

OCR (A) Chemistry A-level

Practicals: Mathematical Skills



Arithmetics

Unit prefixes

Most commonly used prefixes in the exam.

<i>Factor</i>	<i>Name</i>	<i>Symbol</i>
10^6	Mega	M
10^3	kilo	k
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ

- $1 \text{ kg} = 1000\text{g} = 10^3\text{g}$

Power Laws

$$X^m \times X^n = X^{m+n} \quad \text{multiplicative rule}$$

$$\frac{X^m}{X^n} = X^{m-n} \quad \text{division rule}$$

$$(X^m)^n = X^{mn} \quad \text{power rule}$$

$$X^{-m} = \frac{1}{X^m} \quad \text{reciprocal rule}$$

$$X^{m/n} = \sqrt[n]{X^m} \quad \text{root rule}$$

- $\text{mol} \times 1/\text{dm}^3 = \text{mol dm}^{-3}$

Key unit conversions

- $1 \text{ dm}^3 = 1 \text{ L}$
- $1 \text{ cm}^3 = 1 \text{ ml}$
- $1 \text{ dm}^3 = 10^3 \text{ cm}^3$
- Kelvin (K) = 273 + degree celcius ($^{\circ}\text{C}$)



Amount of substance

- Relative masses (isotopic, atomic, formula, molecular, etc) don't have units.
 - E.g relative atomic mass of magnesium is 24.3

Energetics

- Unit of entropy values = $\text{J K}^{-1} \text{mol}^{-1}$
- Unit of enthalpy values = kJ mol^{-1}

Kinetics and equilibria For example, for the equation

$$\text{rate} = k[A]^2[B]$$

$$k = \frac{\text{rate}}{[A]^2[B]} = \frac{\text{mol dm}^{-3} \text{s}^{-1}}{(\text{mol dm}^{-3})^2 (\text{mol dm}^{-3})}$$

When simplified, mol dm^{-3} can often be cancelled. E.g.

$$\frac{\text{mol dm}^{-3} \text{s}^{-1}}{\text{mol}^2 \text{dm}^{-6} \times \text{mol dm}^{-3}} = \frac{\text{s}^{-1}}{\text{mol}^2 \text{dm}^{-6}} = \text{dm}^6 \text{mol}^{-2} \text{s}^{-1}$$

Remember: $\frac{X^m}{X^n} = X^{m-n}$

Note - Put positive indices first when writing compound units

Decimal places

When adding or subtracting the same type of measurements, the answer must also be to the same number of decimal places

Example

- $5.998 \text{ g} + 6.789 \text{ g} = 12.787 \text{ g}$; answer is written to the same number of decimal places and not to the lowest number of significant figures
- *Note - when a calculation involves raw data with varying numbers of significant figures, you must give your answer to the lowest number of significant figures in the raw data used.*

Standard forms

When converting between standard form and decimal, significant figures must be retained.

Example • $0.0080 \text{ mol dm}^{-3} = 8.0 \times 10^{-3} \text{ mol dm}^{-3}$

When using standard form and a calculator:

Calculator make	Convert decimal to standard	Enter numbers in standard form
Sharp	Change	EXP
Casio	S→D	$\times 10^x$



Measuring quantities by difference

Example

Initial mass	30.5 g
After effervescence	21.5 g
Change in mass	9.0 g

The '0' in change in mass is significant in order to have the result to 1 decimal place, so must be included.

The Avogadro constant

Note - The data sheet value of the constant is 6.02×10^{23} , which is to 3 significant figures

Effect of changing parameters

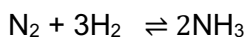
Example

$$A = \frac{XY}{Z \times T^3}$$

In this formula,

- Larger the numerator (increase in X or Y), larger the output (increases A)
- Larger the denominator (increase in Z or T), smaller the output (decreases A)
- The reverse is true in each case

Equilibrium constants



$$K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$$

- Using this equation, if ammonia is removed from the reaction vessel, the concentration of ammonia will decrease so the numerator will also decrease.
- If the denominator remained the same, removing ammonia would cause K_c to decrease. However, as temperature is constant, K_c must stay the same.
- In order to keep K_c the same, if the numerator decreases, the denominator must decrease.
- Hence, the position of equilibrium shifts to the right.

Logarithms

Use 'log' for base 10 logarithms and use 'ln' for base e logarithms



Data Handling

Outliers

Outliers should be omitted from the data set when doing calculations.

Calculating mean titre

	Trial	1st run	2nd run	3rd run
Final reading / cm ³	22.90	45.40	43.05	22.55
Initial reading / cm ³	0.00	22.90	20.95	0.00
Titre / cm ³	22.90	22.50	22.10	22.55

From the table, the 1st and 3rd runs are concordant. The mean titre can be calculated using these values:

$$\frac{22.50 + 22.55}{2} = 22.525 \text{ cm}^3$$

Note – the unrounded value of the mean should be used in the further calculations.

