

M1.(a) $k = \text{rate} / [\text{A}]^2$ or $\frac{3.3 \times 10^{-5}}{(4.2 \times 10^{-3})^2}$ 1

= 1.87 or 1.9

Answer scores 2

1.90 scores first mark only (incorrect rounding) 1

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

Any order and independent of calculation 1

(b) Expt 2 rate = $1.167 \times 10^{-4} - 1.2 \times 10^{-4}$ ($\text{mol dm}^{-3} \text{s}^{-1}$)

If answers in table are not those given here, check their value of k in part (a) or use of alternative k. 1

Expt 3 [A] = $9.7 \times 10^{-3} - 9.8(1) \times 10^{-3}$ (mol dm^{-3})

If their k is incorrect in part (a) mark this part consequentially e.g. if $k = 7.9 \times 10^{-3}$ due to lack of squaring in (a)

Using alternative value for k

expt 2 4.9×10^{-7}

Expt 2 rate = $1.4(4) \times 10^{-4}$ ($\text{mol dm}^{-3} \text{s}^{-1}$)

expt 3 1.5×10^{-1}

Expt 3 [A] = 8.85×10^{-3} (mol dm^{-3})

(expt 2 $6.24 \times 10^{-5} \times \text{their } k$)

(expt 3 $0.0134 / \sqrt{k}$) 1

(c) Slow step or rds involves only A

OR

B does not appear in the slow step or the rds

OR

B only appears after the slow step or the rds

Not B has no effect on the rate or B is not in the rate equation

Allow "it" for B 1

[6]

- M2.** (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⁻² dm⁶ 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 H₂ (and two NO) (appear in rate equation)
or species (in step 2) in ratio/proportion as in the rate equation
- 1

[6]

M3.(a) Consider experiments 1 and 2: [B constant]

[A] increases \times 3: rate increases by 3² therefore 2nd order with respect to A

1

Consider experiments 2 and 3:

[A] increases $\times 2$: rate should increase $\times 2^2$ but only increases $\times 2$

Therefore, halving [B] halves rate and so 1st order with respect to B

1

Rate equation: rate = $k[A]^2[B]$

1

(b) rate = $k [C]^2[D]$ therefore $k = \text{rate} / [C]^2[D]$

1

$$k = \frac{7.2 \times 10^{-4}}{(1.9 \times 10^{-2})^2 \times (3.5 \times 10^{-2})} = 57.0$$

Allow consequential marking on incorrect transcription

1

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

Any order

1

(c) rate = $57.0 \times (3.6 \times 10^{-2})^2 \times 5.4 \times 10^{-2} = 3.99 \times 10^{-3} \text{ (mol dm}^{-3} \text{ s}^{-1}\text{)}$

OR

Their $k \times (3.6 \times 10^{-2})^2 \times 5.4 \times 10^{-2}$

1

(d) Reaction occurs when molecules have $E \geq E_a$

1

Doubling T by 10°C causes many more molecules to have this E

1

Whereas doubling [E] only doubles the number with this E

1

(e) $E_a = RT(\ln A - \ln k) / 1000$

Mark is for rearrangement of equation and factor of 1000 used correctly to convert J into kJ

1

$$E_a = 8.31 \times 300 (23.97 - (-5.03)) / 1000 = 72.3 \text{ (kJ mol}^{-1}\text{)}$$

1

[12]

M4.(a) Exp 2 $14.(4) \times 10^{-3}$ **OR** $1.4(4) \times 10^{-2}$ or 0.014

Allow 2sf

1

Exp 3 0.1(0)

1

Exp 4 0.3(0)

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.

Exp 2 rate = 0.096 × k

Exp 3 [Q] = 0.015/k

Exp 4 [P] = 0.116/k

1

(b)
$$K = \frac{1.8 \times 10^{-3}}{(0.20)^2 \times 0.30}$$

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

1

= 0.15 (min 2sfs) (allow $\frac{3}{20}$)
if upside down, score only units mark
AE (-1) for copying numbers wrongly or swapping two numbers

1

mol⁻² dm⁶ s⁻¹
Any order
If k calculation wrong, allow units conseq to their k

1

(c) G

1

[7]

M5.(a) Exp 2 4.5×10^{-4}

Min 2sf

1

Exp 3 4.5×10^{-3}

If three wrong answers, check their value of k in (b).

