Maths Skills for Chemists

There are some basic Maths skills required for A-Level Chemistry but not as many as you may think. Yes, there are a lot of calculations, but the skills you need are very basic Maths.

This isn't a document to show you how to do specific calculations, those are in the individual topic sections. The aim here is to show you the general maths skills that you will need.

✓ if maths isn't your strong point, try not to let it become a mental block. It's often the chemistry that is misunderstood rather than the maths.

Anything complicated, your calculator takes care of it. However, you need to know how to:

- Rearrange equations
- Work out units
- Draw graphs
- Work out gradients
- Use Logs at a very basic level
- Handle the correct number of decimal places and significant figures
- Not make mistakes with negative signs
- Use your calculator properly!

1. General skills

Simplicity wins every time with calculations.

Write out the calculation steps as fully as you can

This is the quickest way to minimise mistakes. A lot of people try to do too much in their head or on their calculator and end up losing marks.

For example in the Born-Haber cycle topic, there are many numbers that you need to add together. This means that there are several places where you can go wrong:

$$\mathbf{-174 = -324 + (-231) - (-460) - (271)}$$

Don't try to do it all in one go, even in your calculator. Keep the brackets.

The biggest mistake is negative signs not being added or subtracted correctly

Take your time, simplicity will save you marks, even if it feels long winded and time consuming.

Get into the habit of telling the examiner what it is you have actually worked out! A lot of students write down many numbers on the page without any explanation, which inevitably leads to problems if they make just one mistake.

2. Rearranging equations

✓ this is the most important maths skill you will need.

Some people try to memorise every equation and every way that it can be rearranged, which is completely unnecessary. You will save yourself so much time and effort by learning how to rearrange equations, meaning that you will only have to remember the equation in its original form.

Rule 1 – take things to the other side

This might be obvious but it is the starting point. If you had 7 = 5 + 2 and someone asked you to rewrite this to show what 5 is equal to, you **would have to take 2 to the other side**. So you get 7 -2 = 5.

If something is added on one side of the equation then it becomes subtracted on the other side

i.e. +2 become -2 (and vice-versa). The same rule applies to multiplication and division.

Rule 2 – do it step by step, not all in one go

If you had **2 = 8/4** and you were asked to rearrange to show what 4 equals, how would you do it? Now, I know you know the answer to this, but these simple skills apply to the most complicated examples too.

Step 1:

The aim is to get 4 on one side of the equation on its own.

Starting with 2 = 8/4

Take 4 from the bottom on the right hand side to the top line on the left hand side (remember division becomes multiplication when changing sides), to give:

$$2 \times 4 = 8$$

Step 2:

Now we can get 4 on its own on the left hand side by taking 2 from the left hand side to the bottom line on the right hand side. As 2 was multiplied on the left hand side it has to be divided on the right hand side, to give:

$$4 = 8/2$$

This might seem very easy and it is, but this is how you rearrange **any** equation. You need to learn to do these simple examples logically step by step so that you are then confident that you can rearrange something more complicated, especially when it contains only letters.

Example

y = mx + c is the equation of a straight line. Could you rearrange for x?

Step 1: take c to the other side → **mx = y-c**

(I've just switched the equation round as I prefer to have the 'thing' I am trying to work out on the left hand side but you can leave it as y-c = mx if you prefer).

Step 2: take m to the other side → **x = y-c/m**

Always ask yourself: is it multiplied, divided, subtracted or added? Then reverse it when you take it to the other side.

<u>Rule 3</u> – put in some simple numbers

If you are not sure or confident that you have done it correctly:

Put in some simple numbers to replace the letters in the original equation

✓ maybe the best tip I know and means you can rearrange anything.

Example

n = c x v (no. of moles = concentration x volume)

Let's pretend we have no idea what c or v are equal to. The technique is to:

relate this equation to one that you know how to rearrange

I always go back to the **8 = 2 x 4** example.

We know how to rearrange this i.e. 2 =8/4 and 4 = 8/2.

This simple equation has the **same format as n = c x v**:

8 = 2 x 4
n = c x v

→ n = 8, c = 2 and v = 4

So if I want to know what c is equal to, all I need to do is work out **what 2 is equal to**:

→ c = n/v

and similarly:

v = n/c

✓ I used to do this for everything. If I wasn't sure, I'd put in some numbers. Even for the more difficult equations it will work.

Example

The other most common equation you have is:

no. of moles = mass/formula mass

Again, I would use 2 = 8/4 for this one. I still do it mentally even after doing this for years.

So if I wanted to work out the **formula mass**, which is the equivalent of 4 this time, I would ask myself, how do I get to 4? You would do:

4 = 8/2 or formula mass = mass/number of moles

Rule 4 – simplify wherever possible

The simplest equations will only have **3 variables** in them like the ones above.

The goal with a complicated equation is to simplify it down to three variables

Put in numbers

For example at A2 in the acids and bases topic you will use: $K_a = [H^+][A^-]/[HA]$

And more often than not you have to work out the $[H^+]$.

So, as we just said, try to get the equation down to three variables (in this K_a equation there are 4 variables).

