Ratio and proportion

This presentation forms part of the Maths skills for chemistry resources series which can be viewed: rsc.li/4A41ezG. The series offers flexible, targeted support for maths skills which are fundamental to chemistry teaching:

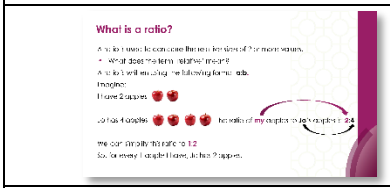
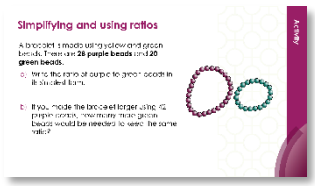
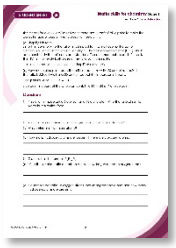
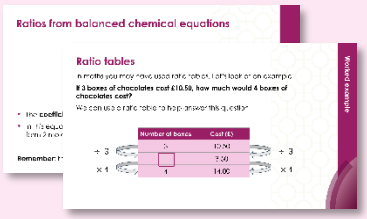
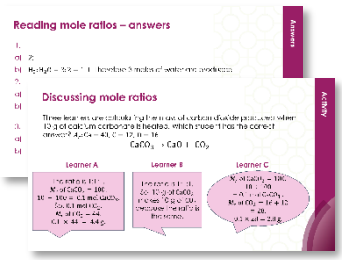
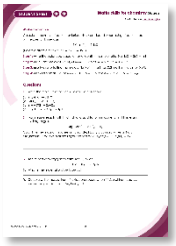
Graphs and data, divided into:

- Creating graphs
- Interpreting graphs

- **Ratio and proportion**
- Understanding number, divided into:
  - Unit conversion
  - Significant figure
- Algebra and equations

Resource series components

The resource series is divided into two stages. Stage 1 (✪) is most suitable for ages 11–14 and stage 2 (✪✪) for ages 14–16. However, older learners with gaps in their fundamental knowledge can use stage 1 as a stepping stone.

Stage 1 ✪		
		
Teacher-led presentation (✪)	**Short activities (✪)**	**Learner worksheet (✪)**
Stage 2 ✪✪		
		
Teacher-led presentation (✪✪): a full lesson including learning objectives, learner-facing instructions and activities.	**Short activities (✪✪):** learner-facing activities, designed as lesson starters or quick activities to engage prior knowledge.	**Learner worksheet (✪✪):** activities for learners to independently practice their maths skills. Suitable as classroom activity following the teacher presentation or as a home-learning task.

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Key terms support

Key vocabulary for each skill area is defined in the key terms support: rsc.li/4wypuqq. You will find the key terms listed by topic area and an accessible glossary slide for each term.

Using the teacher–led presentation

This is a full lesson focused on mastering maths skill in a chemistry context. The aim is for learners to develop key skills and then begin to apply these independently.

Learning objectives

1 Use ratios from balanced symbol equations to determine quantities of reactants and products.

2 Calculate and use mole ratios from chemical equations.

As you move through the presentation, there is a clear progression in skill development. The early slides engage learners' prior knowledge of the chosen maths skill. These slides link back to their learning from mathematics lessons as well as prior chemistry knowledge, where applicable.

Following this, the slides move onto some maths–chemistry translation tasks, then learners complete activities within a chemistry context.

The teacher–led presentation is designed to be used:

- prior to teaching a topic which makes explicit use of the maths skill, such as using ratios when calculating mass or using ratios to express how many elements are in a compound
- after summative assessment as an intervention

Scaffolding

The presentation is scaffolded, moving from worked examples ('I do') to faded examples ('we do'), before learners go on to answer questions themselves ('you do').

Metacognition

This resource supports learners to develop their metacognitive skills in three key areas.

- **Planning** – prompt learners to draw on their existing mathematical knowledge by asking themselves: 'Have I seen a similar question before? Have I come across this mathematical skill before? Have I learned a different method for solving a similar problem?'
- **Monitoring** – prompt learners to ask themselves: 'How confident am I feeling with these mathematical skills? Which parts of the presentation were most helpful to me?'

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- **Evaluation** – prompt learners to ask themselves: 'What have I learned during the presentation? How will I apply this new knowledge in my learning?'

Teaching sequence

Each teacher–led presentation begins with a slide outlining the objectives, followed by a chemistry question which uses the mathematical skill. During the presentation, the learners acquire the mathematical skills relevant to the question. At the end of the presentation, learners answer the question posed at the start, using the mathematical skills they have just developed.

Avoid giving learners access to this presentation independently. It is designed to be teacher-led.

