

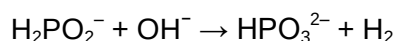
Name of the Student: _____

Max. Marks : 27 Marks

Time : 27 Minutes

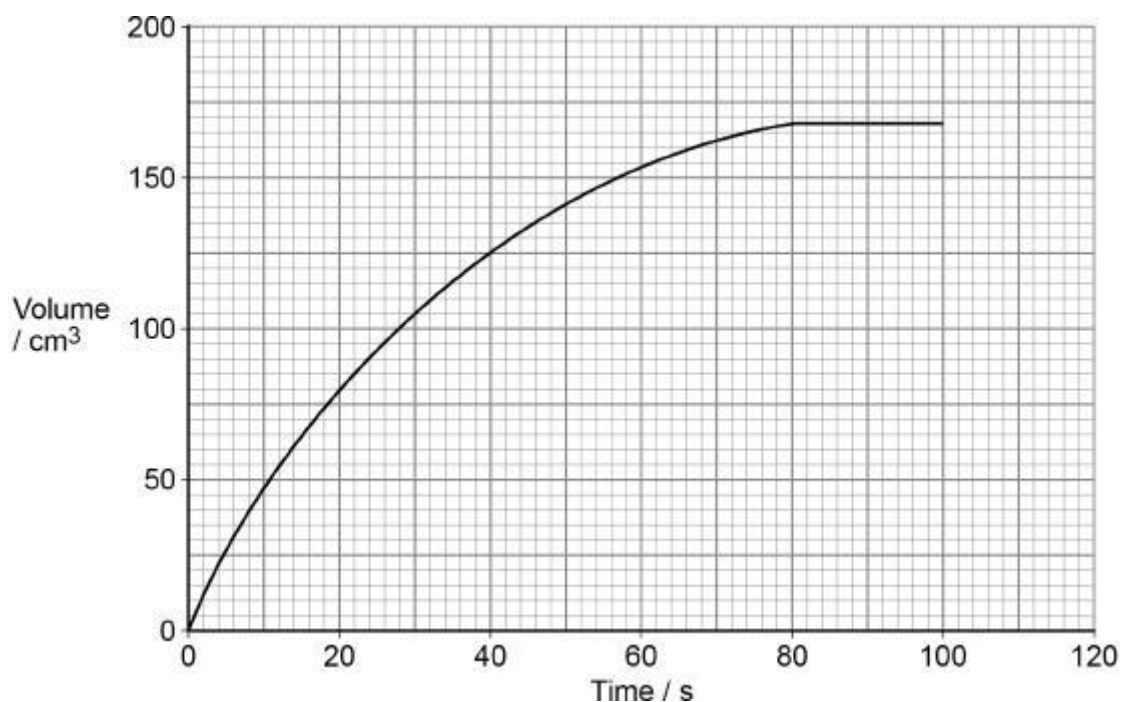
Q1.

This question is about rates of reaction.

Phosphinate ions (H_2PO_2^-) react with hydroxide ions to produce hydrogen gas as shown.

A student completed an experiment to determine the initial rate of this reaction.

The student used a solution containing phosphinate ions and measured the volume of hydrogen gas collected every 20 seconds at a constant temperature.

Figure 1 shows a graph of the student's results.**Figure 1**

- (a) Use the graph in **Figure 1** to determine the initial rate of reaction for this experiment. State its units. Show your working on the graph.

- (b) Another student reacted different initial concentrations of phosphinate ions with an excess of hydroxide ions. The student measured the time (t) taken to collect 15 cm³ of hydrogen gas. Each experiment was carried out at the same temperature. The table shows the results.

Initial [H ₂ PO ₂ ⁻] / mol dm ⁻³	t / s
0.25	64
0.35	32
0.50	16
1.00	4

State the relationship between the initial concentration of phosphinate and time (t).

Deduce the order of the reaction with respect to phosphinate.

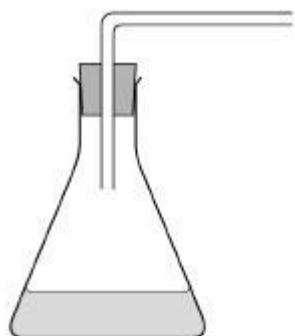
Relationship _____

Order _____

(2)

- (c) Complete the diagram in **Figure 2** to show how the hydrogen gas could be collected and measured in the experiments in part (a) and (b).

Figure 2



The rate equation for a different reaction is

$$\text{rate} = k [\text{L}] [\text{M}]^2$$

(1)

- (d) Deduce the overall effect on the rate of reaction when the concentrations of both **L** and **M** are halved.

(1)

- (e) The rate of reaction is 0.0250 mol dm⁻³ s⁻¹ when the concentration of **L** is 0.0155 mol dm⁻³

Calculate the concentration of **M** if the rate constant is $21.3 \text{ mol}^{-2} \text{ dm}^6 \text{ s}^{-1}$

Concentration of **M** _____ mol dm^{-3}

(3)

(f) Define the term overall order of reaction.

(1)

(Total 11 marks)

Q2.

The rate expression for the reaction between **X** and **Y** is

$$\text{rate} = k [\text{X}]^2 [\text{Y}]$$

Which statement is correct?

- A** The rate constant has units $\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$ ☐
- B** The rate of the reaction is halved if the concentration of **X** is halved and the concentration of **Y** is doubled. ☐
- C** The rate increases by a factor of 16 if the concentration of **X** is tripled and the concentration of **Y** is doubled. ☐
- D** The rate constant is independent of temperature. ☐

(Total 1 mark)

Q3.

