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

In both reactions one of the products is copper chloride.

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

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(4)

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

The equation for the reaction is:

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

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

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

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Mass of copper carbonate = ... g

(4)

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

Calculate the mass of copper chloride the student actually produced.

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Actual mass of copper chloride produced = ... g

(2)

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

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

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

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

The percentage atom economy for a reaction is calculated using:

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

Calculate the percentage atom economy for Reaction 2.

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Percentage atom economy = ... %

(3)

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

Give a reason for the difference.

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(1)
(Total 14 marks)

2 Sodium carbonate reacts with dilute hydrochloric acid:

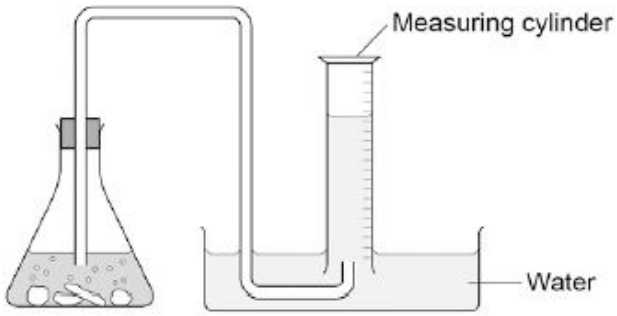
$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

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

This is the method used.

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

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



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

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

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(2)

(b) The student corrected the error.

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

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

The result for 0.29 g of sodium carbonate is anomalous.

Suggest what may have happened to cause this anomalous result.

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(1)

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

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(1)

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

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(1)

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

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

Give your answer in three significant figures.

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..... mol

(2)

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

Give a reason for your answer.

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(2)

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

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

Explain why the second student was correct.

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(2)
(Total 11 marks)

3 This question is about atoms and isotopes.

(a) Atoms contain protons, neutrons and electrons.

A lithium atom has the symbol $^{7}_{3}Li$

Explain, in terms of sub-atomic particles, why the mass number of this lithium atom is 7.

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(3)

(b) Amounts of substances can be described in different ways.

Complete the sentences.

One mole of a substance is the relative formula mass in

.....

The relative atomic mass of an element compares the mass of an atom of an element with the mass of an atom of

.....

(2)

(c) Two isotopes of oxygen are $^{18}_{8}O$ and $^{16}_{8}O$

Describe the similarities and differences between the isotopes $^{18}_{8}O$ and $^{16}_{8}O$

You should refer to the numbers of sub-atomic particles in each isotope.

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(3)
(Total 8 marks)

4 This question is about chemical analysis.

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

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

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

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

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

X .....

Y .....

Z .....

(3)

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

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

Method 1

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

Method 2

- 25 cm^3 of the barium hydroxide solution is titrated with hydrochloric acid of known concentration.
- The concentration of the barium hydroxide solution is calculated from the result of the titration.

Compare the advantages and disadvantages of the two methods.

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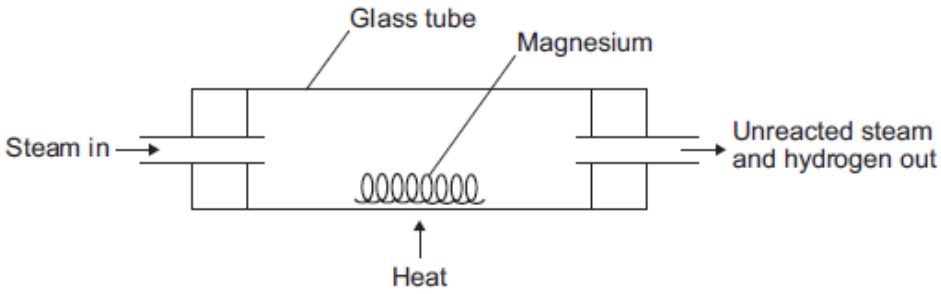
(5)
(Total 8 marks)

5 Magnesium reacts with steam to produce hydrogen gas and magnesium oxide.

A teacher demonstrated the reaction to a class. The figure below shows the apparatus the teacher used.



(a) (i) The hydrogen produced was collected.

Describe how to test the gas to show that it is hydrogen.

Test .....

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Result .....

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(2)

(ii) Explain why the magnesium has to be heated to start the reaction.

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(2)

(b) The equation for the reaction is:

$$Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)$$

(i) The teacher used 1.00 g of magnesium.

Use the equation to calculate the maximum mass of magnesium oxide produced.

Give your answer to three significant figures.