1

Exp 4 0.043 OR 4.3×10^{-2} OR 0.044 OR 4.4×10^{-2}

They can score all 3 if they have used their (incorrect) value of k. see below.

Exp 2 rate = $k \times (1.0125 \times 10^{-4})$

Exp 3 [Q] = $0.02/k$

Exp 4 [P] = $0.0913/k$

1

(b)
$$k = \frac{5.0 \times 10^{-5}}{(2.5 \times 10^{-2})^2 \times (1.8 \times 10^{-2})}$$

Mark is for insertion of numbers into a correctly rearranged rate equ , k = etc

If upside down, score only units mark from their k

AE (-1) for copying numbers wrongly or swapping two numbers

1

$$= 4.4(4) \text{ (allow } 40/9)$$

1

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

Any order

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

1

[6]

M6.(a) (i) $k = \frac{8.4 \times 10^{-5}}{(4.2 \times 10^{-2})^2 \times 2.6 \times 10^{-2}} \text{ OR } \frac{8.4 \times 10^{-5}}{(1.76 \times 10^{-3}) \times 2.6 \times 10^{-2}}$

Mark is for insertion of numbers into a correctly rearranged rate equ , k = etc.

If upside down, score only units mark from their k

AE (-1) for copying numbers wrongly or swapping two numbers

1

$$= 1.8(3)$$

1

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

Any order

If k calculation wrong, allow units consequential to their k = expression

1

(ii) 5.67×10^{-4} (mol dm⁻³ s⁻¹) **OR** their $k \times 3.1 \times 10^{-4}$
Allow 5.57×10^{-4} to 5.7×10^{-4}

1

(b) (i) 2 or second or [D]²

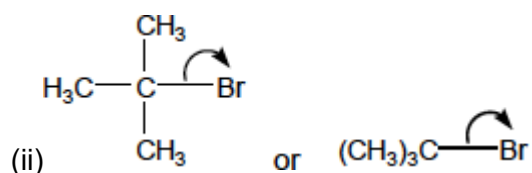
1

(ii) 0 or zero or [E]⁰

1

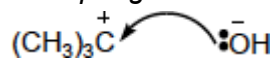
(c) (i) Step 1 or equation as shown
Penalise Step 2 but mark on

1



Ignore correct partial charges, penalise full / incorrect partial charges

If Step 2 given above, can score the mark here for



allow: OH⁻ (must show lp)

If S_N2 mechanism shown then no mark (penalise involvement of :OH⁻ in step 1)

Ignore anything after correct step 1

1

[8]

M7.(a) (i) 2

1

(ii) 0

1

(b) (i)
$$K = \frac{6.64 \times 10^{-5}}{(4.55 \times 10^{-2}) \times (1.70 \times 10^{-2})^2}$$

Correct answer for k with or without working scores 2.

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

1

= 5.05 (range allowed 5.03–5.07)

AE (-1) for copying numbers wrongly or swapping two numbers.

1

mol⁻² dm⁺⁶ s⁻¹

Mark units separately, ie only these units but can be in any order.

1

(ii) 8.3×10^{-6} (mol dm⁻³ s⁻¹)

Allow 0.83×10^{-5} .

Ignore units.

OR if not 8.3×10^{-6} , look at their *k* in part(i) and if not 5.05

Allow ecf for their (incorrect) *k* × (1.64×10^{-6})

1

[6]

M8.(a) (i) 2 or two or second or [E]²

1

(ii) 1 or one or first or [F]¹ or [F]

1

$$(b) \quad (i) \quad k = \frac{8.6 \times 10^{-4}}{(3.8 \times 10^{-2})^2 \times (2.6 \times 10^{-2})}$$

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

$$= 22.9 \text{ (Allow } 22.9 - 24 \text{ after correct rounding)}$$

1

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

Any order.

1

$$(ii) \quad 6.8(2) \times 10^{-3} \text{ (mol dm}^{-3}\text{s}^{-1}\text{)}$$

OR if their k is wrong, award the mark consequentially a quick check can be achieved by using

their answer = 2.9768×10^{-4} Allow $2.9 - 3.1 \times 10^{-4}$ for the mark their k

Allow 6.8×10^{-3} to 6.9×10^{-3}

Ignore units.

1

[6]

M9.B

[1]