Isotopes and relative atomic mass

Student activity • class activity

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The question

Why is relative atomic mass a weighted mean rather than a simple average?

Use isotope cards to model a population of atoms. Count abundances and calculate a weighted mean. The X and Y datasets are invented teaching examples, not measurements of natural samples. Using mass numbers as isotope masses is an explicit IGCSE approximation in these exercises.

Equipment

- Student booklet, pencil and calculator
- Per pair: ten pre-cut cards for fictional element X; eight marked X-10 and two marked X-11
- Each X card also states Z = 5; a labelled tray or paper mat

Desk activity only. Use pre-cut paper cards; keep small pieces out of mouths. No radioactive sources, chemicals or actual isotope samples are used.

Course coverage: 1.16–1.17: relative atomic mass and calculations from isotopic abundances.

Printable model cards • one complete set per pair

X-10 Z = 5	**X-10** Z = 5	**X-10** Z = 5	**X-10** Z = 5	**X-10** Z = 5
X-10 Z = 5	**X-10** Z = 5	**X-10** Z = 5	**X-11** Z = 5	**X-11** Z = 5

Teacher: photocopy and pre-cut this panel if reusable cards are unavailable. Count all ten cards; do not sample a subset.

Method and reasoning

Read the whole sequence before starting

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1. Read the definition: isotopes have the same proton count but different neutron counts. Use Z = 5 to determine the neutrons in X-10 and X-11.

2. Count all ten cards: eight X-10 and two X-11. Record counts, then calculate each percentage as count divided by total count, multiplied by 100.

3. Calculate the population mean using (8 × 10 + 2 × 11) ÷ 10. Show the calculation and identify which isotope pulls the mean closer to its mass number.

4. Repeat using percentages: (80 × 10 + 20 × 11) ÷ 100. Explain why both routes give the same answer. These are supplied model populations, not random sampling results.

5. Use the invented Y dataset: isotope mass numbers 24 and 26 with abundances 25% and 75%. Calculate the weighted mean and compare it with the unweighted average of 24 and 26.

6. In a second invented population of X, the mean is 10.6. Let the fraction of X-11 be f. Form 10(1 – f) + 11f = 10.6 and solve for f.

7. Check that abundances total 100% and that each weighted mean lies between the isotope values. State why no individual atom needs to have a mass number equal to the mean.

Cleanup

- Return all ten isotope cards to the set and retain your calculations. No chemical waste is produced.

Record your evidence

Blank spaces are for your own work

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Reference and task data

Population	Isotope values used	Abundances
X: supplied ten-card set	10 and 11	8 cards and 2 cards
Y: invented calculation	24 and 26	25% and 75%
X: inverse calculation	10 and 11	Unknown; mean = 10.6

Relative atomic mass compares the weighted mean atom mass with one-twelfth of a carbon-12 atom's mass. It has no unit. Here isotope mass numbers approximate isotope masses; X and Y are fictional examples.

Model isotope	Z	Mass number	Neutrons	Count	Abundance / %
X-10	5	10		8	
X-11	5	11		2	

Show the weighted-mean calculation using counts, then using percentages.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Define isotopes and explain why X-10 and X-11 are the same element.

2. Calculate the model X weighted mean using both counts and percentages.

3. Calculate the Y weighted mean and explain why a simple average is inappropriate.

4. Find the percentage of X-11 when the model mean is 10.6.

5. Explain why a decimal relative atomic mass does not mean fractional neutrons.

6. State the reference used to define relative atomic mass and whether it has a unit.