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) $[I^-] \times 2$ initial rate $\times 2$ so 1st order wrt $[I^-]$ **M2:** (expt 1 and 2) $[I^-] \times 2$, $[H_2O_2] \times 0.5$ initial rate $\times 1$ so 1st order wrt $[H_2O_2]$ **OR** (expt 1 and 4) $[I^-] \times 4$ initial rate $\times 4$ **AND** $[H^+] \times 4$ so zero order wrt $[H^+]$ **OR** (expt 1 and 3) $[I^-] \times 4$, $[H_2O_2] \times 0.5$ initial rate $\times 2$ so 1st order wrt $[H_2O_2]$ **M3:** (expt 1 and 4) $[I^-]$ x 4 , $[H^+] \times 4$ initial rate $\times 4$ so zero order wrt $[H^+]$ **OR** (expt 3 and 4) $[H_2O_2] \times 2$ initial rate $\times 2$ **AND** $[H^+]$ x 4 so zero order wrt $[H^+]$ **OR** (expt 3 and 4) $[H_2O_2] \times 2$, $[H^+] \times 4$ initial rate $\times 2$ so 1st order wrt $[H_2O_2]$ **M4:** rate = $k\,[H_2O_2]\,[I^-]$ **OR** rate = $k\,[H_2O_2]\,[I^-]\,[H^+]^0$
3(b)(ii)	**M1:** $k = 2.42 \times 10^{-3} \div (0.045 \times 0.030) = 1.79$ min 2sf **M2:** units = $dm^3\,mol^{-1}\,s^{-1}$
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** $k = 0.693 \div 60 = 0.0116$ min 2sf
3(d)	increases k and increases the rate of reaction

2(a)(i)	homolytic fission
2(a)(ii)	
2(a)(iii)	115–120°
2(b)	**M1:** 3.825×10^{-3} / 0.003825 / 0.00383 / 0.0038 / 3.8×10^{-3} **M2:** units = $mol^{-1}\,dm^3\,s^{-1}$
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]

4(a)(i)	<table><tr><td>the order of reaction with respect to $[H_2]$</td><td>1</td></tr><tr><td>the order of reaction with respect to [NO]</td><td>2</td></tr><tr><td>overall order of the reaction</td><td>3</td></tr></table>
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 $2NO \rightarrow N_2O_2$ step 2 $N_2O_2 + H_2 \rightarrow N_2O + H_2O$ step 3 $N_2O + H_2 \rightarrow N_2 + H_2O$
4(a)(vi)	intermediate formed (step 2) then used up later (step 3)
4(b)	$k = 0.693 / 720 = 9.625 \times 10^{-4}$ min 2sf **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) $2Co^{3+} + 2I^- \rightarrow 2Co^{2+} + I_2$ **M2:** (equation 2) $2Co^{2+} + S_2O_8^{2-} \rightarrow 2Co^{3+} + 2SO_4^{2-}$
4(c)(iii)	repulsion of two negative / same charge ions slows the reaction / raises E_A