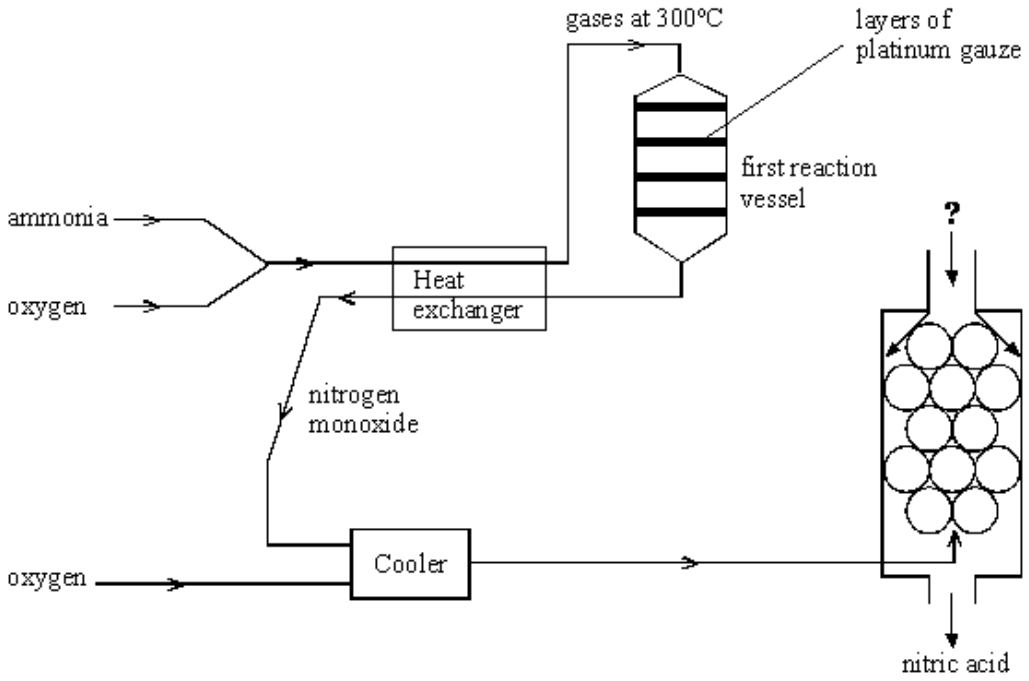
Q1. The chart shows the processes involved in the manufacture of nitric acid from ammonia.



(a) Complete the word equation for the reaction that takes place in the first reaction vessel.

ammonia + ... ⟶ nitrogen monoxide + water

(1)

(b) What is the use of the platinum gauze in the reaction vessel?

.....

(1)

(c) To convert nitrogen monoxide into nitric acid, **two** further reactants are needed.
What are they?

..... and .....

(1)

(d) Complete the word equation below, to show how to make the fertiliser, ammonium nitrate.

..... + ... ⟶ ammonium nitrate + water

(2)

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

.....

.....

.....

.....

(2)
(Total 7 marks)

Q2. 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

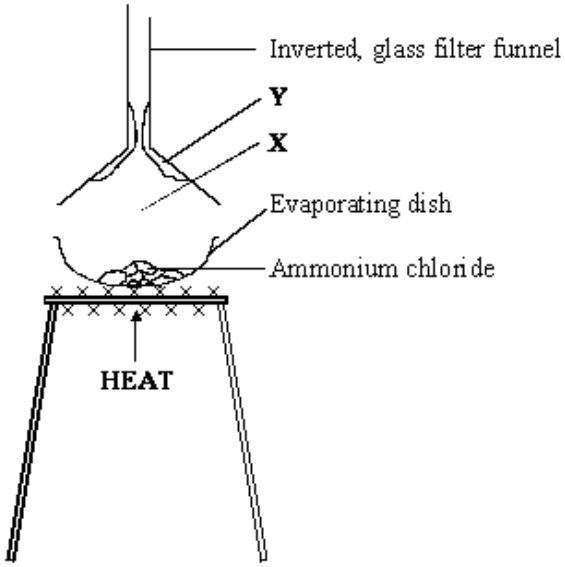
(3)
(Total 6 marks)

Q3. (a) The equation for the reaction that takes place when ammonium chloride is heated is:

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$$

ammonium chloride — ammonia — hydrogen chloride

The diagram shows how a teacher demonstrated this reaction. The demonstration was carried out in a fume cupboard.



(i) Apart from the gases normally in the atmosphere, which two gases would be at **X**?

..... and .....

(1)

(ii) Name the white solid that has formed at **Y**.

.....

(1)

(iii) Why was the demonstration carried out in a fume cupboard?

