For Examiner's Use

A2 Ammonium iodide, NH_4I, is a white solid which decomposes when heated.

$$NH_4I(s) \rightarrow NH_3(g) + HI(g)$$

(a) A small sample of ammonium iodide is heated in a test-tube.

Describe how you would know when all the ammonium iodide has decomposed.

……

……

[1]

(b) Calculate the **total** volume of gas, measured at room temperature and pressure, formed when 2.90 g of ammonium iodide is completely decomposed.

[3]

(b) Aqueous ammonium iodide reacts with three halogens, fluorine, chlorine and bromine, but not with astatine.

(i) Write a general equation to show the reaction of ammonium iodide with a halogen. Use X_2 as the symbol for the halogen.

…… [1]

(ii) Explain why aqueous ammonium iodide has no reaction with astatine.

…… [1]

(c) Solid ammonium iodide does not conduct electricity.
Aqueous ammonium iodide conducts electricity.

Explain these observations.

……

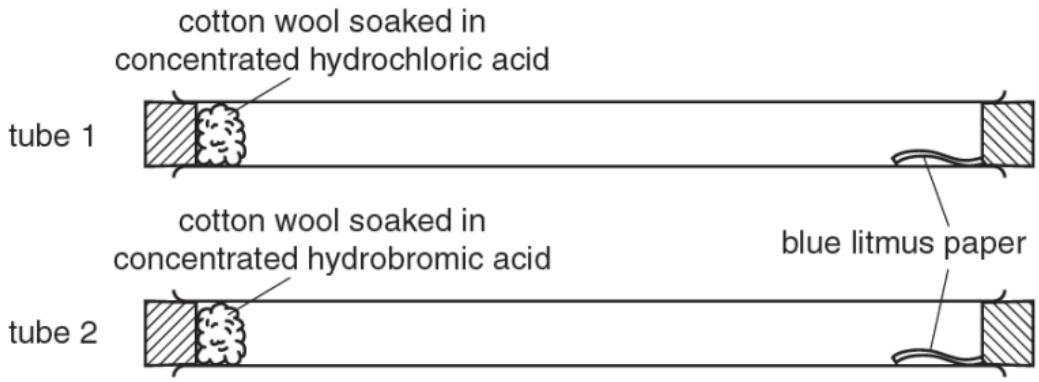
……

…… [2]

[Total: 8]

For Examiner's Use

A3 **(a)** Two students set up an experiment to investigate the rate of diffusion of gases.



Concentrated hydrochloric acid produces fumes of hydrogen chloride, HCl.
Concentrated hydrobromic acid produces fumes of hydrogen bromide. HBr.

The students made the following observations:

Four minutes after setting up the experiment, the litmus paper in tube 1 turns red.
Seven minutes after setting up the experiment, the litmus paper in tube 2 turns red.

One of the students makes this conclusion:

'The rate of diffusion is inversely proportional to the relative molecular mass of each gas.'

Do the observations support this conclusion? Show by means of a calculation.

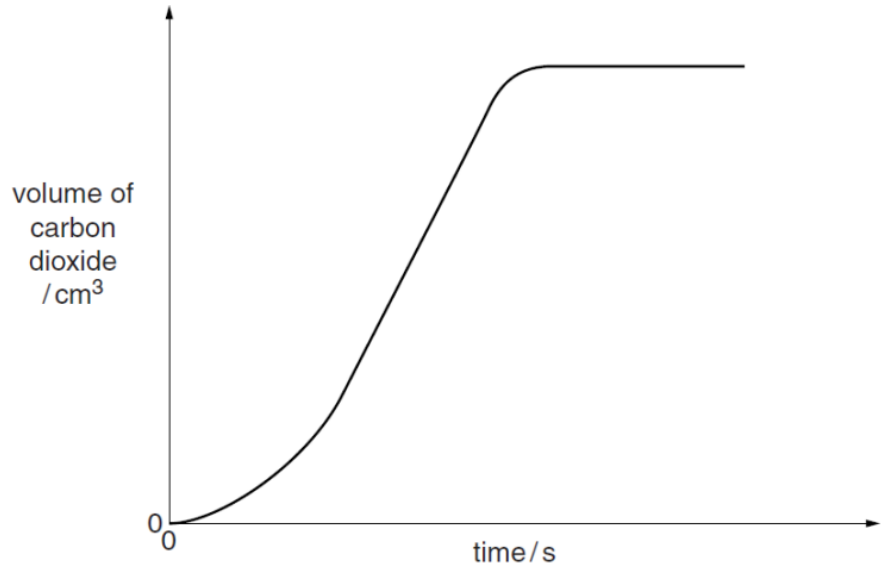
[3]

For Examiner's Use

(b) The students conducted another experiment to investigate the rate of decomposition of three metal carbonates, $CaCO_3$, $FeCO_3$ and $ZnCO_3$.

