OCR A-Level Chemistry A

Reaction rates and equilibrium mark scheme · goes with “Reaction rates and equilibrium” · whiteboardchemistry.com/revision/exam-questions/ocr-a-level-chemistry/

Mark schemes

Reaction rates and equilibrium · 9 questions

Q1 · June 2024 · AS Paper 1 (Breadth in chemistry) · Q12 · [1 mark]

Answer: **A**

More molecules have an energy greater than the activation energy.

Q2 · June 2024 · AS Paper 1 (Breadth in chemistry) · Q13 · [1 mark]

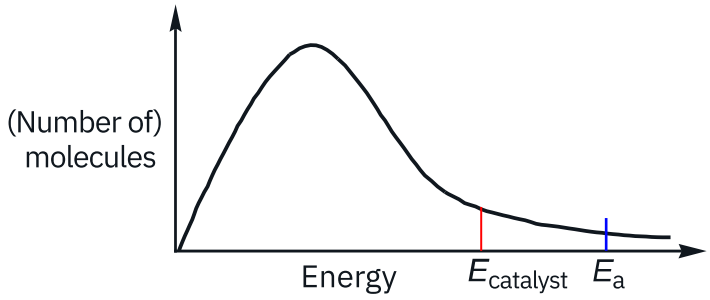
Answer: **B**

$$\frac{[SO_3(g)]^2}{[SO_2(g)]^2\,[O_2(g)]}$$

Q3 · June 2024 · AS Paper 2 (Depth in chemistry) · Q4 · [13 marks]

OCR MARK SCHEME

4(a)



Correct drawing of Boltzmann distribution

Curve starts within one small square of origin

AND

not touching the x axis at high energy ✓

Axes labels

y: (number of) molecules/particles

AND

x: (kinetic) energy ✓

Catalyst and activation energy

Catalyst provides a lower activation energy

OR

EXAMINER GUIDANCE

DO NOT ALLOW *two curves*

Confusion with effect of temperature

IGNORE *a slight inflexion on the curve if less than one small square*

DO NOT ALLOW *‘atoms’ as y-axis label*

DO NOT ALLOW *‘enthalpy’ for x-axis label*

IF *y axis labelled as ‘atoms’*

ALLOW ECF *for atoms (instead of molecules/particles)*

IGNORE *(more) successful collisions*

IGNORE *response implying ‘more collisions’ (confusion with effect of greater temperature)*

E_c shown below E_a on Boltzmann distribution ✓

Particles with $E >$ Ea

More molecules/particles/collisions have energy above activation energy (with catalyst)

OR

more molecules have enough energy to react

OR

greater area under curve above activation energy ✓

[4 marks]

4(b)(i)

Line

Smooth curve using all points

EXCEPT point at 100 s. ✓

Anomaly

Point at 100 s circled ✓

[2 marks]

ALLOW *flexibility around point at 120 s*

Graph should be seen to level off on or very near to 90 cm^3

4(b)(ii)

Tangent on graph

drawn at = 50 s (± 10 s) ✓

Calculation of rate

= gradient (y/x) of tangent drawn

= 0.67 ± 0.2 $cm^3\ s^{-1}$ ✓

[2 marks]

DO NOT ALLOW *interpolation (taking a direct reading from graph),*

Answer must be derived from taking a gradient

ALLOW ECF *from incorrectly drawn tangent or a straight line of best fit*

4(b)(iii)

FIRST CHECK ANSWER ON THE ANSWER LINE

If answer = 0.15 (mol dm^{-3}) award 3 marks

$n(O_2) = \dfrac{90}{24000}$ **OR** $\dfrac{0.09}{24}$ **OR** 0.00375 (mol) ✓

$n(H_2O_2) = 2 \times 0.00375$ **OR** 0.0075 (mol) ✓

$c(H_2O_2) = 0.0075 \times \dfrac{1000}{50.0} = 0.15$ mol dm^{-3} ✓

[3 marks]

ALLOW ECF

COMMON ERRORS

For 2 marks:

0.075 missing x 2

150 missing a cm^3 to dm^3 conversion

ALLOW *use of ideal gas equation using sensible p and T for first mark. e.g.*

from 100 kPa and 293 K

$n = \dfrac{pV}{RT}$

→ n

$= \frac{pV}{RT} =$

$\frac{(100 \times 10^3) \times (90 \times 10^{-6})}{8.314 \times 293} =$

0.00369...

