Relative mass

This resource is part of the **Structure strips** series of resources, designed to support literacy in science teaching. More resources in this series can be found at: rsc.li/4aXYgzt.

Learning objectives

1. Explain why relative, rather than actual, masses are used most in chemistry.
2. Combine writing with calculations to give fuller explanations of chemical concepts.
3. Describe how the relative masses of individual atoms, relative atomic mass, relative formula mass and percentage composition are linked.

Introduction

In chemistry we compare the masses of subatomic particles, atoms, elements and compounds using relative masses, rather than stating the actual mass of the species in grams. The relative mass of any particle is its mass relative (compared) to $\frac{1}{12}$ of the mass of a single carbon-12 (^{12}C) atom. Relative masses are important because we count atoms using their masses as they are far too small to see.

This resource asks learners to demonstrate their thought process, rather than simply using methods they have memorised for carrying out calculations. This will help them to develop deeper understanding. It will also show them how to set out calculations more clearly in exam answers, so that examiners can follow what they have done, and they can check their own answers more easily.

The extended answer question focusses on learning objective 3. It checks how well learners have understood how the relative mass of an individual atom differs from the relative atomic mass of the bulk element and how this may further be different from the relative formula mass that would be used in, for example, reacting mass calculations.

How to use structure strips

Structure strips are a type of scaffolding you can use to support learners to retrieve information independently. Use them to take an overview at the start of a topic, to activate prior knowledge, or to summarise learning at the end of a teaching topic. Visit rsc.li/4f33jAP for more ideas on how to use structure strips with your learners.

Structure strips have sections containing prompts, sized to suggest the amount that learners must write. Learners glue the strips into the margin of an exercise book and write their answers next to the sections, in full sentences or bullet points. When they have finished using the structure strip, they will have an A4 page set of notes and examples.

Scaffolding

Encourage learners to use the suggested key words in their answers. These key words link with our key terms support resources for quantitative chemistry: rsc.li/3Gi9HHN.

To further support learners, you can include additional prompts in the structure strip. If learners are struggling to engage with the task, supply them with sentence starters created from the example answers.

To support with prompts 4 and 5, model some example A_r and M_r calculations for the class (e.g. neon: $^{20}\mathrm{Ne}$ – 91%, $^{22}\mathrm{Ne}$ – 9%; copper: $^{63}\mathrm{Cu}$ – 69%, $^{63}\mathrm{Cu}$ – 31%). Additional support for this topic is available in the form of the Review my learning worksheets on quantitative chemistry (rsc.li/3O1Hw3V), which are particularly useful for reviewing relative formula mass. You can opt to give students the A_r values needed for prompt 5 ($\mathrm{Fe} = 56, \mathrm{C} = 12, \mathrm{O} = 16$) rather than expecting them to find them on the periodic table.

As learners grow in confidence, ask them to attempt the question first and then use the structure strip to improve or self-assess their answer.

Metacognition

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

- **Planning:** the strips provide scaffolding to plan the written response. Learners will decide where to gather information from (textbooks, own notes, revision websites). Ask learners: is the source of information you are using reliable?
- **Monitoring:** learners are prompted by the questions in the structure strip and can check their own answer against the prompts. Ask learners: have you covered all of the prompts in the space provided? Do you need to change anything to complete the task?
- **Evaluation:** learners can self-assess or ask a peer to check their work against the answers. Ask learners: did you achieve what you meant to achieve? What will you do differently another time?

Example answers

Structure strip Relative mass	Example answer
State the number of each subatomic particle you would find in a ^{12}C atom. Explain why the atom has a relative mass of 12.	A ^{12}C atom is made up of: • six protons • six neutrons • six electrons Protons and neutrons each have a relative mass of one, while the relative mass of electrons is so small that their mass is ignored. Therefore, the mass is due to the six protons and six neutrons only.
Explain why we use relative masses when discussing atoms, instead of using grams.	The actual masses of atoms are so small that they would need to be written in standard form. This would make calculations more complicated. Relative masses use whole numbers or just one or two decimal places, to help make the calculations simpler.
Boron occurs naturally as ^{10}B and ^{11}B. What do we call these and how do they compare?	^{10}B and ^{11}B are isotopes of boron. • ^{10}B contains five protons and five neutrons • ^{11}B contains five protons and six neutrons
Explain how relative atomic mass (A_r) is calculated. Why is the A_r of boron 10.8, not 10.5? What does that tell you about boron atoms?	Relative atomic mass is calculated as a weighted average of the relative masses of 100 atoms of boron, based on the percentage of each found in a natural sample. Since the relative atomic mass of boron is closer to 11 than 10, there must be far more ^{11}B atoms than ^{10}B atoms in a naturally occurring sample.
Explain how relative formula mass is calculated. Use the example of $FeCO_3$ (M_r 116).	Relative formula mass is calculated by adding together the relative atomic masses of all the atoms in the formula. For example, in $FeCO_3$, the A_rs are: $Fe = 56, C = 12, O = 16$ So, $M_r = 56 + 12 + (3 \times 16) = 116$
$FeCO_3$ is an iron ore. Explain, using a calculation, what mass of iron you would expect to extract from 100 kg of $FeCO_3$.	We need to find the percentage of iron in the ore. $\text{Percentage of iron} = \frac{\text{relative atomic mass of iron}}{\text{relative formula mass of FeCO}_3} \times 100$ $= \frac{56}{166} \times 100 = 48.3\% \ (3sf)$ Therefore, from 100 kg of ore it should be possible to extract 48.3 kg of iron.
Without doing a calculation, suggest whether you would expect to get more, or less iron from 100 kg of a different ore, Fe_2O_3. Explain your reasoning.	It should be possible to extract more iron from Fe_2O_3. There are twice as many iron atoms per formula unit. In addition, there is no carbon atom present. Therefore, although the overall relative formula mass will be higher than that of $FeCO_3$ the iron atoms make up a bigger percentage of the overall mass of the compound.

Extended answer question

Instruct learners to answer the question after they have attempted the structure strip. The structure strip activates the required knowledge which learners can then apply to the question.

Consider re-framing the context of this question to one that your learners are more familiar with, to empower them to unlock their existing science capital. Read more about science capital here: rsc.li/40FAMLP.

Example answers to extended answer question

The relative formula mass of bromine is $80 + 80 = 160$.

Bromine exists as two isotopes. Bromine atoms with a relative mass of 79 contain 35 protons and 44 neutrons in their nuclei, whereas bromine atoms with a relative mass of 81 still contain 35 protons but have 46 neutrons.

The relative atomic mass of an element is calculated as a weighted average based on the naturally occurring percentages of its isotopes. The fact that bromine's relative atomic mass falls right in the middle of the relative masses of its two isotopes suggests that equal amounts of these exist in nature.

The relative formula mass for bromine is different to its relative atomic mass because bromine atoms are never found on their own. Instead, in the element, the atoms always pair up to make molecules, so the masses of the two atoms are added to give the relative formula mass.