OCR A-Level Chemistry A

Rate equations mark scheme · goes with “Rate equations” · whiteboardchemistry.com/revision/exam-questions/ocr-a-level-chemistry/

Mark schemes

Rate equations · 11 questions

Q1 · June 2019 · Paper 1 (Periodic table, elements and physical chemistry) · Q21 · [6 marks]

OCR MARK SCHEME

21

Level 3 (5–6 marks)

Most evidence used to determine the correct orders **AND** rate equation **AND** rate constant.

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Some evidence used to determine two orders correctly **AND** rate equation **AND** rate constant consistent with orders.

OR

Little evidence used to determine all three orders correctly **AND** rate equation **AND** rate constant.

There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.

Level 1 (1–2 marks)

Little evidence used to determine two orders correctly

OR

One order correct, with attempt to determine the rate equation **AND** rate constant.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks

No response or no response worthy of credit.

[6 marks]

EXAMINER GUIDANCE

Indicative scientific points may include:

Orders

Student 1

- zero order wrt Br_2

Student 2

- 1st order wrt CH_3COCH_3

Student 3

- 1st order wrt H^+

Explanations

Student 1

- constant gradient **OR** linear negative gradient **OR** constant rate **OR** rate independent of concentration **OR** decreasing half-life

Student 2

- straight line through 0,0
- **OR** rate directly proportional to $[CH_3COCH_3]$ **OR** $[CH_3COCH_3] \times 2$, rate × 2

Student 3

- $[H^+] \times 2$, rate × 2

Rate equation, rate constant and units

- rate = $k[CH_3COCH_3][H^+]$

ALLOW *rate = k* $[Br_2]^0 [CH_3COCH_3]^1 [H^+]^1$

- $k = \frac{\text{rate}}{([CH_3COCH_3][H^+])}$ **OR** $\frac{(1.25 \times 10^{-5})}{(1.6 \times 0.2)}$
- $k = 3.9... \times 10^{-5}$
- units: $dm^3\ mol^{-1}\ s^{-1}$ (Any order, e.g. $mol^{-1}\ dm^3\ s^{-1}$)

Q2 · June 2022 · Paper 1 (Periodic table, elements and physical chemistry) · Q8 · [1 mark]

Answer: **A**

8.66×10^{-3}

Q3 · June 2022 · Paper 3 (Unified chemistry) · Q4 · [8 marks]

OCR MARK SCHEME

4(a)

At 90 °C/higher temperature

- Faster rate **AND** more frequent collisions ✓
- More particles have the activation energy/E_a or greater ✓
- $[Co(H_2O)_6]^{2+}$ is lower ✓
- (forward reaction) ΔH –ve **OR** exothermic ✓

[4 marks]

EXAMINER GUIDANCE

ORA for 50 °C

IGNORE *more successful collisions*

ALLOW *more molecules have enough energy to react*

ALLOW *atoms/molecules/ions*

ALLOW *decreases*

4(b)(i)

Cl^- /It/They react with $AgNO_3$ / Ag^+ /silver ions

OR

AgCl formed

OR

$Ag^+ + Cl^- \rightarrow AgCl$ ✓

[1 mark]

IGNORE *chlorine/Cl for chloride ion*

IGNORE *$AgCl_2$*

4(b)(ii)

$[CoCl_4^{2-}]$ decreases **AND** $[Co(H_2O)_6]^{2+}$ increases ✓

Cl^- increase is 4 × change in $[CoCl_4^{2-}]$ / $[Co(H_2O)_6]^{2+}$ ✓

Equilibrium shifts to right ✓

[3 marks]

IGNORE *missing charges and small slips in formulae, e.g. $CoCl_4$ missing bracket, etc*

IGNORE *Cl^- for changes in concentration*

ALLOW *suitable alternatives for 'shifts to right', e.g. towards products*

OR in forward direction **OR** 'favours the right'

Q4 · June 2023 · Paper 1 (Periodic table, elements and physical chemistry) · Q17 · [6 marks]

OCR MARK SCHEME

17

Level 3 (5–6 marks)

ALL 3 correct orders linked to explanations

AND rate equation **AND** rate constant

There is a well-developed line of reasoning which is clear and logically structured.

