

## Mark schemes

<b>1</b>	<p>(a) Exp 2 <math>14.(4) \times 10^{-3}</math> <b>OR</b> <math>1.4(4) \times 10^{-2}</math> or 0.014 <i>Allow 2sf</i></p>	1
	<p>Exp 3 0.1(0)</p>	1
	<p>Exp 4 0.3(0) <i>If three wrong answers, check their value of k in 1(b). They can score all 3 if they have used their (incorrect) value of k. see below.</i></p> <p><i>Exp 2 rate = 0.096 × k</i> <i>Exp 3 [Q] = 0.015/k</i> <i>Exp 4 [P] = 0.116/k</i></p>	1
	<p>(b) <math>K = \frac{1.8 \times 10^{-3}}{(0.20)^2 \times 0.30}</math>  <i>mark is for insertion of numbers into a correctly rearranged rate equ , k = etc</i></p> <p>= 0.15 (min 2sfs)                      (allow <math>\frac{3}{20}</math>)  <i>if upside down, score only units mark</i> <i>AE (-1) for copying numbers wrongly or swapping two numbers</i></p> <p><math>\text{mol}^{-2} \text{dm}^6 \text{s}^{-1}</math> <i>Any order</i> <i>If k calculation wrong, allow units conseq to their k</i></p>	1
	<p>(c) G</p>	1
		<b>[7]</b>

**2**

(a) (i)  $k = \frac{6.2 \times 10^{-6}}{(2.9 \times 10^{-2})^2 \times 2.3 \times 10^{-2}}$

*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

= 0.32 (min 2sfs)

1

mol<sup>-2</sup> dm<sup>6</sup> s<sup>-1</sup> Units must be conseq to their k

*Any order*

*If k calculation wrong, allow units conseq to their k*

1

(ii)  $4.95 \times 10^{-5}$  to  $4.97 \times 10^{-5}$  or  $5.0 \times 10^{-5}$  (min 2 sfs)

(ignore units)

*rate = their k  $\times$   $1.547 \times 10^{-4}$*

1

(b) Step 2

*If wrong no further mark*

1

One H<sub>2</sub> (and two NO) (appear in rate equation)

or species (in step 2) in ratio/proportion as in the rate equation

1

**[6]****3**

(a) (i) propyl methanoate

*must be correct spelling*

1

(ii) rate = k[X][OH<sup>-</sup>]

*allow HCOOCH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub> (or close) for X*

*allow ( ) but penalise missing minus*

1

$$(iii) \quad k = \frac{8.5 \times 10^{-5}}{(0.024)(0.035)}$$

*In (a)(iii), if wrong orders allow*

*mark is for insertion of numbers in correct expression for k*

*If expression for k is upside down, only score units conseq to their expression*

1

$$= 0.10(12) \quad \text{2sf minimum}$$

*1 for conseq answer*

1

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

*1 for conseq units*

*any order*

1

$$(iv) \quad 2.1(3) \times 10^{-5}$$

*or 2.1(2)  $\times 10^{-5}$  ignore units*

*allow 2 sf*

***NB If wrong check the orders in part (a)(iii) and allow (a)(iv) if conseq to wrong k***

***See \* below***

1

$$(v) \quad 1.3 \times 10^{-4} (1.28 \times 10^{-4})$$

*allow (1.26  $\times 10^{-4}$ ) to (1.3  $\times 10^{-4}$ ) ignore units*

*allow 2 sf*

***NB If wrong check the orders in part (a)(iii) and allow (a)(iv) if conseq to wrong k***

***See \*\* below***

1

**For example, if orders given are 1st in X and second in OH<sup>-</sup>**

[The mark in a(ii) and also first mark in a(iii) have already been lost]

So allow mark \* in (iv) for rate = their k  $\times (0.012)(0.0175)^2 = \text{their k} \times (3.7 \times 10^{-6})$   
(allow answer to 2sf)

\*\* in (v) for rate = their k  $\times (0.012)(0.105)^2 = \text{their k} \times (1.32 \times 10^{-4})$   
(allow answer to 2sf)

**The numbers will of course vary for different orders.**

(vi) Lowered  
*if wrong, no further mark*

1

fewer particles/collisions have energy  $> E_a$

**OR**

fewer have sufficient (activation) energy (to react)

