



88146105

**CHEMISTRY  
STANDARD LEVEL  
PAPER 2**

Candidate session number

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Tuesday 18 November 2014 (afternoon)

Examination code

1 hour 15 minutes

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**INSTRUCTIONS TO CANDIDATES**

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer one question.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- A clean copy of the **Chemistry Data Booklet** is required for this paper.
- The maximum mark for this examination paper is [50 marks].



24EP01

**SECTION A**

Answer **all** questions. Write your answers in the boxes provided.

1. A student used a pH meter to measure the pH of different samples of water at 298 K.

<b>Sample</b>	<b>pH ± 0.1</b>
Rain water	5.1
River water	4.4
Tap water	6.5
Bottled water	7.1

(a) Use the data in the table to identify the most acidic water sample. [1]

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(b) Calculate the percentage uncertainty in the measured pH of the rain water sample. [1]

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(c) Determine the ratio of  $[H^+]$  in bottled water to that in rain water.

$$\frac{[H^+] \text{ in bottled water}}{[H^+] \text{ in rain water}} \quad [2]$$

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*(Question 1 continued)*

- (d) The acidity of non-polluted rain water is caused by dissolved carbon dioxide. State an equation for the reaction of carbon dioxide with water. [1]

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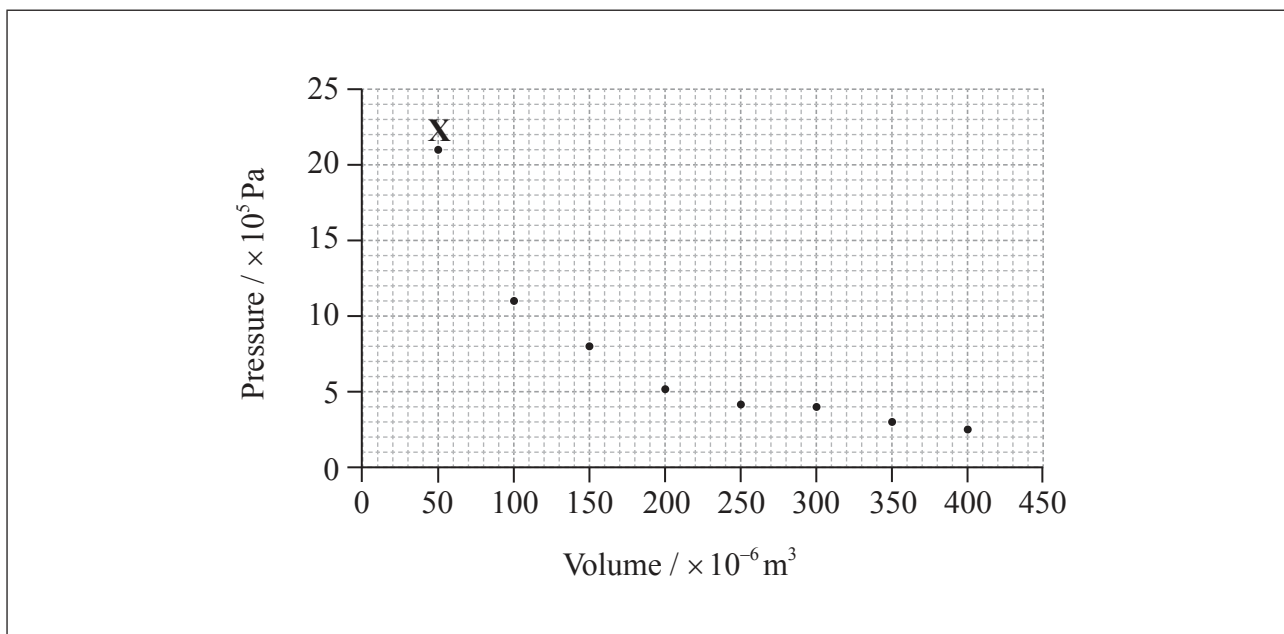
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24EP03

Turn over

2. The graph below shows pressure and volume data collected for a sample of carbon dioxide gas at 330 K.



- (a) Draw a best-fit curve for the data on the graph. [1]
- (b) Deduce the relationship between the pressure and volume of the sample of carbon dioxide gas. [1]

