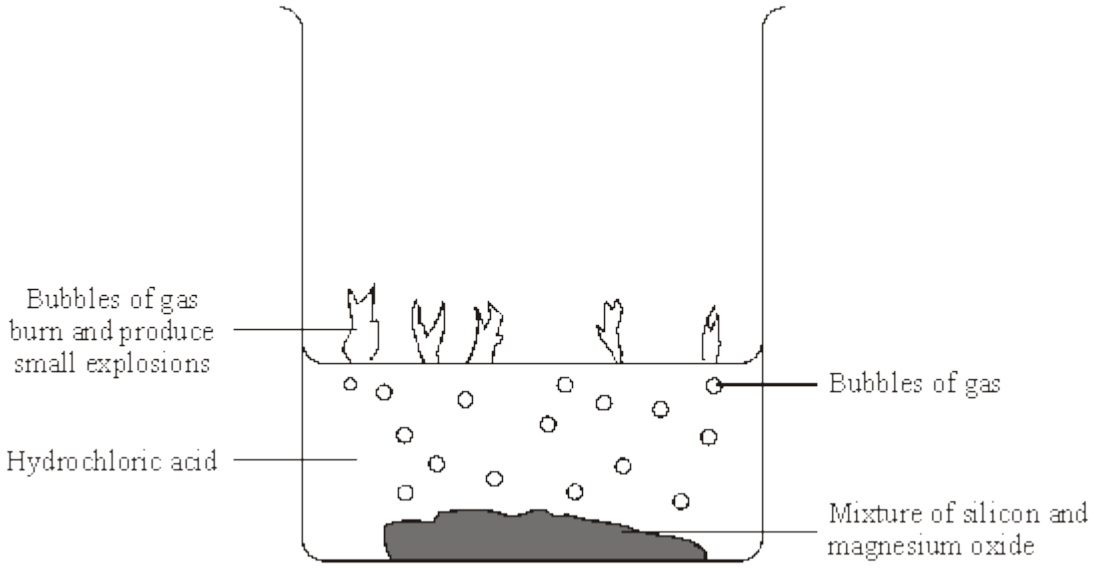
.....

.....

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

.....

.....

.....

.....

.....

.....

.....

(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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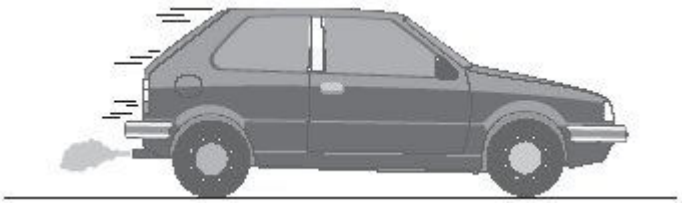
(4)
(Total 15 marks)

35 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.

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

.....

.....

.....

.....

.....

.....

Mass of carbon dioxide = ... g

(Total 3 marks)

36 As the world population increases there is a greater demand for fertilisers.

(a) Explain what fertilisers are used for.

.....

.....

.....

.....

(2)

(b) The amount of nitrogen in a fertiliser is important.

(i) How many nitrogen atoms are there in the formula, NH_4NO_3?

.....

(1)

(ii) Work out the relative formula mass of ammonium nitrate, NH_4NO_3.

Relative atomic masses: H 1; N 14; O 16.

.....

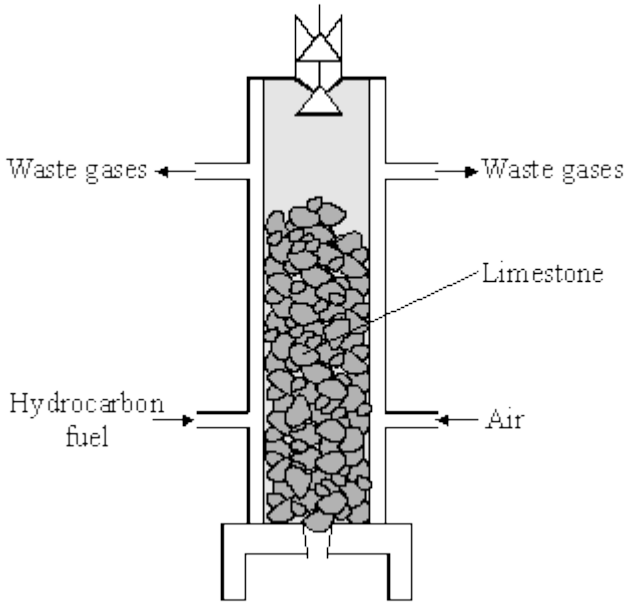
.....