An equal mole of each metal carbonate is heated in a test-tube. The total volume of carbon dioxide formed is measured every 10 seconds, and the results are plotted.

The diagram shows the **typical** shape of the graph for all the metal carbonates.



(i) Suggest why the volume of carbon dioxide does not increase by very much when each metal carbonate is first heated.

……. [1]

(ii) How is the graph used to find out when the decomposition has finished?

……. [1]

The table shows the results.

metal carbonate	time taken for complete decomposition / s
$CaCO_3$	360
$FeCO_3$	60
$ZnCO_3$	70

(iii) Predict and explain the time it would take $MgCO_3$ and $PbCO_3$ to fully decompose.

$MgCO_3$ ..... s

$PbCO_3$ ..... s

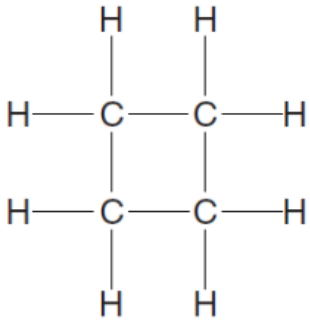
explanation ……

……. [3]

[Total: 8]

For Examiner's Use

A4 **(a)** Cyclobutane is an organic compound with the following structure.



The complete combustion of one mole of cyclobutane releases 2702 kJ of heat energy.

(i) Calculate the heat energy released when 600 dm^3 of cyclobutane, at room temperature, and pressure, is completely combusted.

[2]

(ii) Explain, in terms of the energy changes associated with bond breaking and bond making, why the combustion of cyclobutane is exothermic.

……

……

……

…… [2]

(iii) Cyclobutane has several isomers which are alkenes.

Draw the structure of **one** of these isomers.

[1]

(b) Sorrel is a small green plant.

Sorrel plants contain a poisonous carboxylic acid **Y**.

(i) What can be deduced about the chemistry of **Y** from each of the following pieces of information?

When **Y** is warmed with acidified potassium manganate(VII), the solution changes from pink to colourless.

……

……

A 0.1 mol/dm^3 solution of **Y** has a pH of 5 whereas a 0.1 mol/dm^3 hydrochloric acid solution has a pH of 1.

……

…… [2]

(ii) Analysis of 10.0 g of carboxylic acid **Y** shows that it contains 2.67 g carbon, 0.220 g hydrogen and 7.11 g oxygen.

The relative molecular mass of **Y** is 90.

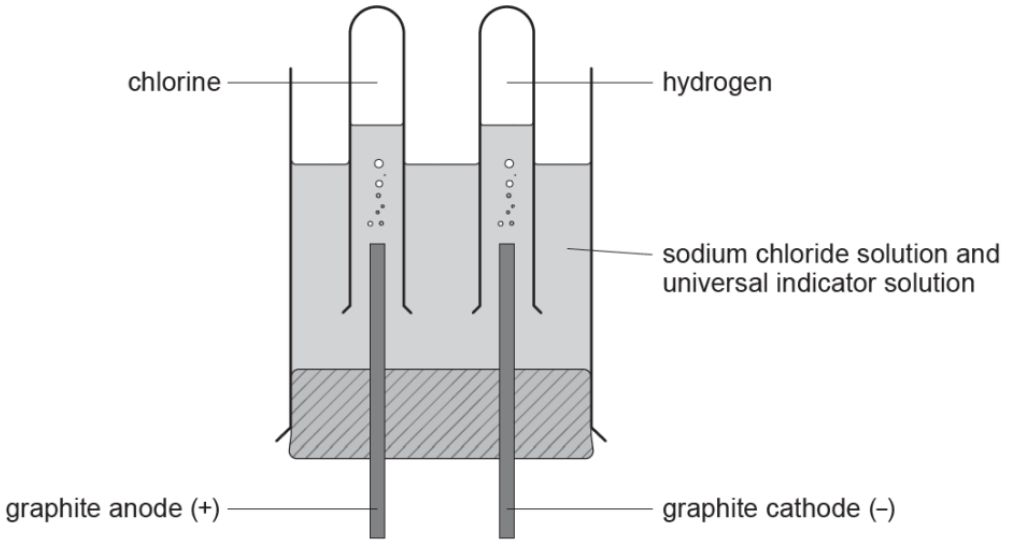
Deduce the empirical formula and the molecular formula of **Y**.

empirical formula …….

molecular formula ……. [3]

[Total: 10]

A5 **(a)** The diagram shows the apparatus that a student sets up for the electrolysis of **concentrated** sodium chloride solution.



Explain why

(i) hydrogen, and **not** sodium, is formed at the cathode.

……

…… [1]

(ii) equal volumes of chlorine and hydrogen gas are produced.

