Candidate Name	Centre Number	Candidate Number
		2

WJEC CBAC

GCE AS/A level

1091/01

CHEMISTRY CH1

P.M. FRIDAY, 21 May 2010

1½ hours

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1-6	
B	7	
	8	
	9	
	10	
	11	
TOTAL MARK		

1091 01 01

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- copy of the **Periodic Table** supplied by WJEC. Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A Answer **all** questions in the spaces provided.
Section B Answer **all** questions in the spaces provided.

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

You are reminded that marking will take into account the Quality of Written Communication used in all written answers.

Page 18 may be used for rough work.

Examiner only

SECTION A

Answer **all** *questions in the spaces provided.*

1. A gaseous isotope of hydrogen, tritium, $^{3}_{1}H$, is produced in the upper atmosphere.

(i) State which of the following correctly describes an atom of tritium. [1]

	Number of protons	Number of neutrons	Number of electrons
A	1	1	1
B	1	1	2
C	1	2	1
D	1	2	0

.....

(ii) Tritium is a radioactive gas with a half-life of 12.5 years. A sample of tritium has a mass of 0.960 g.
Calculate the mass of tritium remaining after 37.5 years. [1]

.....

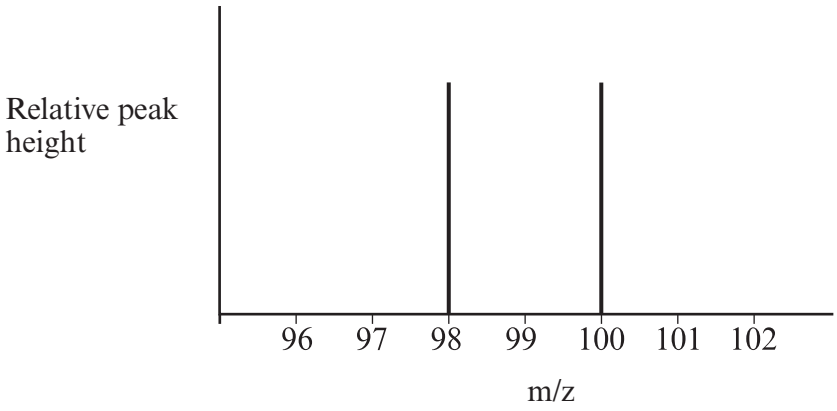
.....

2. Cyanogen is a compound containing only carbon and nitrogen.
It has a relative molecular mass of 52.

(i) State the molecular formula of cyanogen. ..... [1]

(ii) State the empirical formula of cyanogen. ..... [1]

3. The mass spectrum of the colourless gas bromine fluoride, $Br^{19}F$, shows two molecular ions.



(i) State the mass numbers of the two bromine isotopes present in bromine fluoride. [1]

..... and .....

(ii) Bromine fluoride is unstable and readily gives $Br^{19}F_3$.
State the mass/charge (m/z) value for the molecular ion $Br^{19}F_3{}^+$, when all the bromine is present as the isotope ^{85}Br. [1]

.....

4. The first two standard molar ionisation energies for magnesium are shown in the table.

Electron removed	Standard molar ionisation energy / kJ mol^{-1}
first	736
second	1450

State which of the following is the value for the third molar standard ionisation energy, in kJ mol^{-1}, of magnesium. [1]

A 457

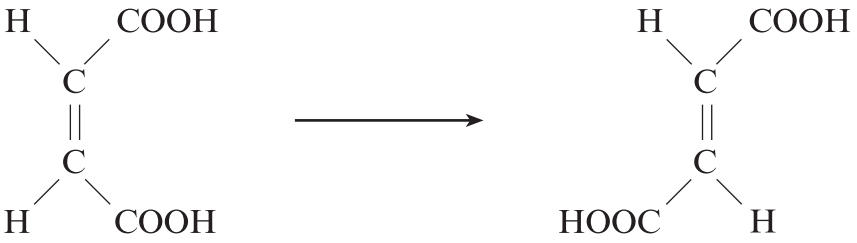
B 923

C 2170

D 7740 .....