Relative formula mass of ammonium nitrate = ...

(1)

(Total 4 marks)

37 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.

.....

.....

.....

.....

(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.

.....

.....

.....

.....

.....

Mass of lime = ... tonnes

(3)

(Total 5 marks)

38 Follow the steps to find the percentage of iron in iron oxide.

Relative atomic masses: O 16; Fe 56.

(i) Step 1

Calculate the relative formula mass of iron oxide, Fe_2O_3.

.....

.....

(1)

(ii) Step 2

Calculate the total relative mass of just the iron atoms in the formula, Fe_2O_3.

.....

(1)

(iii) Step 3

Calculate the percentage (%) of iron in the iron oxide, Fe_2O_3.

.....

.....

Percentage of iron ..... %

(1)

(Total 3 marks)

39 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.

.....

.....

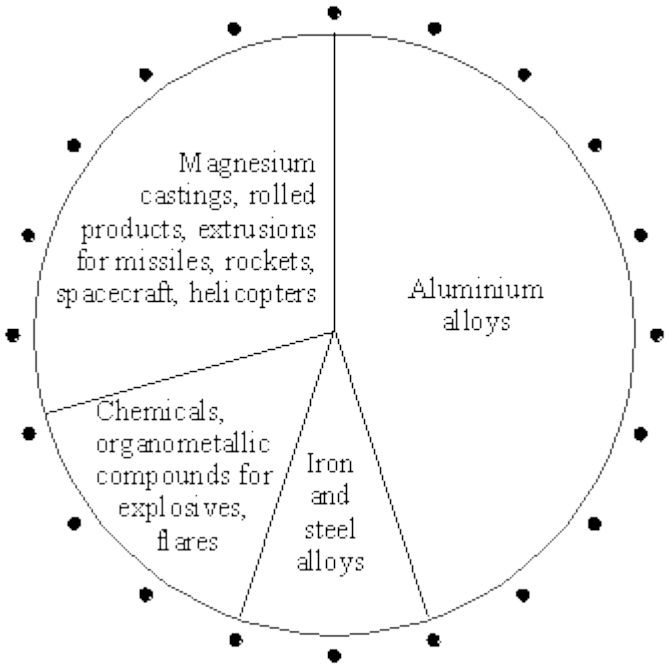
.....

.....

Mass of titanium = ... kg

(Total 3 marks)

40 280 000 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)

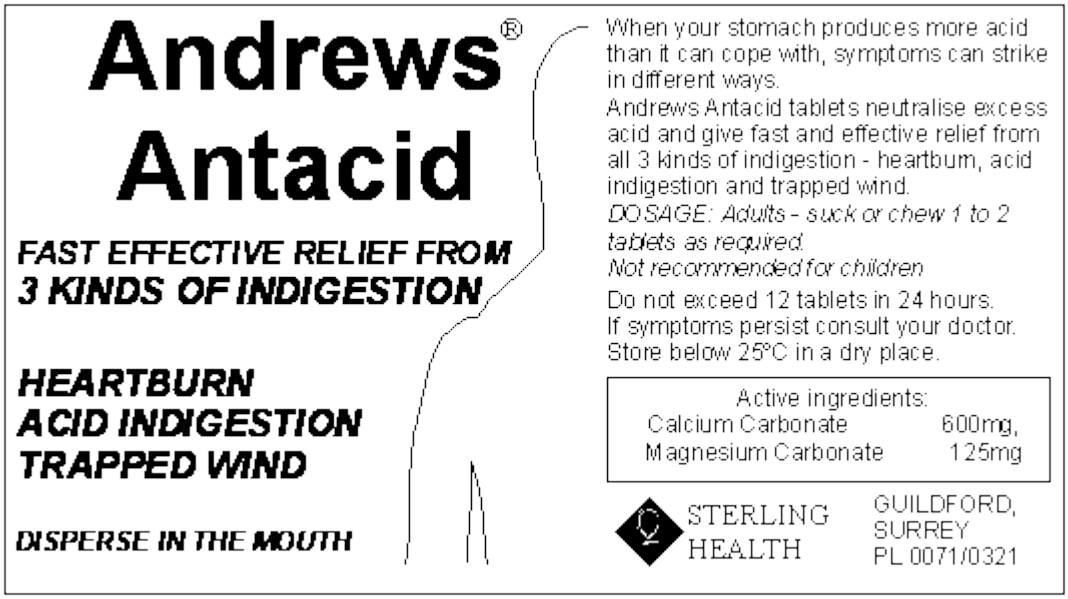
(ii) Give a use for chlorine.

