

Question Number	Acceptable Answers	Reject	Mark
<b>1(a)</b>	<p>So that the phenol is used up / methyl orange is bleached before the rate changes (significantly)</p> <p>OR</p> <p>So that the phenol is used up / methyl orange is bleached during the initial rate period</p> <p>OR</p> <p>So that the concentration of bromide/bromate/reactants does not fall significantly before all the phenol is used up / the methyl orange is bleached</p> <p>OR</p> <p>Within this region/period/time the average rate of reaction approximates to the initial rate</p>	bromine	<b>(1)</b>

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<b>1(b)(i)</b>	<p>So that only the <b>concentration</b> of bromide ions varies (significantly) during the course of the reaction / so that the <b>concentration</b> of the bromide ions is the limiting factor / so that the <b>concentration</b> of bromide ions is the only variable</p> <p>ALLOW</p> <p>So their <b>concentrations</b> / the <math>\text{BrO}_3^-</math> and <math>\text{H}^+</math> <b>concentrations</b> do not change</p> <p>OR</p> <p>So their <b>concentrations</b> / the <math>\text{BrO}_3^-</math> and <math>\text{H}^+</math> <b>concentrations</b> are not the limiting factor</p>		<b>(1)</b>

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<b>1 (b) (ii)</b>	<p><b>M1:</b> Completed table 2.75 (1)</p> <p><b>M2:</b> Axes correct with sensible scales so at least half of the graph paper on both axes is covered (1)</p> <p><b>M3:</b> Axes labels fully correct, with units (1)</p> <p><b>M4:</b> All points plotted correctly (allow <math>\pm 1</math> small square) and straight line drawn <b>through (0,0)</b> and through all appropriate points (1)</p>		<b>(4)</b>																					
Exemplar:																								
<table border="1"> <tbody> <tr> <td>Volume of Br (aq) / cm<sup>3</sup></td> <td>10.0</td> <td>8.0</td> <td>6.0</td> <td>5.0</td> <td>4.0</td> <td>2.0</td> </tr> <tr> <td>Time / s</td> <td>180</td> <td>226</td> <td>300</td> <td>364</td> <td>444</td> <td>900</td> </tr> <tr> <td>(1/time) / 10<sup>-3</sup> s<sup>-1</sup></td> <td>5.56</td> <td>4.42</td> <td>3.33</td> <td>2.75</td> <td>2.25</td> <td>1.11</td> </tr> </tbody> </table>				Volume of Br (aq) / cm <sup>3</sup>	10.0	8.0	6.0	5.0	4.0	2.0	Time / s	180	226	300	364	444	900	(1/time) / 10 <sup>-3</sup> s <sup>-1</sup>	5.56	4.42	3.33	2.75	2.25	1.11
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<b>1 (b) (iii)</b>	<p><b>M1:</b> First order This mark is independent of the graph drawn <b>(1)</b></p> <p><b>M2:</b> Because the graph is a straight line (through the origin) OR rate is proportional to <math>[\text{Br}^-]</math> / rate is proportional to volume of <math>\text{Br}^-</math> OR As concentration / volume increases by (factor of) 2, rate increases by 2 (or any other numbers, including 'x') OR Rate increases linearly (with concentration)</p> <p>ALLOW Gradient of line is constant <b>(1)</b></p> <p><b>M2 can only be awarded if M1 correct</b></p>		<b>(2)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>1 (b) (iv)</b>	<p>Rate = <math>k [\text{Br}^-][\text{BrO}_3^-][\text{H}^+]^2</math> ALLOW 'r =' instead of "rate =" Allow TE on their order wrt <math>\text{Br}^-</math> from (b)(iii) <b>(1)</b></p> <p><math>\text{dm}^9 \text{mol}^{-3} \text{s}^{-1}</math></p> <p>Allow the units in any order Allow TE for M2 on candidate's stated rate equation <b>(1)</b></p> <p>e. if rate = <math>k [\text{BrO}_3^-][\text{H}^+]</math> then TE on units for <math>\text{dm}^6 \text{mol}^{-2} \text{s}^{-1}</math></p>		<b>(2)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>1 (c) (i)</b>	They are spectator ions OR They are unchanged (on both sides of the equation) OR They do not take part in the reaction / they do not play any part in the reaction ALLOW "They cancel out"		<b>(1)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>1 (c) (ii)</b>	Blue-black colour appears / turns blue-black  ALLOW blue or black / shades of blue or black  <b>IGNORE</b> Any INITIAL colour Any reference to precipitate / solid	Black from blue  Purple  Bluer  Blacker	<b>(1)</b>

