

Mark schemes

1

(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

$\text{mol}^{-2} \text{dm}^6 \text{s}^{-1}$ Units must be conseq to their k

Any order

If k calculation wrong, allow units conseq to their k

1

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

(ignore units)

rate = their k \times 1.547×10^{-4}

1

(b) Step 2

If wrong no further mark

1

One H_2 (and two NO) (appear in rate equation)

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

1

[6]

2

(a) (i) propyl methanoate

must be correct spelling

1

(ii) $\text{rate} = k[\text{X}][\text{OH}^-]$

allow $\text{HCOOCH}_2\text{CH}_2\text{CH}_3$ (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⁻

[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]

3

(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⁻

1

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

1

involves ethanal and OH⁻ or species/ “molecules”
in rate equation

1

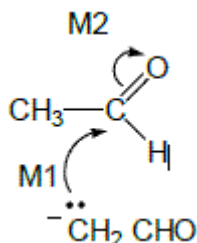
(ii) (B-L) acid or proton donor
not Lewis acid

1

(iii) nucleophilic addition
QOL

1

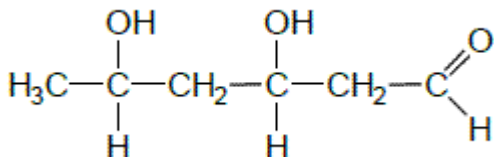
(iv)



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

2

(e)



1

[13]

4

(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 cm³ 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 ± 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]

5

- (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, $k = \text{etc}$

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 1.24×10^{-4}

1

(d) 1 or 2 or 1 and 2

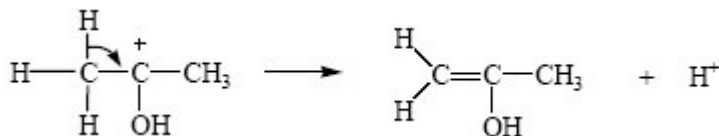
if wrong no further mark but mark on from no answer

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]

6

(a) (i) 2

1

(ii) 0

1

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

1

13

1

mol dm^{-3}

1

(ii) 1.9×10^{-3}

1

(iii) Step 2

1

[7]

7

(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

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

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

Allow 2.87 – 2.91 $\times 10^{-5}$ (1.4 $\times 10^{-3}$ 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

pH = 0.38 mark independently

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

1

[7]

8

(a) exp2 4.0×10^{-3}

1

exp3 0.45×10^{-5}

1

exp4 9.0×10^{-3}

1

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

1

2000

1

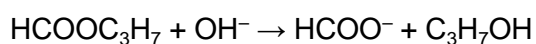
$\text{mol}^{-2} \text{dm}^6 \text{s}^{-1}$

1

[6]

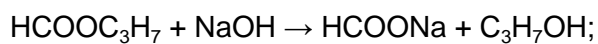
9

(a) propyl methanoate;



1

OR



1

(b) order wrt A = 1;

1

order wrt NaOH = 1;

1

Initial rate in Exp 4 = 2.4×10^{-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

s^{-1} ;

1

(iii) (large) excess of 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]