.....

(1)

(Total 6 marks)

41 (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.

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

(1)

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

.....

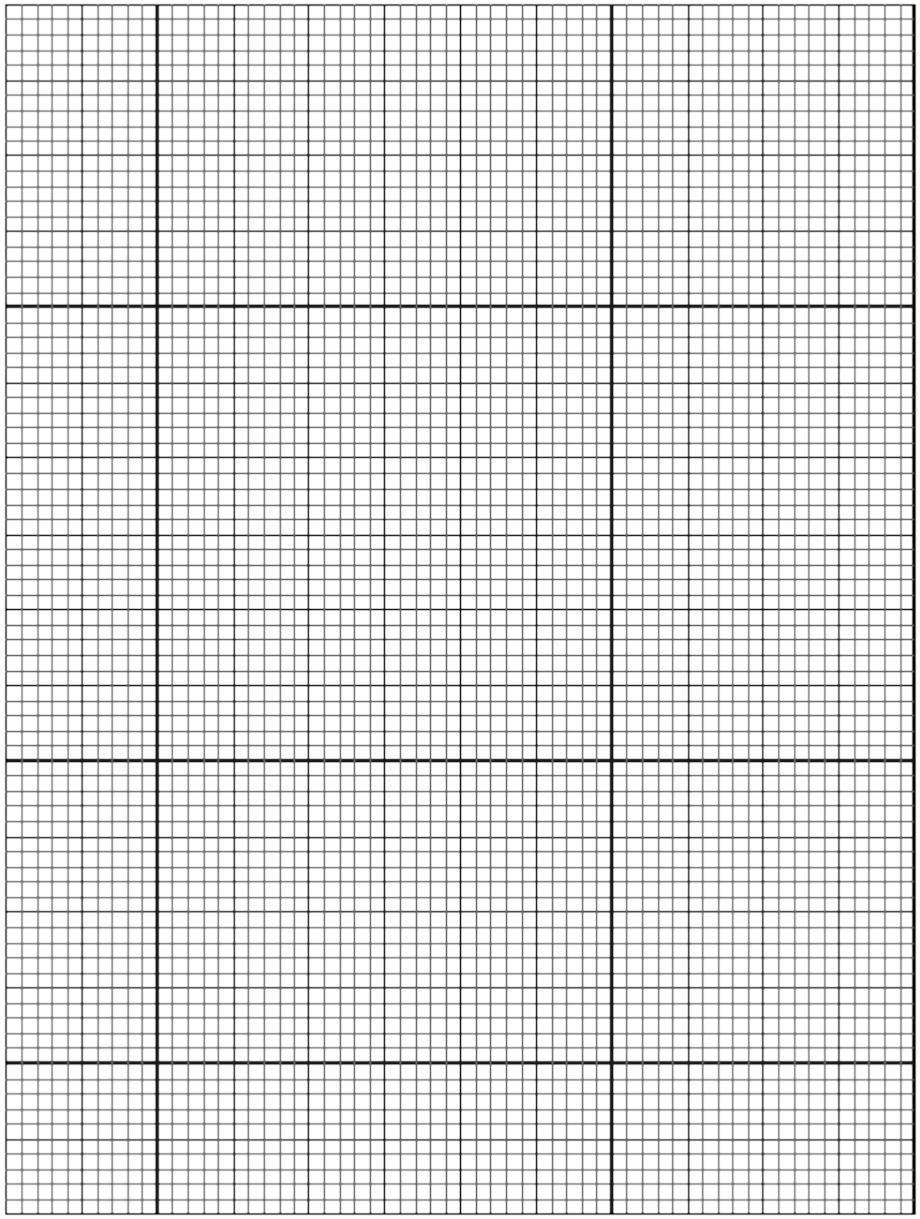
(1)