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

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Maximum mass = ... g

(3)

(ii) The teacher's demonstration produced 1.50 g of magnesium oxide.

Use your answer from part (b)(i) to calculate the percentage yield.

If you could not answer part (b)(i), use 1.82 g as the maximum mass of magnesium oxide. This is **not** the answer to part (b)(i).

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Percentage yield = ... %

(2)

(iii) Give **one** reason why the percentage yield is less than 100%.

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(1)

(Total 10 marks)

6 Thermosoftening polymers can be used to make plastic bottles and food packaging.

(a) Why are thermosoftening polymers **not** suitable for storing very hot food?

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(1)

(b) The reaction to produce the polymers uses a catalyst.

Why are catalysts used in chemical reactions?

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(1)

(c) Compounds from food packaging must not get into food.

Gas chromatography can be used to separate compounds in food.

The output from the gas chromatography column can be linked to an instrument which can identify the compounds.

(i) Name the instrument used to identify the compounds.

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(1)

(ii) Give **one** reason why instrumental methods of analysis are used to identify the compounds.

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(1)

(d) Poly(ethene) is a thermosoftening polymer.

Poly(ethene) can be made with different properties. The properties depend on the conditions used when poly(ethene) is made.

Suggest **two** conditions which could be changed when poly(ethene) is made.

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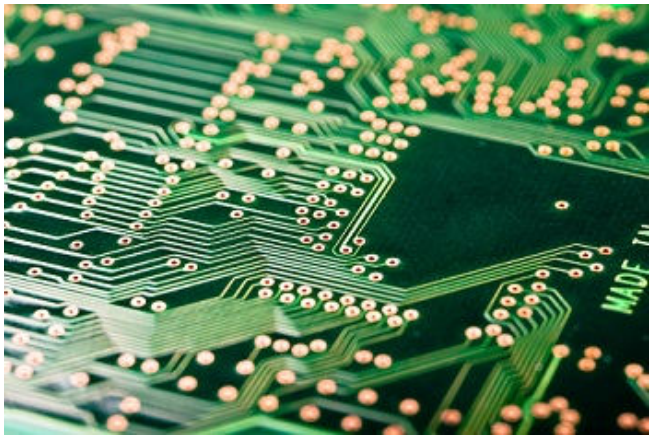
(2)
(Total 6 marks)

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



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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.

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(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.

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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).)

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.....

Percentage yield = ...%

(1)
(Total 6 marks)

8 This question is about lithium and sodium.

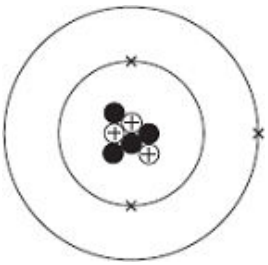
(a) Use the Chemistry Data Sheet to help you to answer this question.

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 ☐

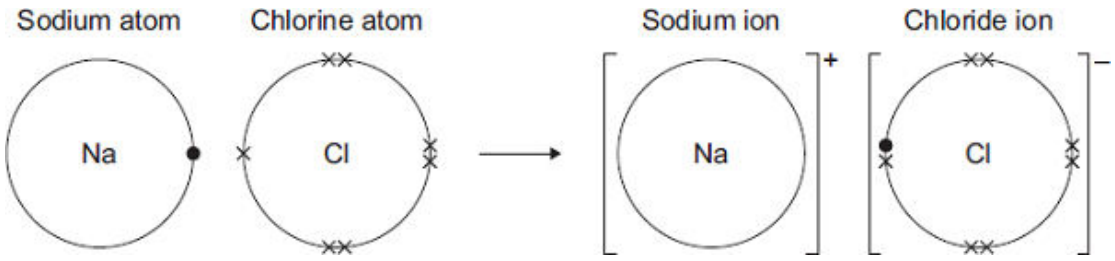
(1)

(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

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.....

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?

