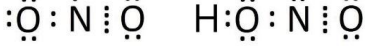
3(a)	heterogeneous **AND** MnO_2 is in a different state / phase to the reactants / H_2O_2
3(b)(i)	**M1:** (expt 2 and 3) $[I^-] \times 2$ initial rate $\times 2$ so 1st order wrt $[I^-]$ **M2:** (expt 1 and 2) $[I^-] \times 2$, $[H_2O_2] \times 0.5$ initial rate $\times 1$ so 1st order wrt $[H_2O_2]$ **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 $t_{1/2} = 60\ s \pm 5\ s$ **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]

<table>
<tr><td>4(a)(i)</td><td>
<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>
</td></tr>
<tr><td>4(a)(ii)</td><td>rate $\times \frac{1}{4}$</td></tr>
<tr><td>4(a)(iii)</td><td>rate $\times$ 27</td></tr>
<tr><td>4(a)(iv)</td><td>a four-particle collision is unlikely</td></tr>
<tr><td>4(a)(v)</td><td>step 1 $2NO \rightarrow N_2O_2$
step 2 $N_2O_2 + H_2 \rightarrow N_2O + H_2O$
step 3 $N_2O + H_2 \rightarrow N_2 + H_2O$</td></tr>
<tr><td>4(a)(vi)</td><td>intermediate formed (step 2) then used up later (step 3)</td></tr>
<tr><td>4(b)</td><td>$k = 0.693 / 720 = 9.625 \times 10^{-4}$ min 2sf
AND units: s^{-1}</td></tr>
<tr><td>4(c)(i)</td><td>homogeneous
AND Co^{3+} / catalyst / it is in the same phase / same state as the reactants</td></tr>
<tr><td>4(c)(ii)</td><td>**M1:** (equation 1) $2Co^{3+} + 2I^- \rightarrow 2Co^{2+} + I_2$
M2: (equation 2) $2Co^{2+} + S_2O_8^{2-} \rightarrow 2Co^{3+} + 2SO_4^{2-}$</td></tr>
<tr><td>4(c)(iii)</td><td>repulsion of two negative / same charge ions slows the reaction / raises E_A</td></tr>
</table>