……

…… [1]

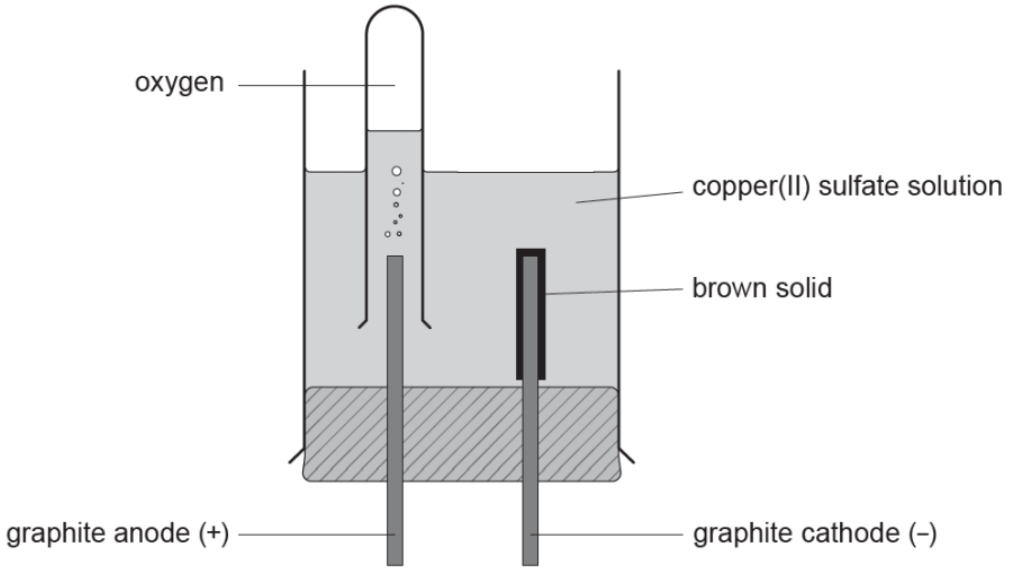
(iii) the Universal Indicator turns purple during the electrolysis.

……

…… [1]

For Examiner's Use

(b) The student modifies the apparatus for the electrolysis of copper(II) sulfate solution.



(i) Explain, using the reaction occurring at the cathode, the meaning of the term *reduction*.

…… [1]

(ii) Over time, the electrolyte turns from blue to colourless. State one change the student could make to the apparatus so that the electrolyte remains blue during the electrolysis. Give a reason for your answer.

……

……

……

…… [2]

[Total: 6]

A6 **(a)** Global warming is believed to be mainly the result of increasing levels of carbon dioxide in the atmosphere.

(i) How is the balance of carbon dioxide and oxygen maintained in the atmosphere? Explain why levels of carbon dioxide are increasing and how this leads to global warming.

