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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 ± 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

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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)	the order of reaction with respect to $[H_2]$: 1; the order of reaction with respect to [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 $2NO \rightarrow N_2O_2$ 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

2(a)(i)	to increase the rate of drying / removal of (distilled) water
2(a)(ii)	iodine is not (very) soluble (in water)
2(a)(iii)	mass change is (too / very) small
2(a)(iv)	repeat without any iodine
2(b)	

time / s	mass of tin reacted / g
0	0.000
100	**0.069**
200	**0.120**
300	**0.218**
400	**0.291**
500	**0.359**

2(c)(i)	**M1** points plotted correctly *centre of all crosses should be on line for × value.* *y value should be on the line for point 1, 3* *point 2, 6 – just below line / on line* *4 – midway between two lines* *5 – just above line / on line*
	M2 straight line of best fit drawn
2(c)(ii)	most anomalous point circled (expected to be at time 200 s, point 3, below line of best fit) **AND** the balance/mass reading was taken before 200 s / too early
2(d)	**M1** two acceptable coordinates from line of best fit expressed in the form (x,y). **M2** gradient correctly calculated from points listed for **M1.** answer correctly rounded to 3 significant figures.

2(e)(i)	<table><tr><td>volume of 0.400 mol dm^{-3} I_2 solution used / cm^3</td><td>volume of methylbenzene used / cm^3</td></tr><tr><td>100.0</td><td>0.0</td></tr><tr><td>**75.0**</td><td>**25.0**</td></tr><tr><td>**50.0**</td><td>**50.0**</td></tr><tr><td>**25.0**</td><td>**75.0**</td></tr></table>
2(e)(ii)	$[I_2]$
2(e)(iii)	**M1** no **AND** the rate of reaction is proportional to the concentration of iodine / a conclusion based on calculations done for **M2**
	M2 explained using actual values from columns 3 and 4 in Table 2.2