

4 (a) Nitrogen monoxide, NO, reacts with hydrogen, as shown in reaction 3.



(i) The rate equation for reaction 3 is shown.

$$\text{rate} = k[\text{H}_2][\text{NO}]^2$$

Complete Table 4.1.

Table 4.1

the order of reaction with respect to $[\text{H}_2]$	
the order of reaction with respect to $[\text{NO}]$	
the overall order of the reaction	

[1]

(ii) Predict how the initial rate for reaction 3 changes when the concentration of NO is halved.

..... [1]

(iii) Predict how the initial rate for reaction 3 changes when the concentrations of NO and H_2 are both increased **three** times.

..... [1]

(iv) Suggest why reaction 3 is unlikely to proceed by a mechanism involving only a single step.

..... [1]

(v) Suggest equations for the **three** steps of the reaction mechanism for reaction 3.

Each step involves a reaction between **two** molecules.

step 1 $\rightarrow$

step 2 + $\rightarrow \text{N}_2\text{O} +$

step 3 $\text{N}_2\text{O} +$ $\rightarrow$ +

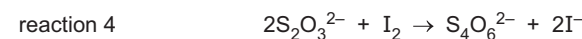
[2]

(vi) Suggest the role of N_2O in this mechanism.

Explain your reasoning.

..... [1]

(b) Iodine, I_2 , reacts with thiosulfate ions, $\text{S}_2\text{O}_3^{2-}$, as shown in reaction 4.



Reaction 4 is carried out in the presence of a large excess of I_2 . Under these conditions, the reaction is first order with respect to $[\text{S}_2\text{O}_3^{2-}]$ and zero order with respect to $[\text{I}_2]$.

The half-life, $t_{1/2}$, for reaction 4 is 720 s under certain conditions.

Calculate the value of the rate constant, k , for reaction 4. Include the units of k .

$k =$ units [1]

(c) The reaction between iodide ions, $\text{I}^-(\text{aq})$, and peroxydisulfate ions, $\text{S}_2\text{O}_8^{2-}(\text{aq})$, is catalysed by $\text{Co}^{3+}(\text{aq})$. The mechanism is similar to the mechanism of this reaction when $\text{Fe}^{3+}(\text{aq})$ is used as the catalyst.

(i) State the type of catalysis that occurs in this reaction.

Explain your reasoning.

..... [1]

(ii) Write **two** equations to show how $\text{Co}^{3+}(\text{aq})$ catalyses this reaction.

equation 1

equation 2 [2]

(iii) Suggest why this reaction is slow in the absence of $\text{Co}^{3+}(\text{aq})$.

..... [1]

[Total: 12]