Question			Expected Answers	Marks	Additional Guidance
2	a		$BrO_3^- + 5Br^- + 6H^+ \longrightarrow 3Br_2 + 3H_2O$ ✓	1	**ALLOW** multiples
	b		***graph:***	1	***ANNOTATIONS MUST BE USED***
			Straight/diagonal line through origin **OR** 0,0 **AND** 1st order with respect to BrO_3^- ✓		**Both** explanation and 1st order required for mark **DO NOT ALLOW** diagonal line **OR** straight line **OR** constant gradient on its own (no mention of origin **OR** 0,0) **ALLOW** 'As BrO_3^- doubles, rate doubles' **AND** 1st order **ALLOW** rate is proportional to concentration **AND** 1st order
			initial rates data: When $[Br^-]$ is doubled, rate × 2 ✓ 1st order with respect to Br^- ✓ When $[H^+]$ × 2, rate × 4 (2^2) ✓ 2nd order with respect to H^+ ✓	4	Mark order and explanation independently Mark order first, then explanation
			Rate equation rate = k $[BrO_3^-]$ $[Br^-]$ $[H^+]^2$ ✓	1	**ALLOW** ECF from candidate's orders above

Question	Expected Answers	Marks	Additional Guidance
	Calculation of rate constant (3 marks) $k = \frac{\text{rate}}{[BrO_3^-][Br^-][H^+]^2}$ **OR** $\frac{1.19 \times 10^{-5}}{(5.0 \times 10^{-2})(1.5 \times 10^{-1})(3.1 \times 10^{-1})^2}$ ✓ $= 1.7 \times 10^{-2}$ **OR** 1.65×10^{-2} ✓ $dm^9\ mol^{-3}\ s^{-1}$ ✓	3	***ANNOTATIONS MUST BE USED*** **Calculation can be from any of the experimental runs – they all give the same value of *k*** **ALLOW** $mol^{-3}\ dm^9\ s^{-1}$ **ALLOW** 1.6510579×10^{-2} and correct rounding to 1.7×10^{-2} **Correct numerical answer subsumes previous marking point** **DO NOT ALLOW** fraction: $\frac{238}{14415}$ --- **ALLOW ECF from incorrect rate equation.** Examples are given below for 1st line of initial rates data. IF other rows have been used, then calculate the rate constant from data chosen. --- **Example 1:** 1st order with respect to H^+ *rate* = $k\ [BrO_3^-]\ [Br^-]\ [H^+]$ $k = \frac{\text{rate}}{[BrO_3^-][Br^-][H^+]}$ **OR** $\frac{1.19 \times 10^{-5}}{(5.0 \times 10^{-2})(1.5 \times 10^{-1})(3.1 \times 10^{-1})}$ ✓ $= 5.1 \times 10^{-3}$ **OR** 5.12×10^{-3} ✓ $dm^6\ mol^{-2}\ s^{-1}$ ✓ **ALLOW** $5.11827957 \times 10^{-3}$ and correct rounding to 5.1×10^{-3} --- **Example 2:** Zero order with respect to BrO_3^- *rate* = $k\ [Br^-]\ [H^+]^2$ $k = \frac{\text{rate}}{[Br^-][H^+]^2}$ **OR** $\frac{1.19 \times 10^{-5}}{(1.5 \times 10^{-1})(3.1 \times 10^{-1})^2}$ ✓ $= 8.3 \times 10^{-4}$ **OR** 8.26×10^{-4} ✓ $dm^6\ mol^{-2}\ s^{-1}$ ✓ **ALLOW** $8.255289629 \times 10^{-4}$ and correct rounding to 8.3×10^{-4}
	Total	**10**	

Question			Answer	Mark	Guidance
1	(a)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = 8.3×10^4 **OR** 83333 award **2 marks** **THEN IF** units are **$dm^6\ mol^{-2}\ s^{-1}$**, award 1 further mark $k = \frac{rate}{[H_2(g)]\ [NO(g)]^2}$ **OR** $\frac{3.6 \times 10^{-2}}{(1.2 \times 10^{-2}) \times (6.0 \times 10^{-3})^2}$ ✓ $= 8.3 \times 10^4$ **OR** 83000 **OR** 83333 ✓ units: $dm^6\ mol^{-2}\ s^{-1}$ ✓	 2 1	**ALLOW** 1 mark for 8.3×10^x with no working (power of 10 is error) **ALLOW** 2 SF up to calculator value of 8.33333333×10^4 correctly rounded **ALLOW ECF** for calculated answer from incorrectly rearranged *k* expression but **not** for units (Marked independently see below) **ALLOW** dm^6, mol^{-2} and s^{-1} in any order, ***eg*** $mol^{-2}\ dm^6\ s^{-1}$ **DO NOT ALLOW** other units (Rate equation supplied on paper – **not** derived from data)
	(b)	(i)	*effect on rate* × 2 ✓	1	**ALLOW** 'doubles' **OR** *rate* = 7.2 x 10^{-2} (mol $dm^{-3}\ s^{-1}$)
		(ii)	*effect on rate* × ¼ **OR** x 0.25 ✓	1	**ALLOW** 'a quarter' **OR** decrease by ¼ **OR** decrease by 0.25 **OR** rate decreases by 4 **OR** decrease by 75% **OR** *rate* = 0.9×10^{-2} (mol $dm^{-3}\ s^{-1}$) **DO NOT ALLOW** just 0.5^2 of rate **OR** rate decreases by 2^2
		(iii)	*effect on rate* × 64 ✓	1	**ALLOW** *rate* = 2.3(04) (mol $dm^{-3}\ s^{-1}$) **DO NOT ALLOW** just 'increases by 4 and then by 16 / 4^2 **OR** increases by 4^3

