Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	• In experiments 1 and 2, $[H^+]$ doubles (whilst keeping other concentrations constant) **and** the rate quadruples / rate increases x 4 **(1)** • Second order (with respect to H^+) **(1)** • In experiments 1 and 3, $[Br^-]$ doubles **and** $[BrO_3^-]$ triples (with $[H^+]$ constant) **(1)** • Rate increases by 3 x 2 / rate increases x 6 / rate increases to 5.04×10^{-5} (then to 1.01×10^{-4} stated or implied) **(1)** • First order with respect to Br^- **(1)** **OR** • In experiments 2 and 3,$[Br^-]$ doubles **and** $[BrO_3^-]$ triples **and** $[H^+]$ halves **(1)** • Rate increases by 3 x 0.25 x 2 / rate increases x 1.5 **(1)** • First order with respect to Br^- **(1)** **Penalise OMISSION of Experiment Numbers once only** **Mark each point independently**		**5**

Question Number	Acceptable Answers	Reject	Mark
1(a)(ii)	Rate = $k\ [BrO^-_3]\ [Br^-]\ [H^+]^2$ Mark CQ on (a)(i) Allow "r" or "R" for "rate" in the rate equation. **IGNORE** If *k* appears to be in upper case.		**1**

Question Number	Acceptable Answers	Reject	Mark
1(a)(iii)	**IGNORE** sf except 1 sf THROUGHOUT **FIRST, CHECK THE FINAL ANSWER** **IF** answer $k = 1.49 \times 10^{-2}$ **dm^9 mol^{-3} s^{-1}** award **(3)** marks $k = \frac{\text{rate}}{[BrO^-_3]\ [Br^-]\ [H^+]^2}$ $= \frac{1.68 \times 10^{-5}}{0.05 \times 0.25 \times (0.30)^2}$ **(1)** $= 0.014933333$ $= 0.0149$ **(1)** **dm^9 mol^{-3} s^{-1} / mol^{-3} dm^9** s^{-1} **(1)** **IGNORE** sf except 1 sf Mark CQ from (a)(ii) or, if no rate equation in (a)(ii), then any rate equation stated in (a)(iii) **NOTE:** **IF** the rate equation in (a)(ii) is given as Rate $= k\ [BrO^-_3]\ [H^+]^2$ CQ $k = 3.73 \times 10^{-3}$ $dm^6\ mol^{-2}\ s^{-1}$ scores **(3)** **IF** $[H^+]$ is not squared in the correct rate equation: $k = 4.48 \times 10^{-3}$ $dm^9\ mol^{-3}\ s^{-1}$ OR $k = 4.48 \times 10^{-3}$ $dm^6\ mol^{-2}\ s^{-1}$ scores **(2)** **ALLOW** Correct answers derived from the data in the table for Experiment 2 or Experiment 3		**3**

Question Number	Acceptable Answers	Reject	Mark
1(b)	The number(s) (of particles) in the rate equation / rate-determining step do not match those in the equation for the reaction **OR** The chance of (simultaneous) collision of 12 particles is unlikely **OR** The chance of (simultaneous) collision of 4 particles is unlikely **OR** The chance of (simultaneous) collision of 3 reactants is unlikely **ALLOW** 'molecules' / 'substances' for 'particles' ***NOTE*** **ALLOW AS A CQ from (a)(ii)** Br^- ions not in rate equation / Br^- ions not in rate-determining step / Zero order with respect to Br^- / (Only) two reactants in the rate-determining step / (only) two reactants in the rate-equation/ particles are in the equation (for the reaction) that are not in the rate equation		**1**

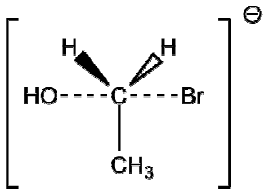
Question Number	Acceptable Answers	Reject	Mark
1(c)	**REMEMBER TO SCROLL DOWN BELOW THE SPACE LEFT FOR A SKETCH-GRAPH TO SEE WHAT CANDIDATE HAS WRITTEN ON THE DOTTED LINES** • (Calculate) gradient (of tangent) **(1)** **ALLOW** 'slope' for 'gradient' • At t = 0 / at the start / at the beginning / when reaction is at its fastest / at the origin **(1)** **Each mark is stand-alone** **NOTE:** Answer may be annotated on a suitable sketch-graph **IGNORE** any sketch-graph that shows an increase in concentration with time **MAX (1)** if sketch-graph shows a **decrease** in the concentration of a reactant / Br_2	Answers relating to half-life score **(0)** overall If sketch-graph or comments suggest that gradient is measured at other than t = 0 or at several values of t then **max (1)**	**2**