(mol)

Examples of 'sensible' p and T:

p = 100 kPa, 101 kPa, 101,325 Pa

T = 273 – 298 K

4(c)

ANY two ✓✓

- Amount of catalyst/metal oxide (allow same mass **OR** same moles)
- Temperature
- Volume of H_2O_2
- Concentration of H_2O_2
- Moles/amount of H_2O_2
- Pressure
- Surface area of catalyst

DO NOT ALLOW
concentration/volume of catalyst/metal oxide

[2 marks]

Q4 · June 2024 · Paper 1 (Periodic table, elements and physical chemistry) · Q8 · [1 mark]

Answer: **B**

How the activation energy changes: decreases · Proportion of molecules with energy > E_a: increases

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Q5 · June 2025 · AS Paper 1 (Breadth in chemistry) · Q12 · [1 mark]

Answer: **B**

Rate of reaction: Increases · Equilibrium yield of HI: No effect

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Q6 · June 2025 · AS Paper 1 (Breadth in chemistry) · Q13 · [1 mark]

Answer: **B**

The position of equilibrium moves towards the products.

Q7 · June 2025 · AS Paper 1 (Breadth in chemistry) · Q23 · [8 marks]

OCR MARK SCHEME

23(a)

Two (✓ ✓) from:

EXAMINER GUIDANCE

IGNORE *reactions take place together/reversible reaction*

- rate of forward reaction = rate of reverse reaction
- Concentrations (of reactants and products) do not change/are constant
- In a closed system/environment

[2 marks]

ALLOW *backward for reverse*

DO NOT ALLOW *concentration of reactants = concentration of products*

ALLOW *'nothing can leave/enter'*

23(b)

FIRST, CHECK THE ANSWER LINE, **IF bond** enthalpy = (+)463 (kJ mol^{-1}) award 3 marks

Energy for bonds broken (4 × S=O in SO_2) + 1 × O=O)

(4 × 522) + (1 × 494) **OR** 2088 + 494

OR 2582 (kJ) ✓

S=O bond enthalpy in 6 x SO_3 correctly calculated

6 × S=O bond enthalpy in SO_3 = 2582 + 196

= 2778 (kJ mol^{-1}) ✓

S=O bond enthalpy in SO_3 correctly calculated

S=O bond enthalpy in SO_3 = $\frac{2778}{6}$

= (+)463 kJ mol^{-1} ✓

Mark is for answer

[3 marks]

IGNORE *sign*

(rearranging assessed below)

ECF for MP2*: Ans to part 1 + 196*

ECF for MP3*: Ans to part 2/6;* ***IGNORE*** *significant figures and rounding errors.*

COMMON ERRORS

Use of 2 S=O (reactants) and 3 S=O (product)

+578 → 1 mark

Wrong sign for 196

+398 → 2 marks (ans: 397.6...)

Use of 2 S=O (reactants) and dividing by 2

+867 → 1 mark

Addition of S=O (product) bonds, not subtraction

-463 → 2 marks

23(c)

K_c expression

(K_c =) $\frac{[SO_3(g)]^2}{[SO_2(g)]^2\,[O_2(g)]}$ ✓

Calculation

(K_c =) $\frac{42.0^2}{25.0^2 \times 108}$ **OR** 0.02613..... ✓

= 2.61×10^{-2} to 3 SF and standard form ✓

[3 marks]

Square brackets required for K_c expression

IGNORE *state symbols, even if wrong*

DO NOT ALLOW

K_c = $\frac{[SO_3(g)]^2}{[SO_2(g)]^2 + [O_2(g)]}$ for first two marks

BUT ALLOW ECF to 3SF and standard form

i.e. 2.41 x 10^0

ALLOW *42^2 and 25^2 in substituted equation*

ALLOW ECF for Calculation *from inverted K_c expression ONLY i.e.*

3.83×10^{1} for two marks (to 3 SF and standard form)

DO NOT ALLOW *0.0261×10^{0}*

ALLOW ECF *from any incorrect K_c value for 3 SF and standard form*

IGNORE *attempts at units*

Q8 · June 2025 · Paper 1 (Periodic table, elements and physical chemistry) · Q18 · [14 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

18(a)(i)

(Pt has) different state / phase (to reactants) ✓

[1 mark]

ALLOW *Pt is a solid but reactants are gases*

IGNORE *products*

18(a)(ii)

Correct drawing of a Boltzmann distribution

curve must start within the first small square nearest to the origin

AND must not touch the x-axis at high energy

AND not be horizontal for more than 1 large square ✓

Catalyst (provides a reaction pathway with) lower activation energy **OR** E_a to the right of $E_{c/cat}$ marked on graph

AND

A greater proportion / more of molecules / particles have energy greater or equal to the activation energy / $E \geq E_a$ ✓

[2 marks]

DO NOT ALLOW *multiple curves*

IGNORE *a slight inflexion at the end of the curve less than one <u>small</u> square*

ALLOW *shading on the graph if linked to the idea of more molecules*

ALLOW *more molecules have (sufficient) energy to react for $E \geq E_a$*

IGNORE *more (frequent) successful collisions BUT*

DO NOT ALLOW *more frequent collisions*

IGNORE *more molecules have / meet / reach activation energy*

DO NOT ALLOW *molecules have more energy (confusion with temperature)*

18(a)(iii)

