

Empirical Formula, Molecular Formula, and Hydrates **Review for the Quiz:**

SHOW ALL WORK, ALL EQUATIONS, and ALL UNITS

Name: _____

1. A sample of cyclohexane was analyzed and 9.0 grams of carbon and 1.5 grams of hydrogen were identified. Determine the molecular formula if the molecular mass is $84.0 \frac{g}{mol}$.

$$C: \frac{9.0 \text{ g}}{12.01 \text{ g}} \times \frac{1 \text{ mol C}}{1} = 0.7494 \text{ mol} ; \frac{0.7494 \text{ mol}}{0.7494 \text{ mol}} = 1$$

$$H: \frac{1.5 \text{ g}}{1.008 \text{ g}} \times \frac{1 \text{ mol H}}{1} = 1.4881 \text{ mol} ; \frac{1.4881 \text{ mol}}{0.7494 \text{ mol}} = 2 ; CH_2 = 14.026 \frac{g}{mol} ; (CH_2)_n$$

$$n = \frac{84.0 \frac{g}{mol}}{14.026 \frac{g}{mol}} = 6 ; \boxed{(CH_2)_6 = C_6H_{12}}$$

2. Determine the empirical formula for a compound containing: 36.5% sodium, 25.4% sulfur, and 38.1% oxygen. When writing the formula - write the symbols in the order given.

$$Na: \frac{36.5 \text{ g}}{22.99 \text{ g}} \times \frac{1 \text{ mol Na}}{1} = 1.5876 \text{ mol} ; \frac{1.5876 \text{ mol}}{0.7923 \text{ mol}} = 2$$

$$S: \frac{25.4 \text{ g}}{32.08 \text{ g}} \times \frac{1 \text{ mol S}}{1} = 0.7923 \text{ mol} ; \frac{0.7923 \text{ mol}}{0.7923 \text{ mol}} = 1$$

$$O: \frac{38.1 \text{ g}}{16.0 \text{ g}} \times \frac{1 \text{ mol O}}{1} = 2.3813 \text{ mol} ; \frac{2.3813 \text{ mol}}{0.7923 \text{ mol}} = 3$$



3. A sample of caffeine was analyzed where 49.5 grams of carbon, 5.20 grams of hydrogen, 28.9 grams of nitrogen and 16.5 grams of oxygen was identified. Determine the molecular formula if the molecular mass for caffeine is $194.0 \frac{g}{mol}$

$$C: \frac{49.5 \text{ g}}{12.01 \text{ g}} \times \frac{1 \text{ mol C}}{1} = 4.1216 \text{ mol} ; \frac{4.1216 \text{ mol}}{1.0313 \text{ mol}} = 4$$

$$H: \frac{5.20 \text{ g}}{1.008 \text{ g}} \times \frac{1 \text{ mol H}}{1} = 5.1587 \text{ mol} ; \frac{5.1587 \text{ mol}}{1.0313 \text{ mol}} = 5$$

$$N: \frac{28.9 \text{ g}}{14.01 \text{ g}} \times \frac{1 \text{ mol N}}{1} = 2.0628 \text{ mol} ; \frac{2.0628 \text{ mol}}{1.0313 \text{ mol}} = 2$$

$$O: \frac{16.5 \text{ g}}{16.0 \text{ g}} \times \frac{1 \text{ mol O}}{1} = 1.0313 \text{ mol} ; \frac{1.0313 \text{ mol}}{1.0313 \text{ mol}} = 1 ; C_4H_5N_2O = 97.10 \frac{g}{mol}$$

$$(C_4H_5N_2O)_n ; n = \frac{194.0 \frac{g}{mol}}{97.10 \frac{g}{mol}} = 2 ; \boxed{(C_4H_5N_2O)_2 = C_8H_{10}N_4O_2}$$

4. Determine the formula for a Hydrate that is 42.3 grams tin, 50.8 grams chlorine, and 32.2 grams H₂O.

$$\text{Sn: } \frac{42.3 \text{ g}}{118.71 \text{ g}} \times \frac{1 \text{ mol Sn}}{1} = 0.3563 \text{ mol} ; \frac{0.3563 \text{ mol}}{0.3563 \text{ mol}} = 1$$

$$\text{Cl: } \frac{50.8 \text{ g}}{35.45 \text{ g}} \times \frac{1 \text{ mol Cl}}{1} = 1.4330 \text{ mol} ; \frac{1.4330 \text{ mol}}{0.3563 \text{ mol}} = 4$$

$$\text{H}_2\text{O: } \frac{32.2 \text{ g}}{18.016 \text{ g}} \times \frac{1 \text{ mol H}_2\text{O}}{1} = 1.7873 \text{ mol} ; \frac{1.7873 \text{ mol}}{0.3563 \text{ mol}} = 5$$



5. A sample was analyzed that contained 20.0 grams of carbon, 3.33 grams of hydrogen, and 26.7 grams of oxygen was identified. Determine the molecular formula if the molecular mass is 180.0 g/mol.

