

2(a)(i)	homolytic fission
2(a)(ii)	$\cdot\ddot{\text{O}}:\ddot{\text{N}}:\ddot{\text{O}} \quad \text{H}:\ddot{\text{O}}:\ddot{\text{N}}:\ddot{\text{O}}$
2(a)(iii)	115–120°
2(b)	M1: $3.825 \times 10^{-3} / 0.003825 / 0.00383 / 0.0038 / 3.8 \times 10^{-3}$ M2: units = $\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$
2(c)	not constant half-life because overall second order
2(d)	8.17 / 8.2
2(e)	- reactants are adsorbed onto the catalyst surface - bonds within reactant molecules are weakened - products are desorbed from catalyst surface Any two [1], all three [2]

3(a)	heterogeneous AND MnO_2 is in a different state / phase to the reactants / H_2O_2
3(b)(i)	M1: (expt 2 and 3) $[\text{I}^-] \times 2$ initial rate $\times 2$ so 1st order wrt $[\text{I}^-]$ M2: (expt 1 and 2) $[\text{I}^-] \times 2$, $[\text{H}_2\text{O}_2] \times 0.5$ initial rate $\times 1$ so 1st order wrt $[\text{H}_2\text{O}_2]$ OR (expt 1 and 4) $[\text{I}^-] \times 4$ initial rate $\times 4$ AND $[\text{H}^+] \times 4$ so zero order wrt $[\text{H}^+]$ OR (expt 1 and 3) $[\text{I}^-] \times 4$, $[\text{H}_2\text{O}_2] \times 0.5$ initial rate $\times 2$ so 1st order wrt $[\text{H}_2\text{O}_2]$ M3: (expt 1 and 4) $[\text{I}^-] \times 4$, $[\text{H}^+] \times 4$ initial rate $\times 4$ so zero order wrt $[\text{H}^+]$ OR (expt 3 and 4) $[\text{H}_2\text{O}_2] \times 2$ initial rate $\times 2$ AND $[\text{H}^+] \times 4$ so zero order wrt $[\text{H}^+]$ OR (expt 3 and 4) $[\text{H}_2\text{O}_2] \times 2$, $[\text{H}^+] \times 4$ initial rate $\times 2$ so 1st order wrt $[\text{H}_2\text{O}_2]$ M4: rate = $k [\text{H}_2\text{O}_2] [\text{I}^-]$ OR rate = $k [\text{H}_2\text{O}_2] [\text{I}^-] [\text{H}^+]^0$
3(b)(ii)	M1: $k = 2.42 \times 10^{-3} \div (0.045 \times 0.030) = 1.79 \text{ min}^{-1}$ M2: units = $\text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$
3(c)(i)	M1: calculation of one $t_{1/2} = 60 \text{ s} \pm 5 \text{ s}$ M2: two $t_{1/2}$ calculated that are constant
3(c)(ii)	$k = \ln 2 \div 60 = 0.0116$ OR $k = 0.693 \div 60 = 0.0116 \text{ min}^{-1}$
3(d)	increases k and increases the rate of reaction

4(a)(i)	the order of reaction with respect to $[\text{H}_2]$	1
	the order of reaction with respect to $[\text{NO}]$	2
	overall order of the reaction	3
4(a)(ii)	rate $\times \frac{1}{4}$	
4(a)(iii)	rate $\times 27$	
4(a)(iv)	a four-particle collision is unlikely	
4(a)(v)	step 1	$2\text{NO} \rightarrow \text{N}_2\text{O}_2$
	step 2	$\text{N}_2\text{O}_2 + \text{H}_2 \rightarrow \text{N}_2\text{O} + \text{H}_2\text{O}$
	step 3	$\text{N}_2\text{O} + \text{H}_2 \rightarrow \text{N}_2 + \text{H}_2\text{O}$
4(a)(vi)	intermediate formed (step 2) then used up later (step 3)	
4(b)	$k = 0.693 / 720 = 9.625 \times 10^{-4} \text{ min}^{-1}$ AND units: s^{-1}	
4(c)(i)	homogeneous AND Co^{3+} / catalyst / it is in the same phase / same state as the reactants	
4(c)(ii)	M1: (equation 1)	$2\text{Co}^{3+} + 2\text{I}^- \rightarrow 2\text{Co}^{2+} + \text{I}_2$
	M2: (equation 2)	$2\text{Co}^{2+} + \text{S}_2\text{O}_8^{2-} \rightarrow 2\text{Co}^{3+} + 2\text{SO}_4^{2-}$
4(c)(iii)	repulsion of two negative / same charge ions slows the reaction / raises E_{A}	