……

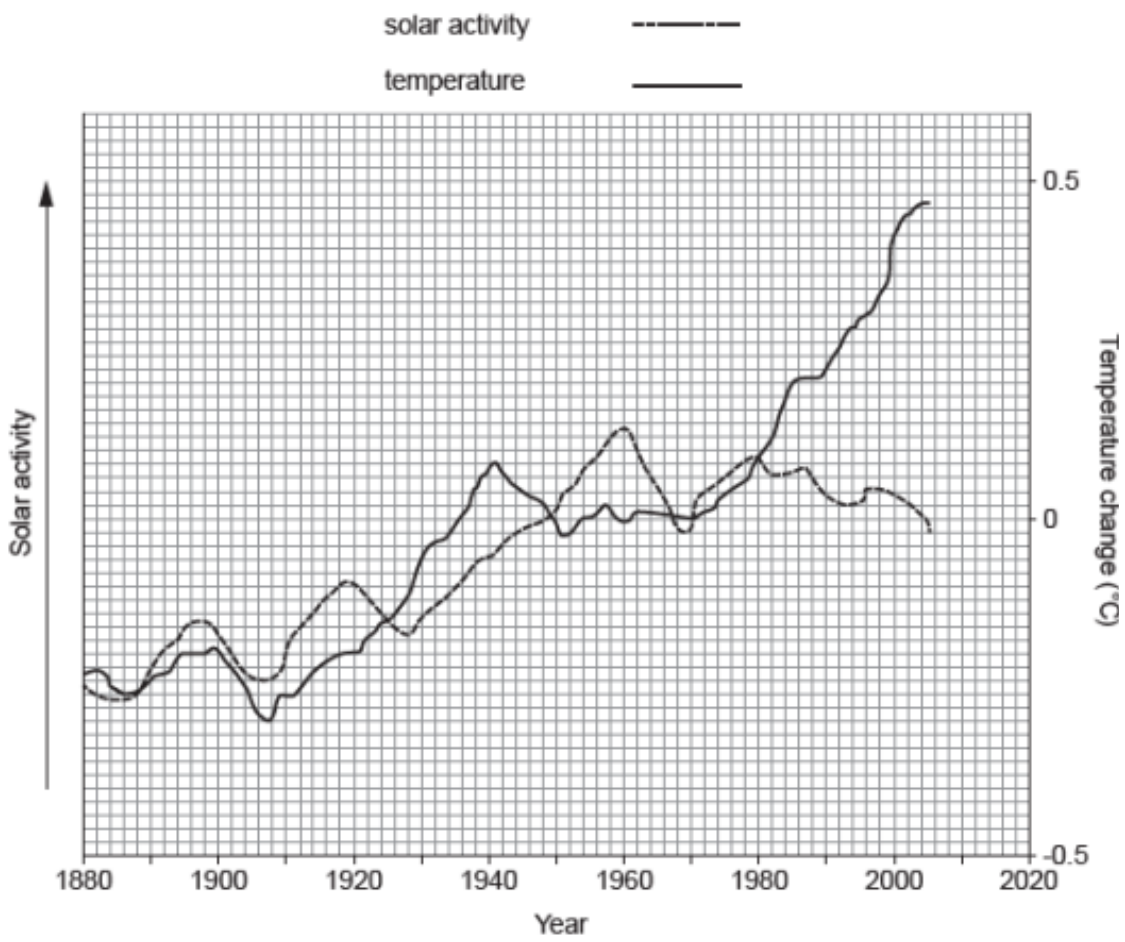
……

……

……

…… [3]

(ii) Some scientists believe that it is changes in solar activity (i.e. changes in the brightness and warmth of the sun) that causes global warming. The graphs below show the changes in solar activity and atmospheric temperature from 1880 to 2020.



Using the information from the graphs, describe how well the evidence supports the argument that solar activity is the cause of global warming.

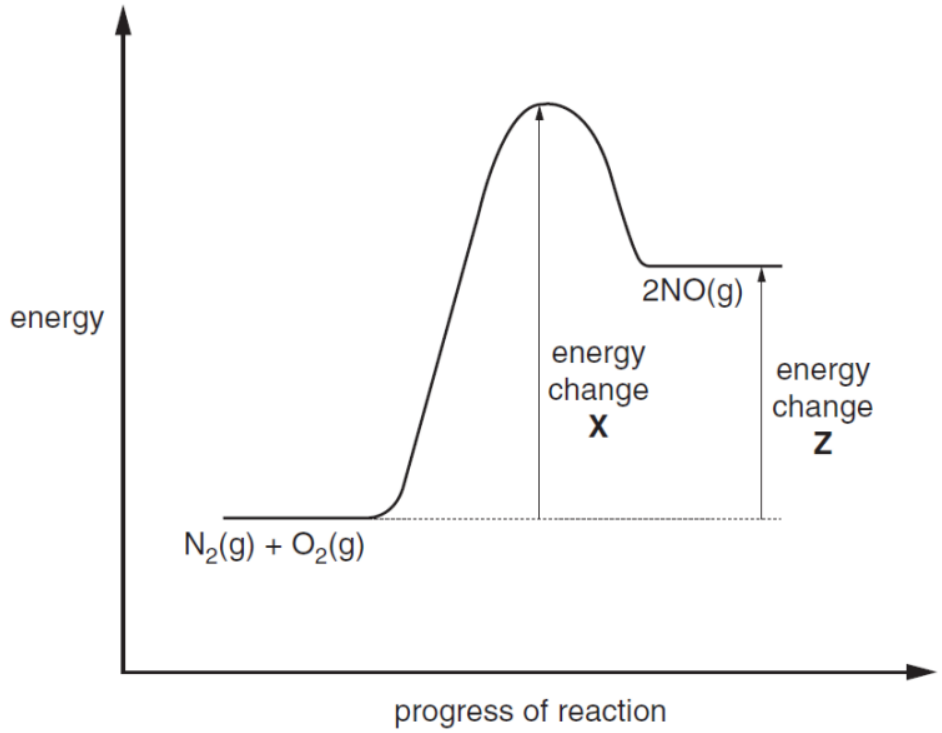
……

…… [2]

(b) Oxides of nitrogen are atmospheric pollutants. Nitrogen monoxide, NO, is formed in an internal combustion engine when nitrogen and oxygen react together.

$$N_2(g) + O_2(g) \rightarrow 2NO(g)$$

The diagram shows the energy profile for this reaction.



(i) Identify the energy changes **X** and **Z**.

X is …….

Z is ……. [2]

(ii) Explain how you can tell from the diagram that the reaction is endothermic.

…….

……. [1]

(c) The exhaust system of a motor car is fitted with a catalytic converter.

When nitrogen monoxide passes through the converter, it reacts with carbon monoxide.

$$2NO(g) + 2CO(g) \rightarrow N_2(g) + 2CO_2(g)$$

The catalyst increases the rate of this reaction.

(i) Explain how the catalyst in the converter increases the rate of this reaction.

…….

[1]

(ii) During the course of a journey, 2.4 dm^3 of nitrogen monoxide was produced by the engine.

