Reaction Rates
A Level only

Question Paper 1

Level	A Level
Subject	Chemistry
Exam Board	OCR
Module	Physical Chemistry & Transition Elements
Topic	Reaction Rates
Paper	A Level only
Booklet	Question Paper 1

Time allowed: **47 minutes**

Score: **/35**

Percentage: **/100**

Grade Boundaries:

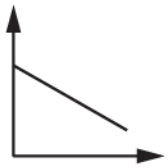
A*	A	B	C	D	E
>85%	73%	60%	47%	34%	21%

Question 1

A reaction is zero order with respect to a reactant **A**.

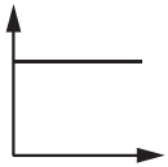
Which concentration–time graph for reactant **A** is the correct shape?

A

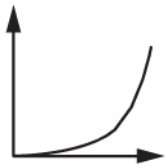


B

C



D



[1]

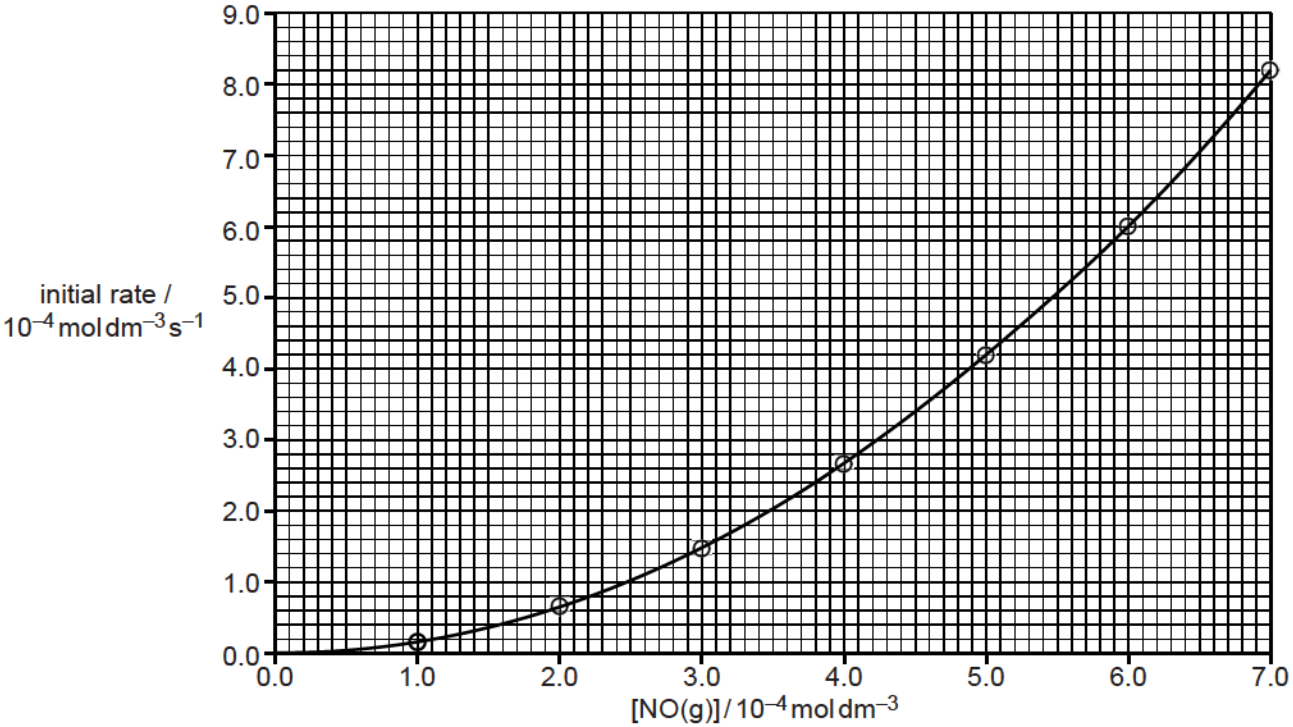
Hydrogen, H_2, reacts with nitrogen monoxide, NO, as shown below:

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

(a) The rate equation for this reaction is:

$$rate = k[H_2(g)][NO(g)]^2$$

The concentration of NO(g) is changed and a rate–concentration graph is plotted.



