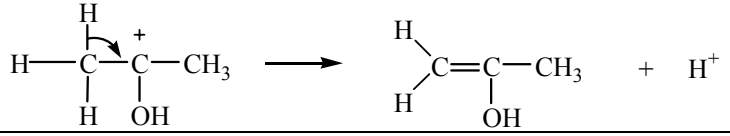
# Rate Equations and Kp Answers

| Question | Part | Sub Part | | Mark | Comment |
|---|---|---|---|---|---|
| 3 | (a) | | 2 or two or second | 1 | |
| 3 | (b) | | $k = \frac{1.24 \times 10^{-4}}{(4.40)(0.82)}$<br><br>$= 3.44 \times 10^{-5}$ (min 3sfs)<br><br>$mol^{-1}dm^3s^{-1}$ | 1<br><br>1<br><br>1 | mark is for insertion of numbers into a correctly rearranged rate equ , k = etc<br>if upside down, (or use of $I_2$ data) score only units mark<br><br>any order |
| 3 | (c) | | no change or no effect or stays the same or $1.24 \times 10^{-4}$ | 1 | |
| 3 | (d) | | 1 or 2 or 1 and 2<br><br>rate equ doesn't involve $I_2$ or only step which includes 2 species in rate equ | 1<br><br>1 | if wrong no further mark<br>but mark on from no answer |
| 3 | (e) | |  | 1 | any second arrow loses the mark |

| Question | Marking Guidance | Mark | Comments |
|---|---|---|---|
| 6(a)(i) | $k = \frac{6.2\times10^{-6}}{(2.9\times10^{-2})^2 \times 2.3\times10^{-2}}$ | 1 | mark is for insertion of numbers into a correctly rearranged rate equ , k = etc<br>AE (-1) for copying numbers wrongly or swapping two numbers |
| | = 0.32 (min 2sfs) | 1 | |
| | $mol^{-2}\,dm^6\,s^{-1}$ Units must be conseq to their *k* | 1 | Any order<br>If k calculation wrong, allow units conseq to their k |
| 6(a)(ii) | $4.95 \times 10^{-5}$ to $4.97 \times 10^{-5}$ or $5.0 \times 10^{-5}$ (min 2 sfs)<br>(ignore units) | 1 | rate = their $k \times 1.547 \times 10^{-4}$ |
| 6(b) | Step 2<br>One $H_2$ (and two NO) (appear in rate equation)<br>or species (in step 2) in ratio/proportion as in the rate equation | 1<br>1 | If wrong no further mark |

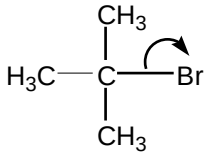
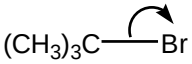
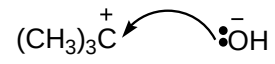
| Question | Marking Guidance | | Mark | Comments |
|---|---|---|---|---|
| 1(a)(i) | propyl methanoate | | 1 | must be correct spelling |
| 1(a)(ii) | rate = $k[X][OH^-]$ | | 1 | allow $HCOOCH_2CH_2CH_3$ (or close) for X<br>allow ( ) but penalise missing minus |
| 1(a)(iii) | $k = \frac{8.5 \times 10^{-5}}{(0.024)(0.035)}$ | In (a)(iii), if wrong orders allow | 1 | mark is for insertion of numbers in correct expression for k<br>If expression for k is upside down, only score units conseq to their expression |
| | = 0.10(12) 2sf minimum | 1 for conseq answer | 1 | |
| | $mol^{-1}\,dm^3\,s^{-1}$ | 1 for conseq units | 1 | any order |
| 1(a)(iv) | $2.1(3) \times 10^{-5}$ | | 1 | or $2.1(2) \times 10^{-5}$ ignore units<br>allow 2 sf<br>**NB If wrong check the orders in part (a)(iii) and allow (a)(iv) if conseq to wrong k**<br>**See * below** |