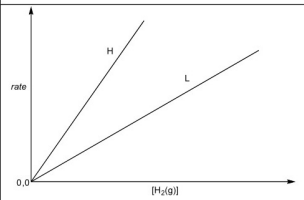
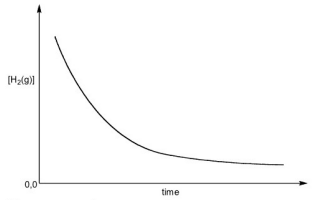
Question			Answer	Mark	Guidance
1	(c)	(i)	(initial) rate increases **AND** more frequent collisions **OR** more collisions **per second/time** ✓	1	**BOTH** points required for mark **ALLOW** rate increases **AND** concentration increases For concentration increases, **ALLOW** particles closer together **OR** less space between particles **DO NOT ALLOW** just more collisions **OR** collisions more likely
		(ii)	rate constant does not change ✓	1	
	(d)		step 1: $H_2(g) + 2\,NO(g) \longrightarrow N_2O(g) + H_2O(g)$ LHS of step one ✓ step 2: $H_2(g) + N_2O(g) \longrightarrow N_2(g) + H_2O(g)$ rest of equations for step 1 **AND** step 2 ✓	2	State symbols **NOT** required For 'rest of equations', This mark can **only** be awarded if 1st mark can be awarded **ALLOW** other combinations of **two** steps that together give the overall equation (shown above part in scoris window), *eg* step 1: $\longrightarrow N_2(g) + ½\,O_2(g) + H_2O(g)$ step 2: $H_2(g) + ½\,O_2(g) \longrightarrow H_2O(g)$ step 1: $\longrightarrow H_2O_2(g) + N_2(g)$ step 2: $H_2(g) + H_2O_2(g) \longrightarrow 2H_2O(l)$ There may be others with species, such as $H_2N_2O_2$ and HNO. Provided the two steps add up to give the overall equation **AND** charges balance, the 2nd mark can be awarded
			Total	**10**	

Question			Expected answers	Marks	Additional guidance
1	a		***graph:*** Rate does not change with concentration **AND** zero-order with respect to I_2 ✓ ***initial rates data:*** Mark independently When $[(CH_3)_2CO]$ × 2, rate × 2 (2^1) ✓ 1st order with respect to $(CH_3)_2CO$ ✓ When [HCl] x 2.5, rate × 2.5 ✓ 1st order with respect to HCl ✓		***ANNOTATIONS MUST BE USED*** **ALLOW** (straight) line with zero gradient **AND** zero-order **ALLOW** horizontal line **AND** zero-order **IGNORE** just 'constant line' **OR** just 'straight line' *also fits 1st order* ***CARE** with comparisons in opposite direction* **ALLOW** $[(CH_3)_2CO]$ × 0.5, rate × 0.5 (0.5^1) **ALLOW** [HCl] × 0.4, rate × 0.4 (0.4^1) **ALLOW** H^+ for HCl **CARE:** Comparison of **Experiments 1** and **3** may be valid despite **BOTH** concentrations changing
			Rate equation and rate constant: rate = $k[(CH_3)_2CO(aq)]\,[HCl(aq)]$ ✓ $k = \dfrac{rate}{[(CH_3)_2CO(aq)]\,[HCl(aq)]}$ **OR** $\dfrac{2.10 \times 10^{-9}}{(1.50 \times 10^{-3}) \times (2.00 \times 10^{-2})}$ ✓ = 7(.00) × 10^{-5} **OR** 0.00007(00) ✓ units: $dm^3\,mol^{-1}\,s^{-1}$ ✓	**9**	**ALLOW ECF** from incorrect orders In rate equation, square brackets **are required** rate = $k[(CH_3)_2CO(aq)][HCl(aq)][I_2(aq)]^0$ **ALLOW** H^+ for HCl **IGNORE** state symbols, even if wrong **ALLOW ECF** for units 'correct' for incorrect expression used to calculate *k, e.g. upside down or wrong orders* $\dfrac{[(CH_3)_2CO(aq)]\,[H^+(aq)]}{rate}$ × units: mol s dm^{-3} ✓