(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)

42 Calcium oxide (quicklime) is made by heating calcium carbonate (limestone).

calcium carbonate	→	calcium oxide	+	carbon dioxide
100 g		?		44 g

(a) 44 grams of carbon dioxide is produced when 100 grams of calcium carbonate is heated.

Calculate the mass of calcium oxide produced when 100 grams of calcium carbonate is heated.

.....

mass ..... g

(1)

(b) What mass of carbon dioxide could be made from 100 tonnes of calcium carbonate?

mass ..... tonnes

(1)

(Total 2 marks)

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

quicklime CaO .....

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

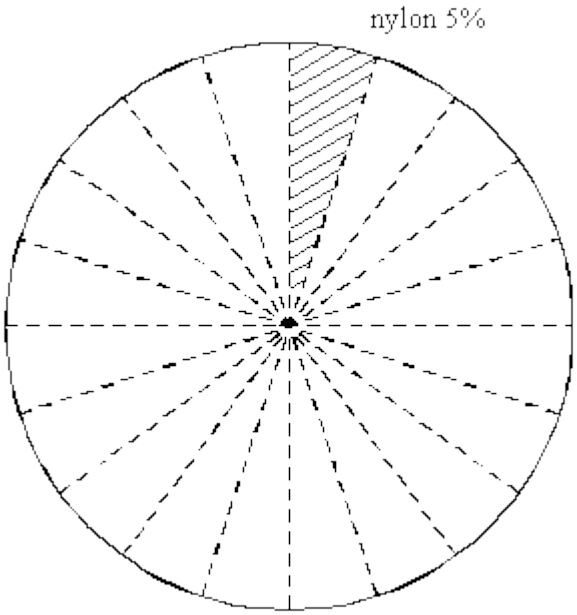
(Total 2 marks)

44 Ammonia is a very important chemical.

(a) The table shows the percentage of ammonia used to make different substances.

SUBSTANCES MADE FROM AMMONIA	PERCENTAGE (%) OF AMMONIA USED
fertilisers	75
nitric acid	10
nylon	5
others	10

Shade on the pie chart the percentage of ammonia used to make nitric acid.



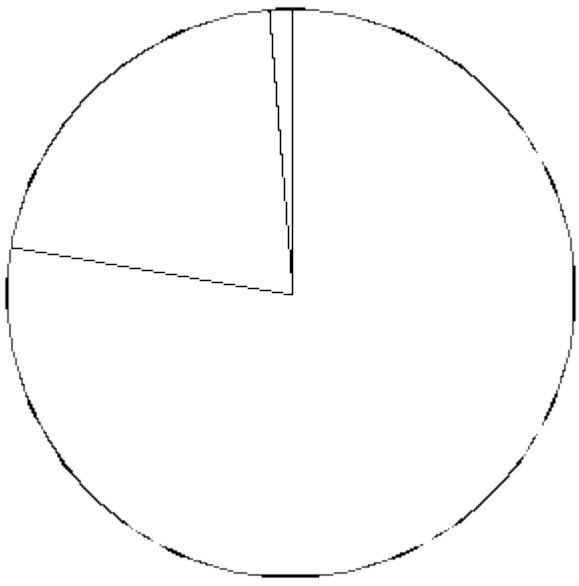
(1)

(b) Ammonia gas is made by the reaction between nitrogen gas and hydrogen gas.
Write a word equation to represent this reaction.

..... + ... ⇌ .....

(1)

(c) Nitrogen is one of the raw materials used to make ammonia.
Nitrogen is obtained from air.
This pie chart shows the proportion of nitrogen, oxygen and other gases in air.
Label the area which represents the proportion of nitrogen in air.



