

- 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, $S_2O_3^{2-}$, 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 $[S_2O_3^{2-}]$ and zero order with respect to $[I_2]$.

The half-life, $t_{\frac{1}{2}}$, 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, $I^-(aq)$, and peroxydisulfate ions, $S_2O_8^{2-}(aq)$, is catalysed by $Co^{3+}(aq)$. The mechanism is similar to the mechanism of this reaction when $Fe^{3+}(aq)$ 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 $Co^{3+}(aq)$ catalyses this reaction.

equation 1

equation 2 [2]

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

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..... [1]

[Total: 12]