Examiner only

5. One industrial method of preparing fumaric acid is to heat maleic acid in the presence of a catalyst.



maleic acid fumaric acid

(i) Deduce the atom economy of this reaction. [1]

..... %

(ii) Data from a manufacturer states that the percentage yield of fumaric acid is 95 % using a 150 kg batch of maleic acid.

Calculate the mass of fumaric acid formed. [1]

..... kg

6. Choose the mass of methane, CH_4, that contains the same number of molecules as there are molecules in 96 g of silane, SiH_4. [1]

A 36 g

B 48 g

C 96 g

D 144 g

.....

Total Section A [10]

SECTION B

Answer **all** *questions in the spaces provided.*

7. Ammonia, NH_3, is produced from nitrogen and hydrogen.

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

(a) Typically, this process is carried out at a temperature of 450 °C, at a pressure of 250 atmospheres and in the presence of an iron catalyst. The yield is around 15%.

(i) If this reaction were carried out using a reduced pressure of 50 atmospheres, the process would be safer because of the lower pressure used.

State **one** disadvantage of using this lower pressure. [1]

.....

(ii) In the actual process some of the ammonia is removed as the reaction proceeds.

State and explain what effect this removal has on the position of equilibrium. [2]

.....

.....

.....

(iii) How would the equilibrium yield be affected if the reaction were run without using the catalyst? [1]

.....

(b) Some of the ammonia is reacted with sulfuric acid to produce the fertiliser ammonium sulfate.

$$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

(i) State the molar masses of

ammonia ..... g ammonium sulfate ..... g [1]

(ii) Calculate the maximum mass of ammonium sulfate, in tonnes, that can be made from 17.03 tonnes of ammonia. [3]

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Examiner only

(c) A member of the public read in an article that the pH of an ammonium sulfate solution was 6. He asked you to explain what was meant by the pH scale.
What would be your reply? [2]

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(d) Ammonium nitrate, NH_4NO_3, is also used as a fertiliser. However, in the presence of certain impurities, it can explode very violently. This explosive reaction gives nitrogen, oxygen and steam.

$$NH_4NO_3(s) \longrightarrow N_2(g) + 2H_2O(g) + \tfrac{1}{2}O_2(g) \quad \Delta H = -296 \text{ kJ mol}^{-1}$$

M_r 80

Some years ago 400 tonnes (4×10^8 g) of ammonium nitrate, stored in a ship in a harbour, exploded, causing extensive damage.

Calculate the energy produced in this explosion, in kJ. [2]

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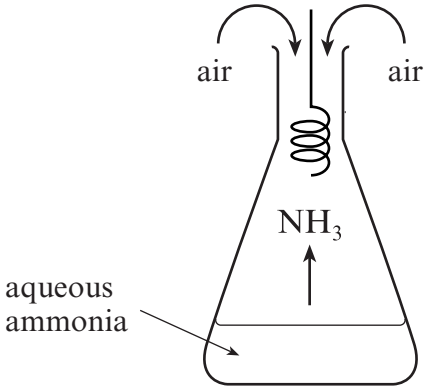
(e) Ammonia gas can be oxidised in air in the presence of a platinum catalyst. One method of showing this is to suspend a red-hot spiral of platinum wire in the neck of a flask containing ammonia gas and air. The platinum wire continues to glow red-hot as the ammonia is oxidised.



(i) Use the information given to explain how this experiment shows that the oxidation of ammonia is an exothermic reaction. [1]

.....

.....

.....

(ii) The platinum wire is acting as a heterogeneous catalyst in this reaction. Explain what is meant by the term 'heterogenous'. [1]

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Total [14]

8. *(a)* Sodium street lights, with their familiar orange-yellow light, have been used for many years. When these lights are first switched on, a red glow is seen as neon is used as the starter gas. The wavelength of the colour produced by each of these elements is shown in the table.