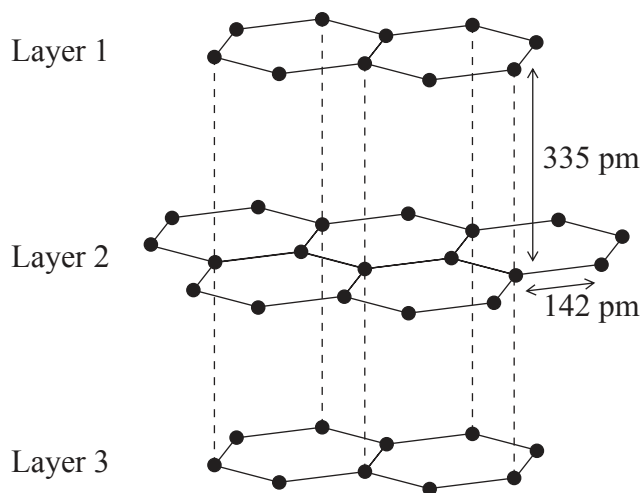
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- (c) Use the data point labelled X to determine the amount, in mol, of carbon dioxide gas in the sample. [3]

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3. Graphite has a layered structure of carbon atoms. A section of the structure is shown below.



(a) Explain why the distance between adjacent carbon atoms within a layer is shorter than the distance between layers. [3]

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(b) Graphite is used as a lubricant. Discuss **two** other uses of graphite with reference to its layered structure. [4]

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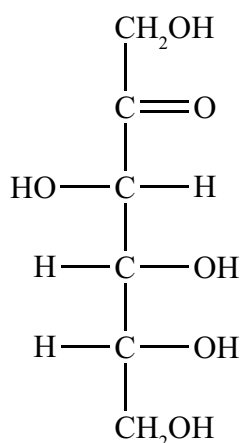
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4. The open-chain structure of D-fructose is shown below.



(a) State the names of **two** functional groups in D-fructose. [1]

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(b) Deduce the empirical formula of D-fructose. [1]

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(c) Calculate the percentage composition by mass of D-fructose. [2]

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*(Question 4 continued)*

(d) State a balanced equation for the complete combustion of D-fructose.

[2]

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24EP07

Turn over

5. The Contact process involves an exothermic reversible reaction.



(a) Deduce the extent of the reaction at 200 °C and 1 atm. [1]

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(b) The Contact process operates at a temperature of 450 °C and a pressure of 2 atm as optimum conditions for the production of SO<sub>3</sub>. Outline the reasons for choosing these conditions. [4]

Temperature:

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Pressure:

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*(Question 5 continued)*

- (c) An engineer at a Contact process plant hypothesized that using pure oxygen, instead of air, would increase the profits. Comment on whether or not her hypothesis is valid, giving your reasons. [2]

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24EP09

**Turn over**

**SECTION B**

Answer **one** question. Write your answers in the boxes provided.

6. (a) A sample of magnesium contains three isotopes: magnesium-24, magnesium-25 and magnesium-26, with abundances of 77.44%, 10.00% and 12.56% respectively.

(i) Calculate the relative atomic mass of this sample of magnesium correct to **two** decimal places. [2]

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(ii) By reference to the deflection and detection stages in the mass spectrometer, explain how the mass and abundance of an isotope are determined. [2]

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(iii) Predict the relative atomic radii of the three magnesium isotopes, giving your reasons. [2]

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(Question 6 continued)

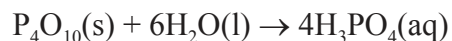
- (b) Describe the bonding in magnesium. [2]

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- (c) State an equation for the reaction of magnesium oxide with water. [1]

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- (d) Phosphorus(V) oxide,  $P_4O_{10}$  ( $M_r = 283.88$ ), reacts vigorously with water ( $M_r = 18.02$ ), according to the equation below.



- (i) A student added 5.00 g of  $P_4O_{10}$  to 1.50 g of water. Determine the limiting reactant, showing your working. [2]

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- (ii) Calculate the mass of phosphoric(V) acid,  $H_3PO_4$ , formed in the reaction. [2]

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*(Question 6 continued)*

- (iii) State a balanced equation for the reaction of aqueous  $\text{H}_3\text{PO}_4$  with excess aqueous sodium hydroxide, including state symbols. [2]

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- (iv) State the formula of the conjugate base of  $\text{H}_3\text{PO}_4$ . [1]

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- (e) (i) Deduce the Lewis structure of  $\text{PH}_4^+$ . [1]

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(Question 6 continued)

(ii) Predict, giving a reason, the bond angle around the phosphorus atom in  $\text{PH}_4^+$ . [2]

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(iii) Predict whether or not the P–H bond is polar, giving a reason for your choice. [1]