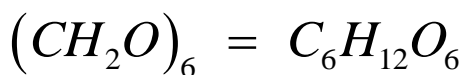
$$\text{C: } \frac{20.0 \text{ grams}}{12.01 \text{ grams}} \times \frac{1 \text{ mol C}}{1} = 1.6653 \text{ mol} ; \frac{1.6653 \text{ mol}}{1.6653 \text{ mol}} = 1$$

$$\text{H: } \frac{3.33 \text{ grams}}{1.008 \text{ grams}} \times \frac{1 \text{ mol H}}{1} = 3.3036 \text{ mol} ; \frac{3.3036 \text{ mol}}{1.6653 \text{ mol}} = 2$$

$$\text{O: } \frac{26.7 \text{ grams}}{16.00 \text{ grams}} \times \frac{1 \text{ mol O}}{1} = 1.6688 \text{ mol} ; \frac{1.6688 \text{ mol}}{1.6653 \text{ mol}} = 1$$

$$(\text{CH}_2\text{O})_n = 12.01\text{g} + (2)1.008\text{g} + 16.00\text{g} = 30.026\text{g} ;$$

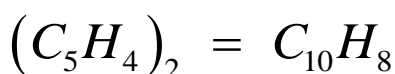
$$n = \frac{180 \text{ g}}{30.026 \text{ g}} = 6$$



6. A sample of Naphthaline was analyzed and the empirical formula was found to be C₅H₄. Determine the molecular formula if the molecular mass is 128.0 g/mol.

$$\text{C}_5\text{H}_4 = 64.082 \frac{\text{g}}{\text{mol}}$$

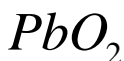
$$(\text{C}_5\text{H}_4)_n ; n = \frac{128.0 \frac{\text{g}}{\text{mol}}}{64.082 \frac{\text{g}}{\text{mol}}} = 2$$



7. What is the empirical formula of a lead oxide compound that contains 41.44 grams of lead, and 6.4 grams of oxygen?

$$Pb: \frac{41.44 \text{ g}}{207.2 \text{ g}} \times \frac{1 \text{ mol Pb}}{1} = 0.20 \text{ mol} : \frac{0.20 \text{ mol}}{0.20 \text{ mol}} = 1$$

$$O: \frac{6.4 \text{ g}}{16.0 \text{ g}} \times \frac{1 \text{ mol O}}{1} = 0.40 \text{ mol} : \frac{0.40 \text{ mol}}{0.20 \text{ mol}} = 2$$



8. A compound that contains only nitrogen and oxygen is 30.4% nitrogen by mass; the molar mass of the compound is $92 \frac{\text{g}}{\text{mol}}$. Determine the molecular formula of this compound?

$$N: \frac{30.4 \text{ g}}{14.01 \text{ g}} \times \frac{1 \text{ mol N}}{1} = 2.1699 \text{ mol} : \frac{2.1699 \text{ mol}}{2.1699 \text{ mol}} = 1$$

$$O: \frac{69.6 \text{ g}}{16.0 \text{ g}} \times \frac{1 \text{ mol O}}{1} = 4.3500 \text{ mol} : \frac{4.3500 \text{ mol}}{2.1699 \text{ mol}} = 2 \quad ; \quad NO_2 = 46.01 \frac{\text{g}}{\text{mol}}$$

$$(NO_2)_n \quad ; \quad n = \frac{92.0 \frac{\text{g}}{\text{mol}}}{46.01 \frac{\text{g}}{\text{mol}}} = 2 \quad ; \quad \boxed{(NO_2)_2 = N_2O_4}$$

9. Determine the formula for a Hydrate that is 26.31 grams of copper, 51.34 grams of nitrate (polyatomic ion), and 22.36 grams of H_2O .

$$Cu: \frac{26.31 \text{ g}}{63.55 \text{ g}} \times \frac{1 \text{ mol Cu}}{1} = 0.4140 \text{ mol} : \frac{0.4140 \text{ mol}}{0.4140 \text{ mol}} = 1$$

$$NO_3^{-1}: \frac{51.34 \text{ g}}{62.01 \text{ g}} \times \frac{1 \text{ mol } NO_3^{-1}}{1} = 0.8279 \text{ mol} : \frac{0.8279 \text{ mol}}{0.4140 \text{ mol}} = 2$$

$$H_2O: \frac{22.36 \text{ g}}{18.016 \text{ g}} \times \frac{1 \text{ mol } H_2O}{1} = 1.2411 \text{ mol} : \frac{1.2411 \text{ mol}}{0.4140 \text{ mol}} = 3$$