1. Outline the learning objectives (slide 2)
2. Review the lesson question (slide 3) without answering it, following the teacher notes (provided in the presentation and copied below).
3. Present the introduction to ratio and simplifying ratio (slide 4–9).
4. Work through the mathematics modelling slides, making explicit links between maths and science (slides 10−17).
5. Learners complete the 'checking for understanding' questions. Ask learners to independently complete the lesson question using the knowledge covered during the lesson (slides 18−19).

Review learning

Use the complementary learner worksheet and short activities presentation as a follow–up or later as a review.

Slide notes

Introduction (slides 1–9)

Slide 1: Title slide

Slide 2: Learning objectives

Slide 3: Lesson question

This slide introduces the challenge question that learners will return to at the end of the lesson. Learners are not expected to attempt it at this point. We will return to complete the question at the end of the session. Alternatively, this question could be used as a diagnostic assessment to see what learners already know.

Slide 4: Ratio recap

This is a quick summary of the learning from the stage 1 materials outlining key information about ratio and proportion that learners already know. The next slide will explore their understanding further.

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Slide 5: Ratios in chemical formulas

This is a recap of some of the information from the stage 1 resources on ratio and proportion. Learners need a firm grasp of ratios before continuing with the content in this unit. If learners are finding this difficult, consider returning to the stage 1 resources to embed key knowledge and understanding.

Discuss the importance of order in ratios by relating the structure of the sentence to the ratio, e.g. the ratio of a to b = a:b.

Slide 6: What is a mole?

To continue with this activity, learners need a firm grasp of the concept of the mole. This term is defined in our key terms support, including our accessible glossary LINK. Share this with learners if they are unfamiliar with the term.

Explain the concept of amount of substance: the amount of matter present.

Emphasise the importance of the word amount in chemistry. Learners can wrongly use this word interchangeably with the words volume or mass. Discuss the fact that mass is measured in grams, volume is measured in cm^3 (or dm^3), and amount is measured in moles.

Slide 7: What is a mole? – continued

Note: 12.04×10^{23} is **not** standard form because the number before the power must be a value greater or equal to 1 but less than 10. Some science mark schemes will accept numbers not written correctly in standard form, but learners are expected to write correctly in standard form in mathematics. Make this distinction and difference clear to learners to avoid confusion and misconceptions developing.

Slide 8: Balanced chemical equations

Before explaining how chemists read ratios from balanced chemical equations, walk through the equation $2Mg + O_2 \rightarrow 2MgO$ and draw attention to the two different types of numbers in the equation.

First, the normal numbers written before the formulas (the **coefficients**) – these tell us how many of each molecule or atom are involved in the reaction.

Second, the **subscript numbers** written within the formulas – these tell us how many atoms of a particular element are in a single molecule. Use the example of O_2 to illustrate this − the subscript '2' tells us there are 2 atoms of oxygen in 1 molecule of oxygen.

Emphasise this distinction to learners, as a common misconception is to confuse the role of these two types of numbers when reading chemical equations. The coefficients are what we use to read the ratio for calculations – this will be developed on the next slide.

Slide 9: Ratios from balanced equations

Emphasise that the coefficient tells us the ratio of moles not the ratio of masses.

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Explain the importance of mole ratios in chemistry: mole ratios are crucial in stoichiometry, allowing chemists to predict how much product can be formed from given amounts of reactants or how much reactant is needed to produce a desired amount of product.

Mathematical modelling (slides 10–18)

Slide 10: Reading mole ratios

Emphasise that we are interested in the normal numbers and coefficients, not the subscript numbers. Highlight the names of any compounds the learners are unfamiliar with calcium carbonate = $CaCO_3$; calcium oxide = CaO; methane = CH_4.

Slide 11: Reading mole ratios (answers)

Extension: Ask learners to say the equations out loud (or write a sentence for each).

1. 1 mole of nitrogen reacts with 3 moles of hydrogen to produce 2 moles of ammonia
2. 2 moles of hydrogen react with 1 mole of oxygen to form 2 moles of water
3. 1 mole of methane reacts with 2 moles of oxygen to form 1 mole of carbon dioxide and 2 moles of water
4. 1 mole of calcium carbonate decomposes into 1 mole of calcium oxide and 1 mole of carbon dioxide

Slide 12: Ratio tables

Explain the concept of the ratio table: we start with what we know (3 boxes cost £10.50), divide both values by 3 to find the unit rate (1 box = £3.50), then multiply both values by 4 to reach our answer (4 boxes = £14.00). Emphasise that we are finding the unit rate or per unit value, i.e. how much does 1 box of chocolates cost?

This is the same as the proportional reasoning used in chemistry, for example in concentration calculations, unit conversions or stoichiometry. The ratio table makes the intermediate steps in proportional reasoning visible and structured, which is particularly helpful for learners who struggle with proportional reasoning across subject areas.

We don't always need to find the unit value (the value of one). Let's look at another example on the next slide.