For me, this is a simple division like the molecular mass one above. So I treat this as 2 = 8/4, where:

$$K_a = 2,\ [H^+][A^-] = 8 \text{ and } [HA] = 4$$

The key part is that I have grouped the top line ($[H^+][A^-]$) as one variable

So I then just do:

$$[H^+][A^-] = K_a \times [HA]$$

Then to get $[H^+]$, just take $[A^-]$ to the bottom line:

$$[H^+] = K_a \times [HA] / [A^-]$$

Alternatively, if you don't need to use the numbers just **take things to the other side:**

Step 1: take [HA] to the other side to give:

$$K_a \times [HA] = [H^+][A^-]$$

Step 2: take $[A^-]$ to the other side:

$$[H^+] = K_a \times [HA] / [A^-]$$

Another method a bit like the Born-Haber example earlier, is to simplify by putting in the real numbers from the question and multiply or divide where you can to remove as many variables as possible.

You can do this before you start to rearrange. This works well for equations with lots of variables.

3.Working out units

Working out units is a very common question, particularly at A2, and comes up in acid and bases, rates and equilibria all the time.

You will work out a numerical value and then you will have to work out the units as they are not always the same every time.

✓ this is more for A2 students although AQA will see it in the equilibrium topic for K_c at AS.

Rule 1 – put in the units that you do know

For example to work out the units of k in a rate equation:

A rate equation has the format:

$$\text{Rate} = k[A][B]$$

And we then we rearrange for k using our new found skills from above:

$$k = \text{Rate}/[A][B]$$

Next, we put in the units for rate (mol dm^{-3} s^{-1}) and concentration of [A] and [B] (mol dm^{-3})

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

Rule 2 – cancel (simplify) wherever you can.

You can cancel similar things that are being divided

This is similar to doing 10/10 to get 1. It's the same with letters.

So we can **cancel the mol dm^{-3}** in the top line and one of them in the bottom line too. Note that the **s^{-1}** has remained in the top line:

$$\mathbf{k = \cancel{mol\ dm^{-3}}\ s^{-1}/\cancel{mol\ dm^{-3}} \times mol\ dm^{-3}}$$

$$\mathbf{k = s^{-1}/mol\ dm^{-3}}$$

Rule 3 – everything must be on the one line, so we can't leave an answer as a division.

So we need to **take mol dm^{-3} to the top line**; the s^{-1} is fine as it is.

We are dealing with **indices** (the small numbers):

Indices **change sign** when they are taken to the top line

- ✓ you have to be careful though, as mol dm^{-3} is actually **mol^{1} dm^{-3}**, we just don't bother writing the one in normally. But when this is taken to the top line we have to be aware of the 1 as we now get mol^{-1} dm^{3} i.e. reversing the signs on the indices.

The overall units are therefore: **mol^{-1} dm^{3} s^{-1}**. It can be written out in this order or s^{-1} mol^{-1} dm^{3}.

Rule 4 – multiplying indices

In another example, you may have units with indices that need to be multiplied. Using a concentration example again, you may have something like:

$$\mathbf{mol\ dm^{-3} \times mol\ dm^{-3}}$$

When multiplying indices, you add them together and when dividing indices you subtract

Remember it's really **mol^{1} dm^{-3} x mol^{1} dm^{-3}**, → **mol^{2} dm^{-6}**

4. Graphs

There are many graphs in chemistry and you will draw a graph or two in exams. The Arrhenius equation in the A2 rates topic is a favourite.

You have probably had plenty of practice at drawing graphs from GCSE anyway. So if you do have to draw a graph just do it the way you have always done it.

5. Gradients

Again this mostly for the A2 Rates topic, but it is worth reminding yourself about gradients.

We were always told at school gradient = "boxes up over boxes along" or y/x

As we were using graph paper and we could count the boxes. The rule still applies. You just have to measure or count whatever is on the y-axis and divide it by whatever you have measured on the x-axis. The units or the spacing on the axes doesn't matter, just count!

Just pick two points on your line. From the point 'higher' up, draw a vertical line straight down. From the lower point, draw a horizontal line across and they should meet. You can now measure the horizontal and vertical distances then divide them to get the gradient.

✓ the larger the distances the better, usually gives a more accurate value.

6. Decimal Places and Significant Figures

This should be easy but people still lose marks with it.

You do not need a whole string of decimal places. Students bash in some numbers into their calculators and come out with something like 3.46856896 and proceed to write all this down in each step of the calculation. They think if they round up or down it will somehow affect their final answer. It won't.

Go with 2 decimal places unless it asks for something different.

7. Logs (A-level)

There are two types of 'logs': **log_{10}** (log to the base 10) and **ln** (natural log).

Log_{10} is used in the acid and base topic at A2 but all you need to do is use the equation and **press the button on the calculator!** Also, the inverse of this on the calculator, which is a **10^x** symbol. That is it.

With ln, you don't see them very often. The rates topic (again) at A2 is probably the only place you will see it.

- ✓ the important point is you don't need to know anything about logs or understand what a log is or how it works. Treat it as a button on your calculator and forget about it.