Combustion Analysis and Mass Balance

Student Worksheet | g10_u01_w03

I can: use supplied combustion-product data to infer carbon and hydrogen, use mass balance only inside a stated system, and explain what the data cannot prove.
Frozen values: H 1.008, C 12.011, N 14.007, O 15.999. Values are from `audits/atomic_masses_v2024.1.json`. All records are paper or digital data cards; do not perform combustion, collect gases, or handle chemicals. In each calculation, state the stated model assumption.

1. Balance $C_3H_8 + O_2 \rightarrow CO_2 + H_2O$. What coefficient ratio links propane to carbon dioxide and water?

2. In a stated complete-combustion, complete-capture model, which product mass is used to infer sample carbon, and which is used to infer sample hydrogen? Name one boundary required for each inference.

3. A product card lists 4.400 g CO_2. Find grams and moles of C assigned to the original sample under the model in item 2.

4. A product card lists 1.800 g H_2O. Find grams and moles of H assigned to the original sample under the model in item 2.

5. A 1.403 g sample, stated to contain only C and H, gives 4.401 g CO_2 and 1.802 g H_2O. Determine its empirical formula. Treat the tiny mass-difference remainder as rounding.

6. The compound in item 5 has molar mass 56.108 g/mol. Find its molecular formula.

7. A 0.901 g sample, stated to contain only C, H, and O, gives 1.320 g CO_2 and 0.540 g H_2O. Use difference for oxygen and find the empirical formula.

8. The substance in item 7 has molar mass 60.052 g/mol. Find its molecular formula.

9. Balance ethanol combustion: $C_2H_6O + O_2 \rightarrow CO_2 + H_2O$. For one mole of ethanol, count oxygen atoms in products; identify how many come from ethanol and how many come from O_2.

10. A 1.504 g hydrocarbon card gives 4.401 g CO_2 and 2.702 g H_2O. Find the empirical formula. If its molar mass is 30.070 g/mol, find the molecular formula.

11. Why can C and H product data alone not establish a unique formula for a sample that might also contain N, a halogen, sulfur, or ash? State when "oxygen by difference" is justified.

12. A 1.000 g sample is stated to contain only C, H, and O. Its cards show 2.200 g CO_2 and 0.900 g H_2O. Find the empirical formula.

13. Revisit item 12. A separate elemental card now assigns 0.200 g of the original sample to N. How many grams of O remain by mass difference? By how much would the C/H/O-only assumption overestimate O mass?

14. A 1.000 g C/H/O-only sample gives 2.200 g CO_2 and 0.900 g H_2O. Verify the C and H masses, then show why the oxygen in the sample is not obtained by subtracting product masses from sample mass.

15. The empirical formula from item 14 is $C_8H_{16}O_3$. Calculate its molar mass.

16. Balance combustion of $C_8H_{16}O_3$. For 0.250 mol, predict moles of O_2 required, CO_2 produced, and H_2O produced.

17. A 0.500 g sample is claimed to be a hydrocarbon, but its cards list 1.50 g CO_2 and 0.900 g H_2O. Use a C-plus-H mass check. Is the claim/data pair exactly self-consistent? Give a non-accusatory next check.

18. A 0.5000 g hydrocarbon card gives 1.497 g CO_2 and 0.817 g H_2O. Find the empirical formula. What measurement precision or model limitation keeps this from proving identity by itself?

19. A 1.000 g C/H/O-only sample gives 1.467 g CO_2 and 0.600 g H_2O. Find the empirical formula.

20. A proposed identity for item 19 is $C_6H_{12}O_6$ (molar mass 180.156 g/mol). Explain why the empirical formula and molar mass can support this proposal, but cannot by themselves establish the sample's identity or purity. Name one corroborating data type.