



Additional Assessment Materials

Summer 2021

Pearson Edexcel GCE in Chemistry 8CH0

Resource Set 1 – Topic Group 4

Topics included:

Topic 8: Energetics I

Topic 9: Kinetics I and Topic 10: Equilibrium I

(Public release version)

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Additional Assessment Materials, Summer 2021

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## General guidance to Additional Assessment Materials for use in 2021

### Context

- Additional Assessment Materials are being produced for GCSE, AS and A levels (with the exception of Art and Design).
- The Additional Assessment Materials presented in this booklet are an **optional** part of the range of evidence teachers may use when deciding on a candidate's grade.
- 2021 Additional Assessment Materials have been drawn from previous examination materials, namely past papers.
- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidate.

### Purpose

- The purpose of this resource is to provide qualification-specific sets/groups of questions covering the knowledge, skills and understanding relevant to this Pearson qualification.
- This document should be used in conjunction with the mapping guidance which will map content and/or skills covered within each set of questions.
- These materials are only intended to support the summer 2021 series.

3 This question is about enthalpy changes.

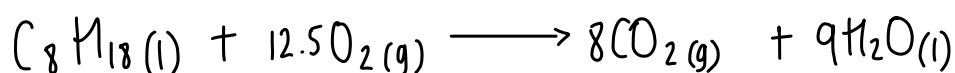
(a) (i) State what is meant by the term 'standard enthalpy change of combustion'.

(2)

enthalpy change when one mole of a substance is completely burned in oxygen, with all reactants and products in standard states under standard conditions.

(ii) Write the equation, including state symbols, for the reaction that occurs when the standard enthalpy change of combustion of octane,  $C_8H_{18}(l)$ , is measured.

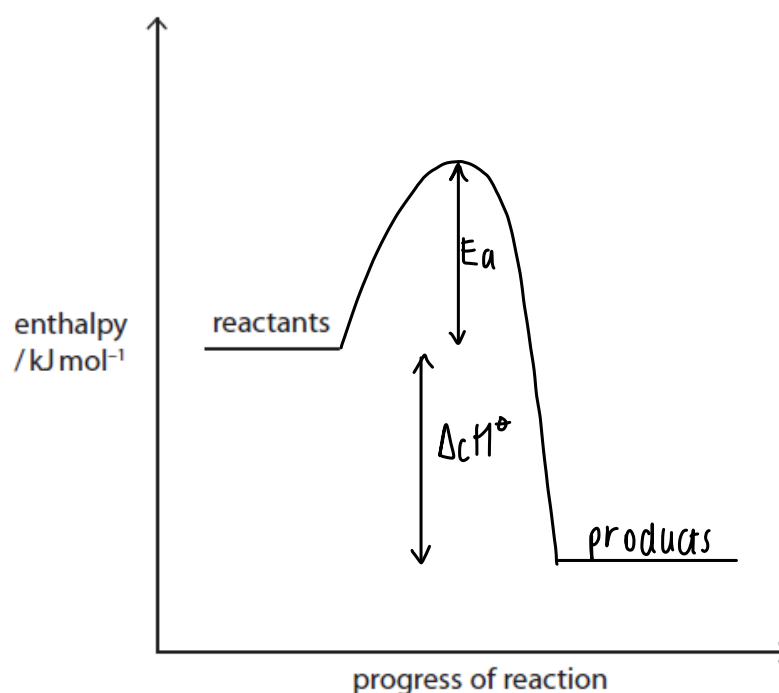
(2)



(iii) The standard enthalpy change of combustion of octane is  $-5470 \text{ kJ mol}^{-1}$ .

Complete the reaction profile diagram for the combustion of octane. Include labels showing the standard enthalpy change of combustion,  $\Delta_c H^\ominus$ , and the activation energy,  $E_a$ .