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24EP13

Turn over

7. Consider the following list of organic compounds.

Compound 1:  $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$

Compound 2:  $\text{CH}_3\text{CH}_2\text{COCH}_3$

Compound 3:  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$

Compound 4:  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$

(a) Apply IUPAC rules to state the name of compound 1. [1]

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(b) (i) Define the term *structural isomers*. [1]

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(ii) Identify the two compounds in the list that are structural isomers of each other. [1]

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(c) Determine the organic product formed when each of the compounds is heated under reflux with excess acidified potassium dichromate(VI). If no reaction occurs write NO REACTION in the table. [4]

Compound	Organic product
$\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$	
$\text{CH}_3\text{CH}_2\text{COCH}_3$	
$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$	
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$	

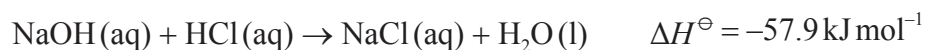
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(Question 7 continued)

- (d) Explain the mechanism for the substitution reaction of bromoethane with sodium hydroxide. Use curly arrows to represent the movement of electron pairs. [4]

- (e) Hydrochloric acid neutralizes sodium hydroxide, forming sodium chloride and water.



- (i) Define the term *standard enthalpy change of reaction*,  $\Delta H^\ominus$ . [2]

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- (ii) Determine the amount of energy released, in kJ, when  $50.0 \text{ cm}^3$  of  $1.00 \text{ mol dm}^{-3}$  sodium hydroxide solution reacts with  $50.0 \text{ cm}^3$  of  $1.00 \text{ mol dm}^{-3}$  hydrochloric acid solution. [2]

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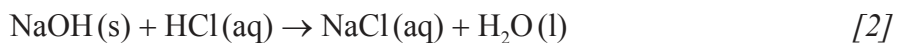
(Question 7 continued)

- (iii) In an experiment, 2.50 g of solid sodium hydroxide was dissolved in 50.0 cm<sup>3</sup> of water. The temperature rose by 13.3 °C. Calculate the standard enthalpy change, in kJ mol<sup>-1</sup>, for dissolving one mole of solid sodium hydroxide in water.



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- (iv) Using relevant data from previous question parts, determine  $\Delta H^\ominus$ , in kJ mol<sup>-1</sup>, for the reaction of solid sodium hydroxide with hydrochloric acid.

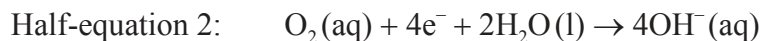


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8. Iron rusts in the presence of oxygen and water. Rusting is a redox process involving several steps that produces hydrated iron(III) oxide,  $\text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O}$ , as the final product. The half-equations involved for the first step of rusting are given below.



(a) (i) Identify whether half-equation 1 represents oxidation or reduction, giving a reason for your answer. [1]

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(ii) Identify the oxidation number of each atom in the three species in half-equation 2. [2]

$\text{O}_2(\text{aq}) + 4\text{e}^- + 2\text{H}_2\text{O(l)} \rightarrow 4\text{OH}^-(\text{aq})$

(iii) Deduce the overall redox equation for the first step of rusting by combining half-equations 1 and 2. [1]

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(iv) Identify the reducing agent in the redox equation in part (iii). [1]

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(Question 8 continued)

- (b) The oxygen in half-equation 2 is atmospheric oxygen that is found dissolved in water in very small concentrations. Explain, in terms of intermolecular forces, why oxygen is not very soluble in water. [2]

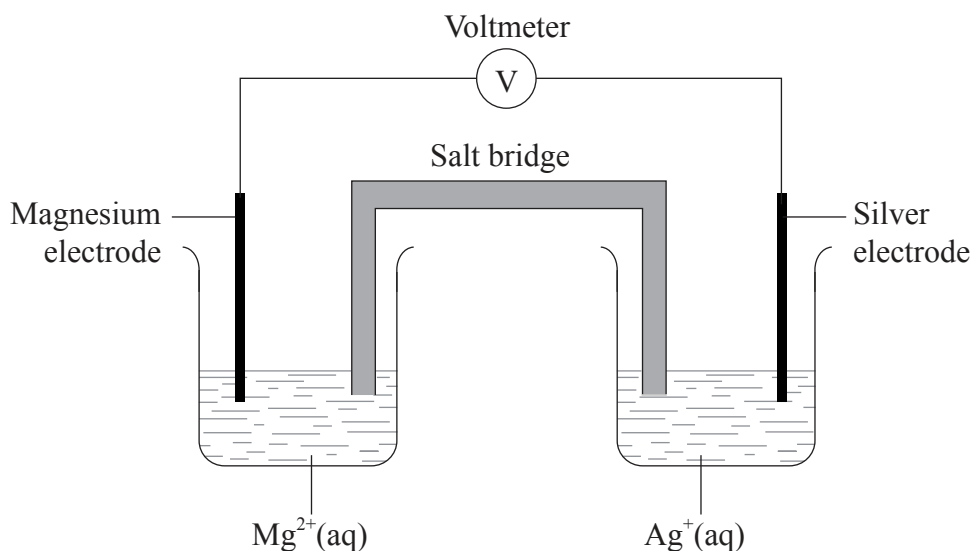
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- (c) A voltaic cell is made from a half-cell containing a magnesium electrode in a solution of magnesium nitrate and a half-cell containing a silver electrode in a solution of silver(I) nitrate.