(1)

(d) An artificial fertiliser contains compounds with the formulae:

NH_4NO_3 and **KCl**

(i) Use the Data Sheet to help you answer this question.
Name the elements in the compound NH_4NO_3.

1 .....

2 .....

3 .....

(2)

(ii) Use the Data Sheet to help you answer this question.
Name the compound KCl.

.....

(1)

(e) (i) Ammonium nitrate is one type of artificial fertiliser.
Calculate the relative formula mass of ammonium nitrate NH_4NO_3.
(Relative atomic masses: H = 1, N = 14, O = 16.)

.....

.....

(1)

(ii) Use your answer to part (f)(i) to help you calculate the percentage by mass of nitrogen present in ammonium nitrate NH_4NO_3.

.....

.....

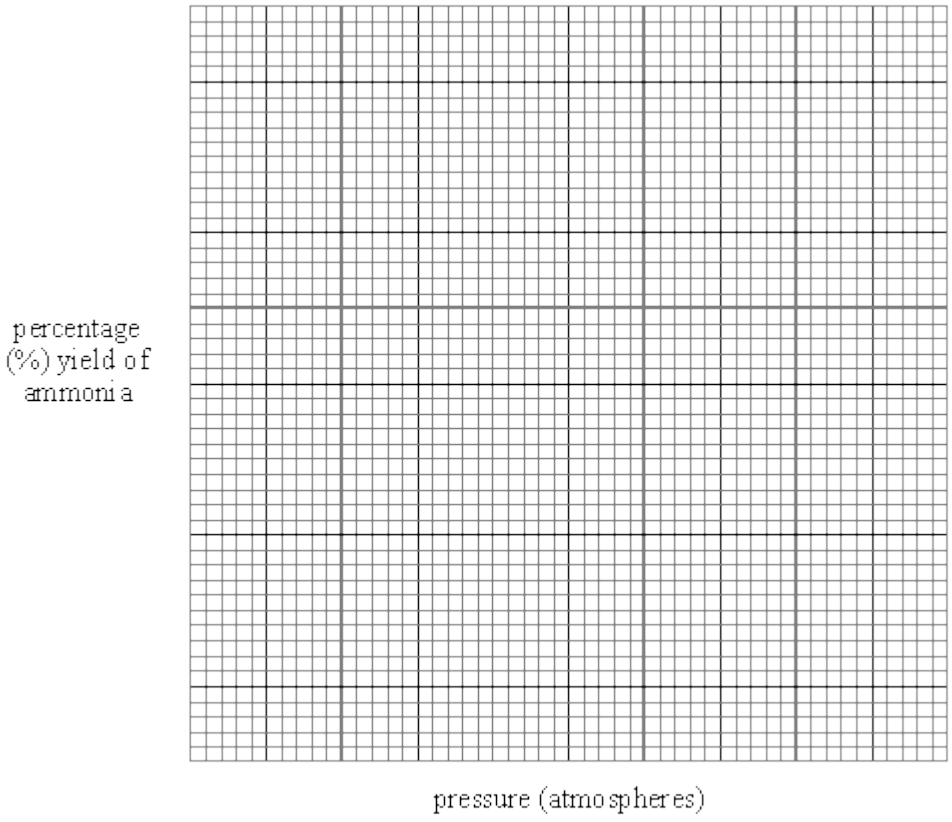
.....

(2)
(Total 9 marks)

45 The Haber process is used to make ammonia NH_3.
The table shows the percentage yield of ammonia at different temperatures and pressures.

PRESSURE (ATMOSPHERES)	PERCENTAGE (%) YIELD OF AMMONIA AT 350°C	PERCENTAGE (%) YIELD OF AMMONIA AT 500°C
50	25	5
100	37	9
200	52	15
300	63	20
400	70	23
500	74	25

(a) (i) Use the data in the table to draw two graphs on the grid below. Draw one graph for a temperature of 350°C and the second graph for a temperature of 500°C.
Label each graph with its temperature.



(4)

(ii) Use your graphs to find the conditions needed to give a yield of 30% ammonia.

..... °C and ..... atmospheres

(1)

(iii) On the grid sketch the graph you would expect for a temperature of 450°C.

(1)

(b) (i) This equation represents the reaction in which ammonia is formed.