Element	Colour	Wavelength / nm
sodium	orange-yellow	590
neon	red	640

(i) State which one of these two colours has the higher frequency, explaining your answer. [1]

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(ii) State the equation linking energy and frequency. [1]

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(b) The atomic emission spectrum of hydrogen consists of several series of lines.

(i) Explain how these lines are formed. [3]

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(ii) State the significance of the frequency of the convergence limit in the Lyman series. [1]

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(iii) Explain why there is more than one series of lines. [1]

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.....

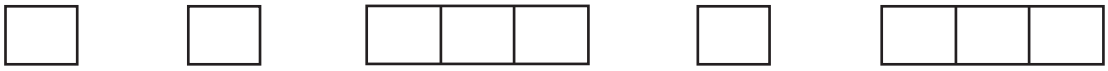
(c) (i) An atom of ^{23}Na absorbs a neutron to give ^{24}Na.
Complete the table to show any **changes** (if any) in the atomic number and mass number. [1]

	Change
Atomic number	
Mass number	

(ii) The isotope ^{24}Na decays by β-emission.
State the mass number and symbol of the species formed by the emission of one β-particle from an atom of ^{24}Na. [1]

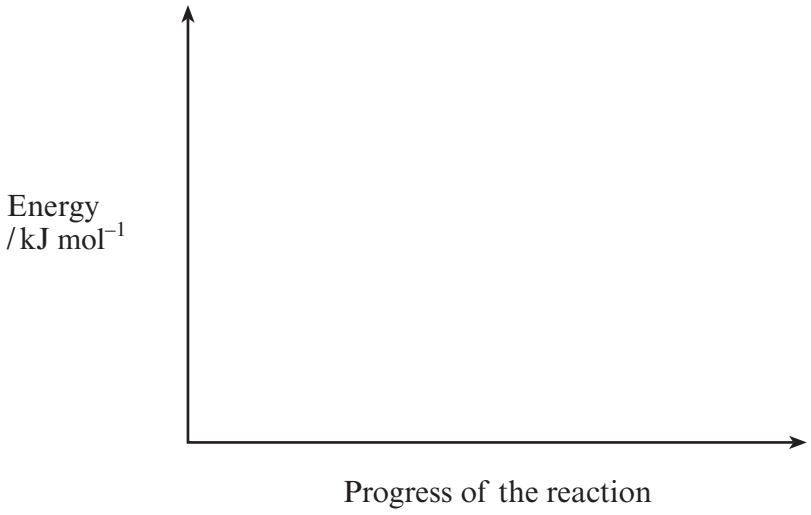
.....

(d) Using the 'arrows in boxes' notation give the electronic configuration of a magnesium atom. [1]



(e) Magnesium burns in air with a brilliant white light, forming magnesium oxide.

(i) Sketch a reaction profile for this reaction, using the axes provided. [1]

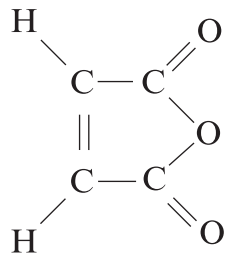


(ii) Indicate, on your profile in (i), the activation energy for the reaction. [1]

Total [12]

Examiner only

9. *(a)* The compound maleic anhydride (Z-butenedioic anhydride) is an important compound that is used in the production of polyester resins.



maleic anhydride

(i) Three compounds, **L**, **M** and **N**, can be used to produce maleic anhydride in the presence of oxygen. The same conditions are used in each method.

Compound	% Yield of maleic anhydride	Other product(s)
L	75	H_2O and CO_2
M	65	H_2O
N	75	H_2O

I Using the **information in the table only** suggest which compound, **L**, **M** or **N**, should be used to produce maleic anhydride. Explain your reasoning. [2]

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II Chemical manufacturers are interested in methods of production that have a minimum effect on the environment – 'Green Chemistry'.
Suggest **two** factors (not from information given in the table) that manufacturers should take into account when considering the production of maleic anhydride. [2]

1. .....