(2)

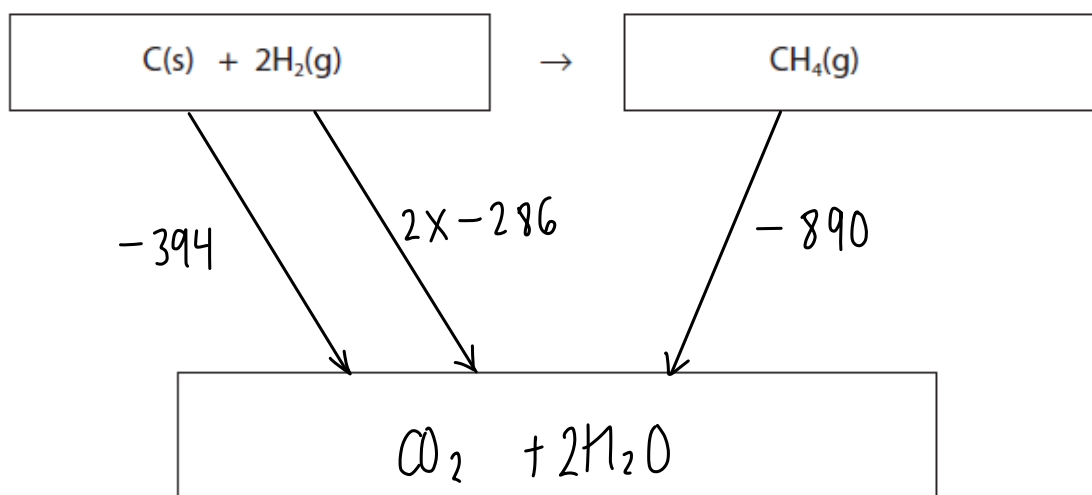


- (b) Enthalpy changes of reactions which cannot be measured directly can be calculated using standard enthalpy changes of combustion. The table shows some of these values.

Substance	$\Delta_c H^\ominus / \text{kJ mol}^{-1}$
C(s)	-394
H <sub>2</sub> (g)	-286
CH <sub>4</sub> (g)	-890

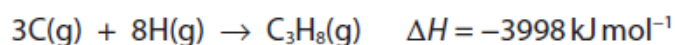
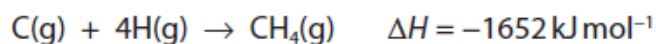
Complete the Hess cycle and use it to calculate the standard enthalpy change for the following reaction.

(4)



$$\begin{aligned} \Delta H_r &= -394 + (2 \times -286) + 890 \\ &= -76 \text{ kJ mol}^{-1} \end{aligned}$$

- (c) The equations for the combination of gaseous atoms of carbon and hydrogen to form methane,  $\text{CH}_4$ , and propane,  $\text{C}_3\text{H}_8$ , are



Calculate:

- (i) the mean bond enthalpy of a C—H bond.

(1)

$$\Delta H = \text{bonds broken} - \text{bonds made}$$

$$-1652 = 0 - 4x$$

$$\Rightarrow x = 1652 \div 4$$

$$x = +413 \text{ kJ mol}^{-1}$$

- (ii) the mean bond enthalpy of a C—C bond.

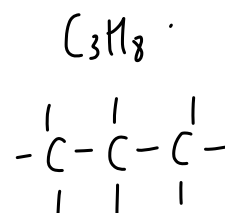
(2)

$$-3998 = 0 - [2x + 8(413)]$$

$$-3998 = 0 - 2x - 3304$$

$$2x = 694$$

$$x = +347 \text{ kJ mol}^{-1}$$

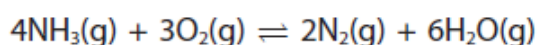


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(Total for Question 3 = 13 marks)

3 This question is about the oxidation of ammonia.

One equation for the oxidation of ammonia is



(a) Write the expression, including units, for the equilibrium constant  $K_c$  for this reaction.