Uncertainty

If a 250 cm³ volumetric flask has an absolute uncertainty of 0.2 cm³, the volume measured with that flask can be between 249.8 cm³ and 250.2 cm³.

$$\% \text{ uncertainty} = \frac{\text{absolute uncertainty}}{\text{quantity measured}} \times 100\%$$

Note - if you are measuring a difference, multiply the numerator by a factor of 2 because there will be an uncertainty associated with both readings.

Algebra

Symbol

< means 'less than'

<< means 'much less than'

> means 'more than'

>> means 'much more than'

∝ means 'is proportional to'

⇌ means 'both forward and backward reactions are happening in the system'

~ means 'roughly equal to'

Rates

Rate ∝ [A]² means the rate of reaction is proportional to the square of the concentration of A.



Rearranging Arrhenius equation

Given the exponential equation

$$k = Ae^{-E_a/RT}$$

Before getting rid of the exponential, put the coefficient (A) on the other side

$$\frac{k}{A} = e^{-E_a/RT}$$

Take natural logs on both side

$$\ln\left(\frac{k}{A}\right) = -\frac{E_a}{RT}$$

According to the log law

$$\log\left(\frac{A}{B}\right) = \log A - \log B$$

$$\ln k - \ln A = -\frac{E_a}{RT}$$

Finally,

$$\ln k = -\frac{E_a}{RT} + \ln A$$

To calculate the activation energy or the pre-exponential factor from data, use the logarithmic form of the Arrhenius Equation with $\ln k$ on the y axis, and $\frac{1}{T}$ the x axis.

Then: $gradient = \frac{-E_a}{R}$, $y \text{ intercept} = \ln A$



Graphs

Plotting graph

Key points to remember

- Use appropriate linear scale
- Label the axes including the units
- All the points must be plotted within the graph area
- Graph should make good use of space available
- Plotted points must be within 1 square of the correct value
- When drawing a line of best fit, a ruler must be used to draw a line which goes through most of the points.

Note - for rate vs concentration graphs, the line of best fit must go through the origin.

Interpolation - the line of best fit can be used to read a value within the experimental range.

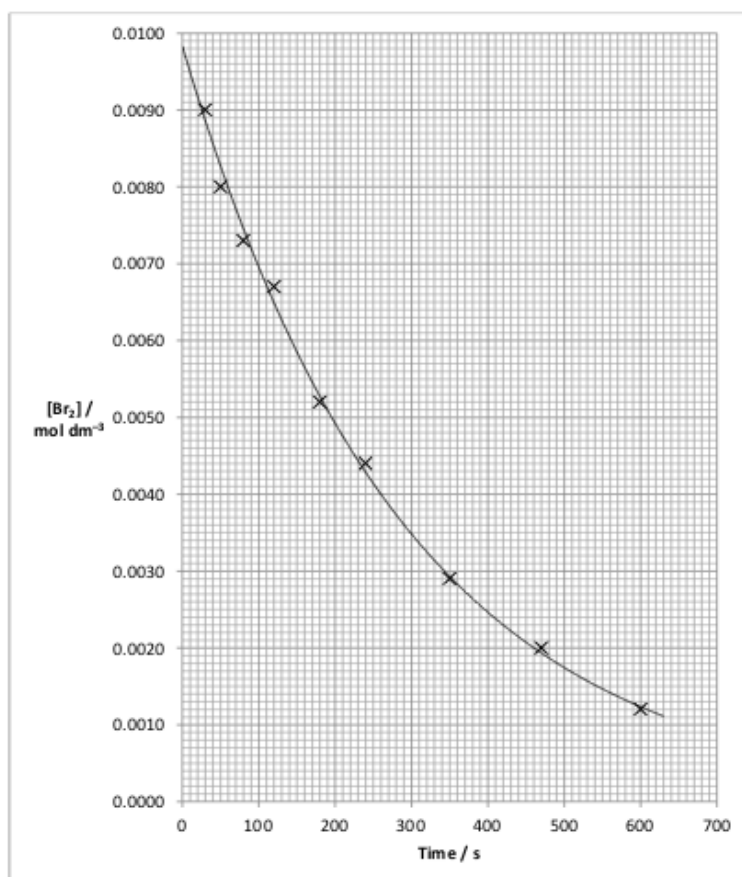
Extrapolation - the line of best fit needs to be extended to the appropriate point

Rate experiment

Time /s	30	50	80	120	180	240	350	470	600
[Br ₂] / mol dm ⁻³	0.0090	0.0080	0.0073	0.0067	0.0052	0.0044	0.0029	0.0020	0.0012

Suitable axis will depend on the size of the graph paper, but sensible axis would be

- 0 - 700 s, with 10 s per square for the x axis
- 0 - 0.0100 mol dm⁻³, with 0.0001 mol dm⁻³ per square for the y axis



Gradient

$$\text{gradient} = \frac{\text{change in } y}{\text{change in } x}$$

Note - to calculate the gradient, the two points selected must be on the line of best fit. You should not use two of the plotted points. You should aim to maximise the values of 'change in y' and 'change in x' when choosing your points.

Tangent

To draw a tangent

- Use a pencil and ruler
- Line the ruler up with the point where the tangent being drawn
- When aligning the ruler, avoid covering the curve with the ruler to ensure that all of the curve is visible.

