OCR (A) Chemistry A-Level

Practicals: Mathematical Skills

Arithmetics

Unit prefixes

Most commonly used prefixes in the exam.

Factor	*Name*	*Symbol*
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 Kg = 1000g = 10^3g

Power Laws

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

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

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

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

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

- mol x 1/ dm^3 = mol dm^{-3}

Key unit conversions

- 1 dm^3 = 1 L
- 1 cm^3 = 1 ml
- 1 dm^3 = 10^3 cm^3
- Kelvin (K) = 273 + degree celcius (℃)

Context

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 = J K^{-1} mol^{-1}
- Unit of enthalpy values = kJ mol^{-1}

Kinetics and equilibria

For example, for the equation

$$rate = k[A]^2[B]$$

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

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

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

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

Note - Put positive indices first when writing compound units

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

Example
- 5.998 g + 6.789 g = 12.787 g; answer is written to the same number of decimal places and not to the lowest number of significant figures
- Note - when calculation involves different types of measurements round up the answer to the lowest number of significant figures

Standard forms
When converting between standard form and decimal significant figures must be retained

Example
- 0.0080 mol dm^{-3} = 8.0 x 10^{-3} 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	x10^x

Context

Measuring quantities by difference

Example

Initial mass	30.5 g
After effervescence	21.5 9
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 x 10^{23} 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

Context

Equilibrium constants

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

$$Kc = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

- 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 increases, the denominator must the decrease.
- Hence, the position 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

Context
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	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:

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

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

Uncertainty

If a 250 cm^3 volumetric flask has an uncertainty of 0.2 cm^3, the volume measured with that flask can be between 249.8 cm^3 and 250.2 cm^3.

$$\%\ uncertainity = \frac{2\ \times\ absolute\ uncertanity}{quantity\ measured} \times\ 100\%$$

Note - only multiply by 2 when calculating the uncertainty for a value that was calculated by a difference.

Algebra

Symbol

∝ means 'is proportional to'
⇌ means 'both forward and backward reactions are happening in the system'
∼ means 'roughly equal to'

Context
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,

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

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 concentration graph the line of best fit must go through the origin

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

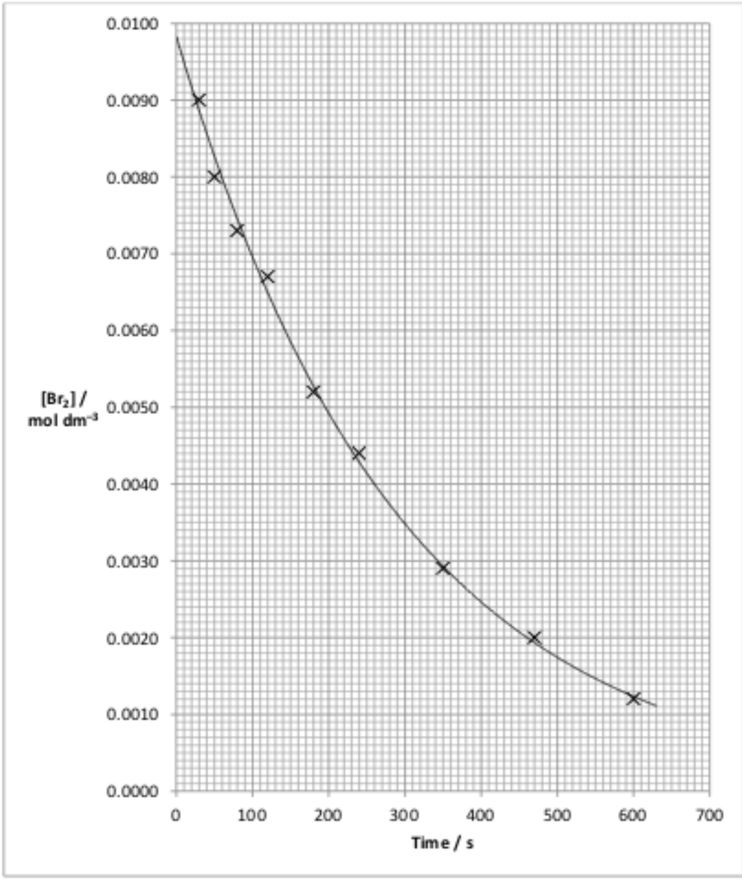
Context

Rate experiment

Time	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

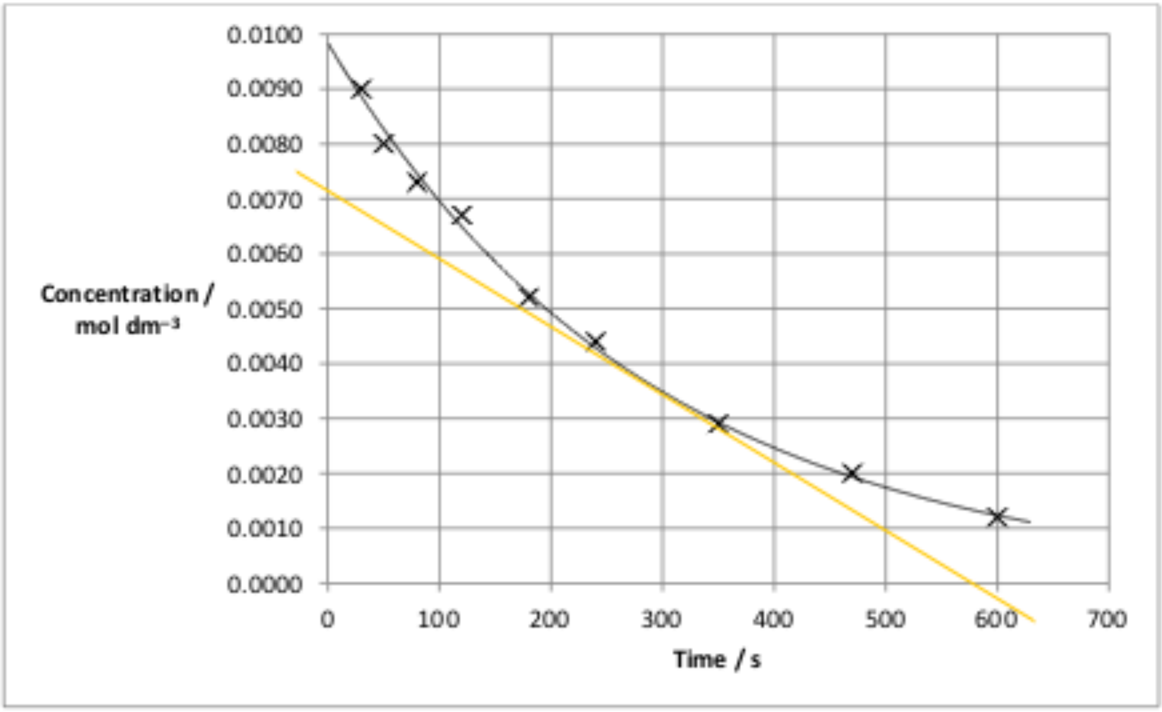
Gradient = change in y / change in x

Note - to calculate the gradient the two points selected must be on the line of best fit and must not use two of the plotted 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.


Concentration / mol dm⁻³
0.0100
0.0090
0.0080
0.0070
0.0060
0.0050
0.0040
0.0030
0.0020
0.0010
0.0000
0
100
200
300
400
500
600
700
Time / s