(2)

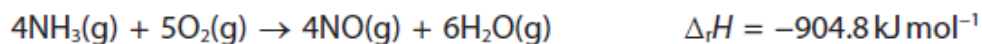
Expression

$$K_c = \frac{[\text{O}_2]^3 [\text{NH}_3]^4}{[\text{N}_2]^2 [\text{H}_2\text{O}]^6} \rightarrow \frac{(\text{mol dm}^{-3})^7}{(\text{mol dm}^{-3})^8} = (\text{mol dm}^{-3})^{-1}$$

↓  
 $\text{mol}^{-1} \text{dm}^3$

Units  $\text{mol}^{-1} \text{dm}^3$

(b) Nitric acid is made from ammonia. One of the stages in nitric acid production involves the oxidation of ammonia to produce nitrogen(II) oxide, NO. In this process, a mixture of ammonia and oxygen is passed over a platinum-rhodium catalyst. One manufacturer uses a pressure of 5 atm and a temperature of 850°C. The equation for this reaction is different from that in 3(a).

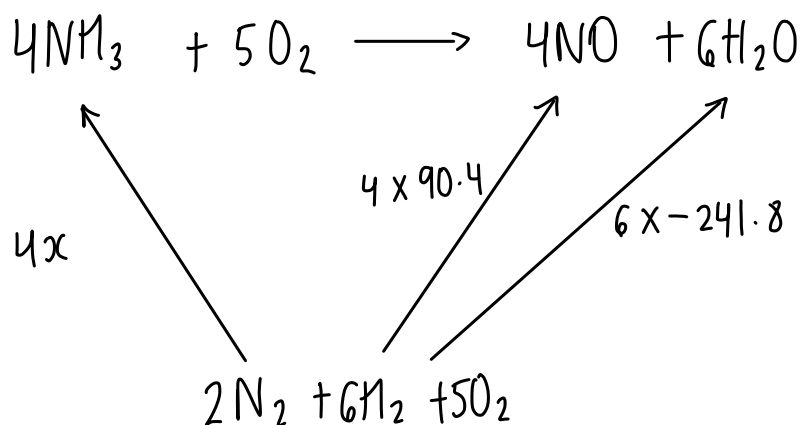


(i) Use this equation, and the enthalpy changes of formation of nitrogen(II) oxide and water, to calculate the enthalpy change of formation of ammonia in  $\text{kJ mol}^{-1}$ . You may find it helpful to draw a Hess cycle first. You must show your working.

$$\Delta_f H (\text{NO}(\text{g})) = +90.4 \text{ kJ mol}^{-1}$$

$$\Delta_f H (\text{H}_2\text{O}(\text{g})) = -241.8 \text{ kJ mol}^{-1}$$

(3)



$$\Rightarrow -4x + (4 \times 90.4) + (6 \times -241.8) = -904.8$$

$$x = -184.4 \div 4 \Rightarrow \underline{\underline{x = -46.1 \text{ kJ mol}^{-1}}}$$

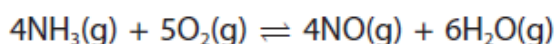
- (ii) Calculate the atom economy by mass for the formation of NO in this reaction. Give your answer to an appropriate number of significant figures.

(2)

$$\frac{30}{4(17) + (5 \times 32)} = 0.132$$

(c) In fact, this oxidation to form nitrogen(II) oxide is an equilibrium reaction.

- (i) Explain the effect, if any, of increasing pressure on the equilibrium **yield** of NO in this reaction.



(2)

decreases yield of NO as there are 9 moles of gas on the left and 10 moles on the right, so the equilibrium moves to the side with less moles of gas (to the left) in order to decrease the pressure, due to Le Chatelier's Principle.

- (ii) Explain the effect, if any, of an increase in pressure on the **rate** of this reaction.

(2)

increasing the pressure increases the rate of reaction as there are more moles in a given volume so more frequent successful collisions take place.