.....

.....

(1)

(iv) Complete the **four** spaces in the passage.

The chemical formula of ammonia is NH_3. This shows that there is one atom of

..... and three atoms of ..... in each

..... of ammonia. These atoms are joined by bonds that

are formed by sharing pairs of electrons. This type of bond is called

a ..... bond.

(4)

(b) Electrons, neutrons and protons are sub-atomic particles.

(i) Complete the **three** spaces in the table.

Name of sub-atomic particle	Relative mass	Relative charge
.....	1	+1
.....	1	0
.....	$\frac{1}{1840}$	–1

(2)

(ii) Which **two** sub-atomic particles are in the nucleus of an atom?

..... and .....

(1)

(Total 10 marks)

Q4. (a) Ammonium sulphate is made by the reaction:

$$2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$$

(i) Complete the **three** answers in the table.

Question	Answer
How many hydrogens are there in the formula of ammonium sulphate?	.....
What is the name of the substance with the formula NH_3?	.....
What is the name of the substance with the formula H_2SO_4?	.....

(3)

(ii) What is the main use for ammonium sulphate?

.....

(1)

(iii) A similar reaction is used to make ammonium nitrate. What is the name of the acid which must be used?

.....

(1)

(b) NH_3 is made by the reversible reaction:

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

(i) Explain what the term *reversible reaction* means.

.....

.....

.....

(2)

(ii) What is the name of the raw material which is the source of nitrogen (N_2)?

.....

(1)

(iii) Nitrogen is an element. Explain what the term *element* means.

.....

.....

.....

(2)

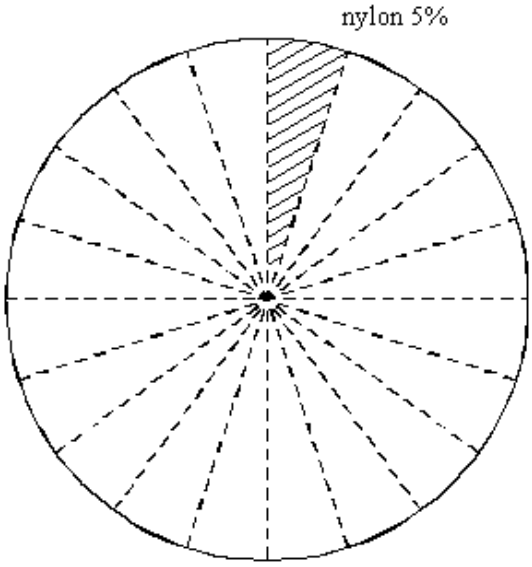
(Total 10 marks)

Q5. 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.



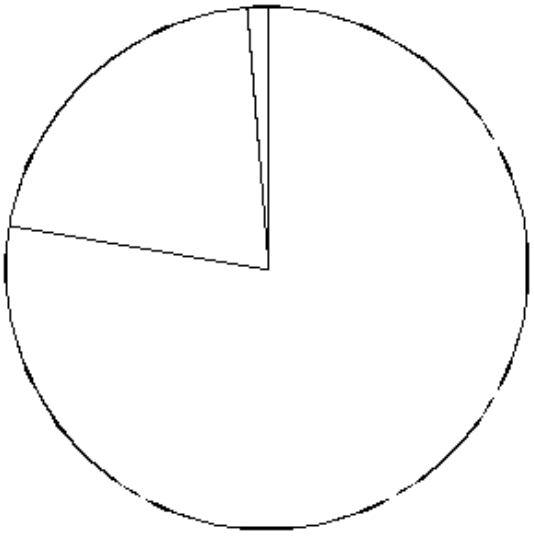
(1)

(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)

Q6. 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.

.....

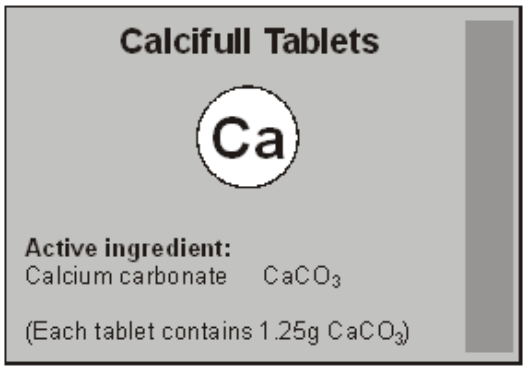
.....

Percentage of iron ..... %

(1)

(Total 3 marks)

Q7. 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)

Q8. 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)

Q9. 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.

.....

.....

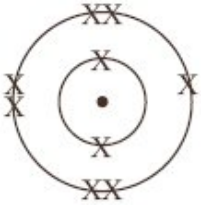
.....