Question Number	Acceptable Answers	Reject	Mark
2(a)(i)	k = (1.54 x 10^{-6}) ÷ (0.1 x 0.15) **(1)** (= 1.0267 x 10^{-4}) = 1.03 x 10^{-4} **(1)** must be to 3 SF dm^3 mol^{-1} s^{-1} **(1)** Unit mark is stand alone and units can be in any order Correct answer with units but no working **(3)** marks	 1.02 x 10^{-4}	**3**

Question Number	Acceptable Answers	Reject	Mark

2(a)(ii)	If correct unrounded answer to (a) (i) stored in calculator then
	4.1067 x 10^{-8} = 4.1 x 10^{-8} (mol dm^{-3} s^{-1})
	
	OR
	
	If 1.0267 x 10^{-4} used then
	4.1068 x 10^{-8} = 4.1 x 10^{-8} (mol dm^{-3} s^{-1})
	
	OR
	
	If 1.03 x 10^{-4} used then
	4.12 x 10^{-8} = 4.1 x 10^{-8} (mol dm^{-3} s^{-1})
	
	IGNORE sf except 1sf
	
	IGNORE units even if incorrect
	TE from (a)(i)
			1

Question Number	Acceptable Answers	Reject	Mark
2(b)(i)	2(nd)/second/two/(1 + 1) = 2 (order)		**1**

Question Number	Acceptable Answers	Reject	Mark
2(b)(ii)	 Structure **(1)** ALLOW structure without wedged bonds Dotted bonds must be shown and OH and Br must be on opposite sides with a C-C or C-H bond between them Charge **(1)** Charge mark can be awarded for a near miss with a single error in the structure (e.g. one hydrogen atom missing) ALLOW –ve charge shown as δ− on both OH and Br Brackets not essential ALLOW –ve charge to be anywhere on the structure IGNORE δ+ on carbon atom		**2**

Question Number	Acceptable Answers	Reject	Mark
2(c)(i)	3.00×10^{-3} **(1)** IGNORE sf for 1/T −5.58 **(1)** IGNORE sf except 1sf	-5.60	**2**

Question Number	Acceptable Answers	Reject	Mark
2(c)(ii)	Appropriate scale **(1)** Plotted points **must** cover at least half of the graph paper on each axis. Points plotted correctly **and** straight line drawn **(1)** through all points Gradient = —10230 ± 500 **(1)** Example E_a = 10230 x 8.31**(1)** allow TE from incorrect gradient E_a = (+) 85.0 kJ(mol^{-1})/(+) 85 000 J (mol^{-1}) **(1)** 3 sf E_a range from 80.9 to 89.2 kJ mol^{-1} ALLOW TE from incorrect gradient IGNORE SF except 1	K^{-1}	**5**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(i)	**These are stand alone marks** **First mark:** (ensures that) $[H^+]$ **and** [propanone] (virtually) constant OR so that the $[H^+]$ **and** [propanone] do not affect the rate **(1)** **Second mark:** the $[I_2]$ / iodine concentration changes OR so that the **overall** order (of reaction) is **not** determined OR otherwise a curve (graph) is obtained **(1)** ***NOTE:-*** "**only** the $[I_2]$ changes **scores (2)** **OR** "**only** the I_2 concentration changes" **scores (2)** **BUT** "only the iodine changes" **scores (1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(ii)	**First mark:** **double** the concentration of propanone *OR* change/increase/decrease the concentration of propanone **(1)** **Second mark (mark consequentially):** slope/gradient of line **doubles** *ALLOW* "rate doubles" *OR* slope or gradient changes/increases/decreases by same factor *ALLOW* "rate changes/increases/decreases by same factor" **(1)** ***NOTE:*** **may suggest a different procedure**:- **First mark:** monitor/measure [propanone] over time **(1)** **Second mark (mark consequentially):** plot [propanone] v. time graph **and** state that $t_{½}$ constant **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(iii)	I_2 not involved in rate-determining step/ I_2 not involved in slow(est) step / H^+ and propanone involved in rate-determining step/ H^+ and propanone involved in slow(est)step **(1)** so there must be another step where I_2 is involved/ so there must be a fast step where I_2 is involved **(1)** ***BUT*:-** I_2 not involved until **after** the rate-determining step/ I_2 not involved until **after** the slow(est) step **(2)** *ALLOW* H^+ involved in rate-determining step **(1)** and is regenerated as it is a catalyst (in another step) **(1)**	I_2 involved **before** rate-determining/slowest step **(0)**	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(i)	$HCO_3^- + H^+ \rightarrow H_2O + CO_2$ OR $HCO_3^- + H^+ \rightarrow H_2CO_3$ OR $HCO_3^- + H_3O^+ \rightarrow 2H_2O + CO_2$ OR $HCO_3^- + H_3O^+ \rightarrow H_2CO_3 + H_2O$ *ALLOW:* $NaHCO_3 + H^+ \rightarrow Na^+ + H_2O + CO_2$ OR $Na^+ + HCO_3^- + H^+ \rightarrow Na^+ + H_2O + CO_2$ *IGNORE* any correct or any incorrect state symbols	$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$ OR any equations with HA	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(ii)	$CH_3COCH_3 + \mathbf{3}I_2 + \mathbf{4}NaOH \rightarrow CHI_3 + CH_3COONa + \mathbf{3}NaI + \mathbf{3}H_2O$ *IGNORE* any correct or any incorrect state symbols **CHI_3** on RHS of equation **(1)** remaining species correct **(1)** balanced equation **(1)** ***NOTE:*** balancing mark is CQ on all species correct **Accept** correct ionic equation (i.e. Na^+ omitted) NOTE: If **CH_3I**, can only access second mark above		**3**

