Relative atomic mass

4.1.1.6 · Atomic structure and the periodic table · revision notes

Relative atomic mass (A_r) is an average value for the atoms of an element that takes account of the abundance of each of its isotopes. You must be able to calculate it from percentage abundances: a common 2 to 3 mark calculation.

Key facts

- A_r = average value for an element's atoms, taking account of the abundance of its isotopes
- A_r has no units
- Chlorine: 75% chlorine-35 + 25% chlorine-37 gives A_r = 35.5
- A_r = sum of (mass number × % abundance) ÷ 100
- A_r is nearer to the mass number of the most abundant isotope

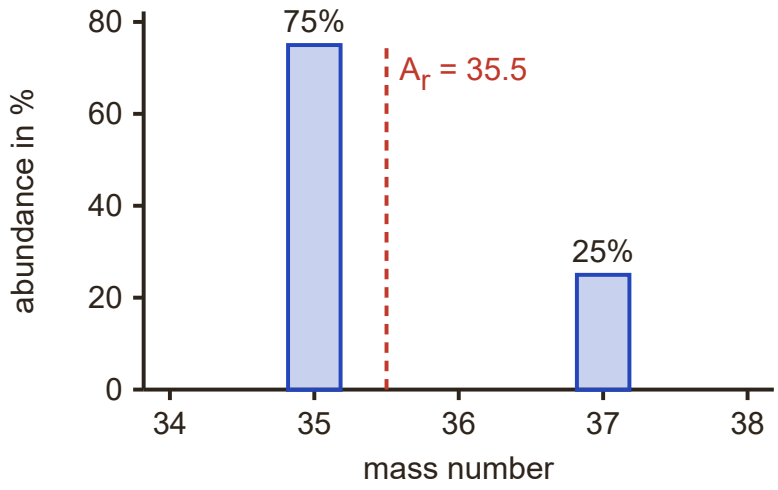
Notes

What relative atomic mass means

- Many elements exist as a mixture of isotopes, which have different masses.
- The **relative atomic mass** (symbol A_r) of an element is an **average** value that takes account of the **abundance** (the percentage of atoms) of each of its isotopes.
- A_r is the number shown for each element in the periodic table on the data sheet, e.g. chlorine 35.5. It has no units.
- A_r is often not a whole number, because it is an average. It is closer to the mass number of the more abundant isotope.

Calculating A_r

- A_r = (mass number × % abundance of the first isotope + mass number × % abundance of the second isotope + …) ÷ 100
- Worked example: chlorine is 75% chlorine-35 and 25% chlorine-37.
  (35 × 75) + (37 × 25) = 2625 + 925 = 3550
  3550 ÷ 100 = 35.5



A_r of chlorine is 35.5: nearer to 35, the more abundant isotope.

- Sense check: the answer must lie between the smallest and largest mass numbers, and nearer to the mass number of the most abundant isotope.
- If you are given the number of atoms of each isotope instead of percentages, divide by the total number of atoms instead of by 100.

How to answer each type of question

Calculate relative atomic mass from two isotopes

2 marks **Grade 5**

1. Multiply each mass number by its percentage abundance.
2. Add the results.
3. Divide by 100 and round as the question asks.

Example. Copper has two isotopes: copper-63 (69%) and copper-65 (31%).
Calculate the relative atomic mass of copper. Give your answer to 1 decimal place.

Model answer.

(63 × 69) + (65 × 31) = 4347 + 2015 = 6362 (1)

6362 ÷ 100 = 63.6 (1)

Calculate relative atomic mass from three isotopes

2 to 3 marks | Grade 7

1. Check the abundances add up to 100%.
2. Multiply each mass number by its abundance and add all three results.
3. Divide by 100.

Example. Magnesium is 79% magnesium-24, 10% magnesium-25 and 11% magnesium-26. Calculate the relative atomic mass of magnesium. Give your answer to 1 decimal place.

Model answer.

$(24 \times 79) + (25 \times 10) + (26 \times 11)$ (1)

$= 1896 + 250 + 286 = 2432$ (1)

$2432 \div 100 = 24.3$ (1)

Explain A_r values and isotope abundance

1 to 2 marks | Grade 5

1. Use the words 'average', 'isotopes' and 'abundance'.
2. To decide which isotope is more common, see which mass number the A_r is closer to.

Example. Lithium has two isotopes, lithium-6 and lithium-7. The relative atomic mass of lithium is 6.9.
(a) Explain why the relative atomic mass of lithium is not a whole number.
(b) Which isotope is more abundant? Give a reason.

Model answer.

(a) It is an average of the masses of the isotopes, taking account of how abundant each isotope is (1).

(b) Lithium-7, because 6.9 is much closer to 7 than to 6 (1).

Don’t lose marks

- Dividing by the number of isotopes (e.g. by 2) instead of by 100.
- Adding the mass numbers and halving, which ignores the abundances.
- Rounding part-way through the calculation, or giving the wrong number of decimal places.
- Giving A_r units such as grams.

More tips

Memory tricks

- Sense check: A_r must lie between the lightest and heaviest mass numbers.
- If two isotopes are 50% each, A_r is exactly halfway between their mass numbers.
- Type it in one go with brackets to avoid rounding errors: (35 × 75 + 37 × 25) ÷ 100.
- For a real element, compare your answer with the A_r in the periodic table: it should be very close.

Exam technique

- Write out the whole expression before you calculate, so you earn the method mark even if you slip on the arithmetic.
- Give the answer to the number of decimal places the question asks for (often 1 decimal place).
- In 'explain' questions about A_r, use the key words: average, isotopes, abundance.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 4 — **Explain what relative atomic mass means**
An average value for the atoms of an element that takes account of the abundance of each isotope.

Grade 5 — **Calculate A_r for two isotopes**
Multiply each mass number by its percentage abundance, add the results, then divide by 100.

Grade 5 — **Explain why A_r is rarely whole**
It is an average of isotopes with different mass numbers, weighted by how common each one is.

Grade 5 — **Decide which isotope is more abundant**
The A_r is closer to the mass number of the more abundant isotope.

Grade 7 — **Calculate A_r for three isotopes**
Same method with three terms; check that the abundances add up to 100%.

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