.....

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)

Q10. 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.

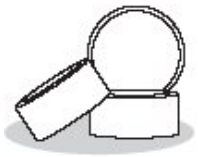
$$Cl_2(g) + H_2O(l) \rightleftharpoons 2H^+(aq) + OCl^-(aq) + Cl^-(aq)$$

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)

Q11. Iron is an essential part of the human diet. Iron(II) sulfate is sometimes added to white bread flour to provide some of the iron in a person's diet.

(a) The formula of iron(II) sulfate is $FeSO_4$

Calculate the relative formula mass (M_r) of $FeSO_4$

Relative atomic masses: O = 16; S = 32; Fe = 56.

.....

.....

The relative formula mass (M_r) = ...

(2)

(b) What is the mass of one mole of iron(II) sulfate? Remember to give the unit.

.....

(1)

(c) What mass of iron(II) sulfate would be needed to provide 28 grams of iron?

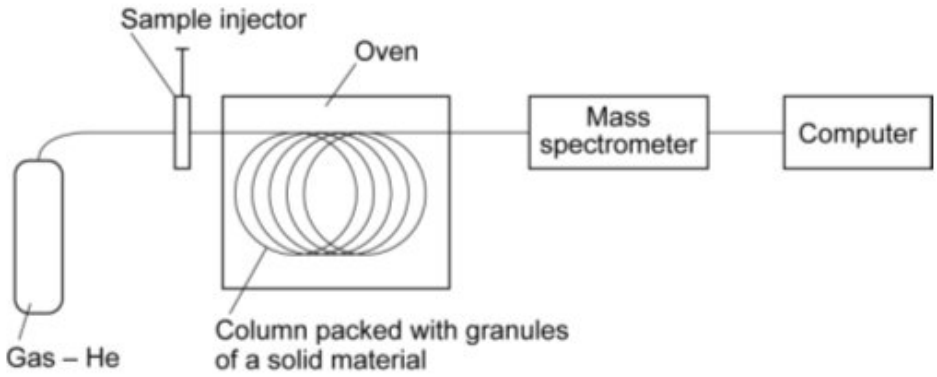
Remember to give the unit.

.....

(1)

(Total 4 marks)

Q12. The diagram shows the main parts of an instrumental method called gas chromatography linked to mass spectroscopy (GC-MS).



This method separates a mixture of compounds and then helps to identify each of the compounds in the mixture.

(a) In which part of the apparatus:

(i) is the mixture separated? .....

(1)

(ii) is the relative molecular mass of each of the compounds in the mixture measured?

.....

(1)

(b) (i) Athletes sometimes take drugs because the drugs improve their performance. One of these drugs is ephedrine.

Ephedrine has the formula:

$$C_{10}H_{15}NO$$

What relative molecular mass (M_r) would be recorded by GC-MS if ephedrine was present in a blood sample taken from an athlete?

Show clearly how you work out your answer.

Relative atomic masses: H = 1; C = 12; N = 14; O = 16.

.....

.....

.....

.....

Relative molecular mass = ...

(2)

(ii) Another drug is amphetamine which has the formula:

$$C_9H_{13}N$$

The relative molecular mass (M_r) of amphetamine is 135.

Calculate the percentage by mass of nitrogen in amphetamine.

Relative atomic mass: N = 14

.....

.....

Percentage of nitrogen = ... %

(2)

(c) Athletes are regularly tested for drugs at international athletics events.

An instrumental method such as GC-MS is better than methods such as titration.

Suggest **two** reasons why.

.....

.....

.....

.....

(2)

(d) When a blood sample is taken from an athlete the sample is often split into two portions. Each portion is tested at a different laboratory.

Suggest why.

.....

.....

.....

.....

(2)

(Total 10 marks)

Q13. (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.

.....

.....

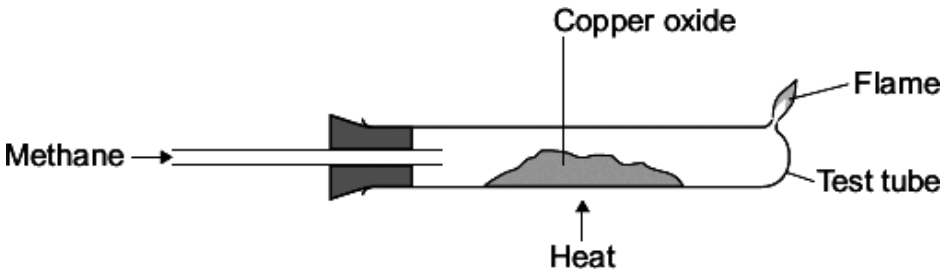
.....