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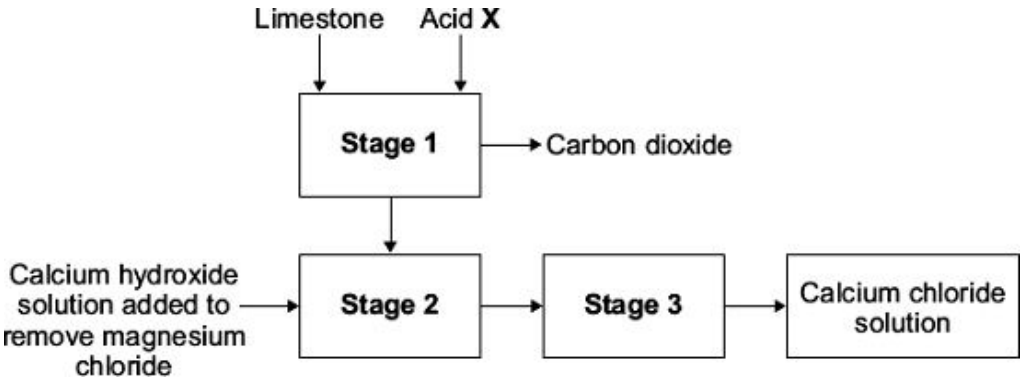
(1)
(Total 12 marks)

9 (a) Calcium chloride is made from limestone. Limestone contains mainly calcium carbonate and a small amount of magnesium carbonate.



(i) In **stage 1** calcium carbonate reacts with acid **X** to form calcium chloride.

Draw a ring around the name of acid **X**.

hydrochloric **nitric** **sulfuric**

(1)

(ii) **Stage 1** produces a concentrated solution of calcium chloride.
The solution also contains magnesium chloride.

Calcium hydroxide solution is added in **stage 2** to remove the magnesium chloride.

The equation for this reaction is:

$$MgCl_2(aq) + Ca(OH)_2(aq) \rightarrow Mg(OH)_2(s) + CaCl_2(aq)$$

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

In **stage 2** a precipitate is made because magnesium hydroxide is [dissolved / insoluble / soluble] in water.

In **stage 3** the solid magnesium hydroxide can be separated from the calcium chloride

solution using [chromatography. / electrolysis. / filtration.]

(2)

(iii) What method can be used to change the calcium chloride solution into solid calcium chloride?
Draw a ring around your answer.

crystallisation **electrolysis** **reduction**

(1)

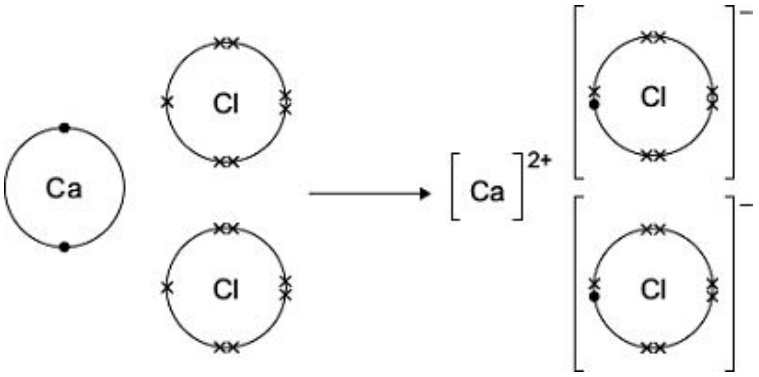
(b) Calcium chloride can also be made by reacting calcium with chlorine:

calcium + chlorine → calcium chloride

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

The dots (●) and crosses (x) are used to represent electrons.

Only the outer electrons are shown.



Use the diagram to help you to answer this question.

Describe, as fully as you can, what happens when calcium reacts with chlorine to make calcium chloride.

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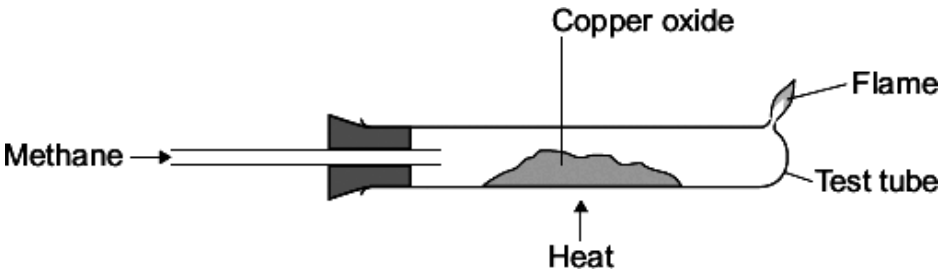
(4)
(Total 8 marks)

10 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.

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(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.

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Percentage of copper = ... %

(2)

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

.....

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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.

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Mean mass of copper made = ... g

(1)

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

.....

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(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 .....

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2 .....

