A-Level Chemistry

Rate Equations

Mark Scheme

Time available: 49 minutes
Marks available: 48 marks

1.

(a) **Stage 1: Calculates value of $[C_6H_5CHO]^2$:**

M1 for the values (0, 0.0625; 0.25; 0.56 and 1) in the table.

Ignore precision.

1

Stage 2: Plots graph:

M2 for the graph labels with units and appropriate scales and using sensible proportion of graph (plotted points must cover at least half the printed grid).

$[C_6H_5CHO]^2$ on x-axis (with units) $mol^2\ dm^{-6}$

Initial rate on y-axis (with units) $mol\ dm^{-3}\ s^{-1}$

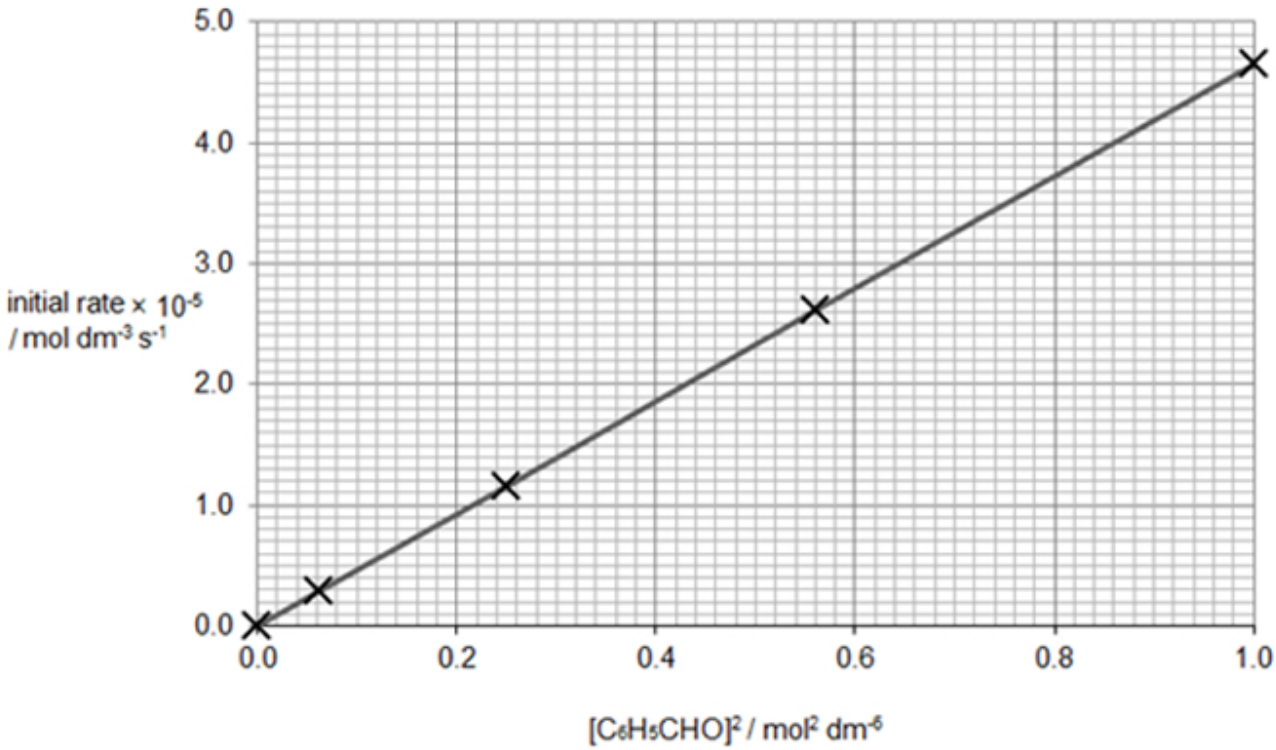
1

M3 for the plotting of 5 points.

1

Stage 3: Line of best fit:

M4 for the line of best fit.



1

(b) 2nd order

1

(since) $[C_6H_5CHO]^2$ plotted against rate is straight line / directly proportional.

1

(c) (Role of CN^-) catalyst

Ignore nucleophile.

1

CN^- appears in the rate equation but is not in the reaction equation.

1

[8]

2. (a) Consider experiments 1 and 2: [B constant]

[A] increases × 3: rate increases by 3^2 therefore 2nd order with respect to A

1

Consider experiments 2 and 3:

[A] increases × 2: rate should increase × 2^2 but only increases × 2

Therefore, halving [B] halves rate and so 1st order with respect to B

1

Rate equation: rate = $k[A]^2[B]$

1

(b) rate = k $[C]^2[D]$ therefore k = rate / $[C]^2[D]$

1

$$k = \frac{7.2\times10^{-4}}{(1.9\times10^{-2})^2 \times (3.5\times10^{-2})} = 57.0$$

Allow consequential marking on incorrect transcription

1

$mol^{-2}\ dm^{+6}\ s^{-1}$

Any order

1

(c) rate = $57.0 \times (3.6 \times 10^{-2})^2 \times 5.4 \times 10^{-2} = 3.99 \times 10^{-3}$ (mol $dm^{-3}\ s^{-1}$)

OR

Their $k \times (3.6 \times 10^{-2})^2 \times 5.4 \times 10^{-2}$

1

(d) Reaction occurs when molecules have $E \geq E_a$

1

Doubling T by 10 °C causes <u>many</u> more molecules to have this E

1

Whereas doubling [**E**] only doubles the number with this E

1

(e) $E_a = RT(\ln A - \ln k) / 1000$

Mark is for rearrangement of equation and factor of 1000 used correctly to convert J into kJ

1

$E_a = 8.31 \times 300\ (23.97 - (-5.03)) / 1000 = 72.3$ (kJ mol^{-1})

1

[12]

3.