Question Number	Acceptable Answers	Reject	Mark
<b>1 (d) (i)</b>	Measure the time taken (for the blue-black colour to appear) and temperature		<b>(1)</b>

Question Number	Acceptable Answers	Reject	Mark
1 (d) (ii)	<p>Temperature converted to kelvin OR <math>K^{-1}</math> given as units on the x-axis of the graph (1)</p> <p><b>M2</b> The vertical axis should be <math>\ln</math> rate / <math>\ln 1/t</math> <b>Note</b> ALLOW <math>\ln k</math> for this mark (1)</p> <p><b>M3</b> The horizontal axis should be <math>1/T</math> (1)</p> <p><b>M4</b> <b>Straight</b> line (with a negative gradient) OR Can be shown by candidate in a sketch graph of a <b>straight</b> line with a negative gradient (1)</p> <p><b>M5</b> Any mention of <b>gradient</b> (of the line) (1)</p> <p><b>M6</b> Rearranges expression so: <math>E_a = -\text{gradient} \times R</math> OR 'Multiply gradient by <math>-R</math>' Negative sign <b>MUST</b> be shown or mentioned specifically (1)</p> <p><b>NOTE:</b> Plot "<math>\ln</math> rate <b>against</b> <math>1/T</math>" scores both M2 and M3 If axes clearly the wrong way round max (4) – namely only marks M1, M4, M5 and M6 are possible</p>	<p>1/T</p> <p>1/t</p>	<b>(6)</b>

Question Number	Correct Answer	Reject	Mark
<b>2 (a)</b>	<p><b>1st mark:</b> Take <b>samples</b> (of reaction mixture) at various times OR Using of different mixtures (e.g. in separate conical flasks) <b>(1)</b></p> <p>THEN: <b>EITHER</b> Quench (with ice) / remove the catalyst <b>(1)</b></p> <p><b>Titrate with acid of known concentration/standard</b> (using a suitable indicator) <b>(1)</b></p> <p><b>OR</b> Quench with acid <b>(1)</b></p> <p><b>Titrate with alkali of known concentration</b> (using a suitable indicator) <b>(1)</b></p> <p>If no quenching, M3 can only be awarded if titrate with acid of known concentration</p>	NaHCO <sub>3</sub>       NaHCO <sub>3</sub>	<b>3</b>

Question Number	Correct Answer	Reject	Mark
<b>2 (b)</b> <b>(i)</b>	<p>(As) rate is (directly) proportional to concentration / as [A] doubles so does rate / rate <math>\propto</math> concentration / rate <math>\propto</math> [A]</p> <p>ALLOW Just 'straight line through origin/(0,0)'</p> <p>IGNORE References just to a 'constant gradient' References to <b>just</b> 'it is a straight line' References to positive correlation</p>		<b>1</b>