The chemist uses $H_2(g)$ of concentration 2.0×10^{-2} mol dm^{-3}.

Using values from the graph, calculate the rate constant, k, for this reaction.

Give your answer to **two** significant figures and in **standard form**.

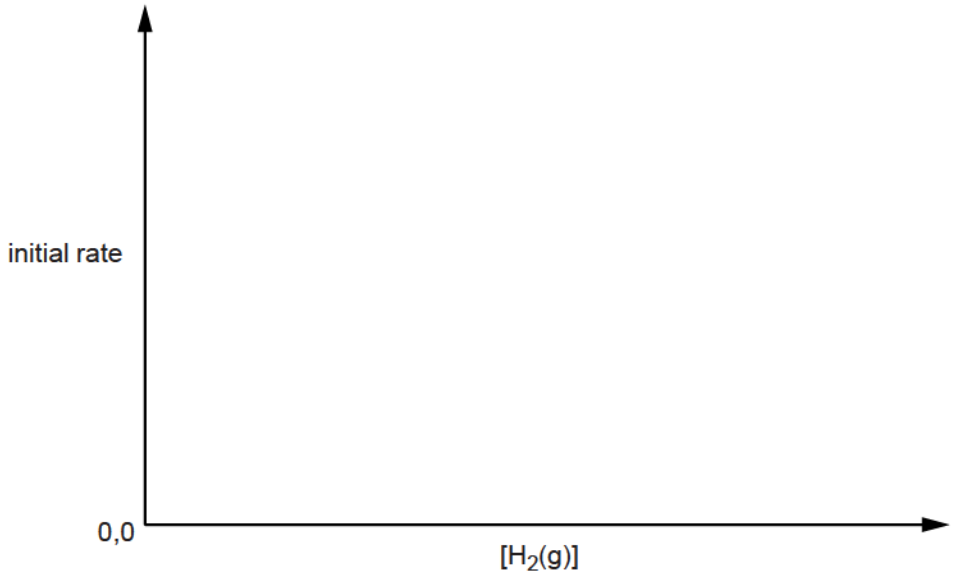
Show your working. [4]

(b) A chemist investigates the effect of changing the concentration of $H_2(g)$ on the initial reaction rate at two different temperatures.

The reaction is first order with respect to $H_2(g)$.

(i) Using the axes below, sketch **two** graphs of the results.

Label the graphs as follows:
- **L** for the lower temperature
- **H** for the higher temperature.

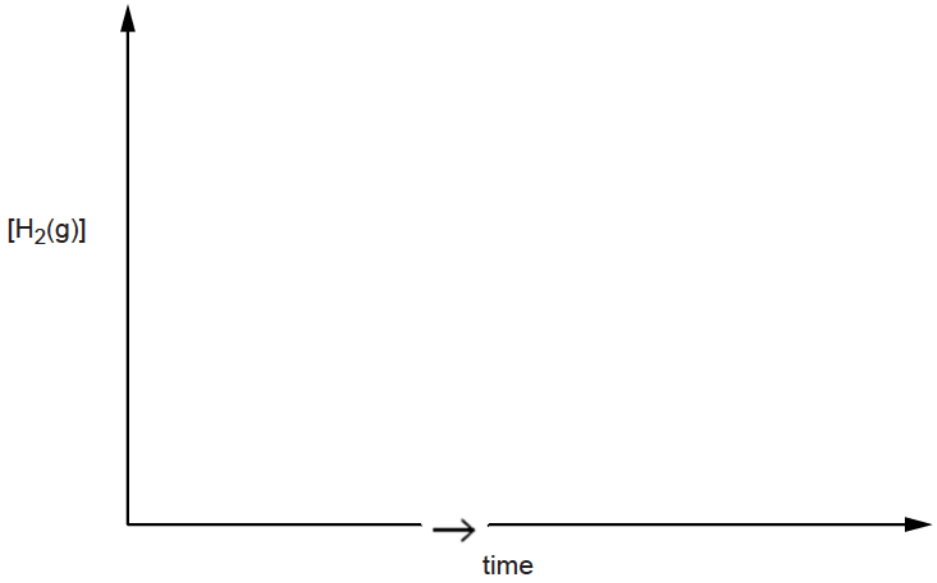


[2]

(ii) State the effect of the higher temperature on the rate constant, *k*. [1]

(c) The reaction can also be shown as being first order with respect to $H_2(g)$ by continuous monitoring of $[H_2(g)]$ during the course of the reaction.

