

**M1.(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]

**M2.** (a) (i) Experiment 2:  $0.4(0) \times 10^{-3}$  (1)  
Experiment 3: 0.15 (1)  
Experiment 4: 0.28 (1)

$$(ii) \quad k = \frac{4.8 \times 10^{-3}}{(0.20)^2 \times (0.30)} = 0.4(0) \text{ mol}^{-2} \text{ dm}^6 \text{ s}^{-1}$$

(1)                      (1)                      (1)

6

(b) (change in) temperature (1)

1

[7]

**M3.** (a) (i) (Experiment 1 → 2) [A] doubled, ([B] constant,) rate doubled **(1)**  
*stated or shown numerically*

(ii) 2 **(1)**  
 or shown as ... [B]<sup>2</sup>

2

(b) (i)  $k = \frac{9.30 \times 10^{-5}}{(0.75)^2 \times (1.50)} = 1.1(0) \times 10^{-4}$   
**(1)** **(1)**

units of k: mol<sup>-2</sup> dm<sup>6</sup> s<sup>-1</sup> **(1)**

(ii) rate = (1.10 × 10<sup>-4</sup>) × (0.20)<sup>2</sup> × (0.10)  
 = 4.4(1) × 10<sup>-7</sup> (mol dm<sup>-3</sup> s<sup>-1</sup>)  
**(1) for the answer**

*Ignore units*

*Conseq on (i)*

*Upside down expression for k scores zero in (i) for 9073*

*but rate = 9073 × (0.2)<sup>2</sup> × (0.1) = 36(.3)*

*conseq scores (1) in (ii)*

4

**[6]**

**M4.** (a) order with respect to **P** is 2

1

order with respect to **Q** is 1

1

(b) (i) rate = k[R][S]<sup>2</sup>

(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

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

1

(iii)  $T_1$

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

1

[8]

**M5.** (a) Power (or index or shown as  $x$  in  $[ ]^x$ ) of concentration term  
(in rate equation) **(1)**

1

(b) **2 (1)**

1

(c) (i) Order with respect to **A**: **2 (1)**

Order with respect to **B**: **0 (1)**

(ii) Rate equation: (rate =)  $k [A]^2$  **(1)**

*Allow conseq on c(i)*

Units for rate constant:  $\text{mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$  **(1)**

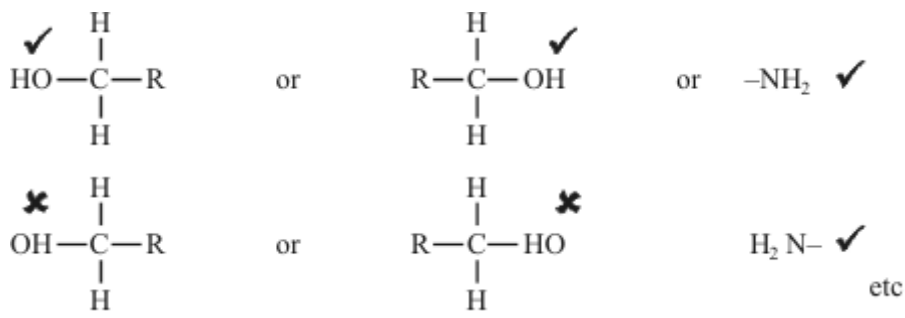
Organic points

- (1) Curly arrows: must show movement of a pair of electrons, i.e. from bond to atom or from lp to atom / space  
e.g.



- (2) Structures

penalise sticks (i.e.  $\begin{array}{c} | \\ -C- \\ | \end{array}$ ) once per paper



Penalise once per paper

allow  $\text{CH}_3-$  or  $-\text{CH}_3$  or  $\begin{array}{c} \text{CH}_3 \\ | \end{array}$  or  $\text{CH}_3$   
or  $\text{H}_3\text{C}-$

**M6.** (a) 2 or two or second

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

*mark is for insertion of numbers into a correctly rearranged rate equ, k = etc  
if upside down, (or use of I<sub>2</sub> data) score only units mark*

1

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

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

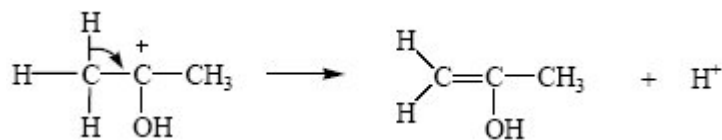
*if wrong no further mark but mark on from no answer*

1

rate equ doesn't involve I<sub>2</sub> or only step which includes 2 species in rate equ

1

(e)



*any second arrow loses the mark*

1

[8]

M7. (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]