Problem Set 7: Molecules and Compounds, Bonding

1. Cobalt forms Co^{2+} and Co^{3+} ions. Write the formulas for the two cobalt oxides formed by these transition metal ions. Oxide = O^{2-}

   Co^{2+} = CoO cobalt (II) oxide

   Co^{3+} = Co_2O_3 cobalt (III) oxide

   * must balance charge

2. Write the formulas for the four ionic compounds that can be formed between cations – Na^+ & Ba^{2+}; and anions – CO_3^{2-} and I^-. Name each of the compounds.

   Na_2CO_3 $BaCO_3$

   NaI BaI_2

3. A. Name each of the following compounds and identify the ionic and/or covalent compounds:

   a) NF_3 nitrogen trifluoride (covalent)

   b) $SrSO_4$ strontium sulfate (ionic + covalent)

   c) Al_2S_3 aluminum sulfide (ionic)

   d) HI hydrogen iodide (covalent)

   e) ClF_3 chlorine trifluoride (covalent)

   f) BI_3 boron triiodide (covalent)

   g) PF_5 phosphorus pentafluoride (covalent)

   B. Give the formula for each and identify the ionic and/or covalent compounds:

   a) Sulfur dichloride SCl_2 covalent

   b) Dinitrogen pentaoxide N_2O_5 covalent

   c) Calcium acetate $Ca(CH_3COO)_2$ ionic + covalent

   d) Silicon tetrachloride $SiCl_4$ covalent

   e) Calcium sulfate ~~pentahydrate~~ $CaSO_4$ ionic + covalent

   f) diboron trioxide B_2O_3 covalent

4. Determine the number of moles of hydrogen atoms in each sample:
   a. 0.0885 mole C_4H_{10}

$$0.0885 \text{ mol } C_4H_{10} \times \frac{10 \text{ mol H}}{1 \text{ mol } C_4H_{10}} = 0.885 \text{ mol H}$$

   b. 1.3 mol CH_4

$$1.3 \text{ mol } CH_4 \times \frac{4 \text{ mol H}}{1 \text{ mol } CH_4} = 5.2 \text{ mol H}$$

   c. 2.4 mol C_6H_{12}

$$2.4 \text{ mol } C_6H_{12} \times \frac{12 \text{ mol H}}{1 \text{ mol } C_6H_{12}} = 28.8 \text{ mol H}$$

   d. 1.87 mol C_8H_{18}

$$1.87 \text{ mol } C_8H_{18} \times \frac{18 \text{ mol H}}{1 \text{ mol } C_8H_{18}} = 33.66 \text{ mol H}$$

5. Calculate the mass percent composition of oxygen in $Al_2(SO_4)_3$.

$$\text{Mass \%} = \frac{(\#\text{ atoms})(\text{atomic weight})}{(\text{molecular weight})} \times 100\%$$

Al: $26.982 \text{ g/mol} \times 2 = 53.964 \text{ g/mol}$

S: $32.066 \text{ g/mol} \times 3 = 96.198 \text{ g/mol}$

O: $15.999 \text{ g/mol} \times 12 = 191.988 \text{ g/mol}$

MW = 342.15 g/mol

$$= \frac{(12)(15.999 \text{ g/mol})}{342.15 \text{ g/mol}} \times 100\%$$

$$= \boxed{56.11\% \text{ oxygen}}$$

6. Pepto-Bismol, which helps provide soothing relief for an upset stomach, contains 300 mg of bismuth subsalicylate, $C_{21}H_{15}Bi_3O_{12}$, per tablet. If you take two tablets, what amount (in moles) of the "active ingredient" are you taking? What mass of Bi are you consuming in 2 tablets?

* first calc. mass % bismuth, then calc mass of Bi in 2 tablets

$$\%\text{mass} = \frac{(\#\text{atoms})(\text{atomic mass})}{(\text{molecular weight})} \times 100\%$$

$$= \frac{(3)(208.98\ g/mol)}{(1086.258\ g/mol)} \times 100\%$$

$$= 57.72\%\ Bi$$

C: $21 \times 12.011\ g/mol = 252.219\ g/mol$

H: $15 \times 1.008\ g/mol = 15.12\ g/mol$

Bi: $3 \times 208.98\ g/mol = 626.94\ g/mol$

O: $12 \times 15.999\ g/mol = 191.988\ g/mol$

MW: $1086.258\ g/mol$

$2\ \text{tablets} \times 300\ mg = 600\ mg$

$57.72\% \times 600\ mg = \boxed{346\ mg\ Bi}$

7. Cumene is a hydrocarbon, composed only of C and H. It is 89.94% C, and its molar mass is 120.2 g/mol. What are the empirical and molecular formulas of cumene?

1) calc mass (assume 100g sample)

C: $100g \times 89.94\% = 89.94\ g\ C$

H: $100g \times 10.06\% = 10.06\ g\ H$

$\%C + \%H = 100\%$

$\%H = 10.06\%$

2) calc moles

$$89.94\ g\ C \frac{1\ mol}{12.01\ g} = \frac{7.488\ mol\ C}{7.488\ mol} = 1\ C$$

$$10.06\ g\ H \frac{1\ mol}{1.008\ g} = \frac{9.98\ mol\ H}{7.488\ mol} = 1.33\ H$$

3) determine mole ratio (÷ by smallest number)

$(C_1 H_{1.33}) \times 3 = \boxed{C_3 H_4 = \text{empirical formula}}$

4) find "multiplier" to get molecular formula

$$\frac{\text{molecular weight}}{\text{Empirical formula weight}} = \text{multiplier}$$

C: $3 \times 12.01 = 36.03$

H: $4 \times 1.008 = 4.032$

$$\frac{120.2\ \text{g/mol}}{40.062\ \text{g/mol}} = 3$$

$$(C_3H_4) \times 3 = C_9H_{12} = \text{molecular formula}$$