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A. Calculate the percent composition for the following compounds.

1. Cr_2O_3

$$\text{Cr} \quad \frac{104 \text{ g Cr}}{152 \text{ g Cr}_2\text{O}_3} = \boxed{68.42\% \text{ Cr in Cr}_2\text{O}_3} \quad \text{O} \quad \frac{48 \text{ g O}}{152 \text{ g Cr}_2\text{O}_3} = \boxed{31.58\% \text{ O in Cr}_2\text{O}_3}$$

2. $\text{Ca}_3(\text{PO}_4)_2$

$$\text{Ca} \quad \frac{120.24 \text{ g Ca}}{310.18 \text{ g Ca}_3(\text{PO}_4)_2} = \boxed{38.76\% \text{ Ca in Ca}_3(\text{PO}_4)_2} \quad \text{P} \quad \frac{61.94 \text{ g P}}{310.18 \text{ g Ca}_3(\text{PO}_4)_2} = \boxed{19.97\% \text{ P in Ca}_3(\text{PO}_4)_2} \quad \text{O} \quad \frac{128 \text{ g O}}{310.18 \text{ g Ca}_3(\text{PO}_4)_2} = \boxed{41.27\% \text{ O in Ca}_3(\text{PO}_4)_2}$$

B. Calculate the percent by mass of iron in each of the following compounds.

3. iron (III) oxide Fe_2O_3

$$\frac{111.7 \text{ g Fe}}{159.7 \text{ g Fe}_2\text{O}_3} = \boxed{69.94\% \text{ Fe in Fe}_2\text{O}_3}$$

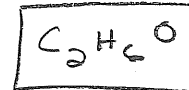
4. iron (II) oxide FeO

$$\frac{55.85 \text{ g Fe}}{71.85 \text{ g FeO}} = \boxed{77.73\% \text{ Fe in FeO}}$$

C. Determine the empirical formula for each compound.

5. A compound contains 0.0130 mol carbon, 0.0390 mol hydrogen, and 0.0065 mol oxygen.

$$\frac{0.0130 \text{ mol C}}{0.0065 \text{ mol O}} = 2 \quad \frac{0.0390 \text{ mol H}}{0.0065 \text{ mol O}} = 6$$



6. A compound consists of 72.2% magnesium and 27.8% nitrogen by mass.

$$\frac{1 \text{ mol Mg} \mid 72.2 \text{ g Mg}}{24.31 \text{ g Mg}} = \frac{2.9700 \text{ mol Mg}}{1.9843} = 1.5 \times 2 = 3$$

$$\frac{1 \text{ mol N} \mid 27.8 \text{ g N}}{14.01 \text{ g N}} = \frac{1.9843 \text{ mol N}}{1.9843} = 1 \times 2 = 2$$

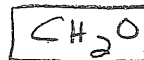


7. Glucose contains 40.0% carbon, 6.7% hydrogen, and 53.3% oxygen by mass.

$$\frac{1 \text{ mol C} \mid 40.0 \text{ g C}}{12.01 \text{ g C}} = \frac{3.3306 \text{ mol C}}{3.3306} = 1$$

$$\frac{1 \text{ mol H} \mid 6.7 \text{ g H}}{1.01 \text{ g H}} = \frac{6.6337 \text{ mol H}}{3.3306} = 2$$

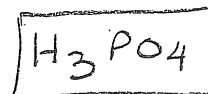
$$\frac{1 \text{ mol O} \mid 53.3 \text{ g O}}{16.00 \text{ g O}} = \frac{3.3312 \text{ mol O}}{3.3306} = 1$$



8. Phosphoric acid is found in some soft drinks. A sample of phosphoric acid contains 0.3086 g of hydrogen, 3.161 g of phosphorus, and 6.531 g of oxygen.

$$\frac{1 \text{ mol H} \mid 0.3086 \text{ g H}}{1.01 \text{ g H}} = \frac{0.30554 \text{ mol H}}{0.10207} = 3$$

$$\frac{1 \text{ mol P} \mid 3.161 \text{ g P}}{30.97 \text{ g P}} = \frac{0.10207 \text{ mol P}}{0.10207} = 1$$



$$\frac{1 \text{ mol O} \mid 6.531 \text{ g O}}{16.00 \text{ g O}} = \frac{0.40819 \text{ mol O}}{0.10207} = 4$$