.....

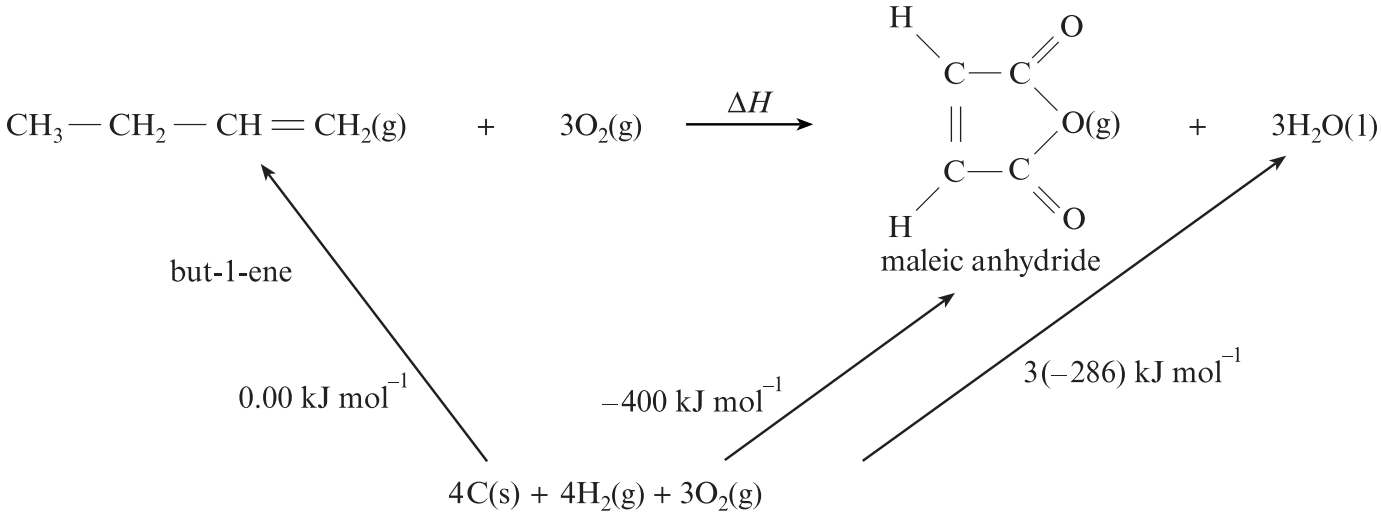
2. .....

.....

Examiner only

(ii) One method of preparation of maleic anhydride is the oxidation of but-1-ene.

Use the energy cycle to calculate the enthalpy change, ΔH, for the production of maleic anhydride from but-1-ene. [2]



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(b) In the complete oxidation of ethene, carbon dioxide and water are formed.

Use the bond energy values in the table to calculate the enthalpy change in the reaction given. [4]

Bond	Average bond energy / kJ mol^{-1}
C — H	412
C = C	612
O = O	496
C = O	743
O — H	463

ethene

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Examiner only

(c) In sea water there are equilibria between carbon dioxide, hydrogencarbonate (HCO_3^-) ions and carbonate (CO_3^{2-}) ions.

$$CO_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

$$H^+(aq) + CO_3^{2-}(aq) \rightleftharpoons HCO_3^-(aq)$$

(i) Use Le Chatelier's Principle to predict the effect on the first equilibrium and the change in pH when more carbon dioxide is dissolved. [2]

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.....

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(ii) State what would be the effect on the concentration of carbonate (CO_3^{2-}) ions of increasing the concentration of hydrogen (H^+) ions in the second equilibrium. [1]

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(d) The solubility of carbon dioxide, M_r 44, in water at 25 °C and atmospheric pressure is 0.145 g / 100 g H_2O.