- (iii) The platinum-rhodium catalyst used in this reaction is a **heterogeneous** catalyst. State what is meant by the term 'heterogeneous' and why a catalyst has no effect on the yield of the products in the reaction.

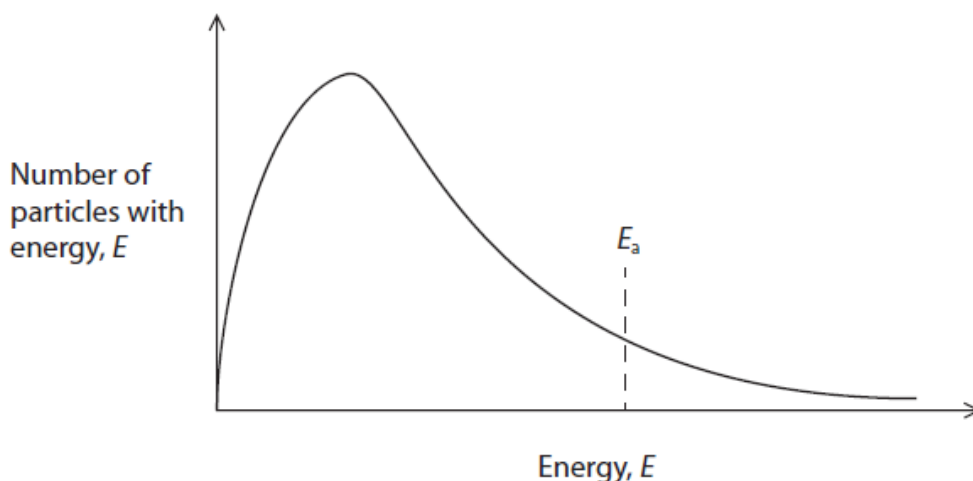
(2)

a different state to the reactants

a catalyst increases the rate of both the forward and reverse reactions equally

- (d) The diagram shows a Maxwell-Boltzmann distribution of particle energies, including the activation energy,  $E_a$ , for a reaction.

(1)

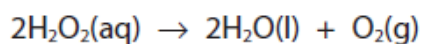


An increase in temperature will

- A increase the area under the curve.
- B move the peak of the curve to the right.
- C raise the height of the peak.
- D move the position of the activation energy,  $E_a$ , to the left.

(Total for Question 3 = 14 marks)