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)} + \text{heat}$$

What does the symbol $\rightleftharpoons$ in this equation tell you about the reaction?

.....

(1)

(ii) Use your graphs and your knowledge of the Haber process to explain why a temperature of 450°C and a pressure of 200 atmospheres are used in industry.

.....

.....

.....

.....

.....

.....

(5)

(c) (i) Ammonium nitrate is one type of artificial fertiliser.
Calculate the relative formula mass of ammonium nitrate NH_4NO_3.
(Relative atomic masses: H = 1, N = 14, O = 16.)

.....

.....

(1)

(ii) Use your answer to part (c)(i) to help you calculate the percentage by mass of nitrogen present in ammonium nitrate NH_4NO_3.

.....

.....

(2)

(Total 15 marks)

46 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)

47 Nitrates, such as ammonium nitrate, are added to soil to help plant growth.

(a) When rain falls nitrates dissolve and can end up in drinking water.
Nitrates in drinking water can stop respiration in babies. This only happens if there is a lot of nitrate in the drinking water.

Plants use nitrates for growth. Humans need plants. Should large amounts of nitrates be added to soil?
Give **two** reasons for your answer.

Answer .....

Reason 1 .....

.....

Reason 2 .....

.....

(2)

(b) The amount of nitrogen in a nitrate compound is important.

(i) How many nitrogen atoms are there in the formula of ammonium nitrate, NH_4NO_3

.....

(1)

(ii) Calculate the percentage of nitrogen in ammonium nitrate, NH_4NO_3.

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

.....

.....

.....

Percentage of nitrogen in ammonium nitrate = ... %

(3)

(Total 6 marks)

48 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)

49 Calculate the percentage of iron in iron sulphate ($FeSO_4$).

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

.....

.....

.....

.....

Percentage of iron in iron sulphate = ...%

(Total 3 marks)

50 '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)

.....

.....

.....

.....

.....

.....

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)

51 Ammonium chloride, NH_4Cl, is made up of nitrogen, hydrogen and chlorine atoms.

(i) Complete the table to show the number of atoms of each element present in NH_4Cl.

Element	**Number of atoms in NH_4Cl**
nitrogen	1
hydrogen	
chlorine	

(1)

(ii) Calculate the relative formula mass of ammonium chloride, NH_4Cl.

(Relative atomic masses: H = 1, N = 14, Cl = 35.5)

.....

.....

.....

.....

Relative formula mass = ...

(2)

(Total 3 marks)

52 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)

.....

.....

.....

.....

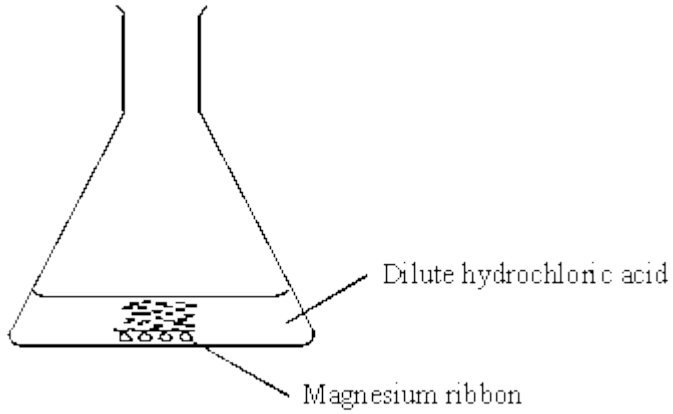
Mass of hydrogen chloride = ... g

(Total 3 marks)

53 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)

54 (a) 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) What is the source of the nitrogen?

.....

(1)

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

.....

.....

(1)

(iii) The percentage yield of ammonia is the percentage, by mass, of the nitrogen and hydrogen which has been converted to ammonia. Calculate the mass, in tonnes, of ammonia which can be produced from 90 tonnes of hydrogen when the percentage yield is 50%. The relative atomic masses are: H 1; N 14.

Show clearly how you get to your answer.

.....