Level 2 (3–4 marks)

Three correct orders

AND two out of:

EXAMINER GUIDANCE

Indicative scientific points may include

Orders

- 1st order wrt Br^-
- 1st order wrt BrO_3^-
- 2nd order wrt H^+

Rate equation

- rate = $k[Br^-][BrO_3^-][H^+]^2$

Calculation of k from any row of data, e.g.

some evidence of an explanation linked to an order

rate equation

rate constant

OR

Three correct orders

with an attempt at:

Some evidence of an explanation link to an order

rate equation

rate constant

OR

Two correct orders linked to explanations

AND rate equation

AND rate constant consistent with the candidate's orders

There is a line of reasoning with some structure and supported by some evidence.

Level 1 (1–2 marks)

Two correct orders

OR

One correct order

AND attempts to determine rate equation **OR** rate constant.

OR

One correct order

AND attempts an explanation.

There is an attempt at a logical structure with a reasoned conclusion from the evidence.

0 marks No response worthy of credit.

[6 marks]

$k = \frac{\text{Rate}}{[Br^-][BrO_3^-][H^+]^2}$

$k = \frac{2.52 \times 10^{-4}}{0.020 \times 0.120 \times (0.080)^2} = 16.4(0625)$

Explanations from results e.g.

Br^-	$[Br^-]$ × 3	rate × 3	Expts 1 and 2
BrO_3^-	$[Br^-]$ × 2 **AND** **[**BrO_3^-**]** ÷ 2	rate: no change	Expts 1 and 3
	OR		
	$[Br^-]$ × 2/3 **AND** **[**BrO_3^-**]** ÷ 2	rate: × 1/3	Expts 2 and 3
H^+	$[BrO_3^-]$ ÷ 2 **AND** **[**H^+**]** × 5	rate × 12.5	Expts 1 and 4
	OR		
	$[Br^-]$ ÷ 3 and $[BrO_3^-]$ ÷ 2 and $[H^+]$ × 5	rate × 4.17	Expts 2 and 4
	OR		
	$[Br^-]$ ÷ 2 and $[H^+]$ × 5	rate × 12.5	Expts 3 and 4

ALLOW *a sequential approach where they apply known orders first*

ALLOW *minor slips as we are looking for an holistic approach to LoR marking*

NOTE*: A clear and logically structured response would link orders to the experiment and experimental results*

provided. They could provide units

Units

$dm^9\ mol^{-3}\ s^{-1}$

***ALLOW** any order, e.g. $mol^{-3}\ dm^9\ s^{-1}$*

Q5 · June 2024 · Paper 1 (Periodic table, elements and physical chemistry) · Q10 · [1 mark]

Answer: **D**

Q6 · June 2024 · Paper 1 (Periodic table, elements and physical chemistry) · Q17 · [7 marks]

OCR MARK SCHEME

17(a)

(Over time) concentration decreases **AND** collisions are less frequent ✓

[1 mark]

EXAMINER GUIDANCE

***ALLOW** less moles/particles per unit volume.*

***ALLOW** fewer collisions per second/per unit time*

***IGNORE** (over time) fewer reacting particles*

***IGNORE** ...chance of..*

***IGNORE** amount decreases*

***IGNORE** successful*

***IGNORE** particles more spread out/further apart*

***DO NOT ALLOW** particles have less energy in terms of energy distribution.*

17(b)

Level 3 (5–6 marks)

A comprehensive conclusion using quantitative data from graph to correctly determine

1st order conclusion for CV using half lives/gradients

AND rate at 3 minutes

AND determination of *k*

There is a well-developed line of reasoning which is clear and logically structured.

Level 2 (3–4 marks)

Reaches a conclusion using quantitative data from graph to correctly determine rate at 3 minutes **AND** determination of *k*.

OR

Half- lives/gradient with 1st order conclusion for CV

AND determination of *k*

OR

determined rate **AND** half-life/first order for CV

Indicative scientific points may include:

Care: ALLOW the use of **ECF** for values obtained from a previously, incorrectly, calculated value.

***ALLOW** minor slips as we are looking for a holistic approach to LoR marking.*

OR

Attempts to determine rate, *k* and order for CV

There is a line of reasoning with some structure and supported by some evidence.

