Molar Mass and 1-Step Mole Calculations

NH_4^+ SO_4^{2-}

1. What is the molar mass of ammonium sulfate?

$(NH_4)_2SO_4$

N : 2 x 14.01g = 28.02g
H : 8 x 1.01g = 8.08g
S : 1 x 32.06g = 32.06g
O : 4 x 16g = 64g

132.16 g $(NH_4)_2SO_4$ = 1 mol

2. What is the molar mass of lithium phosphate? Li^+ PO_4^{3-}

Li_3PO_4

Li : 3 x 6.94g = 20.82g
P : 1 x 30.97g = 30.97g
O : 4 x 16g = 64g

115.79 g Li_3PO_4 = 1 mol

3. What is the molar mass of dinitrogen pentoxide?

N_2O_5

N : 2 x 14.01g = 28.02g
O : 5 x 16g = 80g

108.02 g N_2O_5 = 1 mol

4. If you have 2.34×10^{24} formula units of iron (III) carbonate, how many moles do you have?

$$\frac{2.34 \times 10^{24} \text{ form units}}{1} \times \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ form units}} = 3.89 \text{ mol } Fe_2(CO_3)_3$$

5. If you have 5.5 moles of barium chloride, how many grams do you have?

molar mass = 208.23 g/mol

$$\frac{5.5 \text{ mol } BaCl_2}{1} \times \frac{208.23 \text{ g}}{1 \text{ mol}} = 1{,}145.3 \text{ g } BaCl_2$$

6. If you have 25 L of Cl_2 gas, how many moles do you have?

$$\frac{25 \text{ L } Cl_2}{1} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = 1.12 \text{ mol } Cl_2$$

2-Step Mole Calculations

1. How many molecules of CH_4 are in 48.2 g of this compound?

$$\frac{48.2\text{ g } CH_4}{1} \times \frac{1\text{ mol}}{16.05\text{ g}} \times \frac{6.02\times10^{23}\text{ molec}}{1\text{ mol}} = 1.81\times10^{24}\text{ molec } CH_4$$

(16.05 g: molar mass)

2. Find the mass in grams of 5 liters of nitrogen gas (N_2).

$$\frac{5\text{ L } N_2}{1} \times \frac{1\text{ mol}}{22.4\text{ L}} \times \frac{28.02\text{ g}}{1\text{ mol}} = 6.25\text{ g } N_2$$

(28.02 g: molar mass)

3. If you have 2.41×10^{23} formula units of sodium carbonate, how many grams do you have?

Na^+ CO_3^{2-} Na_2CO_3

$$\frac{2.41\times10^{23}\text{ form. units}}{1} \times \frac{1\text{ mol}}{6.02\times10^{23}\text{ form. units}} \times \frac{105.99\text{ g}}{1\text{ mol}} = 42.4\text{ g } Na_2CO_3$$

(105.99 g: molar mass)

4. How many liters will 1.20×10^{24} molecules of the gas CO_2 contain?

$$\frac{1.20\times10^{24}\text{ molec. } CO_2}{1} \times \frac{1\text{ mol}}{6.02\times10^{23}\text{ molec}} \times \frac{22.4\text{ L}}{1\text{ mol}} = 44.7\text{ L } CO_2$$

5. How many molecules are in 35 g of water?

$$\frac{35\text{ g } H_2O}{1} \times \frac{1\text{ mol}}{18.02\text{ g}} \times \frac{6.02\times10^{23}\text{ molec}}{1\text{ mol}} = 1.17\times10^{24}\text{ molec. } H_2O$$

(18.02 g: molar mass)

Percent Composition

1. Aluminum sulfate is a substance used in water treatment plants to help purify water. Write the formula for aluminum sulfate and find the percent composition of all elements in this compound.

Al^{+3} SO_4^{2-} $Al_2(SO_4)_3$

Al : $2 \times 26.98g = 53.96g$ %Al : $53.96/342.14 \times 100 = 15.8\%$

S : $3 \times 32.06g = 96.18g$ %S : $96.18/342.14 \times 100 = 28.1\%$

O : $12 \times 16g = 192g$ %O : $192/342.14 \times 100 = 56.1\%$

$342.14g$

2. Cesium bromide is used to make optical devices such as prisms and spectrophotometer cells. Write the formula for cesium bromide and find the percent composition of all elements in this compound.

Cs^{+1} Br^{-1} CsBr

Cs : $1 \times 132.91g = 132.91g$ %Cs = $132.91/212.81 \times 100 = 62.5\%$

Br : $1 \times 79.9g = 79.9g$ %Br = $79.9/212.81 \times 100 = 37.5\%$

$212.81g$

3. CCl_2F_2 is a Freon which is a gaseous compound used in refrigeration. What percent of this compound is from carbon?

C : $1 \times 12.01g = 12.01g$ %C = $\frac{12.01g}{120.91g} \times 100 = 9.93\%$

Total mass → $120.91g$

4. Which has a higher percentage by mass of iron?

$Fe(NO_3)_3$ A. iron (III) nitrate molar mass → $241.88g$

$FeSO_4$ (B. iron (II) sulfate) molar mass → $151.91g$

A. %Fe = $\frac{55.85g}{241.88g} \times 100 = 23.1\%$

(B.) %Fe = $\frac{55.85g}{151.91g} \times 100 = 36.8\%$

Empirical Formulas

1. Benzoic acid is a compound used as a food preservative. The compound contains 68.8% C, 4.95% H and 26.2% O by mass.
   A. What is its empirical formula?
   B. If given 324 g of benzoic acid, how many moles would you have?