Calculate its concentration in mol dm^{-3}. [2]

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Total [15]

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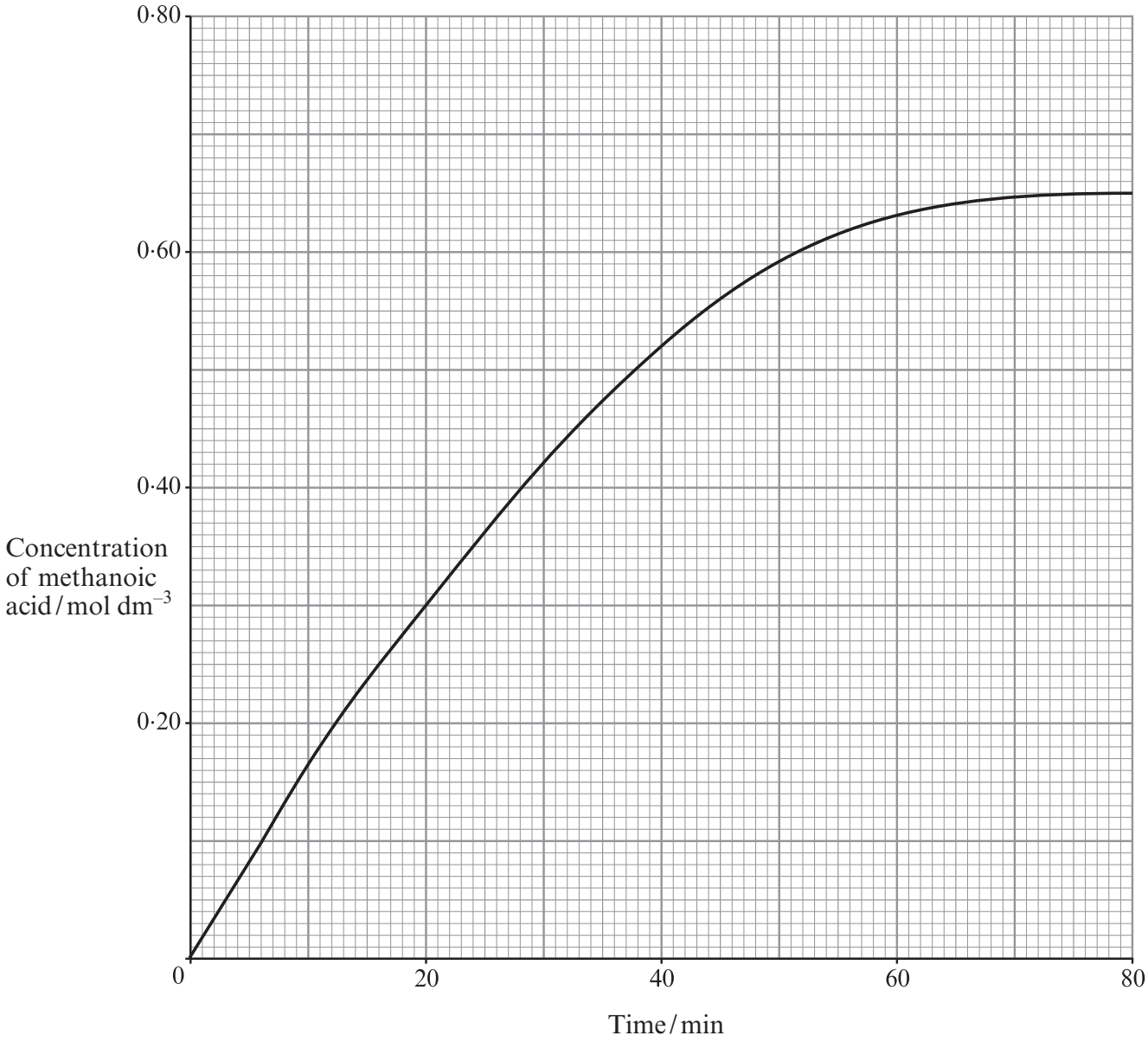
10. An organic solvent, **A**, can be slowly decomposed at room temperature, using water in the presence of catalyst **X**. Methanoic acid is one of the products and its concentration is measured at various times during the reaction. The results are shown in the following graph.