| | | | |
|---|---|---|---|
| 1(a)(v) | $1.3 \times 10^{-4}$ $(1.28 \times 10^{-4})$ | 1 | allow $(1.26 \times 10^{-4})$ to $(1.3 \times 10^{-4})$ ignore units<br>allow 2 sf<br>**NB If wrong check the orders in part (a)(iii) and allow (a)(iv) if conseq to wrong k**<br>**See ** below** |
| | **For example, if orders given are 1st in X and second in $OH^-$** [The mark in a(ii) and also first mark in a(iii) have already been lost]<br>So allow mark * in (iv) for rate = their k $\times(0.012)(0.0175)^2$ = their k $\times(3.7 \times 10^{-6})$ (allow answer to 2sf)<br>** in (v) for rate = their k $\times$ $(0.012)(0.105)^2$ = their k $\times(1.32 \times 10^{-4})$ (allow answer to 2sf)<br>**The numbers will of course vary for different orders.** | | |
| 1(a)(vi) | Lowered<br>fewer particles/collisions have energy $>E_a$<br>**OR**<br>fewer have sufficient (activation) energy (to react) | 1<br>1 | if wrong, no further mark<br>not just fewer successful collisions |
| 1(b) | Step 2<br>(this step with previous) involves one mol/molecule/particle A and two Bs<br>or 1:2 ratio or same amounts (of reactants) as in rate equation | 1<br>1 | if wrong, no further mark |

| Question | Marking Guidance | Mark | Additional Guidance |
|---|---|---|---|
| 2(a) | Exp 2 $4.5 \times 10^{-4}$<br>Exp 3 $4.5 \times 10^{-3}$<br>Exp 4 0.043 OR $4.3 \times 10^{-2}$ OR 0.044 OR $4.4 \times 10^{-2}$ | 1<br>1<br>1 | Min 2sf<br>If three wrong answers, check their value of *k* in 2(b).<br>They can score all 3 if they have used their (incorrect) value of *k*. see below.<br>Exp 2 rate = $k \times (1.0125 \times 10^{-4})$<br>Exp 3 [**Q**] = $0.02/k$<br>Exp 4 [**P**] = $0.0913/\sqrt{k}$ |
| 2(b) | $k = \frac{5.0 \times 10^{-5}}{(2.5 \times 10^{-2})^2 \times (1.8 \times 10^{-2})}$<br>= 4.4(4) (allow 40/9)<br>$mol^{-2}dm^{+6}s^{-1}$ | 1<br>1<br>1 | Mark is for insertion of numbers into a correctly rearranged rate equ , *k* = etc<br>If upside down, score only units mark from their *k*<br>AE (-1) for copying numbers wrongly or swapping two numbers<br>Any order<br>If *k* calculation wrong, allow units conseq to their *k* expression |

| Question | Marking Guidance | Mark | Comments |
|---|---|---|---|
| 1(a) | Exp 2 $14.(4) \times 10^{-3}$ ***OR*** $1.4(4) \times 10^{-2}$ or 0.014<br>Exp 3 0.1(0)<br>Exp 4 0.3(0) | 1<br>1<br>1 | Allow 2sf<br>If three wrong answers, check their value of *k i*n 1(b).<br>They can score all 3 if they have used their (incorrect) value of *k*. see below.<br>Exp 2 rate = $0.096 \times k$<br>Exp 3 [**Q**] = $0.015/k$<br>Exp 4 [**P**] = $0.116/\sqrt{k}$ |
| 1(b) | $k = \frac{1.8 \times 10^{-3}}{(0.20)^2 \times 0.30}$<br>= 0.15 (min 2sfs) (allow $\frac{3}{20}$)<br>$mol^{-2}\,dm^{+6}\,s^{-1}$ | 1<br>1<br>1 | mark is for insertion of numbers into a correctly rearranged rate equ , k = etc<br>if upside down, score only units mark<br>AE (-1) for copying numbers wrongly or swapping two numbers<br>Any order<br>If k calculation wrong, allow units conseq to their k |
| 1(c) | G | 1 | |