*not just fewer successful collisions*

1

(b) Step 2

(this step with previous) involves one mol/molecule/particle  
A and two Bs

or 1:2 ratio or same amounts (of reactants) as in rate equation

*if wrong, no further mark*

1

[11]

4

(a) 3-hydroxybutanal

*ignore number 1 i.e. allow 3-hydroxybutan-1-al  
not hydroxyl*

1

(b)  $k = \frac{2.2 \times 10^{-3}}{(0.10)(0.02)}$

1

= 1.1

1

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

1

(c) planar or flat C=O or molecule

*allow planar molecule*

1

equal probability of attack from above or below

*must be equal; not attack of OH<sup>-</sup>*

1

(d) (i) Step 1 if wrong – no mark for explanation.

1

involves ethanal and OH<sup>-</sup> or species/ "molecules"  
in rate equation

1

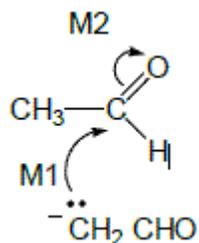
- (ii) (B-L) acid or proton donor  
*not Lewis acid*

1

- (iii) nucleophilic addition  
QOL

1

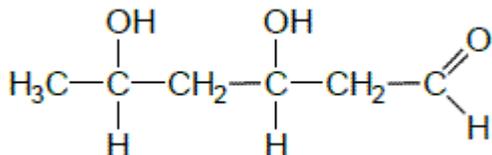
- (iv)



*not allow M2 before M1, but allow M1 attack on C+ after non-scoring carbonyl arrow*  
*ignore error in product*

2

- (e)



1

[13]

5

- (a) Log (1 / time) on the y-axis + log (vol) on x-axis

*If axes unlabelled use data to decide that log (1 / time) is on the y-axis*

1

Sensible scales

*Lose this mark if the plotted points do not cover at least half of the paper*

*Lose this mark if the graph plot goes off the squared paper*

*Lose this mark if plots a non-linear / broken scale*

*Lose this mark if uses an ascending y-axis of negative numbers*

1

Plots points correctly  $\pm$  one square

1

Line through the points is smooth

*Lose this mark if the candidate's line is doubled*

1

Line through the points is best fit – ignores last point

*Must recognise that point at 25 cm<sup>3</sup> is an anomaly*

*If wrong graph, mark consequentially on anomaly if correctly plotted.*

*A kinked graph loses smooth **and** best fit marks*

1

(b) Uses appropriate *x* and *y* readings

*Allow taken from table or taken or drawn on graph*

*Must show triangle on graph or such as  $\frac{1.65 - 1.2}{1.4 - 0.9}$*

1

Correctly calculates gradient  $0.95 \pm 0.02$

*Ignore positive or negative sign*

*Correct answer only with no working scores this mark*

1

Answer given to 2 decimal places

1

(c) First order or order is 1

*Allow consequential answer from candidate's results*

1

(d) Thermostat the mixture / constant temperature / use a water bath  
or Colorimeter / uv-visible spectrometer / light sensor to monitor colour change

1

Reaction / rate affected by temperature change

or Eliminates human error in timing / more accurate time of colour change

1

[11]

6

(a) 2 or two or second

1

(b)  $k = \frac{1.24 \times 10^{-4}}{(4.40)(0.82)}$

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

*if upside down, (or use of  $I_2$  data) score only units mark*

1

$= 3.44 \times 10^{-5}$  (min 3sfs)

1

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

*any order*

1

(c) no change or no effect or stays the same or  $1.24 \times 10^{-4}$

1

(d) 1 or 2 or 1 and 2

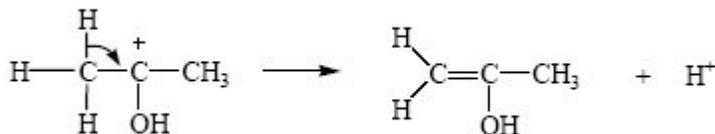
*if wrong no further mark but mark on from no answer*

1

rate equ doesn't involve  $I_2$  or only step which includes 2 species in rate equ

1

(e)