Chemistry I

D. Determine the *molecular formula* for each compound described.

9. A compound has an empirical formula of NO_2 and a molar mass of 92.02 g/mol.

$$\text{NO}_2 = 46.01 \text{ g/mol} \quad \frac{92.02 \text{ g/mol}}{46.01 \text{ g/mol}} = 2 \quad \boxed{\text{N}_2\text{O}_4}$$

10. A compound has an empirical formula of $\text{C}_2\text{H}_3\text{O}$ and a molar mass of 172 g/mol.

$$\text{C}_2\text{H}_3\text{O} = 43.05 \text{ g} \quad \frac{172 \text{ g/mol}}{43.05 \text{ g/mol}} = 4 \quad \boxed{\text{C}_8\text{H}_{12}\text{O}_4}$$

11. Ibuprofen, a common headache remedy, has an empirical formula of $\text{C}_7\text{H}_9\text{O}$ and a molar mass of approximately 215 g/mol.

$$\text{C}_7\text{H}_9\text{O} = 109.23 \text{ g} \quad \frac{215 \text{ g/mol}}{109.23 \text{ g/mol}} = 2 \quad \boxed{\text{C}_{14}\text{H}_{18}\text{O}_2}$$

12. Nicotine is 74.1% carbon, 8.6% hydrogen, and 17.3% nitrogen by mass. Its molar mass is about 160 g/mol.

$\frac{1 \text{ mol C}}{12.01 \text{ g C}} \mid \frac{74.1 \text{ g C}}{12.01 \text{ g C}} = 6.1699 \text{ mol C} = 5$	<u>Empirical</u> $\text{C}_5\text{H}_7\text{N} = 81.13 \text{ g}$
$\frac{1 \text{ mol H}}{1.01 \text{ g H}} \mid \frac{8.6 \text{ g H}}{1.01 \text{ g H}} = 8.5149 \text{ mol H} = 7$	$\frac{160 \text{ g/mol}}{81.13 \text{ g/mol}} = 2$
$\frac{1 \text{ mol N}}{14.01 \text{ g N}} \mid \frac{17.3 \text{ g N}}{14.01 \text{ g N}} = 1.2348 \text{ mol N} = 1$	$\boxed{\text{Molecular C}_{10}\text{H}_{14}\text{N}_2}$

13. Epinephrine (adrenaline) is a hormone secreted into the bloodstream in times of danger and stress. It is 59.0% carbon, 7.1% hydrogen, 26.2% oxygen, and 7.7% nitrogen by mass. Its molar mass is about 180 g/mol.

$\frac{1 \text{ mol C}}{12.01 \text{ g C}} \mid \frac{59.0 \text{ g C}}{12.01 \text{ g C}} = 4.9126 \text{ mol C} = 9$	<u>Empirical</u> $\text{C}_9\text{H}_{13}\text{O}_3\text{N} = 183.23 \text{ g}$
$\frac{1 \text{ mol H}}{1.01 \text{ g H}} \mid \frac{7.1 \text{ g H}}{1.01 \text{ g H}} = 7.0297 \text{ mol H} = 13$	$\frac{180 \text{ g/mol}}{183.23 \text{ g/mol}} = 1$
$\frac{1 \text{ mol O}}{16.00 \text{ g O}} \mid \frac{26.2 \text{ g O}}{16.00 \text{ g O}} = 1.6375 \text{ mol O} = 3$	
$\frac{1 \text{ mol N}}{14.01 \text{ g N}} \mid \frac{7.7 \text{ g N}}{14.01 \text{ g N}} = 0.5496 \text{ mol N} = 1$	$\boxed{\text{Molecular C}_9\text{H}_{13}\text{O}_3\text{N}}$

E. Questions

14. Can the molecular formula of a compound ever be the same as the empirical formula?

Explain your answer.

Yes. If the molar mass matched the mass of the compound's empirical formula, then the empirical formula and molecular formula are the same.

15. What is the empirical formula of a compound that has three times as many hydrogen atoms as carbon atoms, but only half as many oxygen atoms as carbon atoms?

$$3 \times \text{H as C} \quad \frac{1}{2} \text{ O as C}$$