Calculate the volume of nitrogen gas produced if all the nitrogen monoxide reacted in the converter.

[1]

(iii) In reality, only 1.0 dm^3 of nitrogen was produced after the gases had passed over the catalytic converter. Calculate the percentage of nitrogen monoxide that had reacted.

[2]

[Total: 12]

For Examiner's Use

Section B

Answer all **three** questions from this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

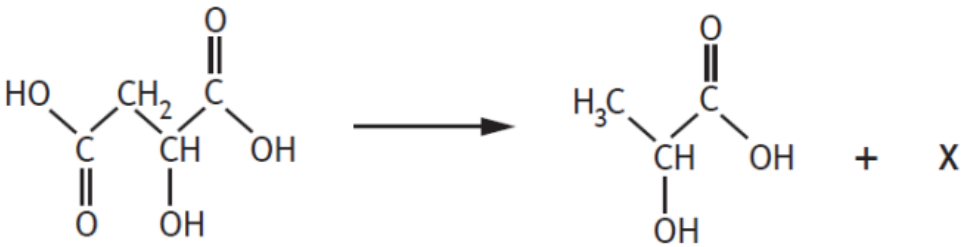
B7 Cider is made from apples in a process that involves crushing and pressing the apples, converting the sugars into alcohol, maturing and bottling.

Brewers add yeast, which contains enzymes to convert the glucose in the apples into an alcohol and carbon dioxide.

The alcohol content in the cider can be calculated using the formula:

$$\%\,\text{mass of alcohol} = \frac{\text{mass of alcohol}}{\text{mass of cider}} \times 100$$

During the maturing process, malic acid in the apples is converted to lactic acid and another product, X.



malic acid lactic acid

The maturing process is complete when all of the malic acid has been converted to lactic acid, and the cider is now ready to be bottled.

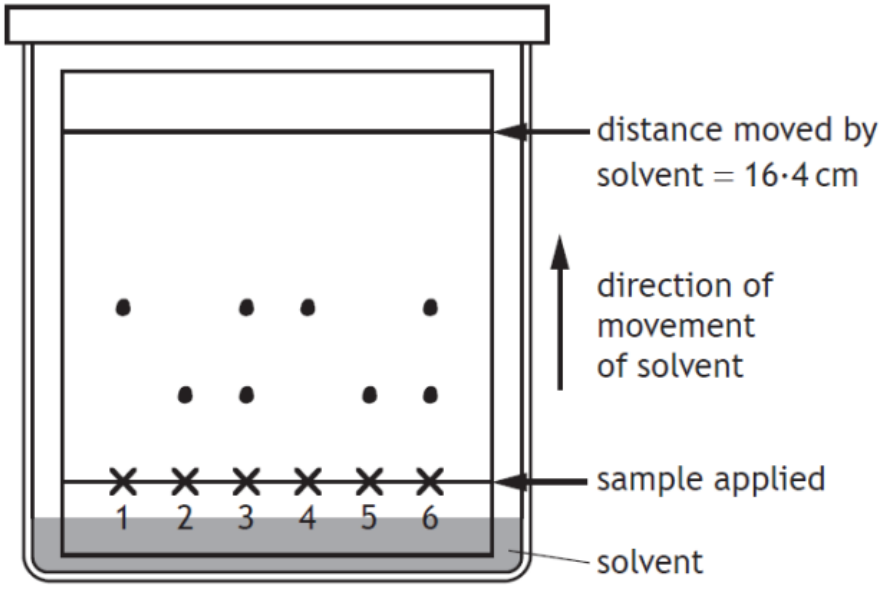
The maturing process in cider samples can be monitored using thin layer chromatography. Samples of lactic acid, malic acid and four ciders A, B, C, and D are applied on a silica plate and the solvent allowed to travel up the plate. The chromatogram obtained is shown.

