

- M1.** (a) (i) propyl methanoate
must be correct spelling 1
- (ii) rate = $k[X][OH^-]$
allow $HCOOCH_2CH_2CH_3$ (or close) for X
allow () but penalise missing minus 1
- (iii) $k = \frac{8.5 \times 10^{-5}}{(0.024)(0.035)}$
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) 2sf minimum
1 for conseq answer 1
- $mol^{-1} dm^3 s^{-1}$
1 for conseq units
any order 1
- (iv) $2.1(3) \times 10^{-5}$
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) 1.3×10^{-4} (1.28×10^{-4})
allow (1.26×10^{-4}) to (1.3×10^{-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

1

(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

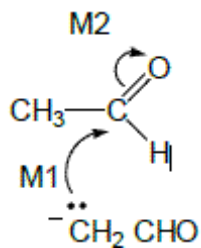
[11]

M2. (a) 3-hydroxybutanal

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

1

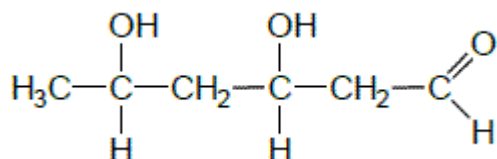
- (b) $k = \frac{2.2 \times 10^{-3}}{(0.10)(0.02)}$ 1
- = 1.1 1
- mol⁻¹ dm³ s⁻¹ 1
- (c) planar or flat C=O or molecule 1
allow planar molecule
- equal probability of attack from above or below 1
must be equal; not attack of OH⁻
- (d) (i) Step 1 if wrong – no mark for explanation. 1
- involves ethanal and OH⁻ or species/ “molecules” 1
 in rate equation
- (ii) (B-L) acid or proton donor 1
not Lewis acid
- (iii) nucleophilic addition 1
 QOL
- (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]

M3. (a) order with respect to **P** is 2

1

order with respect to **Q** is 1

1

(b) (i) rate = $k[\mathbf{R}][\mathbf{S}]^2$
(if wrong expression, no further marks)

1

$$\text{rate} = (4.2 \times 10^{-4}) \times 0.16 \times 0.84^2$$

1

$$= 4.7 \times 10^{-5} \text{ (mol dm}^{-3} \text{ s}^{-1}\text{)}$$

ignore units even if wrong

1

$$(ii) \quad k = \frac{\text{rate}}{[R][S]^2} = \frac{8.1 \times 10^{-5}}{0.76 \times 0.98^2}$$

$$= 1.1 \times 10^{-4}$$

1

1

(iii) T_1

**If calculated value for $k > 4.2 \times 10^{-4}$, then answer to (iii) is T_2*

1

[8]

M4. (a) exp2 4.0×10^{-3}

1

exp3 0.45×10^{-5}

1

exp4 9.0×10^{-3}

1

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

1

2000

1

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

1

[6]

M5. (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

mol⁻¹ dm³ s⁻¹

1

(b) ans = rate constant × (½ × 0.150) × (½ × 0.555)
ignore units

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

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

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

1

(c) [H⁺] = rate/ k[CH₃COOCH₂CH₃]

1

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

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

1

pH = 0.38 mark independently

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

1

[7]

M6. (a) (i) 2

1

(ii) 0

1

- (b) (i) rate/[NO₂]²[O₂] 1
- 13 1
- mol dm⁻³ 1
- (ii) 1.9 × 10⁻³ 1
- (iii) Step 2 1
- [7]**

M7. (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 I₂ data) score only units mark

1

= 3.44 × 10⁻⁵ (min 3sfs) 1

mol⁻¹ dm³ 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

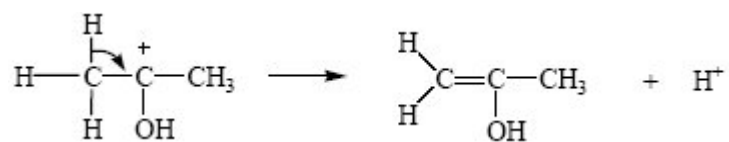
if wrong no further mark but mark on from no answer

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]