Question			Expected answers	Marks	Additional guidance
1	b		**step 1**: $H_2(g)$ + ICl(g) ⟶ LHS of step 1 ✓ ⟶ HCl(g) + HI(g) **step 2**: HI(g) + ICl(g) ⟶ HCl(g) + $I_2(g)$ products of step 1 **AND** step 2 ✓	2	State symbols **NOT** required **2nd mark** can **ONLY** be awarded provided that • **1st mark** has been awarded • **step 1 AND step 2** add up to the overall equation. e.g. **ALLOW** ⟶ $H_2ICl(g)$ **step 2**: $H_2ICl(g)$ + ICl(g) ⟶ 2HCl(g) + $I_2(g)$ In **step 2**, **ALLOW** inclusion of extra species on **both** sides of the equation **only** if they cancel, e.g. HI(g) + HCl(g) + ICl(g) ⟶ 2HCl(g) + $I_2(g)$
			Total	**11**	

Question			Answer	Marks	Guidance
2	(a)		**NOTE: First 3 marks are ONLY available from an expression using $[NO]^2$** **Units are marked independently** --- **Using values ON THE CURVE in CORRECT expression 1 mark** Use of any two correct values for rate and [NO] from graph e.g. for 5.0×10^{-4} and 4.2×10^{-4}, $k = \frac{4.2 \times 10^{-4}}{(2.0 \times 10^{-2}) \times (5.0 \times 10^{-4})^2}$ **OR** $4.2 \times 10^{-4} = k(2.0 \times 10^{-2}) \times (5.0 \times 10^{-4})^2$ ✓ --- **Calculation of *k* 2 marks** **FOR 1 MARK** *k* calculated **correctly** from values obtained from graph **BUT NOT** in standard form **AND/OR** more than 2 SF e.g. $k = \frac{6.0 \times 10^{-4}}{(2.0 \times 10^{-2}) \times (6.0 \times 10^{-4})^2} = 83333.33$ ✓ **OR FOR 2 MARKS** *k* calculated **correctly** from values obtained from graph **AND** in standard form **AND** TO 2 SF e.g. *k* = 83333.33 gives **8.3×10^4** ✓ --- **UNITS FOR 1 MARK:** $dm^6\ mol^{-2}\ s^{-1}$ ✓	4	**Note**: rate and [NO] are any correct pair of readings from the graph, The [NO] below are the most commonly seen. For these [NO] values, these are the **ONLY** rates allowed **IF OTHER values are given, mark using the same principle. If any doubt, contact TL.** **NOTE: IGNORE any numbers used from tangents** --- **SPECIAL CASES that ALLOW ECF for calculation of *k* from ONLY ONE of the following *(2 marks)*** **1.** Powers of 10 incorrect or absent in initial *k* expression **2.** $[H_2]^2[NO]$ used instead of $[H_2][NO]^2$ **3.** Any value within ±0.2 of actual values from graph --- **ALLOW** units in any order, e.g. $mol^{-2}\ dm^6\ s^{-1}$

[NO]	rate	*k*	*k*
1.0×10^{-4}	0.1×10^{-4} to 0.2×10^{-4}	50000 to 100000	5.0×10^4 to 1.0×10^5
2.0×10^{-4}	0.6×10^{-4} to 0.7×10^{-4}	75000 to 87500	7.5×10^4 to 8.8×10^4
3.0×10^{-4}	1.5×10^{-4}	83333	8.3×10^4
4.0×10^{-4}	2.7×10^{-4}	84375	8.4×10^4
5.0×10^{-4}	4.2×10^{-4}	84000	8.4×10^4
6.0×10^{-4}	6.0×10^{-4}	83333	8.3×10^4
7.0×10^{-4}	8.2×10^{-4}	83673	8.4×10^4

Question			Answer	Marks	Guidance
2	(b)	(i)	 One straight upward line **AND** starting at 0,0 ✓ 2nd straight upward line starting at 0,0 and steeper **AND** Steeper line labelled H **OR** less steep line labelled L ✓	2	**ALLOW** 1 mark for two upward sloping curves starting at origin **AND** upper curve labelled H and lower curve labelled L **NOTE: ALLOW** some leeway for lines starting from origin **ALLOW** straight line not drawn with ruler, i.e. is a straight line rather than a curve **ALLOW** similar labelling as long as it is clear which line is which
2	(b)	(ii)	increases ✓	1	
2	(c)		**MARK INDEPENDENTLY** ---  Downward curve ✓ Half life is constant ✓	2	**ALLOW** curve touching y axis **ALLOW** curve touching x axis **ALLOW** Two half lives are the same **IGNORE** 'regular' half life (not necessarily the same)

Question			Answer	Marks	Guidance
2	(d)	(i)	$H_2 + N_2O \rightarrow N_2 + H_2O$ ✓	1	**ONLY** correct answer **DO NOT ALLOW** multiples
2	(d)	(ii)	Steps 1 **AND** Step 2 together give $2NO + H_2$ ✓	1	**ALLOW** Step 1 **AND** Step 2 together give species in same ratio as in rate equation **ALLOW** rate-determining step/slow step for Step 2 **ALLOW** H_2 reacts with N_2O_2 which is formed from 2NO **NOTE**: The response must link Step 1 with Step 2 Steps can be referenced from the species in each step
			Total	11	