*any second arrow loses the mark*

1

**[8]**

**7**

(a) (i) 2

1

(ii) 0

1

(b) (i)  $\text{rate}/[\text{NO}_2]^2[\text{O}_2]$

1

13

1

$\text{mol dm}^{-3}$

1

(ii)  $1.9 \times 10^{-3}$

1

(iii) Step 2

1

**[7]**

**8**

(a)  $k = \text{rate}/[\text{CH}_3\text{CH}_2\text{COOCH}_3][\text{H}^+]$

1

or

$$= \frac{1.15 \times 10^{-4}}{(0.150)(0.555)}$$

$$= 1.38 \times 10^{-3} \text{ to } 1.4 \times 10^{-3}$$

1

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

1

(b)  $\text{ans} = \text{rate constant} \times (\frac{1}{2} \times 0.150) \times (\frac{1}{2} \times 0.555)$

*ignore units*

$$= \text{rate constant} \times 0.0208$$

$$2.88 \times 10^{-5} \quad (1.38 \times 10^{-3} \text{ gives } 2.87 \times 10^{-5})$$

$$\text{Allow } 2.87 - 2.91 \times 10^{-5} \text{ (} 1.4 \times 10^{-3} \text{ gives } 2.91 \times 10^{-5})$$

1

(c)  $[\text{H}^+] = \text{rate}/k[\text{CH}_3\text{COOCH}_2\text{CH}_3]$

1

$$= \frac{4.56 \times 10^{-5}}{(8.94 \times 10^{-4})(0.123)}$$

$$= 0.415 \text{ (} 0.4146)$$

1

$$\text{pH} = 0.38 \text{ mark independently}$$

$$[\text{H}^+] = 0.41 \text{ gives } \text{pH} = 0.39$$

1

**[7]****9**

(a) exp2  $4.0 \times 10^{-3}$

1

exp3  $0.45 \times 10^{-5}$

1

exp4  $9.0 \times 10^{-3}$

1

(b)  $\frac{1.8 \times 10^{-5}}{(3.0 \times 10^{-3})^2 (1.0 \times 10^{-3})}$

1

2000

1

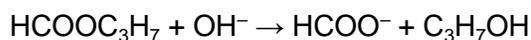
$\text{mol}^{-2} \text{dm}^6 \text{s}^{-1}$

1

[6]

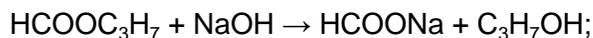
10

(a) propyl methanoate;



1

OR



1

(b) order wrt A = 1;

1

order wrt NaOH = 1;

1

Initial rate in Exp 4 =  $2.4 \times 10^{-3}$ ;

1

(c) (i)  $r(\text{ate}) = k[\text{A}]$

OR

$$r(\text{ate}) = k[\text{A}][\text{NaOH}]^0;$$

*(penalise missing [ ] but mark on)*

*(penalise missing [ ] once per paper)*

*(if wrong order, allow only units mark conseq on their rate eqs)*

*(penalise  $k_a$  or  $k_w$  etc)*

1

(ii)  $k = \frac{9.0 \times 10^{-3}}{0.02};$

1

= 0.45;

1

$\text{s}^{-1}$ ;

1

(iii) (large) excess of  $\text{OH}^-$  or  $[\text{OH}^-]$  is large/high; 1

$[\text{OH}^-]$  is (effectively) constant

OR

$[\text{A}]$  is the limiting factor *(Q of L mark)* 1

(d) (i) 
$$\begin{array}{c} \text{CH}_2\text{OH} \\ | \\ \text{CHOH} \\ | \\ \text{CH}_2\text{OH} \end{array}$$
 1

propan(e)-1,2,3-triol

OR

1,2,3-propan(e)triol

OR

Glycerol; 1

(ii)  $\text{CH}_3(\text{CH}_2)_{16}\text{COONa}$  or  $\text{C}_{17}\text{H}_{35}\text{COONa}$  or  $\text{C}_{18}\text{H}_{35}\text{O}_2\text{Na}$ ;   
*(ignore 3 in front of formula but not if indicating trimer)* 1

(not just anion and penalise Na shown as covalently bonded) soap -   
allow with detergent but not detergent alone; 1

**[15]**