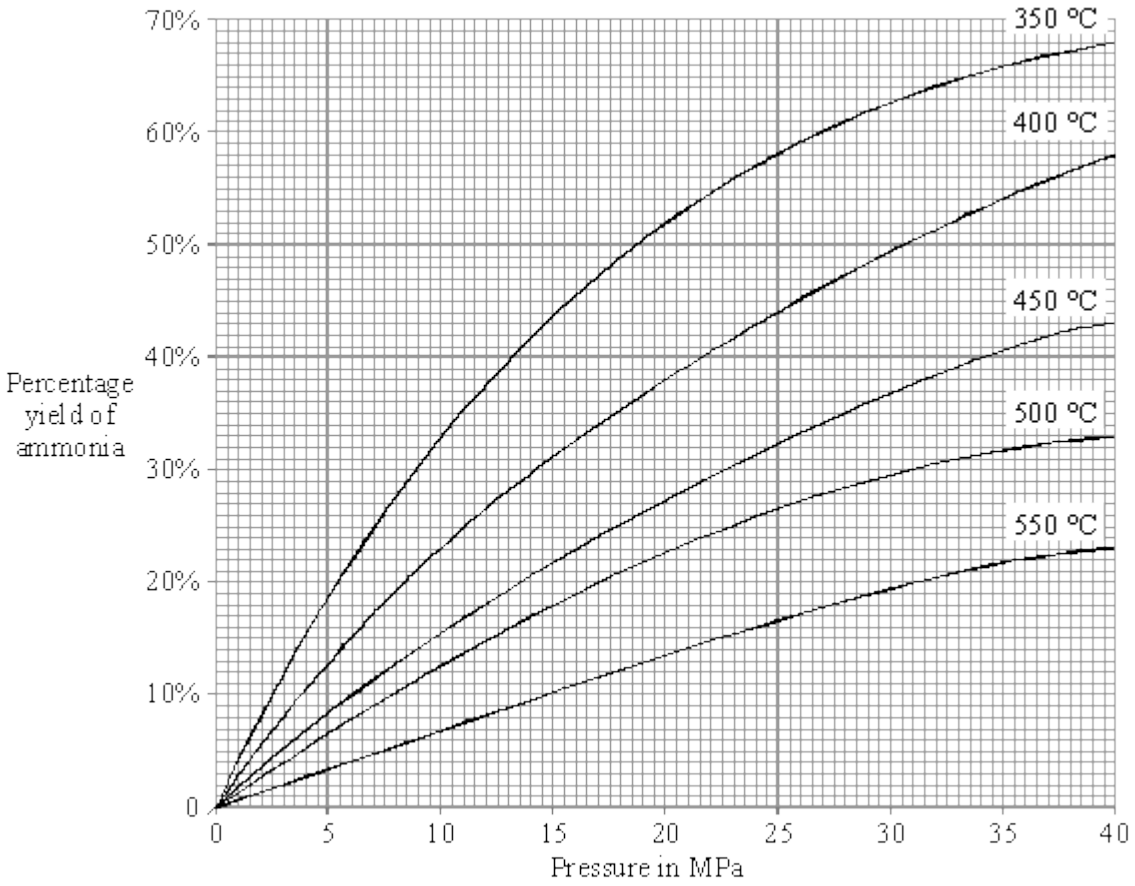
.....

.....

Mass = ... tonnes

(2)

(b) The percentage yield of ammonia depends on the temperature and pressure inside the reaction vessel. The set of graphs show this.



(i) MPa is the symbol for which unit?

.....

(1)

(ii) What is the percentage yield of ammonia produced at a temperature of 450 °C and a pressure of 20 MPa?

.....

(1)

(iii) Suggest what changes the chemical engineers should make to both the temperature and the pressure to **increase** the percentage yield of ammonia.

Temperature .....

Pressure .....

(1)

(iv) How can the rate of ammonia production be increased without changing the temperature or pressure or the mass of hydrogen and nitrogen?

.....