$$\underset{\text{1 mole}}{\text{A}} \longrightarrow \underset{\text{1 mole}}{\text{methanoic acid}} + \text{other products}$$

Examiner only

Use the graph to

(i) calculate the initial rate of the reaction, giving its units, [2]

.....

..... *Units* .....

(ii) describe how the rate changes during the reaction. Explain the reason for this change in terms of simple collision theory. [4]

QWC [2]

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(iii) A more effective catalyst, **Y**, has been found for this reaction. The decomposition of solvent **A** is repeated under the same conditions using catalyst **Y**.

I Use the graph to suggest a possible concentration of methanoic acid after 20 minutes when catalyst **Y** is used in place of catalyst **X**. [1]

..... mol dm^{-3}

II Using catalyst **X** the concentration of methanoic acid at the end of the reaction is 0.65 mol dm^{-3}.
State and explain if this final concentration would change when catalyst **Y** replaces catalyst **X**. [2]

.....

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(iv) At the start of the reaction using catalyst **X** the concentration of solvent **A** was 48.1 g dm^{-3}.
If the concentration of methanoic acid at the end of the reaction was 0.65 mol dm^{-3}, use the word equation under the graph to calculate the relative molecular mass of solvent **A**. [2]

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Total [13]

Examiner only

11. Potash is a common name for potassium carbonate. Originally, potash was obtained by adding water to the ash produced from the burning of wood, filtering and evaporating the filtrate.

(a) Meirion was asked to find the percentage of potash that could be obtained from some wood ash. He added water to a known mass of wood ash, stirred the mixture and then filtered the product. The filtrate was then made up to a volume of 250 cm^3.

(i) State why the mixture was stirred. [1]

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(ii) Describe, giving full practical details, how the volume was made up to **exactly** 250 cm^3. [4]

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(iii) The filtrate was an alkaline solution of potassium carbonate. This was titrated against a standard hydrochloric acid solution to find the concentration of the potassium carbonate.

$$K_2CO_3 + 2HCl \longrightarrow 2KCl + CO_2 + H_2O$$

Methyl orange was used as an indicator; this turns from yellow in the potassium carbonate solution to pink when the potassium carbonate is neutralised by the hydrochloric acid. The following results were obtained using 25.00 cm^3 samples of the potassium carbonate solution.

Burette finish / cm^3	24.80	26.20	26.55
Burette start / cm^3	0.00	1.60	2.00

I Calculate the mean volume of hydrochloric acid added, using all three sets of results. [1]

.....

.....

Examiner only

II Describe the practical steps used to obtain a titration value. You should start by measuring 25.00 cm^3 of the potassium carbonate solution from the 250 cm^3 stock solution, with the acid already in the burette. [5]

QWC [1]

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(b) In another experiment Penny obtained white crystals of potassium carbonate, K_2CO_3, from the wood ash.

(i) Show that the percentage by mass of potassium in K_2CO_3 is 56.6. [2]

.....

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(ii) Some of Penny's crystals were analysed for potassium by flame emission spectroscopy. The results showed that the percentage of potassium present was 44.9%.
Penny suggested that the crystals of potassium carbonate might be a hydrate, $K_2CO_3.2H_2O$.

Explain why the percentage of potassium in the hydrate is lower than the value stated in (i). [1]

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.....

(c) Potassium compounds are usually obtained from mineral deposits of potassium chloride rather than from wood ash.

Suggest **one** environmental disadvantage of using wood ash to obtain potassium compounds. [1]

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Total [16]

Section B Total [70]

Rough Work