Slide 13: Ratio tables (example 2)

Explain how to read this ratio table: we start with what we know (2 packets contain 5 sheets). This time, instead of finding the unit value, we scale up by multiplying both values by the same factor: multiplying by 2 gives us 4 packets and 10 sheets, multiplying by 3 gives us 6 packets and 15 sheets and multiplying by 5 gives us 10 packets and 25 sheets.

This example shows that ratio tables don't always require finding the **unit value**. Here we scale up in multiples of the original ratio ($\times 2$, $\times 3$, $\times 5$). The key point for learners

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is that if you multiply both sides of the ratio by the same number, the relationship holds. This approach directly mirrors how ratio tables can be used in science. For example, using stoichiometric ratios to find the number of moles of oxygen needed to react with a given number of moles of hydrogen (as shown on the next slide).

Slide 14: Ratio tables in science

Explain how this slide connects the ratio table approach to a science context. We start with what we know from the balanced equation: 2 moles of hydrogen react with 1 mole of oxygen. We then scale up in multiples of the original ratio: multiplying by 2 gives us 4 moles of hydrogen and 2 moles of oxygen, multiplying by 3 gives us 6 moles of hydrogen and 3 moles of oxygen.

Explain that we do not necessarily need to draw the actual table to do this. Instead, the ratios could be written as below:

$2H_2 + O_2 \rightarrow 2H_2O$

2:1

4:2

6:3

The ratio table makes the proportional relationship in the balanced equation visible and structured, helping learners see that stoichiometry is the same proportional reasoning they have already practised in mathematics. This is a good opportunity to highlight to learners that the skills they develop in maths lessons are directly transferable to science.

Slide 15: Using mole ratios to calculate masses

This slide provides learners with a clear, step–by–step method for using mole ratios to calculate masses of reactants or products. Walk through each step briefly to explain the process before applying it to a worked example on the following slide. Remind learners that the ratio works with moles not masses.

1. Use the balanced equation and identify the mole ratio from the coefficients. Remind learners that this is the skill they have just practised, reading the ratio from the numbers in front of the formulas.
2. Calculate the moles you know. This is where learners use the formula:
$$\text{moles} = \frac{\text{mass}}{\text{relative formula mass } (M_r)}$$
They will typically be given a mass in the question and will need to have calculated or been given the M_r.
3. Use the ratio to find the moles you need. This is where the ratio table approach comes in. Learners scale up or down using the mole ratio from the balanced equation, just as they did in the earlier maths and chemistry examples.
4. Convert moles back to mass using:
$$\text{mass} = \text{moles} \times M_r$$
This final step gives learners the answer in grams, which is typically what the question asks for.

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Emphasise to learners that this is a process they can follow every time, the four steps remain the same regardless of the reaction or the substance they are asked to find. Confidence with this structured approach will help learners tackle a wide range of calculation questions.

Slide 16: Problem pairs

Explain the meaning of the term 'in excess'. A reactant is in excess when there is more of a reactant than is needed to completely react with the other reactant(s) in a chemical reaction. So, in the first question, oxygen is in excess. This means at the end of the reaction all the magnesium will be used up and there will be oxygen left over. The magnesium is the limiting reactant. This is an important concept for learners to understand, as it tells us which reactant to use as the starting point for our calculation. We always start with the limiting reactant, not the one in excess.

Model the first question step by step, talking through each stage of the method. Emphasise how the four–step process from the previous slide is being applied here. Draw attention to the 1:1 ratio, this is a straightforward example to build confidence before learners encounter more complex ratios.

Ask learners to complete the faded example (the calcium carbonate question). Steps 1 and 2 are provided; learners need to complete Steps 3 and 4 independently.

Slide 17: Problem pairs (answer)

Extension: ask learners to calculate the M_r of carbon dioxide (44) and then find the mass of carbon dioxide produced when 25 g of calcium carbonate decomposes ($0.25 \times 44 = 11\,\text{g}$). This extension also provides an opportunity to check understanding of conservation of mass. The mass of the two products ($14\,\text{g} + 11\,\text{g} = 25\,\text{g}$) equals the mass of the reactant.

Slide 18: Returning to the lesson question

Explain to learners that we are returning to the question from the opening slide. Learners should now have the skills and confidence to attempt this question independently. Allow learners time to work through the problem using the four–step method they have practised throughout the session.

Slide 19: Lesson question (answer)

Step 3: this is the step to emphasise. This time, learners need to multiply rather than divide, as the ratio tells us we get more moles of product than we started with of reactant. The ratio table approach (see slides 12–14) can help learners see this scaling clearly.

This is a good opportunity to check whether learners can independently identify which direction to scale. In the previous example they divided, here they multiply. Confidence with this decision is key to success with reacting masses calculations.

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