| Question | Marking Guidance | Mark | Comments |
|---|---|---|---|
| 1(a)(i) | 2 or two or second or $[E]^2$ | 1 | |
| 1(a)(ii) | 1 or one or first or $[F]^1$ or [F] | 1 | |
| 1(b)(i) | $k = \frac{8.6 \times 10^{-4}}{(3.8 \times 10^{-2})^2 \times (2.6 \times 10^{-2})}$ | 1 | mark is for insertion of numbers into a correctly rearranged rate equ , $k$ = etc.<br>AE (-1) for copying numbers wrongly or swapping two numbers. |
| | = 22.9 (Allow 22.9 – 24 after correct rounding) | 1 | |
| | $\underline{mol^{-2}\,dm^{+6}\,s^{-1}}$ | 1 | Any order. |
| 1(b)(ii) | $6.8(2) \times 10^{-3}$ (mol $dm^{-3}s^{-1}$)<br>***OR*** if their k is wrong, award the mark consequentially<br>a quick check can be achieved by using<br>$\frac{\text{their answer}}{\text{their k}}$ = $2.9768 \times 10^{-4}$ Allow $2.9 – 3.1 \times 10^{-4}$ for the mark | 1 | Allow $6.8 \times 10^{-3}$ to $6.9 \times 10^{-3}$<br>Ignore units. |

| Question | Marking Guidance | Mark | Comments |
|---|---|---|---|
| 1(a)(i) | $k = \frac{8.4\times10^{-5}}{(4.2\times10^{-2})^2 \times 2.6\times10^{-2}}$ ***OR*** $\frac{8.4\times10^{-5}}{(1.76\times10^{-3}) \times 2.6\times10^{-2}}$ | 1 | Mark is for insertion of numbers into a correctly rearranged rate equ , k = etc.<br>If upside down, score only units mark from their k |
| | = 1.8(3) | 1 | AE (-1) for copying numbers wrongly or swapping two numbers |
| | $mol^{-2}\,dm^{+6}\,s^{-1}$ | 1 | Any order<br>If *k* calculation wrong, allow units consequential to their *k* = expression |
| 1(a)(ii) | $5.67 \times 10^{-4}$ (mol $dm^{-3}s^{-1}$) ***OR*** their $k \times 3.1 \times 10^{-4}$ | 1 | Allow $5.57 \times 10^{-4}$ to $5.7 \times 10^{-4}$ |
| 1(b)(i) | 2 or second or $[D]^2$ | 1 | |
| 1(b)(ii) | 0 or zero or $[E]^0$ | 1 | |
| 1(c)(i) | Step 1 or equation as shown | 1 | Penalise Step 2 but mark on |
| 1(c)(ii) |  or  <br>Ignore correct partial charges, penalise full / incorrect partial charges | 1 | If Step 2 given above, can score the mark here for<br>  allow **:**$OH^-$ (must show lp)<br>If $S_N2$ mechanism shown then no mark (penalise involvement of :$OH^-$ in step 1)<br>Ignore anything after correct step 1 |

| Question | Marking Guidance | Mark | Comments |
|---|---|---|---|
| 3(a)(i) | 2 | 1 | |
| 3(a)(ii) | 0 | 1 | |
| 3(b)(i) | $k = \dfrac{6.64 \times 10^{-5}}{(4.55 \times 10^{-2}) \times (1.70 \times 10^{-2})^2}$<br><br>= 5.05 (range allowed 5.03–5.07)<br><br>$\underline{mol^{-2}\,dm^{+6}\,s^{-1}}$ | 1<br><br>1<br><br>1 | Correct answer for *k* with or without working scores 2<br>First mark is for insertion of numbers into a correctly rearranged rate equ , *k* = etc.<br><br>AE (-1) for copying numbers wrongly or swapping two numbers.<br><br>Mark units separately, ie only these units but can be in any order. |
| 3(b)(ii) | $8.3 \times 10^{-6}$ (mol $dm^{-3}\,s^{-1}$)<br>**OR** if not $8.3 \times 10^{-6}$, look at their *k* in 3(b)(i) and if not 5.05<br>Allow ecf for their (incorrect) $k \times (1.64 \times 10^{-6})$ | 1 | Allow $0.83 \times 10^{-5}$<br>Ignore units |

