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

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

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 × (0.012)(0.0175)² = their k ×(3.7 × 10⁻⁶)
(allow answer to 2sf)
** in (v) for rate = their k × (0.012)(0.105)² = their k ×(1.32 × 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
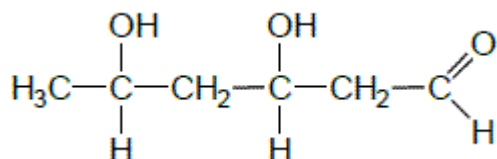*ignore number 1   i.e. allow 3-hydroxybutan-1-al*
not hydroxyl

1

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

1

= 1.1

1

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

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)

M2

M1

CH₃—C with =O and H, and ⁻CH₂ CHO below
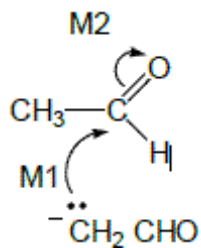
not allow M2 before M1, but allow M1 attack on C+ after non-scoring carbonyl arrow

ignore error in product

2

(e)

$H_3C-\underset{\underset{H}{|}}{\overset{\overset{OH}{|}}{C}}-CH_2-\underset{\underset{H}{|}}{\overset{\overset{OH}{|}}{C}}-CH_2-C\overset{O}{\underset{H}{\diagdown}}$

1

[13]

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

1

order with respect to **Q** is 1

1

(b) (i) rate = k**[R][S]**^{2}

(if wrong expression, no further marks)

1

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

1

= 4.7×10^{-5} (mol dm⁻³ s⁻¹)

ignore units even if wrong

1

(ii) $\quad k = \dfrac{\text{rate}}{[R][S]^2} = \dfrac{8.1\times10^{-5}}{0.76 \times 0.98^2}$

1

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

1

(iii) $\quad T_1$

If calculated value for k > 4.2 × 10⁻⁴, then answer to (iii) is T₂

1

[8]

M4. (a) exp2 $\quad 4.0 \times 10^{-3}$

1

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

1

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

1

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

1

2000

1

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

1

[6]

M5. (a) $\quad k = \text{rate}/[CH_3CH_2COOCH_3][H^+]$

or

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

= 1.38 × 10⁻³ to 1.4 × 10⁻³

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

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

      = rate constant × 0.0208

   2.88 × 10⁻⁵   (1.38 × 10⁻³ gives 2.87 × 10⁻⁵)
            Allow 2.87 – 2.91 × 10⁻⁵ (1.4 × 10⁻³ gives 2.91 × 10⁻⁵)

(c) $[H^+]$ = rate/ $k[CH_3COOCH_2CH_3]$

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

= 0.415 (0.4146)

   pH = 0.38 mark independently
         [H⁺] = 0.41 gives pH = 0.39

M6.   (a)   (i)   2

      (ii)   0

(b)   (i)   rate/$[NO_2]^2[O_2]$

$\qquad\qquad$ **1**

$\qquad$ 13

$\qquad\qquad$ **1**

$\qquad$ mol dm^{-3}

$\qquad\qquad$ **1**

$\qquad$ (ii) 1.9×10^{-3}

$\qquad\qquad$ **1**

$\qquad$ (iii)   Step 2

$\qquad\qquad$ **1**

$\qquad\qquad\qquad\qquad\qquad$ **[7]**

M7.   (a)   2 or two or second

$\qquad\qquad$ **1**

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

$\qquad$ *mark is for insertion of numbers into a correctly rearranged*
$\qquad$ *rate equ, k = etc*
$\qquad$ *if upside down, (or use of I_2 data) score only units mark*

$\qquad\qquad$ **1**

$\qquad$ = $3.4\underline{4} \times 10^{-5}$ (min 3sfs)

$\qquad\qquad$ **1**

$\qquad$ mol^{-1} dm^3 s^{-1}
$\qquad\qquad$ *any order*

$\qquad\qquad$ **1**

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

$\qquad\qquad$ **1**

(d)   1 or 2 or 1 and 2
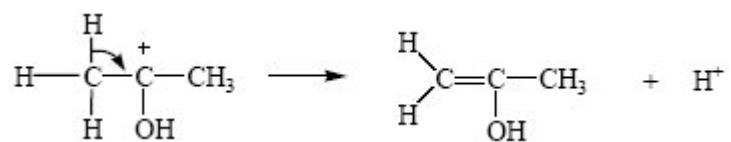   *if wrong no further mark but mark on from no answer*

                                                                              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]