Question Number	Correct Answer	Reject	Mark
<p><b>2 (b)</b> <b>(ii)</b></p>	<p><b>1st mark:</b> Rate higher than expected / rate unusually high / higher rate (for the anomalous points on the graph) <b>(1)</b></p> <p><b>2nd mark:</b> Reaction is exothermic / (heat) energy is released during the reaction <b>(1)</b></p> <p><b>3rd mark:</b> <b>EITHER</b> (So) there are more particles/collisions with energy <math>&gt; E_a</math>  ALLOW Higher <b>proportion of</b> successful collisions / just more successful collisions  <b>IGNORE</b> <b>Just</b> 'more collisions' / 'more frequent collisions'  <b>OR</b> At higher concentrations of <b>A</b>, the effect of the reaction being exothermic is greater  <b>(1)</b></p>		<b>3</b>

Question Number	Correct Answer	Reject	Mark
<b>2 (c) (i)</b>	<p>Increases reliability / improves validity (of the data obtained) / confirms the initial results / to check for anomalous results IGNORE References to average / precision / accuracy</p> <p><b>OR</b></p> <p>To determine order w.r.t. B and X / to see the effect of B and X (on the rate) / enables order of other reagents to be determined / to determine order w.r.t. B / find overall order / determine rate equation / to calculate <math>k</math></p>		<b>1</b>

Question Number	Correct Answer	Reject	Mark
<b>2 (c) (ii)</b>	<p>0 order w.r.t. B <span style="float: right;"><b>(1)</b></span></p> <p>1st order w.r.t. X <span style="float: right;"><b>(1)</b></span></p> <p>Rate = <math>k [A][X]</math> OR Rate = <math>k [A][X][B]^0</math></p> <p>ALLOW TE for CQ correct rate equation on incorrect order(s) <span style="float: right;"><b>(1)</b></span></p> <p><b>Correct reasoning using data from table</b> to deduce the <b>CORRECT</b> order w.r.t. B</p> <p>NOTE that there must be reference to <b>TWO</b> relevant concentrations changing</p> <p>Eg (Expt 1 &amp; 3) [A] triples, so does rate <b>AND</b> [B] doubles so order w.r.t. B is 0</p> <p>(Expt 2 &amp; 3) [A] x 1.5, rate x 1.5 <b>AND</b> [B] doubles so order w.r.t. B is 0</p> <p>This mark can only be awarded if the reasoning shows that order w.r.t B is zero. <span style="float: right;"><b>(1)</b></span></p> <p>Not enough <b>just</b> to say 'as [B] doubles, rate unchanged' <b>Correct reasoning using data from table</b> to</p>		<b>5</b>



	<p>deduce the <b>CORRECT</b> order w.r.t. X</p> <p>NOTE that there must be reference to <b>TWO</b> relevant concentrations changing</p> <p>E.g.          (Expt 1 &amp; 4) [A] x 4 (and [B] x 2) <b>AND</b> [X] ÷ 2          rate doubles          so order w.r.t. X is 1</p> <p>(Expt 2 &amp; 4) [A] x 2 (and [B] x 2) <b>AND</b> [X] ÷ 2          rate stays the same          so order w.r.t. X is 1</p> <p>(Expt 3 &amp; 4) [A] x 4/3 (and [B] stays the same)  <b>AND</b> [X] ÷ 2          rate decreases by 2/3, so order w.r.t. X is 1</p> <p>This mark can only be awarded if the reasoning shows that order w.r.t X is one.</p> <p>Not enough <b>just</b> to say 'as [X] doubles, rate doubles'</p> <p style="text-align: right;"><b>(1)</b></p> <p>IGNORE          Any justification not concluded from data in the table          Working to confirm order w.r.t. A = 1 (already given in question)</p> <p>NOTE          Correct rate equation <b>alone</b> scores M1, M2 and M3</p>		
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<b>2 (c) (iii)</b>	$k = \text{rate} / [\text{A}][\text{X}] = 4.2 \times 10^{-3} \div (0.08 \times 0.25)$ $= 0.21$ <p style="text-align: right;"><b>(1)</b></p> $\text{dm}^3 \text{mol}^{-1} \text{s}^{-1} / \text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$ ALLOW units in any order <p style="text-align: right;"><b>(1)</b></p> Comment Unit mark is independent of the value <b>Allow use of data from experiments 1, 2 &amp; 3</b> Allow TE from an incorrect rate equation given in answer to Q14(c)(ii) or a 'new' rate equation given at the start of answer to Q14(c)(iii), if of the form rate = k ...		<b>2</b>

