Empirical and molecular formulae: the ratio test

Student activity • observation and reasoning

YEAR 11 / LESSON 71 / CHEMISTRY + SCIENCE (DOUBLE AWARD)

The question

When does the simplest ratio stop identifying a molecule?

Reduce atom ratios, derive a formula from composition and use relative molecular mass to recover a molecular formula. Explain what the numbers can and cannot reveal.

Equipment

- Booklet, pencil, periodic table and optional molecular model kit

Desk activity only; keep small model pieces away from mouths.

Course coverage: Shared formula representation: 4.2 and quantitative recall from 1.29–1.31. Structure cannot be inferred uniquely from an empirical formula.

Plan, model or apparatus sketch

Draw a labelled structure or model to explain your reasoning for this lesson.

Method and reasoning

Read the whole sequence before starting

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1. Reduce C_2H_6, C_3H_6 and $C_6H_{12}O_6$ to their simplest whole-number atom ratios.

2. Explain why C_3H_8 cannot be simplified and why an empirical formula is not necessarily a molecule.

3. Use the invented composition 85.7% carbon and 14.3% hydrogen. Assume 100 g, divide masses by A_r values and find the simplest ratio.

4. Use M_r=56 and the empirical formula from the preceding task to calculate the integer multiplier and molecular formula.

5. Compare C_2H_4 and C_4H_8: explain their common empirical formula without claiming identical connectivity or physical properties.

6. Audit a worked error: a learner reduces subscripts by subtracting one rather than dividing by a common factor. Correct with an example.

Cleanup

- Return shared equipment and retain corrected reasoning.

Record your evidence

Blank spaces are for your own work

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Reference and task data

Use $A_r(C)=12$, $A_r(H)=1$, $A_r(O)=16$. Invented composition: C 85.7%, H 14.3%; $M_r=56$. An empirical formula gives the simplest whole-number ratio. Molecular formula=(empirical formula)×integer multiplier, where multiplier=M_r/(empirical formula mass). A_r and M_r are relative quantities with no unit.

Task	My structure / working	Reason / correction
Subscript simplification		
Composition → ratio		
M_r → molecular formula		

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Give empirical formulae for C_2H_6 and $C_6H_{12}O_6$.

2. Why is the empirical formula of propane C_3H_8?

3. Derive the empirical formula from the invented percentage composition.

4. Use M_r=56 to obtain its molecular formula.

5. Can an empirical formula alone identify structural isomers? Explain.

6. Correct the claim that C_4H_8 simplifies to C_3H_7.