A2 LEVEL CHEMISTRY

5.1.1 HOW FAST?

5.1.2 HOW FAR?

TEST

Answer all questions

Max 53 marks

Name	……..
Mark	……../53 ……....% Grade ……

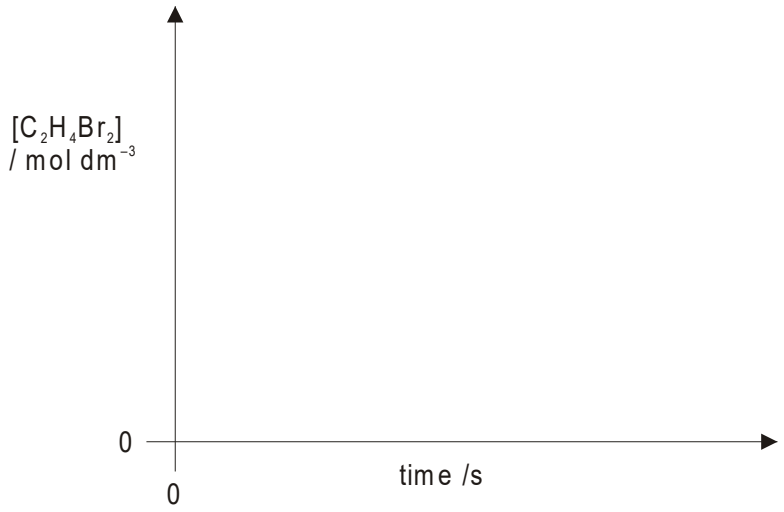
1. 1, 2-Dibromoethane, $C_2H_4Br_2$, reacts with potassium iodide as shown in the equation below.

$$C_2H_4Br_2 + 3KI \rightarrow C_2H_4 + 2KBr + KI_3$$

A series of experiments was carried out to investigate the kinetics of this reaction.

(a) In a first experiment the concentration of $C_2H_4Br_2$ was measured during the course of the reaction and a concentration-time graph was plotted. The reaction was shown to be first order with respect to $C_2H_4Br_2$.

(i) On the axes below, sketch a graph to show how $[C_2H_4Br_2]$ changed during the course of the reaction.



[2]

(ii) Show on the graph how you would measure the **initial** rate of the reaction.

[1]

(iii) How would you use the graph to show that the reaction is first order with respect to $C_2H_4Br_2$?

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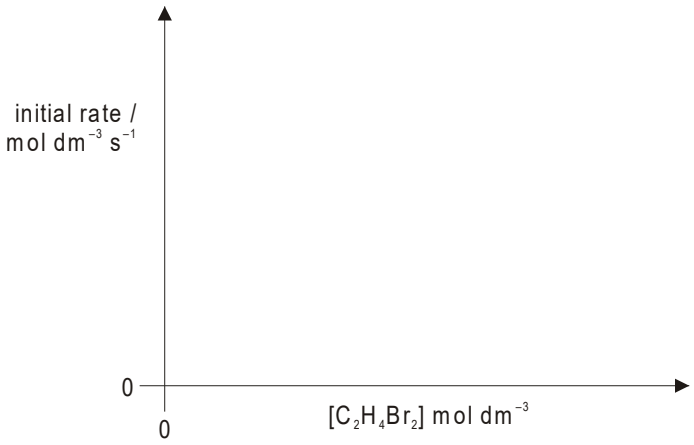
[1]

(iv) The experiment was repeated using different initial concentrations of $C_2H_4Br_2$.

Using the axes below, sketch a graph to show how the initial rate of the reaction changes with different concentrations of $C_2H_4Br_2$.



[1]

(b) In a second experiment, the initial concentration of KI was varied and the initial rate was measured. The results are shown in the table below.

experiment	$[C_2H_4Br_2]$ /mol dm^{-3}	[KI] /mol dm^{-3}	initial rate /mol dm^{-3}s^{-1}
1	0.50	0.18	0.027
2	0.50	0.72	0.108

Deduce the order of reaction with respect to KI. Show your reasoning.

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[2]

(c) (i) Construct the rate equation for the reaction.

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[1]

(ii) Calculate the rate constant, *k,* for this reaction. State the units for *k.*

k = ... units .....

[3]

[Total 11 marks]

2. Nitrogen monoxide reacts with hydrogen at 500 °C as in the equation below.

$$2NO(g) + 2H_2(g) \rightarrow N_2(g) + 2H_2O(g)$$

A series of experiments was carried out to investigate the kinetics of this reaction. The results are shown in the table below.

experiment	[NO] / mol dm^{-3}	[H_2] / mol dm^{-3}	initial rate / mol dm^{-3} s^{-1}
1	0.10	0.20	2.6
2	0.10	0.50	6.5
3	0.30	0.50	58.5

In this question, one mark is available for the quality of spelling, punctuation and grammar.

(i) For each reactant, deduce the order of reaction. Show your reasoning.