.....

.....

(2)
(Total 6 marks)

Q14. 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)

Q15. 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+}).

.....

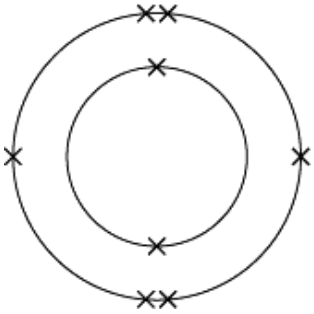
.....

.....

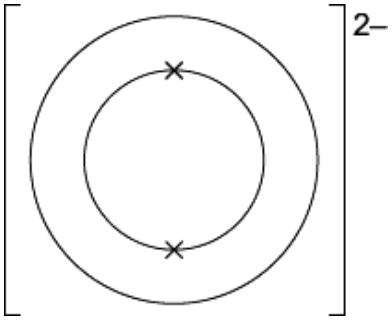
.....

(2)

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



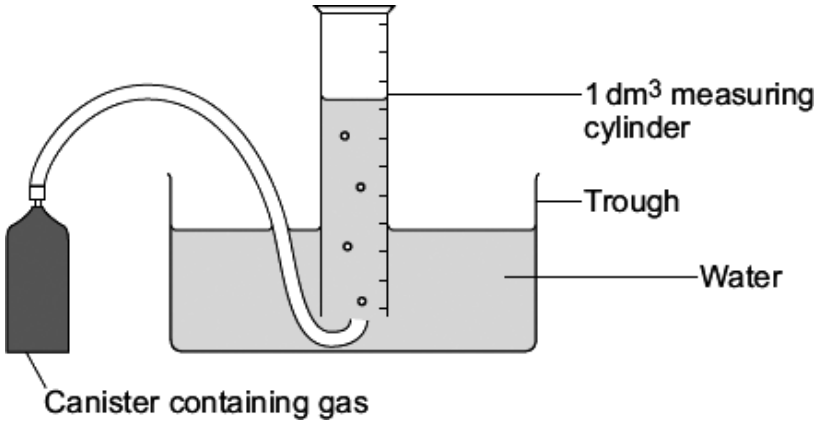
Complete the diagram below to show the electronic structure of an oxide ion (O^{2-}).



(1)

(Total 6 marks)

Q16. 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)

Q17. The symbol equation for the decomposition of hydrogen peroxide is:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

(a) This reaction is *exothermic*.

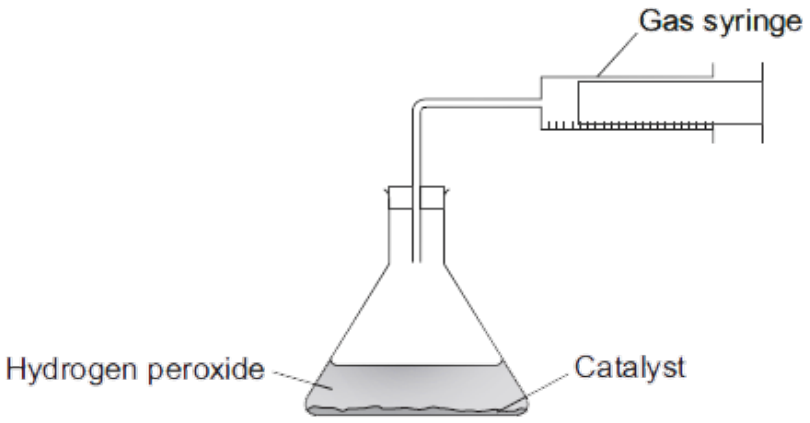
What is an *exothermic* reaction?

.....

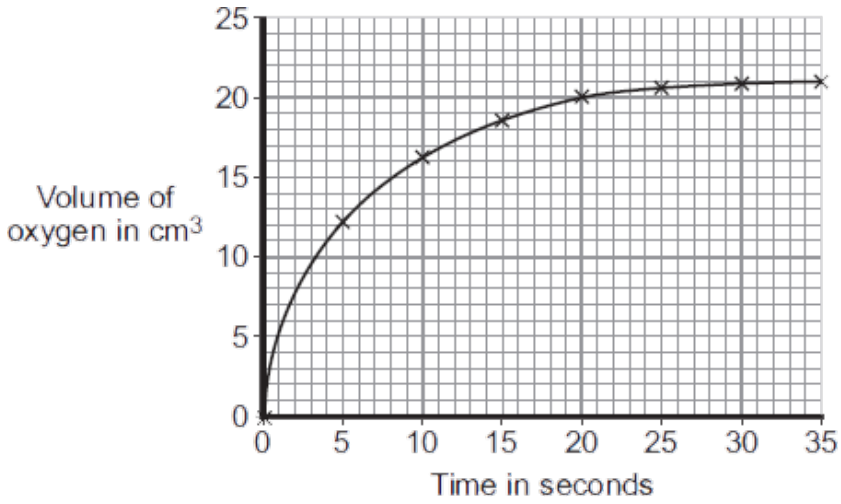
.....

