LESSON MAKER PRO

Formula Detectives

Use mass and mole ratios to uncover a compound's formula.

HIGH SCHOOL · CHE.4.a

CHE.4.a "Quantitatively apply the concepts of the mole and Avogadro's number to conceptualize and calculate percent composition and empirical or molecular formulas of common compounds."

NAME _____ DATE _____

FROM MASS TO FORMULA

Use these atomic masses in g/mol: H = 1, C = 12, N = 14, O = 16, Mg = 24, S = 32, and Ca = 40. Divide each element's mass by its atomic mass to find moles, then reduce the mole amounts to the smallest whole-number ratio for the empirical formula. To find percent by mass, divide an element's mass by the total mass and multiply by 100.

WORKED EXAMPLE

A sample contains 24 g of magnesium and 16 g of oxygen. Find its empirical formula and the percent by mass that is magnesium.

1. Magnesium: 24 g / 24 g/mol = 1 mol. Oxygen: 16 g / 16 g/mol = 1 mol.
2. The mole ratio is 1:1, so the empirical formula is MgO.
3. Total mass = 24 g + 16 g = 40 g.
4. Percent magnesium = 24/40 × 100 = 60%.

Answer: MgO; 60% magnesium

PRACTICE 6 problems

1 Find the percent by mass of carbon in methane, CH_4.

ANSWER _____

2 Find the percent by mass of sulfur in SO_3.

ANSWER _____

3 Find the percent by mass of hydrogen in C_2H_6.

ANSWER _____

4 A sample contains 6 g of carbon and 1 g of hydrogen. Find its empirical formula.

ANSWER _____

5 A sample contains 28 g of nitrogen and 48 g of oxygen. Find its empirical formula.

ANSWER _____

6 A sample contains 40 g of calcium, 12 g of carbon, and 48 g of oxygen. Find its empirical formula and its percent by mass of oxygen.

ANSWER _____

APPLY IT Show your work

1 A sports gel contains 45 g of pure glucose, $C_6H_{12}O_6$. How many grams of carbon are in the glucose?

WORK SPACE

ANSWER _____

2 A camping stove uses propane. A sample of propane contains 36 g of carbon and 8 g of hydrogen. What is propane's empirical formula?

WORK SPACE

ANSWER _____

CHALLENGE One step up

A compound contains 42 g of nitrogen and 96 g of oxygen in one sample. Its molar mass is 92 g/mol. Find its empirical and molecular formulas. Explain how you found the multiplier.

WORK SPACE AND ANSWER

ANSWER KEY

Formula Detectives

PART 1 · PRACTICE

#	PROBLEM	ANSWER
1	Find the percent by mass of carbon in methane, CH_4.	**75% carbon**
2	Find the percent by mass of sulfur in SO_3.	**40% sulfur**
3	Find the percent by mass of hydrogen in C_2H_6.	**20% hydrogen**
4	A sample contains 6 g of carbon and 1 g of hydrogen. Find its empirical formula.	**CH_2**
5	A sample contains 28 g of nitrogen and 48 g of oxygen. Find its empirical formula.	**N_2O_3**
6	A sample contains 40 g of calcium, 12 g of carbon, and 48 g of oxygen. Find its empirical formula and its percent by mass of oxygen.	**$CaCO_3$; 48% oxygen**

PART 2 · APPLY IT

1. **18 g of carbon** Carbon contributes 72 g to glucose's 180 g/mol molar mass. Multiply 45 g by 72/180 to get 18 g of carbon.
2. **C_3H_8** Divide by atomic mass to get 3 mol of carbon and 8 mol of hydrogen. The 3:8 ratio gives C_3H_8.

CHALLENGE

The sample contains 3 mol of nitrogen and 6 mol of oxygen, so its empirical formula is NO_2. The empirical formula mass is 46 g/mol, and 92/46 = 2, so its molecular formula is N_2O_4.

Accept equivalent calculations that show the correct mole ratios or mass fractions. In the challenge, the multiplier is 2.