- Using the axes below, sketch a graph to show the results.
- State how you would use the graph to show this first order relationship for $H_2(g)$.



[2]

(d) The chemist proposes a three-step mechanism for the reaction:

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

(i) On the dotted line below, write the equation for step 3.

step 1: $2NO \rightarrow N_2O_2$ fast

(ii) step 2: $H_2 + N_2O_2 \rightarrow N_2O + H_2O$ slow

(iii) step 3: fast

[1]

(ii) Explain why this mechanism is consistent with the rate equation $rate = k[H_2(g)][NO(g)]^2$

[1]

[Total: 11 Marks]

A student carries out an initial rates investigation on the reaction below.

$$5I^-(aq) + IO_3^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l)$$

From the results, the student determines the rate equation for this reaction:

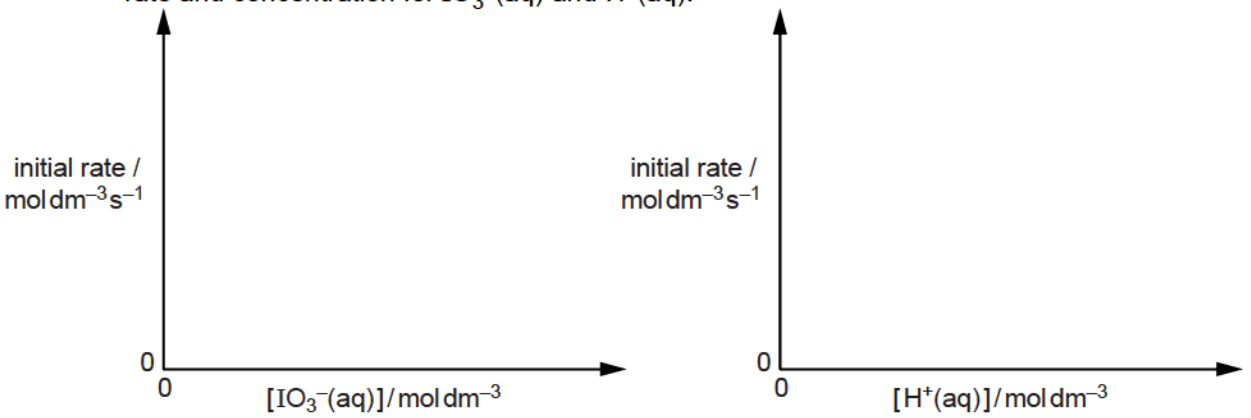
$$\text{rate} = k\,[I^-(aq)]^2\,[IO_3^-(aq)][H^+(aq)]^2$$

(a) (i) What is the overall order of reaction? [1]

(ii) A proposed mechanism for this reaction takes place in several steps.

Suggest **two** reasons why it is unlikely that this reaction could take place in one step. [2]

(b) On the rate–concentration graphs below, sketch lines to show the relationship between initial rate and concentration for $IO_3^-(aq)$ and $H^+(aq)$.



[2]

(c) The table below shows some of the student's results.

(i) Complete the table by adding the missing initial rates in the boxes.

	$[I^-(aq)]$ / mol dm^{-3}	$[IO_3^-(aq)]$ /mol dm^{-3}	$[H^+(aq)]$ / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
Experiment 1	0.015	0.010	0.020	0.60
Experiment 2	0.045	0.010	0.020	
Experiment 3	0.060	0.040	0.080	

[2]

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

Give your answer to **two** significant figures. [3]

(iii) The student repeats Experiment 1 using 0.020 mol dm^{-3} methanoic acid, HCOOH(aq) (pK_a = 3.75), instead of 0.020 mol dm^{-3} HCl(aq) as a source of $H^+(aq)$.