6 Aqueous hydrogen peroxide decomposes according to the following equation.

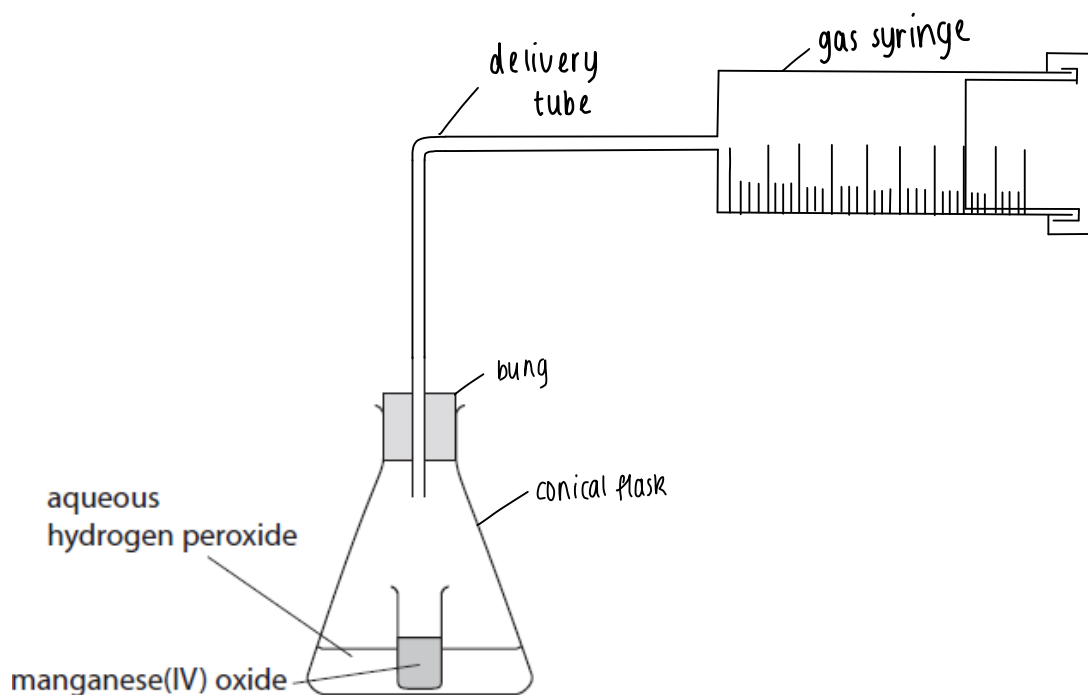


The decomposition is catalysed by manganese(IV) oxide.  $\rightarrow \text{Mn}^{4+} \text{O}^{2-} \rightarrow \text{MnO}_2$

This can be investigated by measuring the volume of oxygen produced at various times as the reaction proceeds. Part of