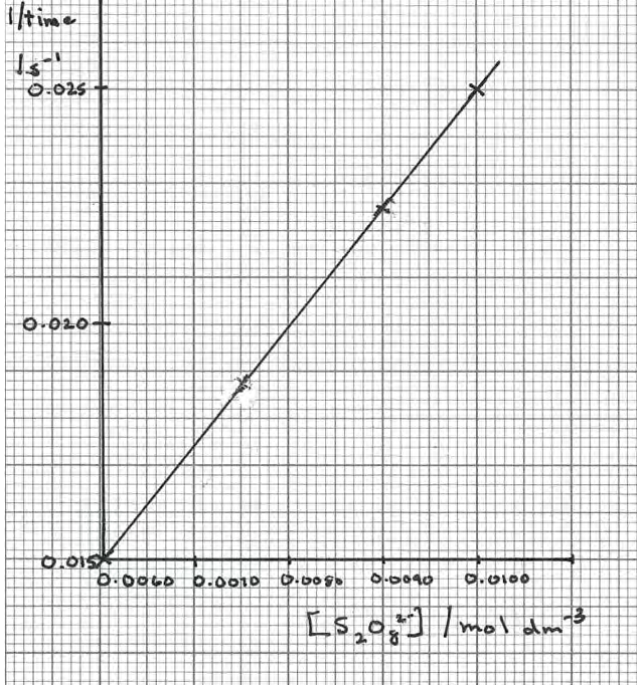
Question Number	Correct Answer	Reject	Mark
2 (d)	<p><b>Correct feature</b></p> <p><b>ANY <u>one</u> of:</b></p> <p>First step does involve carbocation formation / carbocation is correct / two electrons taken by Br atom in C–Br bond / C–Br bond breaks (heterolytically)</p> <p>(Second step does involve) attack of hydroxide ion</p> <p>First order wrt the halogenoalkane / 1st order wrt 2-bromomethylpropane</p> <p>(S<sub>N</sub>1) is a two-step process</p> <p>Curly arrows<u>s</u> are correct</p> <p style="text-align: right;"><b>(1)</b></p> <p><b>Incorrect features</b></p> <p><b>ANY <u>two</u> of:</b></p> <ul style="list-style-type: none"> <li>• Should be S<sub>N</sub>1 (not S<sub>N</sub>2)</li> <li>• First step is slow</li> <li>• Second step is fast</li> <li>• (It is not) S<sub>N</sub>2</li> <li>• C<sup>δ+</sup> – Br<sup>δ-</sup> not shown / dipole on C–Br bond not shown</li> </ul> <p style="text-align: right;"><b>(2)</b></p>		<b>3</b>

Question Number	Correct Answer	Reject	Mark
<b>3(a)</b>	$\text{S}_2\text{O}_8^{2-} + 2\text{I}^- \rightarrow 2\text{SO}_4^{2-} + \text{I}_2$ <p>ALLOW multiples</p> <p>Ignore state symbols even if incorrect</p>		<b>1</b>

Question Number	Correct Answer	Reject	Mark
<b>3 (b) (i)</b>	<p>Blue/black /blue-black</p> <p>OR</p> <p>Colourless to blue-black/ blue/black</p>	Purple	<b>1</b>

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<b>3 (b) (ii)</b>	<p>The mixture would change colour/ go blue/black /blue-black</p> <p><b>immediately/straight away</b></p> <p>ALLOW</p> <p>...too quick(ly)/too early</p> <p>...quicker</p> <p>...no time delay</p>		<b>1</b>

