Empirical formulas

1. Define empirical formula.

Elements in lowest whole # ratio

1.5 Define molecular formula and give 3 examples.

some multiple of the emp C_2H_4 C_3H_6 H_2O_2

1.8 Give the empirical formula that corresponds to each of the following molecular compounds.

Sodium peroxide Na_2O_2 NaO

terephthalic acid $C_8H_6O_4$ $C_4H_3O_2$

Phenolbarbital $C_{12}H_{12}N_2O_3$

1,4-dichloro-2-butene $C_4H_6Cl_2$ C_2H_3Cl

2. A compound was found to contain 11.2% hydrogen and 88.8% oxygen by mass. What is the empirical formula of this compound? What assumption is made? 100g sample

$11.2\,g\,H \times \frac{1\,mol\,H}{1.008\,g\,H} = \frac{11.11\,mol\,H}{5.55} = 2\,mol\,H$

H_2O

$88.8\,g\,O \times \frac{1\,mol\,O}{16.00\,g\,O} = \frac{5.55\,mol\,O}{5.55} = 1\,mol\,O$

3. A compound was found to contain 29.4% calcium, 23.5% sulfur, and 47.1% oxygen by mass. What is its empirical formula? What assumption is made? 100g sample

$29.4\,g\,Ca \times \frac{1\,mol\,Ca}{40.08\,g\,Ca} = \frac{.734\,mol\,Ca}{.733} = 1\,mol\,Ca$

$CaSO_4$

$23.5\,g\,S \times \frac{1\,mol\,S}{32.07\,g\,S} = \frac{.733\,mol\,S}{.733} = 1\,mol\,S$

$47.1\,g\,O \times \frac{1\,mol\,O}{16.00\,g\,O} = \frac{2.94\,mol\,O}{.733} = 4\,mol\,O$

4. A compound was found to contain 33.8% copper, 14.9% nitrogen and the rest oxygen. What is its empirical formula? What assumption is made? 100g sample

$33.8\,g\,Cu \times \frac{1\,mol\,Cu}{63.55\,g\,Cu} = \frac{.532\,mol\,Cu}{.532} = 1\,mol\,Cu$

$14.9\,g\,N \times \frac{1\,mol\,N}{14.01\,g\,N} = \frac{1.06\,mol\,N}{.532} = 2\,mol\,N$

CuN_2O_6 or $Cu(NO_3)_2$

$51.3\,g\,O \times \frac{1\,mol\,O}{16.00\,g\,O} = \frac{3.21\,mol\,O}{.532} = 6\,mol\,O$

5. A compound was found to contain 69.9% iron and the rest oxygen by mass. What is its empirical formula? What assumption is made? 100g sample

Fe_2O_3

$69.9\text{ g Fe} \times \frac{1\text{ mol Fe}}{55.85\text{ g Fe}} = \frac{1.25\text{ mol Fe}}{1.25} = 1\text{ mol Fe} \times 2 = 2$

$30.1\text{ g O} \times \frac{1\text{ mol O}}{16.00\text{ g O}} = \frac{1.88\text{ mol O}}{1.25} = 1.5\text{ mol O} \times 2 = 3$

6. When 4.01 g of mercury is strongly heated in air, the resulting oxide weighs 4.33 g. Calculate the empirical formula of the oxide.

HgO

$4.01\text{ g Hg} \times \frac{1\text{ mol Hg}}{200.6\text{ g Hg}} = \frac{.0200\text{ mol Hg}}{.02} = 1\text{ mol Hg}$

$.32\text{ g O} \times \frac{1\text{ mol O}}{16.00\text{ g O}} = \frac{.0200\text{ mol O}}{.02} = 1\text{ mol O}$

7. The compound A_2O is 63.7% A (a mystery element) and 36.3% oxygen. What is the identity of element A? 100g sample

$36.3\text{ g O} \times \frac{1\text{ mol O}}{16.00\text{ g O}} = 2.27\text{ mol O} \times \frac{2\text{ mol A}}{1\text{ mol O}} = 4.54\text{ mol A}$

$\text{molar mass} = \frac{63.7\text{ g A}}{4.54\text{ mol A}} = 14.0\text{ g A} = N$

8. A compound containing only sulfur and ~~oxygen~~ nitrogen is 69.6% S by mass; the molar mass is 184 g/mol. What are the empirical and molecular formulas of the compound? 100g sample

$69.6\text{ g S} \times \frac{1\text{ mol S}}{32.07\text{ g S}} = \frac{2.17\text{ mol S}}{2.17} = 1\text{ mol S}$

$30.4\text{ g N} \times \frac{1\text{ mol N}}{14.01\text{ g N}} = \frac{2.17\text{ mol N}}{2.17} = 1\text{ mol N}$

empirical: $SN = 46.08\text{ g/mol}$

$\frac{184}{46} = 4 \times SN = S_4N_4$ molecular

9. Maleic acid is an organic compound composed of 41.39% C, 3.47% H, and the rest O. If 0.129 mol of maleic acid has a mass of 15.0 g, what are the empirical and molecular formulas for maleic acid? 100g sample

$41.39\text{ g C} \times \frac{1\text{ mol C}}{12.01\text{ g C}} = \frac{3.446\text{ mol C}}{3.44} = 1\text{ mol C}$

$3.47\text{ g H} \times \frac{1\text{ mol H}}{1.008\text{ g H}} = \frac{3.44\text{ mol H}}{3.44} = 1\text{ mol H}$

$55.14\text{ g O} \times \frac{1\text{ mol O}}{16.00\text{ g O}} = \frac{3.44\text{ mol O}}{3.44} = 1\text{ mol O}$

$CHO = 29.02\text{ g/mol}$

$\text{molar mass} = \frac{15.0\text{ g}}{.129\text{ mol}} = 116.3\text{ g/mol}$

$\frac{116.3\text{ g/mol}}{29.02\text{ g}} = 4$

$CHO \times 4 = C_4H_4O_4$