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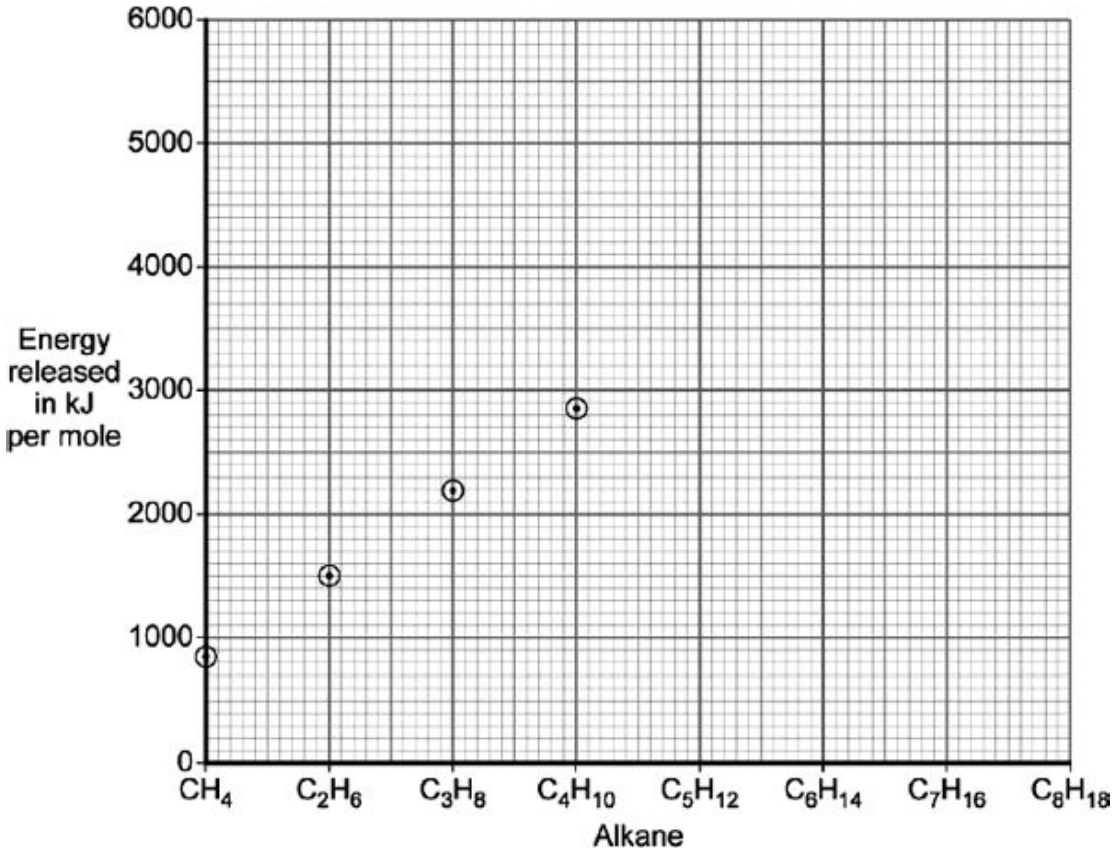
(2)
(Total 10 marks)

11 (a) Alkanes are important hydrocarbon fuels. They have the general formula C_nH_{2n+2}

The points on the graph show the amount of energy released when 1 mole of methane (CH_4), ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}) are burned separately.



(i) Draw a line through the points and extend your line to the right-hand edge of the graph.

(1)

(ii) Use the graph to estimate the amount of energy released when 1 mole of octane (C_8H_{18}) is burned.

Energy released = ... kJ

(1)

(iii) Suggest why we can make a good estimate for the energy released by 1 mole of pentane (C_5H_{12}).

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(1)

(iv) A student noticed that octane (C_8H_{18}) has twice as many carbon atoms as butane (C_4H_{10}), and made the following prediction:

"When burned, 1 mole of octane releases twice as much energy as 1 mole of butane."

Use the graph to decide if the student's prediction is correct. You **must** show your working to gain credit.

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(2)

(b) Some information about four fuels is given in the table.

			Combustion products			
Fuel	**Type**	**Heat released in kJ per g**	**CO_2**	**SO_2**	**H_2O**	**Type of flar**
Bio-ethanol	Renewable	29	✓		✓	Not smoky
Coal	Non-renewable	31	✓	✓	✓	Smoky
Hydrogen	Renewable	142			✓	Not smoky
Natural gas	Non-renewable	56	✓		✓	Not smoky

From this information a student made two conclusions.

For each conclusion, state if it is correct **and** explain your answer.

(i) "Renewable fuels release more heat per gram than non-renewable fuels."

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(2)

(ii) “Non-renewable fuels are better for the environment than renewable fuels.”

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(2)
(Total 9 marks)