Mark Scheme

Question	Answer	Marks	AO element	Guidance
1	C	1	AO1.1	
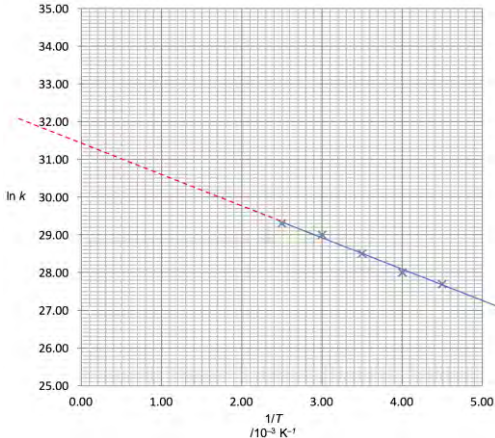
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	Question		Answer	Marks	Guidance

2	**(a)***		*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.*
			
			Level 3 (5–6 marks)
			A comprehensive conclusion which uses quantitative results for determination of the reaction orders.
			AND
			Determines *k* from correct rate equation.
			AND
			Proposes the two-step mechanism which adds up to overall equation *with no intermediate electrons*.
			
			There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated. The working for the scientific content is clearly linked to the experimental evidence.
			
			Level 2 (3–4 marks)
			Reaches a sound, but not comprehensive, conclusion based on the quantitative results.
			AND
			Correctly identifies the orders and rate equation.
			AND
			
			Calculates the rate constant
			OR
			Proposes the two-step mechanism with reactants of first step matching rate equation or matches orders
			
			There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence. The working for the scientific content is clearly linked to the experimental evidence.
				6	**Indicative scientific points may include:**
					Orders and rate equation
					• Fe^{3+} 1st order **AND** I^- 2nd order
					  OR *rate* $= k[Fe^{3+}][I^-]^2$
					• Supported by experimental results
					
					Calculation of *k*, including units
					• *k* correctly calculated **AND** correct units, e.g.
					  $k = \dfrac{8.10 \times 10^{-4}}{(4.00 \times 10^{-2}) \times (3.00 \times 10^{-2})^2} = 22.5$
					• $dm^6\,mol^{-2}\,s^{-1}$ **OR** $mol^{-2}\,dm^6\,s^{-1}$
					
					Two-step mechanism
					• Two steps add up to give overall equation
					• Slow step/ rate-determining step matches stoichiometry of rate equation.
					• Each step balances by species and charge
					e.g.
					$Fe^{3+}(aq) + 2I^-(aq) \rightarrow [FeI_2]^+$ SLOW
					$Fe^{3+}(aq) + [FeI_2]^+ \rightarrow 2Fe^{2+}(aq) + I_2(aq)$ FAST
					
					$Fe^{3+}(aq) + 2I^-(aq) \rightarrow Fe^{2+}(aq) + I_2^-(aq)$ SLOW
					$Fe^{3+}(aq) + I_2^-(aq) \rightarrow Fe^{2+}(aq) + I_2(aq)$ FAST
					
					$Fe^{3+}(aq) + 2I^-(aq) \rightarrow Fe^+ + I_2$ SLOW
					$Fe^{3+}(aq) + Fe^+ \rightarrow 2Fe^{2+}(aq)$ FAST
					
					There may be other feasible possibilities

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			Level 1 (1–2 marks) Attempts to reach a simple conclusion for orders **AND** Attempts a relevant rate equation. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant The working for the scientific content is clearly linked to the experimental evidence.* **0 marks** No response or no response worthy of credit.		

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(b)	(i)		 **Gradient** 　Correct gradient calculated from best-fit straight line drawn within the range ±800 → ±1040 ✓ **E_a calculation** 　E_a = (−) gradient × 8.314 ✓ 　*e.g. from ±820, E_a = (+)6817.48 (J mol^{-1})* **E_a to 3 SF AND** use of 10^{-3} for gradient ✓ 　*e.g. from ±820, E_a = (+)6820 (J mol^{-1})*	3	**ALLOW** lines which do not intercept y-axis **ALLOW** mark for gradient if correct working shown within E_a calculation without gradient being calculated separately **ALLOW** ±0.8(00) → ±1.04(0) *(omission of 10^{-3})* **ALLOW** ECF for calculated gradient x 8.314 If value of gradient not shown separately, **ALLOW** E_a in range: 6650 → 8650 **OR** 6.65 → 8.65 *(omission of 10^{-3})* **This mark subsumes gradient mark** **NOTE: Omission of 10^{-3} can get 1st 2 marks**

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		(ii)	Intercept shown on graph *could be by extrapolation of line, or label on y axis* **AND** ln A linked to intercept value *e.g. ln A = 31.4* ✓ Calculation of $A = e^{\text{intercept}}$ ✓ *e.g. $A = e^{31.4} = 4.33 \times 10^{13}$*	2	***ALLOW** y = 31.4* **ALLOW** substitution of correct values of ln k and 1/T into ln k = –E_a/R x 1/T + ln A to give a value of ln A which approximately matches the intercept if given *ln A = ln k + (E_a/R x 1/T)* *Calculation of $A = e^{lnA}$* **OR** $e^{ln\,k+\,(\,Ea/R\ \times\ 1/T)}$ **ALLOW** ECF from incorrect ln *A* $e^{31.2} = 3.55 \times 10^{13}$ $e^{31.3} = 3.92 \times 10^{13}$ $e^{31.35} = 4.12 \times 10^{13}$ $e^{31.45} = 4.56 \times 10^{13}$ $e^{31.5} = 4.79 \times 10^{13}$ $e^{31.6} = 5.29 \times 10^{13}$ $e^{31.7} = 5.85 \times 10^{13}$ $e^{31.8} = 6.46 \times 10^{13}$ $e^{31.9} = 7.14 \times 10^{13}$ $e^{32.0} = 7.9(0) \times 10^{13}$ $e^{32.1} = 8.73 \times 10^{13}$ IF 2 DP answer given, check rounding from calculator value, not 3 DP values given Eg $e^{31.7} = 5.8497 \times 10^{13}$ and $= 5.8 \times 10^{13}$(2SF)
			Total	**11**	

Mark Scheme

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3	D	1	1.1	