Level 1 (1–2 marks)

Reaches a simple conclusion using at least one piece of quantitative data from the graph, i.e.

Attempts to calculate rate at three minutes **OR** *k* **OR** links half lives to 1^{st} order.3

There is an attempt at a logical structure with a reasoned conclusion from the evidence.

0 marks No response worthy of credit

[6 marks]

	Minutes	Seconds
Half life values	2.4 to 2.6 min	144 to 156 s
Rate at three minutes	(-) (1.5 to 1.8) $\times 10^{-8}$ mol dm^{-3} min^{-1}	(-) (2.5 to 3.0)$\times 10^{-10}$ m dm^{-3} s^{-1}
Value of *k*	0.24 to 0.30 min^{-1}	(4.0 to 5.0) x 10^{-3} s^{-1}
Units of *k*	min^{-1}	s^{-1}

Examples of the communication statement being met would typically include:

- For L1 and L2: full working on the graph and/or appropriate units for calculated values.
- For L3: full working on the graph and appropriate units for calculated values.

If time has been measured in minutes

(see below for values using seconds).

Indicative scientific points may include:

Evidence for 1st order

1st order clearly linked to half-life **OR** 2 gradients:

Half life

Half- life shown on graph

Half- life range 2.4 to 2.6 min

Two ‘constant’ half lives

OR Two gradients → two rates

2 tangents shown on graph at *c* and *c*/2

This could include $c = 0.61 \times 10^{-7}$ mol dm^{-3} ($t = 3$ min)

Gradient at *c*/2 is half gradient at *c*

e.g. $c = 0.8 \times 10^{-7}$ mol dm^{-3}, gradient = 2.2×10^{-8} (mol dm^{-3} min^{-1})

AND $c = 0.4 \times 10^{-7}$ mol dm^{-3}, gradient = 1.1×10^{-8} (mol dm^{-3} min^{-1})

For chosen method, conclude that the reaction is 1st order wrt CV.

Rate at three minutes

Tangent shown on graph as line at t = 3 min

Gradient in range: $(1.5 - 1.8) \times 10^{-8}$

rate as gradient with units: mol dm^{-3} min^{-1}

OR $k = \frac{\ln 2}{t_{½}} = 0.28 \text{min}^{-1}$

And k substituted into rate equation.

e.g.

Rate = k [CV]

Rate = $0.277 \times 0.61 \times 10^{-7}$

= 1.7×10^{-8} mol dm^{-3} min^{-1}

Determination of k

k clearly linked to rate **OR** half-life:

e.g. $k = \frac{\text{rate}}{[\text{CV}]} = \frac{1.75 \times 10^{-8}}{0.62 \times 10^{-7}} = 0.28$

k in range: 0.24 - 0.30 min^{-1}

OR e.g. $k = \frac{\ln 2}{t_{½}} = 0.28$ min^{-1}

Units of k: min^{-1}

If time has been measured in seconds:

Evidence for 1st order

1st order clearly linked to half-life **OR** 2 gradients:

Half life

Half- life shown on graph

Half- life range 144 to 156 s

Two 'constant' half lives

OR Two gradients → two rates

2 tangents shown on graph at c and $c/2$

This could include $c = 0.6 \times 10^{-8}$ mol dm^{-3} (t = 3 min)

Gradient at $c/2$ is half gradient at c

e.g. $c = 0.8 \times 10^{-7}$ mol dm^{-3},

gradient = 3.7×10^{-10} mol dm^{-3} s^{-1}

AND $c = 0.4 \times 10^{-7}$ mol dm^{-3},

gradient = 1.8×10^{-10} mol dm^{-3} s^{-1}

For chosen method, conclude that the reaction is 1st order wrt CV.

Rate at 180 seconds

Gradient in range (2.5 to 3.0) $\times 10^{-10}$

rate as gradient with units: mol dm^{-3} s^{-1}

OR $k = \frac{\ln 2}{t_{½}} = 4.6 \times 10^{-3}$ s^{-1}

And k substituted into rate equation.

e.g.