Lower temperature can be used (for the same yield)

OR less energy demand / required to heat reaction

OR less fossil fuels need to be burnt

OR reduction in CO_2

OR catalyst can be reused ✓

[1 mark]

18(b)

(Experiments 1 & 2)

As $[O_2]$ × 2, rate × 2

AND 1st order with respect to O_2 ✓

(Experiments 1 & 3)

As [NO] × 1.5, rate × 2.25

AND 2nd order with respect to NO

OR

(Experiments 2 & 3)

As [NO] × 1.5 and $[O_2]$ ÷ 2, rate × 1.13

$(1.13 = \frac{1.5^2}{2})$

AND 2nd order with respect to NO ✓

rate = $k\,[NO]^2\,[O_2]$ ✓

$k = \frac{7.45 \times 10^{-4}}{0.04^2 \times 0.035} = 13(.30357...$

OR

$k = \frac{1.49 \times 10^{-3}}{0.04^2 \times 0.070} = 13(.30357...$

OR

$k = \frac{1.68 \times 10^{-3}}{0.06^2 \times 0.035} = 13(.33333...$ ✓

Units: $dm^6\ mol^{-2}\ s^{-1}$ ✓

***ALLOW ORA** throughout*

Check table for working if none shown

***ALLOW** 2 SF up to calculator value*

***ALLOW ECF** from incorrect orders*

***ALLOW** in any order*

***ALLOW ECF** from incorrect rate equation*

e.g. 1st order wrt NO

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

zero order wrt NO

units: s^{-1}

[5 marks]

18(c)(i)

11.4 / 11.35 ✓

[1 mark]

18(c)(ii)

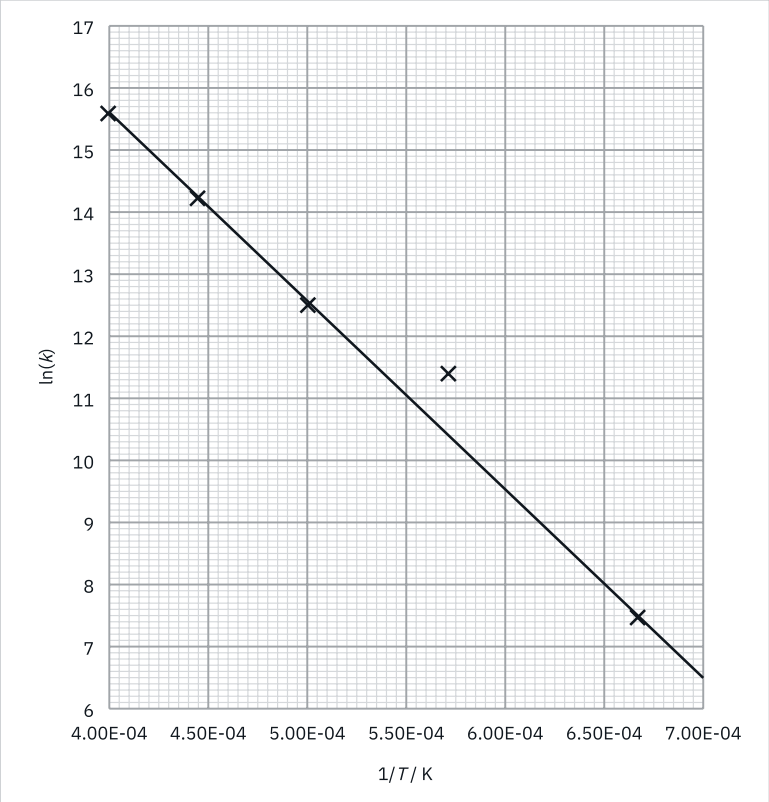
Straight line of best fit ✓

Mark first two marking points independently

***ALLOW** rounding to 2SF*

Best fit line judged from their points using the following guidance:

Line should go through ranges:



Top left	15.3 – 15.7
Bottom right	6.3 – 6.8

and exclude anomalous point at ln(*k*) = 11.4

Marks are for intermediate calculations

ALLOW ECF *from an incorrect gradient*

IGNORE *signs for both* E_a *calculation and gradient*

DO NOT ALLOW *a negative* E_a

Gradient

Gradient from a straight line in range of (–)28300 to (–)31300 ✓

CHECK THE ANSWER ON ANSWER LINE

If answer = 240 to 260 (kJ mol^{-1}) award last two marks

E_a calculation

Ea = (–) gradient × *R* (8.314) ✓

e.g. from –30000, E_a = (+)249420 (J mol^{-1})

Ea to 2 SF and in kJ mol^{-1} ✓

e.g. 250(kJ mol^{-1})

[4 marks]

Q9 · June 2025 · Paper 1 (Periodic table, elements and physical chemistry) · Q5 · [1 mark]

Answer: **B**

1.2

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