distance moved by solvent = 16.4 cm

direction of solvent movement

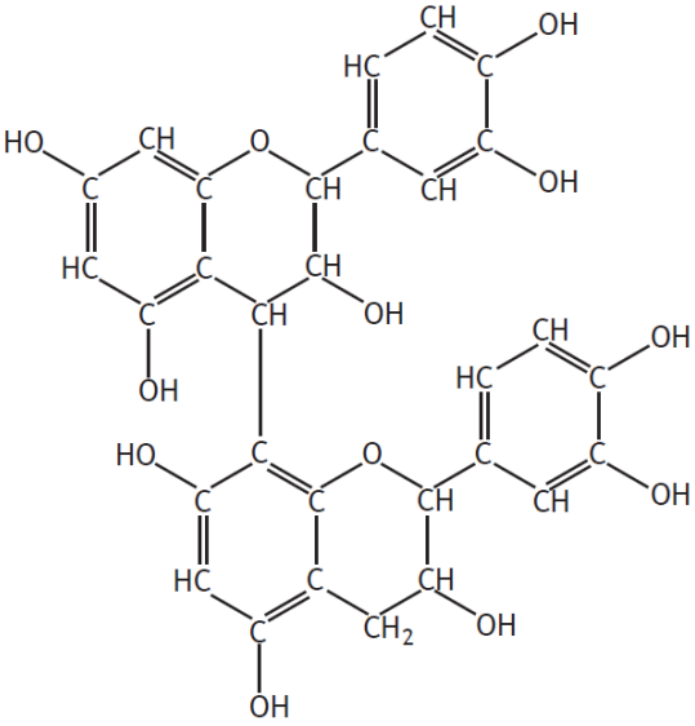
sample

solvent



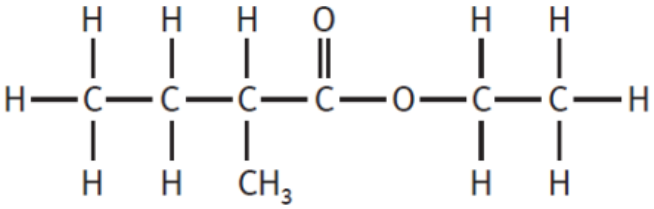
number	sample applied	distance travelled by spot(s) in cm
1	lactic acid	8.2
2	malic acid	4.1
3	cider A	4.1, 8.2
4	cider B	8.2
5	cider C	4.1
6	cider D	4.1, 8.2

Cider contains many naturally occurring compounds that affect taste and aroma. Procyanidin B2 provides a bitter taste to cider.



procyanidin B2

Cider smells of apples because it contains ethyl 2-methylbutanoate.



ethyl 2-methylbutanoate

(a) Brewers add yeast, which contains enzymes to convert the glucose in the apples into an alcohol and carbon dioxide.

What is another role of the enzymes?

……..…. [1]

(b) A 50·0 cm^3 sample of cider was found to contain 3.05 g of alcohol.
1·0 cm^3 of the cider weighed 1.36 g.

Use this data and the formula in the passage to calculate the alcohol content in the cider.

[1]

(c) During the maturing process, malic acid is converted to lactic acid and another product, X. Identify X.

……..…. [1]

(d) **(i)** Calculate the R_f value of malic acid, to 2 decimal places.

[1]

(ii) Use the data in the passage to determine which cider, A to D, is ready to be bottled.

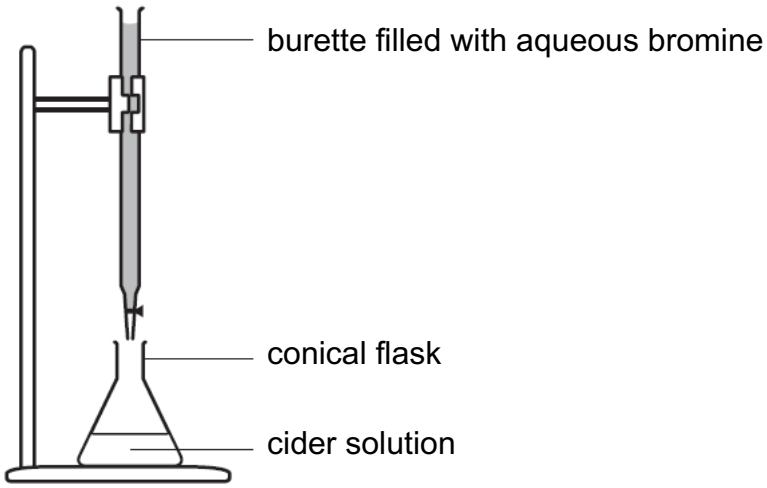
Give your reasoning.

…….

…….

……. [2]

(e) The following apparatus can be used to compare the level of bitter taste in ciders A to D.



Describe and explain how the comparison can be made, stating any assumption you make.

……..….

For Examiner's Use

……

……

……

…… [4]

(f) Draw the structural formula of the alcohol and the carboxylic acid used to make ethyl 2-methylbutanoate.