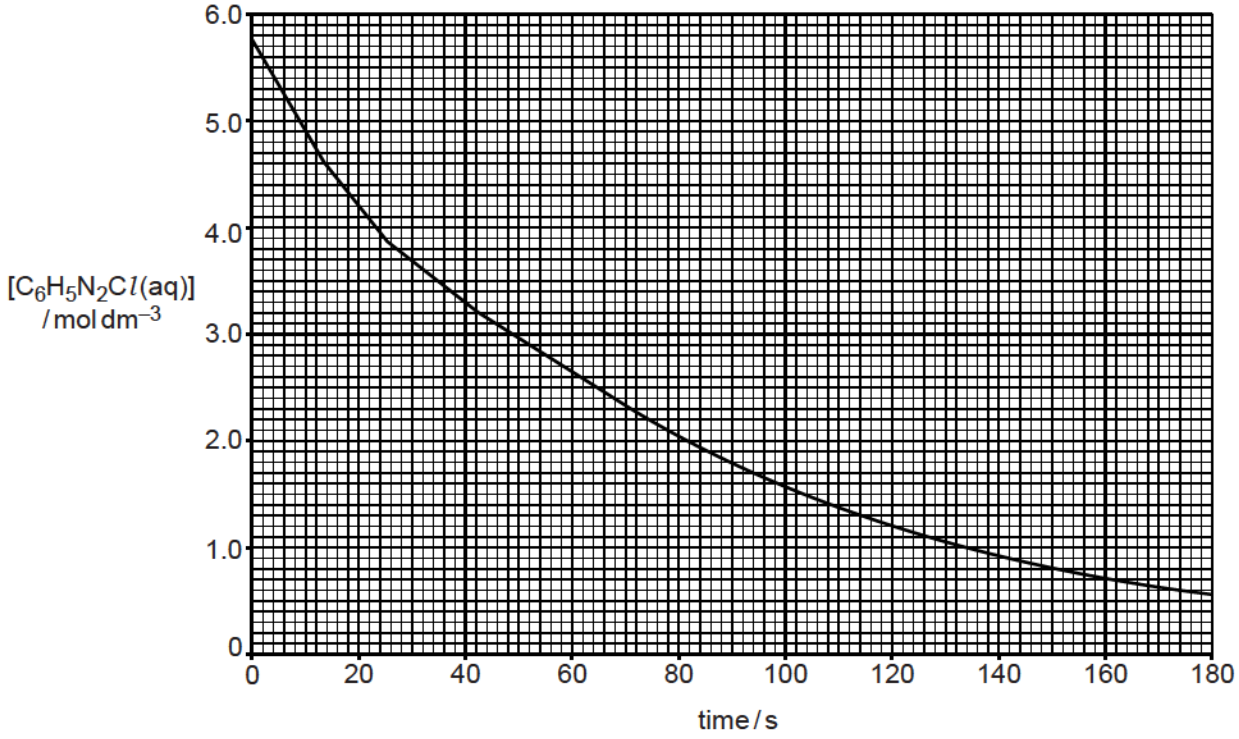
Determine the initial rate in this experiment. Show your working. [3]

[Total: 13 Marks]

In aqueous solution, benzenediazonium chloride, $C_6H_5N_2Cl$, decomposes above 10 °C.

$$C_6H_5N_2Cl(aq) + H_2O(l) \rightarrow C_6H_5OH(aq) + N_2(g) + HCl(aq)$$

A student investigates the rate of this reaction using an excess of water at 50 °C. The student takes measurements at intervals during the reaction and then plots his experimental results to give the graph shown below.



(a) The student uses half-life to suggest the order of reaction with respect to $C_6H_5N_2Cl$.

(i) What is meant by the *half-life* of a reaction? [1]

(ii) Confirm the order of reaction with respect to $C_6H_5N_2Cl$.

Show your working on the graph. [2]

(iii) What would be the effect, if any, on the half-life of this reaction of doubling the initial concentration of $C_6H_5N_2Cl$? [1]

(b) The student predicts that the rate equation is: rate = $k[C_6H_5N_2Cl]$.

(i) Using the graph and this rate equation, determine the rate of reaction after 40 s.

Show your working on the graph. [3]

(ii) Calculate the rate constant, k, for this reaction and give its units. [2]

(c) The order of this reaction with respect to H_2O is effectively zero.

Explain why. [1]

[Total 10 Marks]