- (i) Given that magnesium is more reactive than silver, deduce the half-equations for the reactions occurring at each electrode, including state symbols. [2]

Negative electrode (anode):

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Positive electrode (cathode):

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24EP18

*(Question 8 continued)*

(ii) Outline **one** function of the salt bridge. [1]

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(d) (i) State the property that determines the order in which elements are arranged in the periodic table. [1]

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(ii) State the relationship between the electron arrangement of an element and its group and period in the periodic table. [2]

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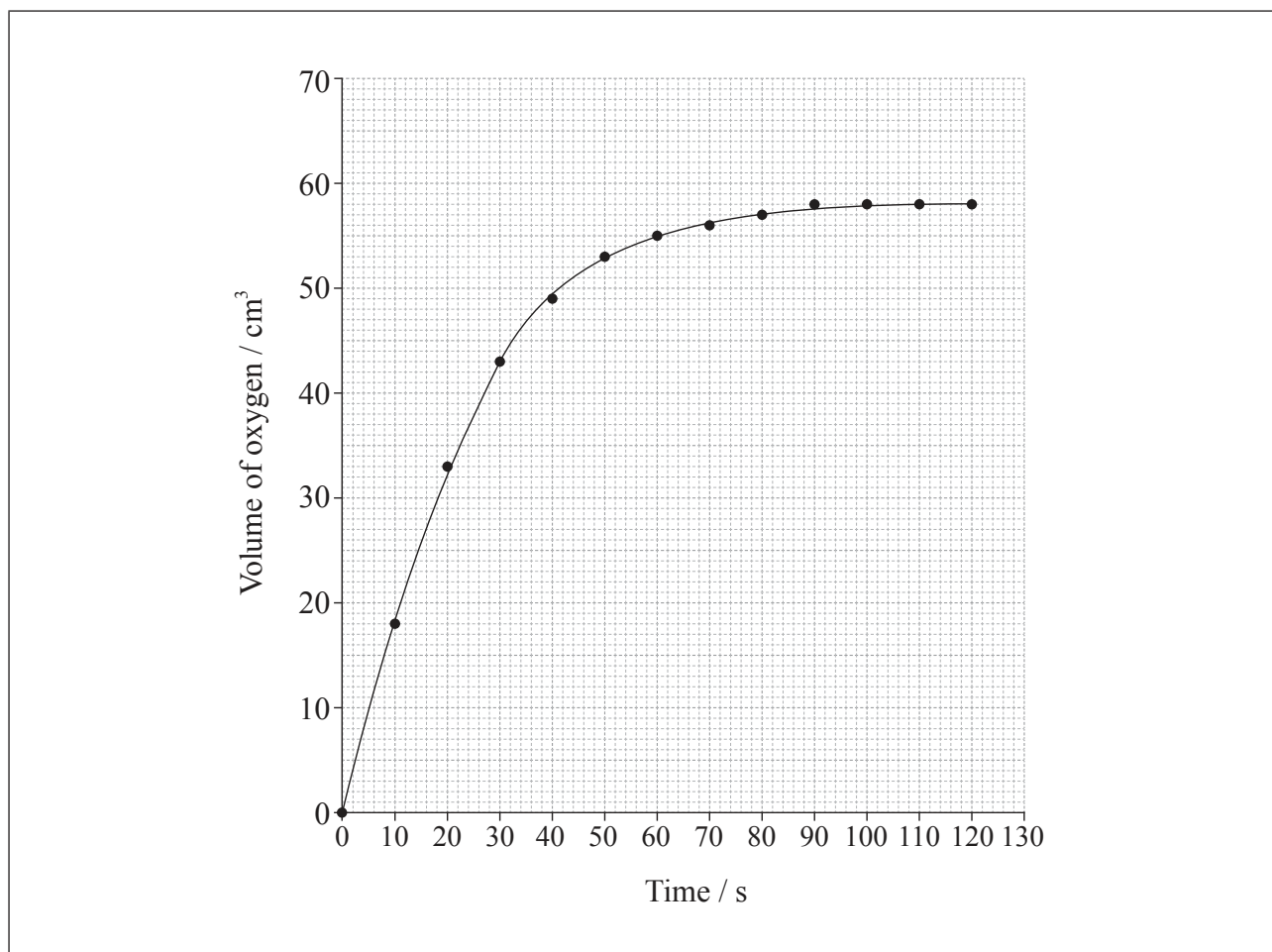