alcohol

carboxylic acid

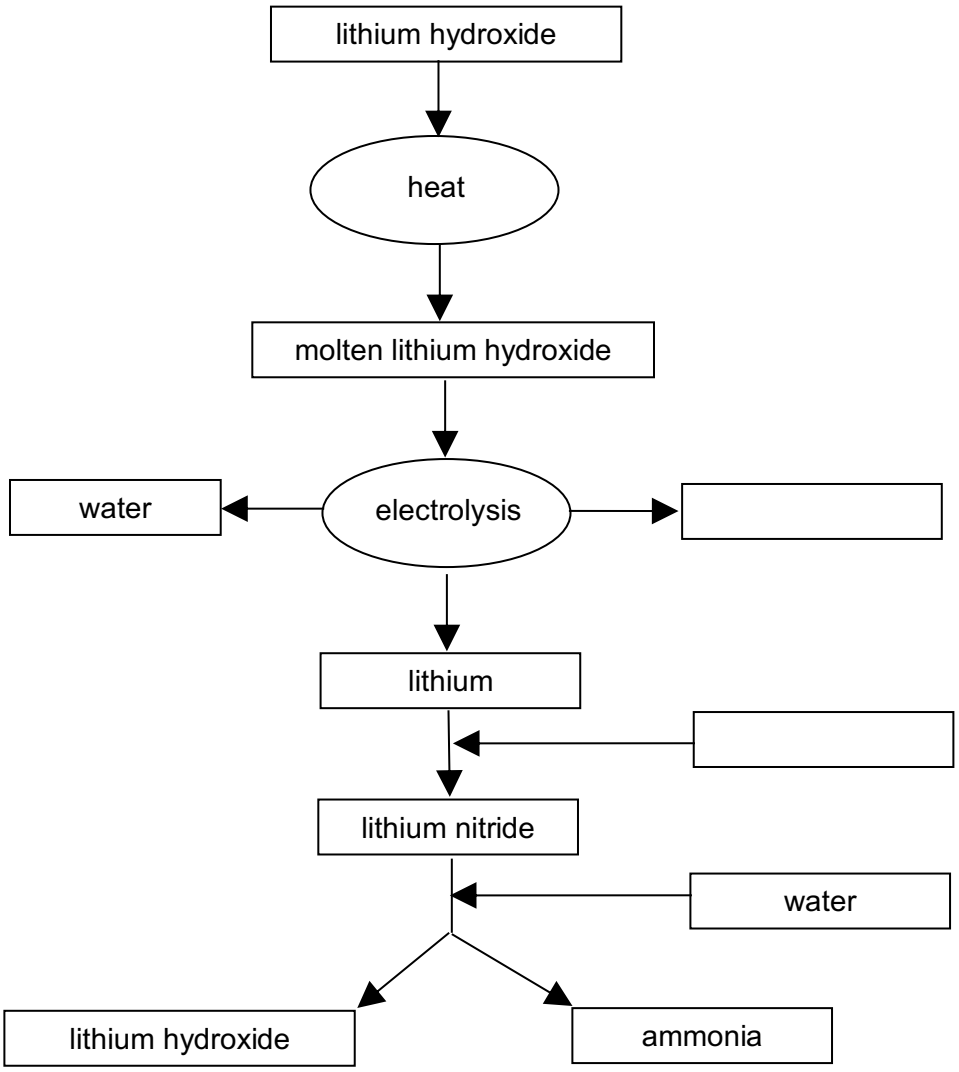
[2]

[Total: 12]

For Examiner's Use

B8 Scientists are developing an alternative industrial process to produce ammonia, which is more efficient than the Haber process.

This process involves the electrolysis of molten lithium hydroxide to produce lithium, water and oxygen. Lithium is then reacted with nitrogen gas, which is obtained from air, to produce lithium nitride (Li_3N). Ammonia and lithium hydroxide are produced when lithium nitride reacts with water.



(a) Complete the **two** boxes in the flow chart using the information provided. [1]

(b) Write an ionic equation for the **cathode** in the electrolysis of molten lithium hydroxide.

…… [1]

(c) Draw 'dot-and-cross' diagrams to show the bonding in lithium nitride (Li_3N) and nitrogen (N_2).

Show outer electrons only.

[4]

(d) Write a chemical equation for the making of ammonia from the reaction between lithium nitride and water.

……..…. [1]

(e) By drawing an arrow on the flow chart, suggest how the process is managed to keep waste products to a minimum. [1]

[Total: 8]

EITHER

B9 **(a)** Oil tankers transport crude oil.

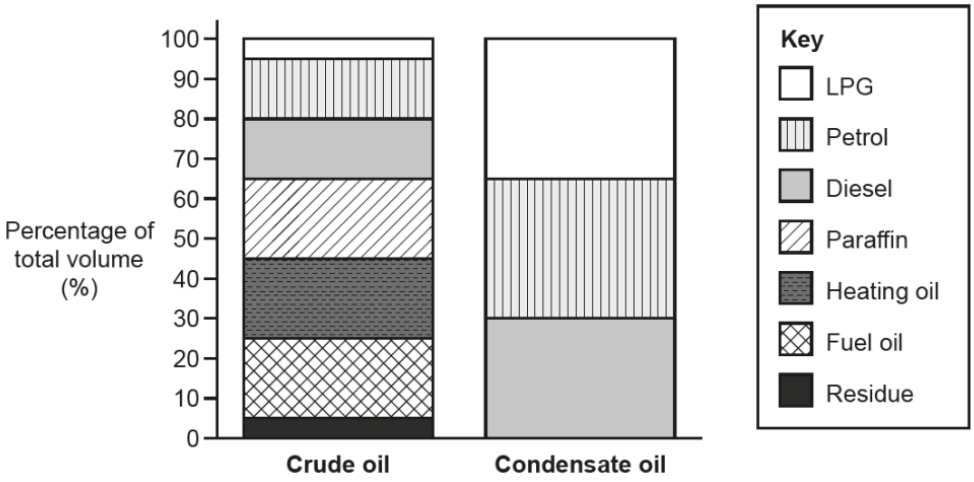
Occasionally they may be involved in an accident and catch fire as shown.