Cisplatin, $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$, is used as an anti-cancer drug.

- (a) Cisplatin works by causing the death of rapidly dividing cells.

Name the process that is prevented by cisplatin during cell division.

(1)

After cisplatin enters a cell, one of the chloride ligands is replaced by a water molecule to form a complex ion, **B**.

- (b) Give the equation for this reaction.

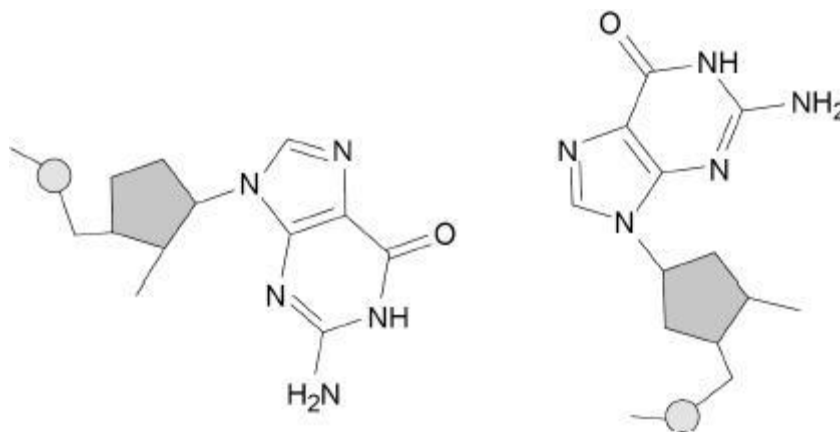
(2)

- (c) When the complex ion **B** reacts with DNA, the water molecule is replaced as a bond forms between platinum and a nitrogen atom in a guanine nucleotide. The remaining chloride ligand is also replaced as a bond forms between platinum and a nitrogen atom in another guanine nucleotide.

Figure 1 represents two adjacent guanine nucleotides in DNA.

Complete **figure 1** to show how the platinum complex forms a cross-link between the guanine nucleotides.

Figure 1



(2)

An experiment is done to investigate the rate of reaction in part (b).

- (d) During the experiment the concentration of cisplatin is measured at one-minute intervals.

Explain how graphical methods can be used to process the measured results, to confirm that the reaction is first order.

(3)

In another experiment, the effect of temperature on the rate of the reaction in part (b) is investigated.

The table shows the results.

Temperature T / K	$\frac{1}{T} / \text{K}^{-1}$	Rate constant k / s^{-1}	$\ln k$
293	0.00341	1.97×10^{-8}	-17.7
303	0.00330	8.61×10^{-8}	-16.3
313	0.00319	3.43×10^{-7}	-14.9
318		6.63×10^{-7}	
323	0.00310	1.26×10^{-6}	-13.6

(e) Complete the table above.

(2)

(f) The Arrhenius equation can be written in the form

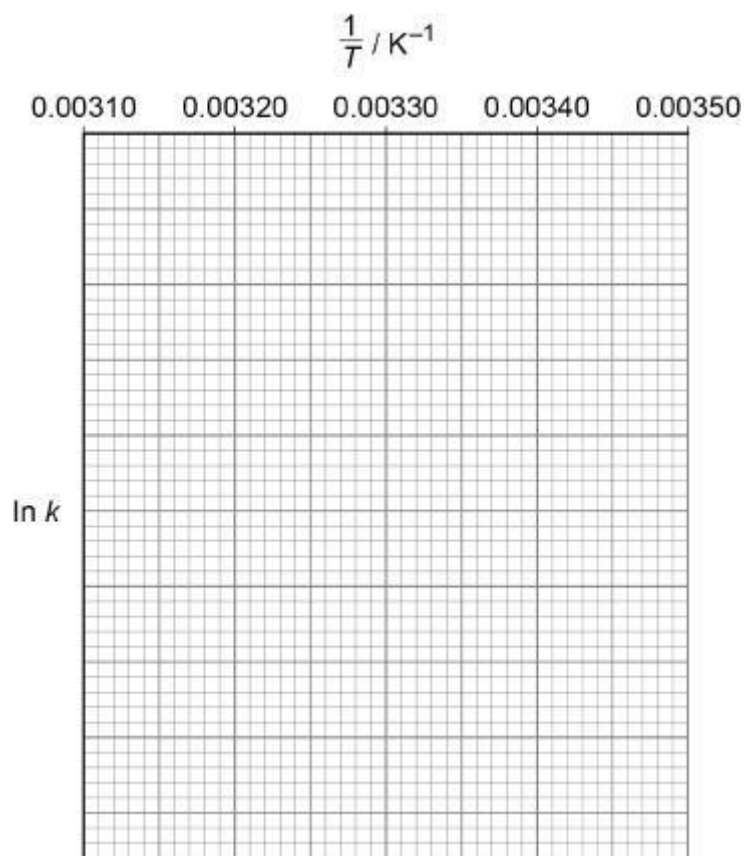
$$\ln k = \frac{-E_a}{RT} + \ln A$$

Use the data in the table above to plot a graph of $\ln k$ against $\frac{1}{T}$ on the grid in **Figure 2**.

Calculate the activation energy, E_a , in kJ mol^{-1}

The gas constant, $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

Figure 2



E_a _____ kJ mol^{-1} (5)
(Total 15 marks)