(Question 8 continued)

- (e) Hydrogen peroxide decomposes according to the equation below.



The rate of the decomposition can be monitored by measuring the volume of oxygen gas released. The graph shows the results obtained when a solution of hydrogen peroxide decomposed in the presence of a CuO catalyst.



- (i) The experiment is repeated with the same amount of a more effective catalyst, MnO<sub>2</sub>, under the same conditions and using the same concentration and volume of hydrogen peroxide. On the graph above, sketch the curve you would expect. [1]

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(Question 8 continued)

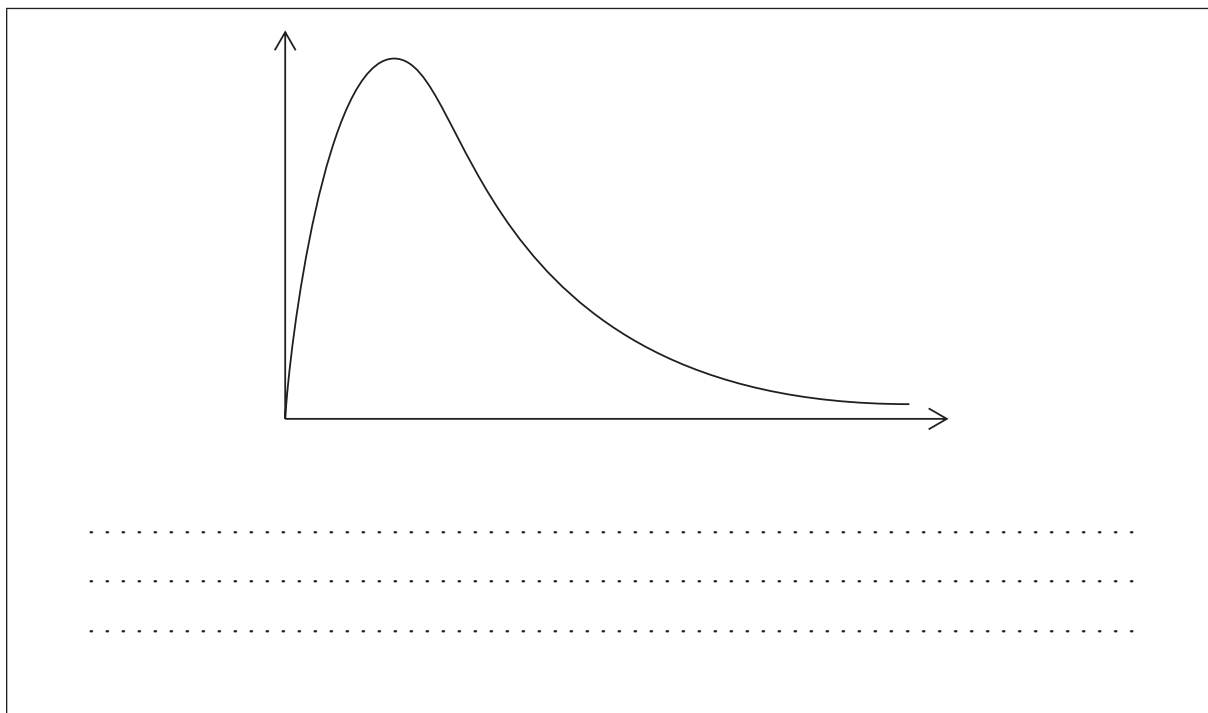
- (ii) Outline how the initial rate of reaction can be found from the graph. [2]

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- (iii) Outline a different experimental procedure that can be used to monitor the decomposition rate of hydrogen peroxide. [1]

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- (iv) A Maxwell–Boltzmann energy distribution curve is drawn below. Label both axes and explain, by annotating the graph, how catalysts increase the rate of reaction. [3]



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24EP24