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[4]

Quality of Written Communication [1]

(ii) Deduce the rate equation for this reaction.

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[1]

(iii) Calculate the rate constant, *k*, for this reaction. State the units for *k*.

k = ... units .....

[3]

[Total 9 marks]

3. A student investigated the hydration of 2-methylpropene, $(CH_3)_2C=CH_2$, with dilute aqueous acid to form 2-methylpropan-2-ol, $(CH_3)_3COH$.

The following mechanism has been proposed for this hydration.

step 1 $(CH_3)_2C=CH_2 + H^+(aq) \rightarrow (CH_3)_3C^+$ rate determining step

step 2 $(CH_3)_3C+ + H_2O \rightarrow (CH_3)_3COH + H^+(aq)$

(i) Step 1 is the rate-determining step for this hydration.

What is meant by the term *rate-determining step*?

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[1]

(ii) Write a balanced equation for the overall hydration reaction.

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[1]

(iii) Suggest the role of $H^+(aq)$ in this mechanism. Explain your reason.

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[2]

(iv) Use the mechanism above to suggest the rate equation for this hydration.

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[1]

[Total 5 marks]

4. One cause of low-level smog is the reaction of ozone, O_3, with ethene. The smog contains methanal, $CH_2O(g)$, and the equation for its production is shown below.

$$O_3(g) + C_2H_4(g) \rightarrow 2CH_2O(g) + \frac{1}{2} O_2(g) \qquad \textbf{equation 1}$$

(a) The rate of the reaction doubles when the initial concentration of either $O_3(g)$ or $C_2H_4(g)$ is doubled.

(i) What is the order of reaction with respect to

O_3 .....

C_2H_4? .....

[1]

(ii) What is the overall order of the reaction?

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[1]

(iii) Write the rate equation for this reaction.

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[1]

(b) For an initial concentration of ozone of 0.50×10^{-7} mol dm^{-3} and one of ethene of 1.0×10^{-8} mol dm^{-3}, the initial rate of methanal formation was 1.0×10^{-12} mol dm^{-3} s^{-1}.

(i) How could the **initial** rate of methanal formation be measured from a concentration/time graph?

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[2]

(ii) Calculate the value of the rate constant and state the units.

rate constant =..... units.....

[3]

(iii) The initial rate of methanal formation is different from that of oxygen formation in **equation 1**.

Explain why.

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[1]

(iv) The experiment was repeated but at a higher temperature. What would be the effect of this change on the rate and the rate constant of the reaction?

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[2]

[Total 11 marks]

5. The preparation of hydrogen iodide, HI(g), from hydrogen and iodine gases is a reversible reaction which reaches equilibrium at constant temperature.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(a) Write the expression for K_c for this equilibrium.

[1]

(b) A student mixed together 0.30 mol $H_2(g)$ with 0.20 mol $I_2(g)$ and the mixture was allowed to reach equilibrium. At equilibrium, 0.14 mol $H_2(g)$ was present.

(i) Complete the table below to show the amount of each component in the equilibrium mixture.

component	$H_2(g)$	$I_2(g)$	HI(g)
initial amount / mol	0.30	0.20	0
equilibrium amount / mol			

[2]

(ii) Calculate K_c to an appropriate number of significant figures. State the units, if any.

K_c = ...

units, if any .....

[3]

(c) The student compressed the equilibrium mixture so that its volume was reduced. The temperature was kept constant.

Comment on the value of K_c **and** the composition of the equilibrium mixture under these new conditions.

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[2]

[Total 8 marks]

6. When heated, phosphorus pentachloride, PCl_5, dissociates.

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

A chemist placed a mixture of the three gases into a container. The initial concentration of each gas was the same: 0.30 mol dm^{-3}. The container was left until equilibrium had been reached.

Under these conditions, K_c = 0.245 mol dm^{-3}.

(a) Write an expression for K_c for this equilibrium.

[1]

(b) Use the value of K_c for this equilibrium to deduce whether the concentration of each gas increases, decreases or stays the same as the mixture approaches equilibrium.

(i) Show your answer by placing a tick in the appropriate cells in the table below.

	initial concentration / mol dm^{-3}	greater than 0.30 mol dm^{-3}	less than 0.30 mol dm^{-3}	equal to 0.30 mol dm^{-3}
PCl_5	0.30			
PCl_3	0.30			
Cl_2	0.30			

[1]

(ii) Explain your deduction.

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[1]

(c) The chemist compressed the equilibrium mixture at constant temperature and allowed it to reach equilibrium under these new conditions.

(i) Explain what happens to the value of K_c.

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[1]

(ii) Explain what happened to the composition of the equilibrium mixture.

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[2]

(d) The chemist heated the equilibrium mixture and the equilibrium moved to the left.

(i) Explain what happens to the value of K_c.

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[1]

(ii) Explain what additional information this observation reveals about the reaction.

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[2]

[Total 9 marks]