the apparatus used in the experiment is shown. The manganese(IV) oxide is placed in a small glass container, which is then tipped over to start the reaction. A stop clock is started at the same time.

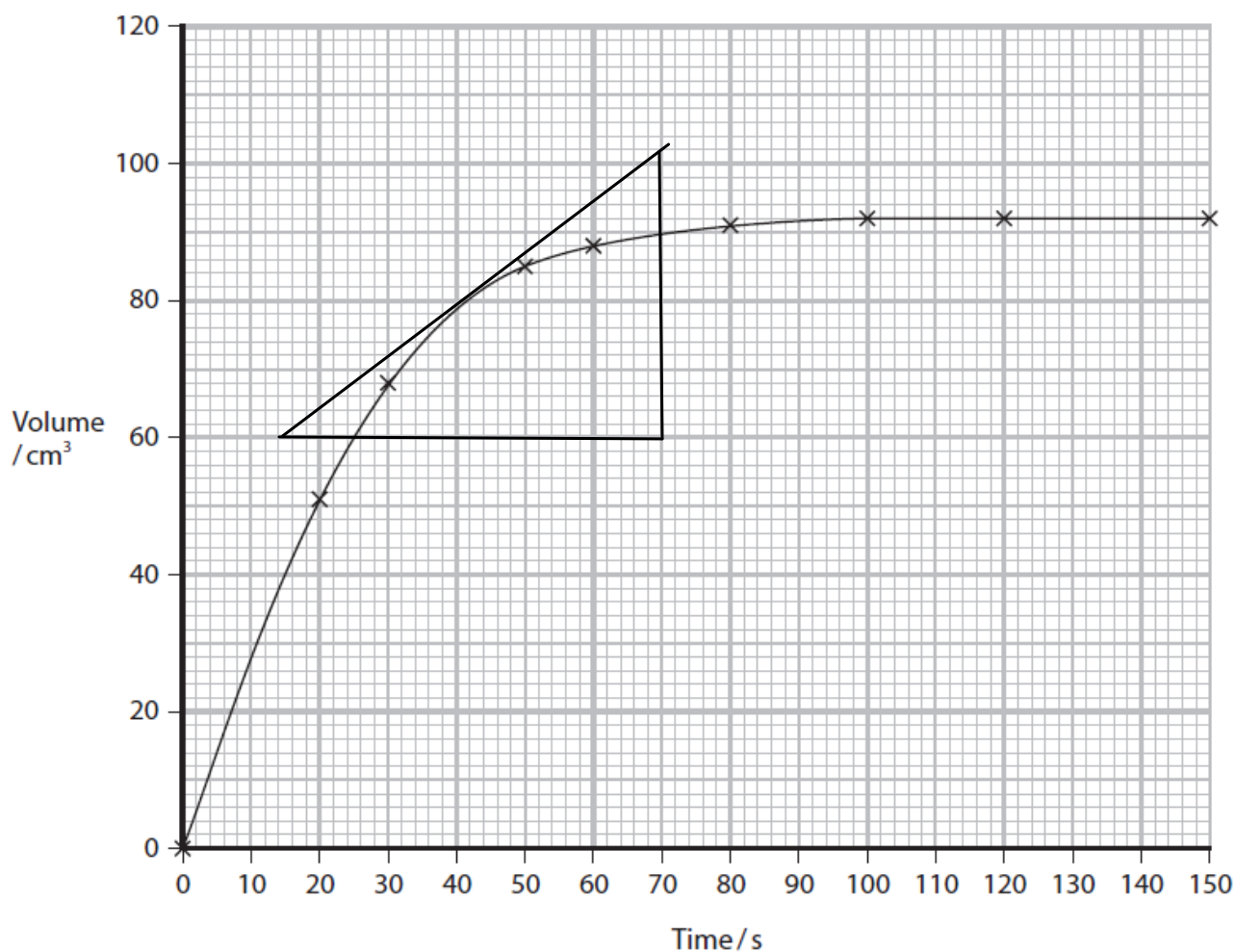
(a) Complete the diagram to show how the gas can be collected **and** its volume measured, labelling the apparatus used.