(a) Order wrt **D** = 1 OR first OR [D] OR $[D]^1$

Ignore working

1

Order wrt **E** = 2 OR second OR $[E]^2$

1

(b) (At time zero/start) the concentrations are known

1

(c) M1 (Calculate) gradient (of tangent/curve/graph)

Allow description of gradient calculation:

Change in conc / time

1

M2 at t=0 or at start of graph/curve

M2 scored only if M1 gained

Ignore the word initial

1

[5]

4.

(a) Iodine is not involved in (or before) the rate determining / slow(est) / limiting step (in the mechanism)

Ignore, iodine does not appear in the rate equation or iodine concentration does not affect the rate

1

(b) $k = \left(\frac{8.64 \times 10^{-7}}{(5.82 \times 10^{-2}) \times (4.76 \times 10^{-1})}\right) = 3.1(2) \times 10^{-5}$

Mark for answer

1

$\underline{mol^{-1}\ dm^{+3}\ s^{-1}}$

Mark units separately, i.e. only these units but can be in any order

1

(c) Rate = $k\ [H^+]$

If wrong or missing CE = 0

1

(Large excess of propanone) so $\underline{[CH_3COCH_3]\ is}$ (effectively) $\underline{constant}$

1

[5]

5.

(a) k = rate / $[A]^2$ or $\frac{3.3\times10^{-5}}{(4.2\times10^{-3})^2}$ **1**

= 1.87 or 1.9

Answer scores 2

1.90 scores first mark only (incorrect rounding)

1

$mol^{-1}dm^3s^{-1}$

Any order and independent of calculation

1

(b) Expt 2 rate = $1.167 \times 10^{-4} - 1.2 \times 10^{-4}$ (mol dm^{-3} s^{-1})

If answers in table are not those given here, check their value of k in part (a) or use of alternative k.

1

Expt 3 [A] = $9.7 \times 10^{-3} - 9.8(1) \times 10^{-3}$ (mol dm^{-3})

If their k is incorrect in part (a) mark this part consequentially e.g. if $k = 7.9 \times 10^{-3}$ due to lack of squaring in (a)

Using alternative value for *k*

expt 2 4.9×10^{-7}

Expt 2 rate = $1.4(4) \times 10^{-4}$ (mol dm^{-3} s^{-1})

expt 3 1.5×10^{-1}

Expt 3 [A] = 8.85×10^{-3} (mol dm^{-3})

(expt 2 6.24×10^{-5} × their k)

(expt 3 0.0134 / √k)

1

(c) Slow step or rds involves only A

OR

B does not appear in the slow step or the rds

OR

B only appears after the slow step or the rds

Not B has no effect on the rate or B is not in the rate equation

Allow "it" for B

1

[6]

6.

(a) (i) 2

1

(ii) 0

1

(b) (i) $K = \dfrac{6.64 \times 10^{-5}}{(4.55 \times 10^{-2}) \times (1.70 \times 10^{-2})^2}$

Correct answer for k with or without working scores 2.

First mark is for insertion of numbers into a correctly rearranged rate equ , k = etc.

1

= 5.05 (range allowed 5.03−5.07)

AE (−1) for copying numbers wrongly or swapping two numbers.

1

$\underline{\text{mol}^{-2}\ \text{dm}^{+6}\ \text{s}^{-1}}$

Mark units separately, ie only these units but can be in any order.

1

(ii) 8.3×10^{-6} (mol dm^{-3} s^{-1})

Allow 0.83×10^{-5}.

Ignore units.

OR if not 8.3×10^{-6}, look at their *k* in part(i) and if not 5.05

Allow ecf for their (incorrect) *k* × (1.64×10^{-6})

1

[6]

7. (a) (i) 2 or two or second or $[E]^2$

1

(ii) 1 or one or first or $[F]^1$ or [F]

1

(b) (i) $k = \dfrac{8.6 \times 10^{-4}}{(3.8 \times 10^{-2})^2 \times (2.6 \times 10^{-2})}$

mark is for insertion of numbers into a correctly rearranged rate equ , k = etc.

AE (−1) for copying numbers wrongly or swapping two numbers.

1

= 22.9 (Allow 22.9 − 24 after correct rounding)

1

$\underline{\text{mol}^{-2}\text{dm}^{+6}\ \text{s}^{\&8722;1}}$

Any order.

1

(ii) $6.8(2) \times 10^{-3}$ (mol dm$^{&8722;3}$s^{-1})

OR if their k is wrong, award the mark consequentially

a quick check can be achieved by using

<u>their answer</u> = 2.9768×10^{-4} Allow $2.9 - 3.1 \times 10^{-4}$ for the mark

their *k*

Allow 6.8×10^{-3} to 6.9×10^{-3}

Ignore units.

1

[6]