Rate = k [CV]

Rate = $0.00462 \times 0.61 \times 10^{-7}$

= 2.8×10^{-10} mol dm^{-3} s^{-1}

Determination of k

k clearly linked to rate **OR** half-life:

e.g. $k = \frac{\text{rate}}{[\text{CV}]} = \frac{2.75 \times 10^{-10}}{0.62 \times 10^{-7}} = 4.4 \times 10^{-3}$ s^{-1}

k in range $(4.0 \text{ to } 4.8) \times 10^{-3}$ s^{-1}

OR e.g. $k = \frac{\ln 2}{t_{½}} = 0.28$ min^{-1} **OR** 4.6×10^{-3} s^{-1}

Units of k: s^{-1}

Q7 · June 2024 · Paper 1 (Periodic table, elements and physical chemistry) · Q9 · [1 mark]

Answer: **B**

OCR MARK SCHEME

+133

EXAMINER GUIDANCE

ALLOW *+133 (correct numerical answer)*

Q8 · June 2025 · Paper 1 (Periodic table, elements and physical chemistry) · Q12 · [1 mark]

Answer: **C**

112

Q9 · June 2025 · Paper 1 (Periodic table, elements and physical chemistry) · Q9 · [1 mark]

Answer: **B**

rate = $k[H_2]$ [ICl]

Q10 · November 2020 · Paper 1 (Periodic table, elements and physical chemistry) · Q8 · [1 mark]

Answer: **D**

+457

Q11 · November 2021 · Paper 1 (Periodic table, elements and physical chemistry) · Q21 · [10 marks]

OCR MARK SCHEME EXAMINER GUIDANCE

21(a)(i)

(Expt 1 and 2)

$[S_2O_3^{2-}]$ halves, ($[H^+]$ constant),

AND rate halves

AND first order (with respect to $[S_2O_3^{2-}]$) ✓

(Expt 2 and 3)

$[S_2O_3^{2-}]$ quarter **AND** $[H^+]$ halves,

AND rate quarters

AND zero order (with respect to $[H^+]$) ✓

[2 marks]

ALLOW ORA i.e.

(Expt 2 and 1)

$[S_2O_3^{2-}]$ doubles, ($[H^+]$ constant),

AND rate doubles

AND first order with respect to $[S_2O_3^{2-}]$

ALLOW *comparison of Expt 1 and 3:*

$[S_2O_3^{2-}] \times 1/8$ **AND** $[H^+]$ halves,

AND rate × 1/8

AND zero order with respect to $[H^+]$

21(a)(ii)

$S_2O_3^{2-}$ as only reactant species in step 1 ✓

Rest of mechanism correct ✓

[2 marks]

Step 1: $S_2O_3^{2-} \rightarrow S + SO_3^{2-}$

Step 2 $SO_3^{2-} + 2H^+ \rightarrow SO_2 + H_2O$

OR

Step 1 $S_2O_3^{2-} \rightarrow SO_2 + SO^{2-}$

Step 2 $SO^{2-} + 2H^+ \rightarrow S + H_2O$

21(b)(i)

Gradient

gradient in range of –5700 to –6100 ✓

E_a calculation

E_a = (–) gradient × 8.314

e.g. from –5900, E_a = (+) 49052.6 (J mol^{-1}) ✓

E_a to 3SF and in kJ mol^{-1} ✓

e.g. 49.1 (kJ mol^{-1})

[3 marks]

Marks are for intermediate calculations

ALLOW ECF *from an incorrect gradient*

ALLOW ECF *on missing × 10^{-3},*

e.g. **ALLOW** 2 marks for:

gradient = –5.9,

leading to E_a = 49.0526 (J mol^{-1})

AND 0.0491 (kJ mol^{-1})

DO NOT ALLOW *a negative E_a*

21(b)(ii)

ln *A* is intercept at 0 when $\frac{1}{T}$ **OR** x axis is 0 ✓

[1 mark]

21(b)(iii)

ln k

ln k = –2.59 ✓

Temperature

$\frac{1}{T} = 3.10 \times 10^{-3}$ (s^{-1})

T = 49.6 ºC ✓

Correct T scores 2 marks

ALLOW ECF *for 1/T from incorrect lnK shown on the graph*

ALLOW in the range

$1/T = 3.09 – 3.11$ (× 10^{-3} s^{-1})

T = 48.5 to 50.6 ºC

ALLOW *T = 50 ºC*

[2 marks]

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