

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  $\text{H}_2$  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  $\text{N}_2\text{O} +$  .....  $\rightarrow$  ..... + .....

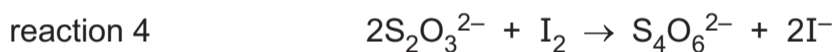
[2]

(vi) Suggest the role of  $\text{N}_2\text{O}$  in this mechanism.

Explain your reasoning.

..... [1]

(b) Iodine,  $\text{I}_2$ , 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  $\text{I}_2$ . 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,  $t_{\frac{1}{2}}$ , for reaction 4 is 720s 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]