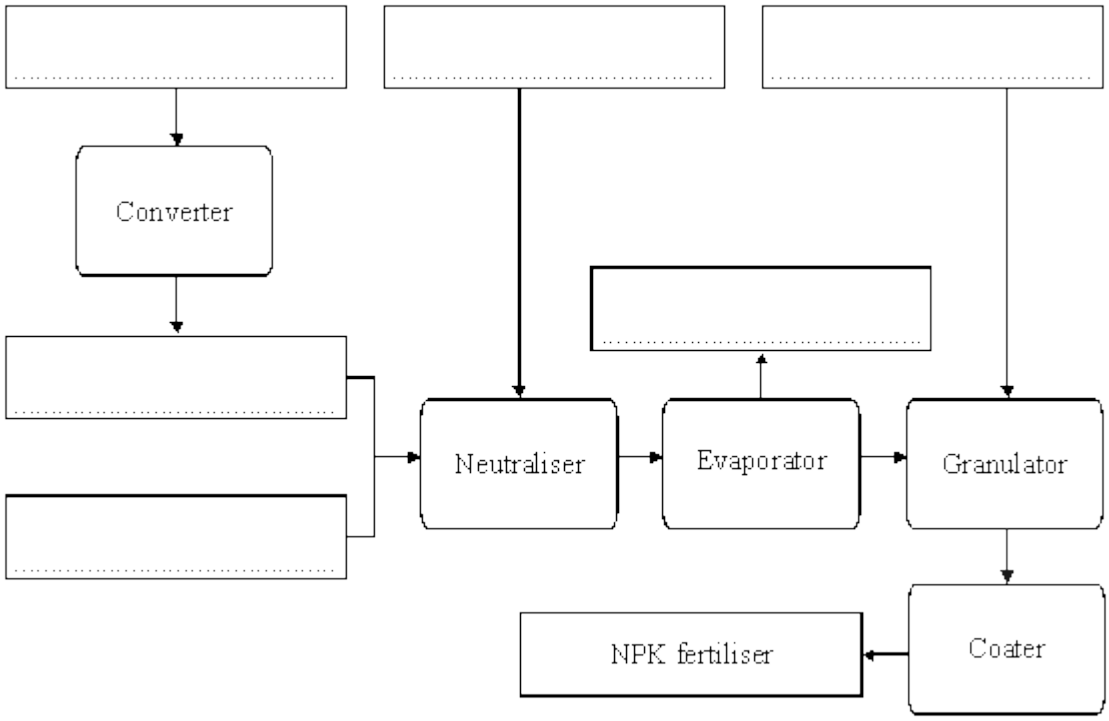
.....

(1)

(c) About four-fifths of ammonia production is used to produce fertilisers. One of them is known as NPK. It is made in the following way.

- Some ammonia is converted to nitric acid which is then mixed with phosphoric acid.
- The mixture is neutralised with more ammonia and the solution is partly evaporated.
- Potassium chloride is added to form granules.
- The granules are coated to make the fertiliser free-flowing.

Complete the flow-chart for the production of NPK by writing in the names of the correct chemicals in the **six** boxes.



(2)
(Total 10 marks)

55 (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)

56 (a) The formula for ammonia is NH_3. What does the formula tell you about each molecule of ammonia?

.....

.....

.....

.....

(3)

(b) Ammonia is used to make nitric acid (HNO_3). Calculate the formula mass (Mr) for nitric acid. (Show your working).

.....

.....

.....

.....

.....

(3)
(Total 6 marks)

57 The information on the Data Sheet will be helpful in answering this question.

(a) Calculate the formula mass (M_r) of the compound iron (III) oxide, Fe_2O_3.

(Show your working.)

.....

.....

.....

.....

.....

(3)

(b) Calculate the mass of iron produced when 32g of iron (III) oxide is completely reduced by aluminium.

The reaction is shown in the symbol equation:

$$Fe_2O_3 + 2Al \rightarrow 2Fe + Al_2O_3$$

(Show your working.)

.....

.....

.....

.....

Answer = ... grams

(3)

(Total 6 marks)

58 Calculate the formula mass (Mr), of the compound

calcium hydroxide, $Ca(OH)_2$.

(Show your working)

.....

.....

.....

.....

.....

.....

(Total 3 marks)

59 The formula for the chemical compound magnesium sulphate is $MgSO_4$.

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

.....

.....

.....

.....

(Total 2 marks)

60 (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.)

.....

.....

.....

.....

.....

.....

Answer..... g

(2)

(Total 4 marks)