C : $\frac{68.8g}{1} \times \frac{1mol}{12.01g} = 5.73\,mol / 1.64\,mol = (3.5)2 \rightarrow 7$

H : $\frac{4.95g}{1} \times \frac{1mol}{1.01g} = 4.90\,mol / 1.64\,mol = (3)2 \rightarrow 6$

O : $\frac{26.2g}{1} \times \frac{1mol}{16g} = 1.64\,mol / 1.64\,mol = (1)2 \rightarrow 2$

A. $C_7H_6O_2$

molar mass

B. $\frac{324g\ C_7H_6O_2}{1} \times \frac{1mol}{122.13g} =$

$2.65\,mol\ C_7H_6O_2$

2. 2-Methylpropene is a compound used to make synthetic rubber. A sample of this compound contains 0.556 g C and 0.0933 g H.
   A. Determine its empirical formula.
   B. If given 4.33×10^{22} molecules of this compound, how many grams would you have?

C : $\frac{0.566g}{1} \times \frac{1mol}{12.01g} = 0.0471\,mol / 0.0471mol = 1$

H : $\frac{0.0933g}{1} \times \frac{1mol}{1.01g} = 0.0923\,mol / 0.0471mol = 2$

A. CH_2

molar mass ↓

B. $\frac{4.33 \times 10^{22}\,molec\ CH_2}{1} \times \frac{1mol}{6.02 \times 10^{23}\,molec} \times \frac{14.03g}{1mol} =$

$1.0g\ CH_2$

3. A major oil company has used gasoline additive called MMT to boost the octane rating of its gasoline. What is the empirical formula of MMT if it is 49.5% C, 3.2% H, 22.9% O and 25.2 % Mn

C : $\frac{49.5g}{1} \times \frac{1mol}{12.01g} = 4.12\,mol / 0.459\,mol = 9$

H : $\frac{3.2g}{1} \times \frac{1mol}{1.01g} = 3.17\,mol / 0.459\,mol = 7$

O : $\frac{22.9g}{1} \times \frac{1mol}{16g} = 1.43\,mol / 0.459\,mol = 3$

Mn : $\frac{25.2g}{1} \times \frac{1mol}{54.94g} = 0.459\,mol / 0.459\,mol = 1$

$C_9H_7O_3Mn$

Molecular Formulas

1. Determine the molecular formula of a compound that is composed of 40.0% C, 53.4% O and 6.6% H. The molar mass is 120 g/mol.

C : $\frac{40.0g}{1} \times \frac{1mol}{12.01g} = 3.33\ mol / 3.33\ mol = 1$

H : $\frac{6.6g}{1} \times \frac{1mol}{1.01g} = 6.53\ mol / 3.33\ mol = 2$

O : $\frac{53.4g}{1} \times \frac{1mol}{16g} = 3.33\ mol / 3.33\ mol = 1$

emp. form → CH_2O

emp. form mass → 30.03g

$\frac{120g}{30.03g} = 4\ (CH_2O) \rightarrow C_4H_8O_4$

2. Find the molecular formula for a compound with the following percent composition – 85.6% C, 14.4% H. The molecular mass is 42.1 g/mol.

C : $\frac{85.6g}{1} \times \frac{1mol}{12.01g} = 7.13\ mol / 7.13\ mol = 1$

H : $\frac{14.4g}{1} \times \frac{1mol}{1.01g} = 14.3\ mol / 7.13\ mol = 2$

emp. form → CH_2

emp. form mass → 14.03 g/mol

$\frac{42.1\ g/mol}{14.03\ g/mol} = 3\ (CH_2) \rightarrow C_3H_6$

3. The action of bacteria on meat and fish produces a compound called cadaverine. As its name and origin imply, it stinks! (It is also present in bad breath and adds to the odor of urine). It is 58.77% C, 13.81% H, and 27.40% N. Its molar mass is 102.2 g/mol. Determine the molecular formula of cadaverine.

C : $\frac{58.77g}{1} \times \frac{1mol}{12.01g} = 4.89\ mol / 1.96\ mol = (2.5)\ 2 \rightarrow 5$

H : $\frac{13.81g}{1} \times \frac{1mol}{1.01g} = 13.67\ mol / 1.96\ mol = (7.)\ 2 \rightarrow 14$

N : $\frac{27.40g}{1} \times \frac{1mol}{14.01g} = 1.96\ mol / 1.96\ mol = (1)\ 2 \rightarrow 2$

emp. form $C_5H_{14}N_2$

emp. form. mass 102.21 g/mol

$\frac{102.2\ g/mol}{102.21\ g/mol} = 1 \rightarrow C_5H_{14}N_2$

empirical & molecular formulas are the same!