(2)



(b) An experiment was carried out using 0.25 g of manganese(IV) oxide granules and 50 cm<sup>3</sup> of aqueous hydrogen peroxide of concentration 0.16 mol dm<sup>-3</sup>. The results are shown in the table and plotted on a graph.

Time/s	0.0	20.0	30.0	50.0	60.0	80.0	100	120	150
Volume of O <sub>2</sub> /cm <sup>3</sup>	0	51	68	85	88	91	92	92	92



- (i) The rate of reaction may be assumed to be approximately constant up to the first volume measurement (20.0 s in this experiment).

Use this approximation to calculate the initial rate of this reaction, giving the **units** with your answer.

(1)

$$\frac{51}{20} = 2.55 \text{ cm}^3 \text{ s}^{-1}$$

- (ii) Draw a tangent at 40s on the graph on Page 20 and use it to calculate the rate of reaction at this time.

(2)

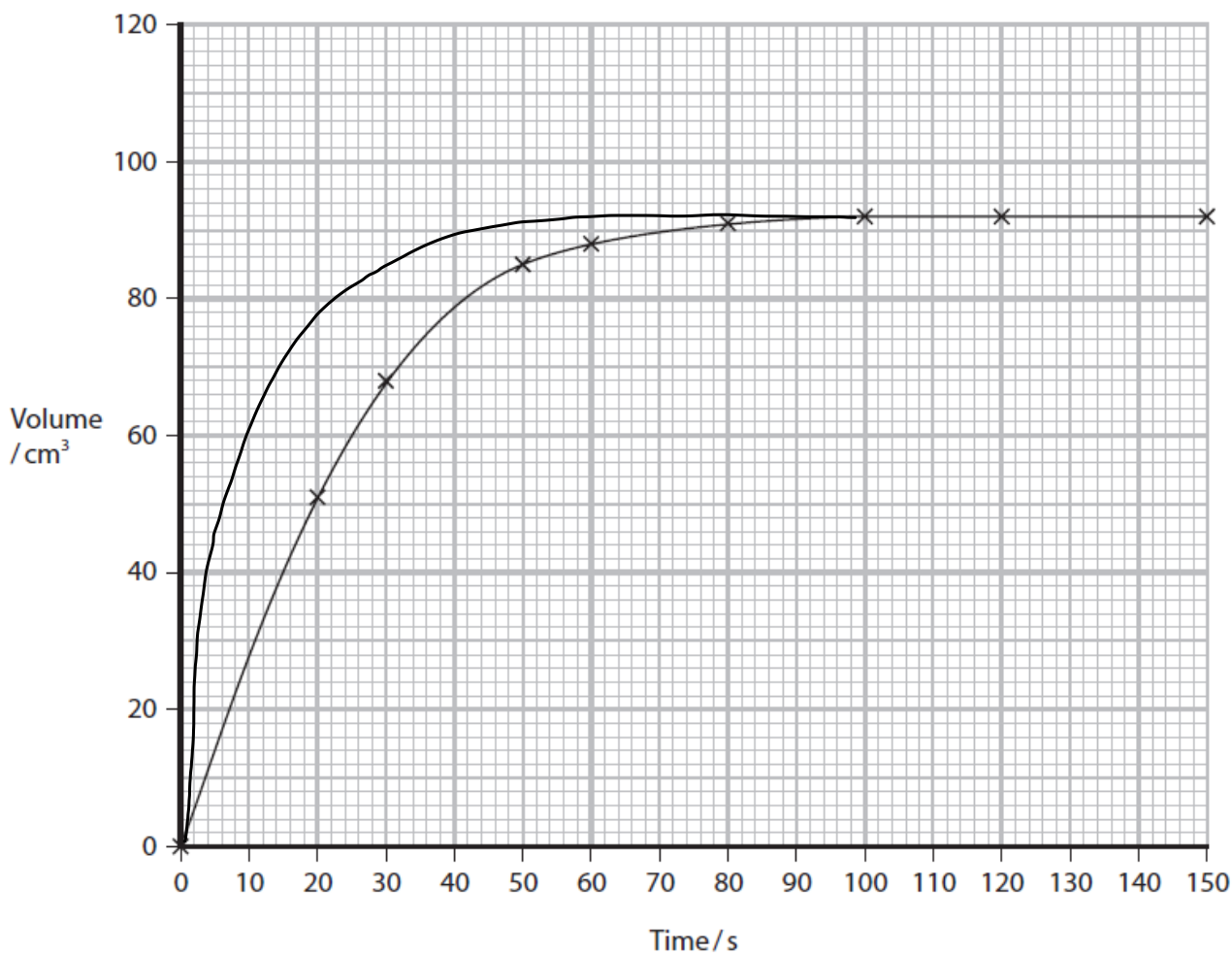
$$\text{gradient} = \frac{\text{volume}}{\text{time}} = \text{rate of reaction} (\text{cm}^3 \text{s}^{-1})$$

$$\frac{\Delta y}{\Delta x} = \frac{102 - 60}{70 - 15} = 0.764 \text{ cm}^3 \text{s}^{-1}$$

- (iii) The experiment was repeated on a different day when the laboratory was 20°C warmer. The volume of oxygen was recorded for the same total time of 150s.

Draw the line that you would expect to obtain in this experiment. Assume the pressure in the laboratory is the same. No calculation is required.

(2)



(iv) Explain, using collision theory, any differences between the line you have drawn and the original line of best fit.

(2)

At a higher temperature the particles gain kinetic energy so move faster, so there are more frequent successful collisions and therefore a faster rate of reaction in the first 50 seconds.

(c) Catalysts are not used up during a reaction. Manganese(IV) oxide acts as a heterogeneous catalyst.

Describe in outline a method to show that the manganese(IV) oxide is not used up in the decomposition of hydrogen peroxide **and** that it still functions as a catalyst.

(4)

Weigh the contents of the conical flask and then allow the  $H_2O$  to evaporate. Reweigh the catalyst and repeat the experiment using fresh  $H_2O_2$ . The volume of  $O_2$  gas collected over the 150s, and therefore the rate, should be the same if the catalyst isn't used up.

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(Total for Question 6 = 13 marks)

Total for Test = 40 marks