(1)

(b) A student measured the volume of oxygen produced by 50 cm^3 of hydrogen peroxide.



The graph shows the results.



(i) Use the graph to describe the changes in the rate of the reaction from 0 to 35 seconds.

.....

.....

.....

.....

.....

.....

(3)

(ii) What was the total volume of oxygen gas collected?

..... cm^3

(1)

(iii) The student had calculated that the hydrogen peroxide used should produce 25 cm^3 of oxygen.

Calculate the percentage yield of oxygen.

.....

.....

.....

Answer = ...

(2)

(c) An increase in the temperature of the hydrogen peroxide increases the rate of the reaction.

Use your knowledge of particles to explain why.

.....

.....

.....

.....

.....

.....

(3)

(Total 10 marks)

Q18. 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.

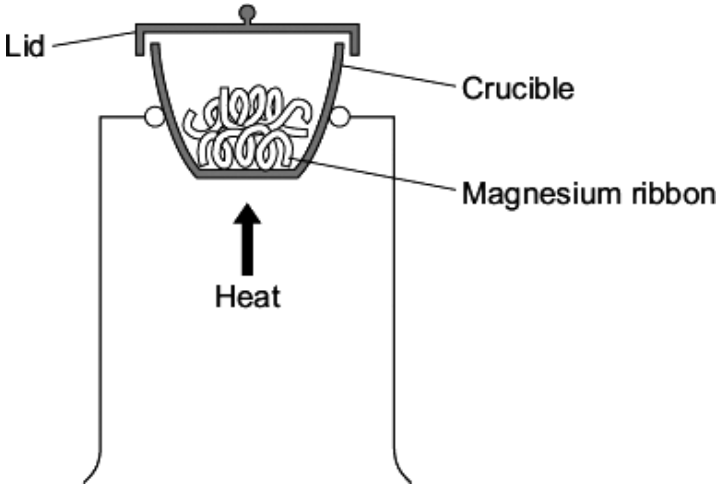
.....

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.

.....

.....

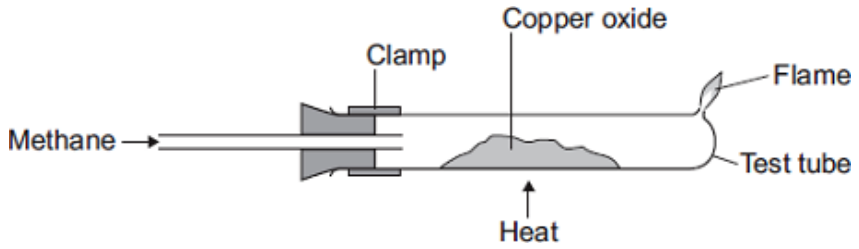
.....

.....

(2)

(Total 9 marks)

Q19. 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

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.....

.....

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 .....

.....

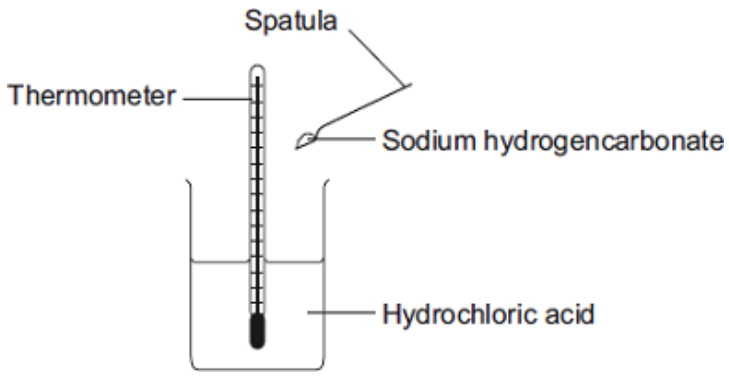
2 .....

.....

(2)

(Total 10 marks)

Q20. (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.

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.....

.....

(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:

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

(i) The cake mixture rises when baked.

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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)

(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

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.....

.....

Relative formula mass (M_r) = ...

(2)

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

.....

.....

Percentage of carbon = ... %

(1)

(Total 9 marks)