Question Number	Acceptable Answers	Reject	Mark
4 (a)(i)	**These are stand alone marks** **First mark:** (ensures that) $[H^+]$ **and** [propanone] (virtually) constant OR so that the $[H^+]$ **and** [propanone] do not affect the rate **(1)** **Second mark:** the $[I_2]$ / iodine concentration changes OR so that the **overall** order (of reaction) is **not** determined OR otherwise a curve (graph) is obtained **(1)** ***NOTE:-*** **"only** the $[I_2]$ changes **scores (2)** **OR** **"only** the I_2 concentration changes" **scores (2)** **BUT** "only the iodine changes" **scores (1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
4 (a)(ii)	**First mark:** **double** the concentration of propanone *OR* change/increase/decrease the concentration of propanone **(1)** **Second mark (mark consequentially):** slope/gradient of line **doubles** *ALLOW* "rate doubles" *OR* slope or gradient changes/increases/decreases by same factor *ALLOW* "rate changes/increases/decreases by same factor" **(1)** ***NOTE:*** **may suggest a different procedure**:- **First mark:** monitor/measure [propanone] over time **(1)** **Second mark (mark consequentially):** plot [propanone] v. time graph **and** state that $t_{½}$ constant **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
4 (a)(iii)	I_2 not involved in rate-determining step/ I_2 not involved in slow(est) step / H^+ and propanone involved in rate-determining step/ H^+ and propanone involved in slow(est)step **(1)** so there must be another step where I_2 is involved/ so there must be a fast step where I_2 is involved **(1)** ***BUT:-*** I_2 not involved until **after** the rate-determining step/ I_2 not involved until **after** the slow(est) step **(2)** *ALLOW* H^+ involved in rate-determining step **(1)** and is regenerated as it is a catalyst (in another step) **(1)**	I_2 involved **before** rate-determining/slowest step **(0)**	**2**

Question Number	Acceptable Answers	Reject	Mark
4 (b)(i)	$HCO_3^- + H^+ \rightarrow H_2O + CO_2$ OR $HCO_3^- + H^+ \rightarrow H_2CO_3$ OR $HCO_3^- + H_3O^+ \rightarrow 2H_2O + CO_2$ OR $HCO_3^- + H_3O^+ \rightarrow H_2CO_3 + H_2O$ *ALLOW:* $NaHCO_3 + H^+ \rightarrow Na^+ + H_2O + CO_2$ OR $Na^+ + HCO_3^- + H^+ \rightarrow Na^+ + H_2O + CO_2$ *IGNORE* any correct or any incorrect state symbols	$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$ OR any equations with HA	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (b)(ii)	$CH_3COCH_3 + \mathbf{3}I_2 + \mathbf{4}NaOH \rightarrow CHI_3 + CH_3COONa + \mathbf{3}NaI + \mathbf{3}H_2O$ *IGNORE* any correct or any incorrect state symbols **CHI_3** on RHS of equation **(1)** remaining species correct **(1)** balanced equation **(1)** ***NOTE:*** balancing mark is CQ on all species correct **Accept** correct ionic equation (i.e. Na^+ omitted) NOTE: If **CH_3I**, can only access second mark above		**3**