Question Number	Correct Answer	Reject	Mark
<b>3 (b) (iii)</b>	<p>(As quickly as iodide reacts to form iodine it is) reduced/turned back to iodide by the thiosulfate ions</p> <p>ALLOW</p> <p>Persulfate reacts with thiosulfate first.</p> <p>OR</p> <p>Iodine reacts with thiosulfate.</p>		<b>1</b>

Question Number	Correct Answer	Reject	Mark
<p><b>3</b></p> <p>(c) (i)</p>	 <p><b>First mark</b>  Correct graph of rate v concentration,  with axes correct <b>and</b> values increasing on both axes  labelled with quantity <b>and</b> units  Note  Units may be given in brackets with no slash.  s/time meaning s divided by time is fine. (1)</p> <p><b>Second mark</b>  Sensible scales to use at least half the graph paper but allow graphs starting at the origin and points cover two by two big squares.  Linear scales  All points reasonably correct with straight line drawn (1)  Second mark depends on correct graph of rate v concentration, but not other detail of first mark</p>		<p><b>2</b></p>

Question Number	Correct Answer	Reject	Mark
<b>3</b> <b>(c) (ii)</b>	<p>First order</p> <p>This mark is independent of the graph drawn <b>(1)</b></p> <p>Because the graph is a straight line (through the origin)/ rate is proportional to <math>[S_2O_8^{2-}]</math></p> <p>OR</p> <p>As concentration increases by (factor of) 2 rate increases by 2 (or any other numbers, including 'x')</p> <p>OR</p> <p>Rate increases linearly (with concentration)</p> <p>OR</p> <p>Gradient of line is constant <b>(1)</b></p> <p>Second mark depends on first order</p>	Just 'as concentration increases rate increases'	<b>2</b>

Question Number	Correct Answer	Reject	Mark
<b>3</b> <b>(c) (iii)</b>	<p>Rate = <math>k[S_2O_8^{2-}][I^-]</math> <b>(1)</b></p> <p>TE from (c)(ii)</p> <p>Units - <math>dm^3 mol^{-1} s^{-1}</math></p> <p>ALLOW</p> <p>Internal TE from rate equation <b>(1)</b></p> <p>Units in any order</p>	Incorrect formulae	<b>2</b>

Question Number	Correct Answer	Reject	Mark
<b>3 (d) (i)</b>	<p><b>Method 1</b></p> <p><b>First mark</b></p> <p>Gradient = <math>- E_a/R</math></p> <p>OR</p> <p><math>E_a = - R \times \text{gradient}</math> <b>(1)</b></p> <p><b>Second mark</b></p> <p>(Gradient =) <math>\frac{-3.0 - (-3.69)}{(3.30 - 3.41) \times 10^{-3}}</math></p> <p>OR</p> <p>= <math>-6272.7</math> (K)</p> <p>Please award this mark if <math>-6272.7</math> is seen anywhere! <b>(1)</b></p> <p><b>Method 2</b></p> <p><b>First mark</b></p> <p>Setting up two simultaneous equations <b>(1)</b></p> <p><b>Second mark</b></p> <p>Subtracting one equation from the other or other correct methods of solution <b>(1)</b></p> <p><b>Third mark (applies to both methods)</b></p> <p><math>(E_a) = +52126 \text{ J mol}^{-1}</math>  <math>/+52.1(26)\text{kJ mol}^{-1}</math></p> <p>Note: TE can only be given if either method 1 or method 2 has been clearly carried out.</p> <p>Positive sign given</p> <p>OR</p> <p>Two negative signs clearly cancel in method and no sign given <b>(1)</b></p> <p>Correct answer with or without working, with sign and units <b>(3)</b></p> <p>Ignore SF unless only one</p>	Negative sign	<b>3</b>

Question Number	Correct Answer	Reject	Mark
<b>3</b> <b>(d) (ii)</b>	Either Take readings at different temperatures  OR Repeat at the same two temperatures  ALLOW  Just 'repeat the experiment'		<b>1</b>