| Question | Marking Guidance | Mark | Comments |
|---|---|---|---|
| 1(a)<br>Marked with 1(b) | k = rate / $[A]^2$ or $\frac{3.3\times10^{-5}}{(4.2\times10^{-3})^2}$<br>= 1.87 or 1.9<br>$mol^{-1}dm^3s^{-1}$ | 1<br>1<br>1 | <br>Answer scores 2<br>1.90 scores first mark only (incorrect rounding)<br>Any order and independent of calculation |
| 1(b)<br>Marked with 1(a) | Expt 2 rate = $1.167 \times 10^{-4} - 1.2 \times 10^{-4}$ (mol $dm^{-3}$ $s^{-1}$)<br>Expt 3 [A] = $9.7 \times 10^{-3} - 9.8(1) \times 10^{-3}$ (mol $dm^{-3}$)<br>Using alternative value for *k*<br>Expt 2 rate = $1.4(4) \times 10^{-4}$ (mol $dm^{-3}$ $s^{-1}$)<br>Expt 3 [A] = $8.85 \times 10^{-3}$ (mol $dm^{-3}$) | 1<br>1 | If answers in table are not those given here, check their value of k in part 1(a) or use of alternative k.<br>If their k is incorrect in part 1(a) mark 1(b) consequentially e.g. if k = $7.9 \times 10^{-3}$ due to lack of squaring in 1(a)<br>expt 2 $4.9 \times 10^{-7}$<br>expt 3 $1.5 \times 10^{-1}$<br>(expt 2 $6.24 \times 10^{-5}$ x their k)<br>(expt 3 0.0134 / √k) |
| 1(c) | Slow step or rds involves only A<br>***OR***<br>B does not appear in the slow step or the rds<br>***OR***<br>B only appears after the slow step or the rds | 1 | Not B has no effect on the rate or B is not in the rate equation<br>Allow "it" for B |

| Question | Answers | Mark | Additional Comments/Guidance | ID details |
|---|---|---|---|---|
| **G** 6a | Order wrt **D** = 1 OR first OR [D] OR [D]$^1$<br>Order wrt **E** = 2 OR second OR [E]$^2$ | 1<br>1 | Ignore working | |
| 6b | (At time zero/start) the concentrations are known | 1 | | |
| 6c | M1 (Calculate) gradient (of tangent/curve/graph)<br>M2 at t=0 or at start of graph/curve | 1<br>1 | Allow description of gradient calculation: Change in conc / time<br>M2 scored only if M1 gained<br>Ignore the word initial | |
| **Total** | | **5** | | |

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|---|---|---|---|---|
| 7a | Iodine is not involved in (or before) the<br>rate determining / slow(est) / limiting step (in the mechanism) | 1 | Ignore, iodine does not appear in the rate equation<br>or iodine concentration does not affect the rate | |
| 7b | $k = \left(\frac{8.64\times10^{-7}}{(5.82\times10^{-2})\times(4.76\times10^{-1})}\right) = 3.1(2)\times10^{-5}$<br><br>$\underline{mol^{-1}\ dm^{+3}\ s^{-1}}$ | 1<br><br>1 | Mark for answer<br><br>Mark units separately,<br>i.e. only these units but can be in any order | |
| 7c | rate = $k$ $[H^+]$<br>(large excess of propanone) so $\underline{[CH_3COCH_3]\ is}$ (effectively) $\underline{constant}$ | 1<br>1 | If wrong or missing CE = 0 | |
| **Total** | | **5** | | |