Explain why the burning hydrocarbons in the oil produce thick black smoke.

……

…… [2]

(b) Some ships carry condensate oil, rather than crude oil.
The figure shows the composition of fractions in crude oil and condensate oil.



Outline **one** similarity and **one** difference between crude oil and condensate oil.

……

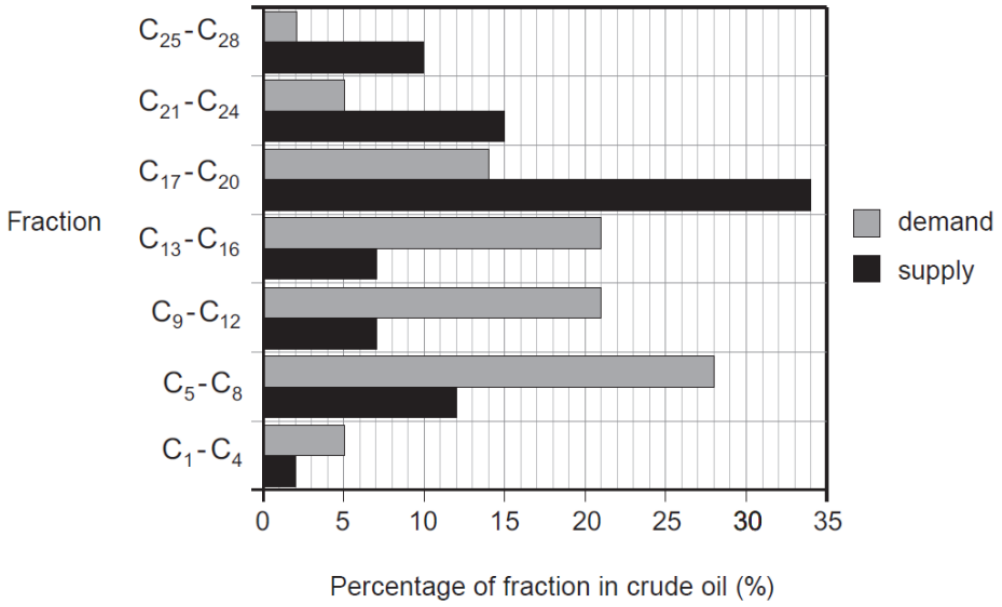
……

……

……

[2]

(c) The bar chart shows the relative supply and demand for some fractions obtained from crude oil.



Use the bar chart to describe how the **difference** between supply and demand of the fractions changes as chain length of the molecules increases.

……

……

…… [2]

(d) Oil companies have solved the problem of the over-supply of some fractions by cracking.

$C_{14}H_{30}$ can be cracked to form C_6H_{12}, butane and ethene in a cracking tower.

(i) Construct a **balanced** equation for this reaction.

…… [1]

(ii) 1.00 tonne of $C_{14}H_{30}$ entered a cracking tower.

After the reaction, 0.212 tonne of ethene had been made. Show that the percentage yield of ethene is 75%. (1 tonne = 10^6 g)

[3]

[Total: 10]

OR

For Examiner's Use

B9 **(a)** On Anglesey, an island off the north-west coast of Wales, there is a large copper mine called Parys Mountain. Unwanted rock from the mining process has been dumped forming waste tips. As rainwater passes through the waste tips it dissolves copper salts. One of the salts is copper(II) sulfate.

During the 18th century large shallow pits were dug all over the mountain. These filled with rainwater. Scrap iron was placed into the water and after a few months, the pits were drained and a copper-rich solid sludge was collected.

Describe and explain the reaction taking place in the pits. Include a relevant **ionic** equation and use your equation to explain which is the reducing agent.

……

……

……

……

……

……

[4]

(b) Many metal ores contain sulfides. Chalcocite is an important copper ore which contains copper(I) sulfide, Cu_2S.

Copper can be obtained from the ore by heating in air.

A reaction takes place as follows.

$$Cu_2S + O_2 \rightarrow 2Cu + SO_2$$

When the extraction process was carried out with 20.5 tonnes of chalcocite, only 12.3 tonnes of copper was formed.

(i) Show that the percentage purity by mass of copper(I) sulfide in the ore is 75%. (1 tonne = 10^6 g)

[4]

(ii) Describe an atmospheric pollution problem associated with this method of copper extraction.

…….

…….

……. [2]

[Total: 10]

**********End of Paper**********