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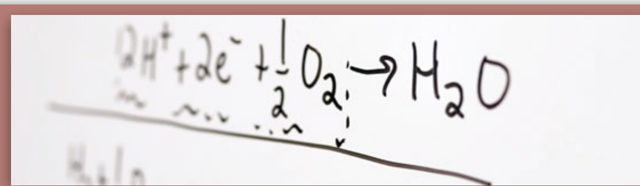
Unit 3 - Bonding, Moles, & Stoichiometry

IB Chemistry 11

In-Class Practice Problems



Determining Empirical Formula

A compound formed in the lab is 47% Lithium and 53% Oxygen. What is its empirical formula?

① 47 g Li ② $\frac{1 \text{ mol Li}}{6.941 \text{ g}} \times \frac{47 \text{ g}}{1} = $ **6.77 mol Li**　$\frac{6.77}{3.31} = 2.01$　$\frac{3.31}{3.31} = 1$

53 g O　$\frac{1 \text{ mol O}}{16 \text{ g}} \times \frac{53 \text{ g}}{1} = $ **3.31 mol O**

Li_2O

Determining Molecular Formula

A compound composted of 75% carbon and 25% hydrogen has a molecular mass of 32 amu. Determine its molecular formula.

75 g , 25 g

$\frac{1 \text{ mol C}}{12.01 \text{ g}} \times \frac{75 \text{ g}}{1} = $ **6.25 mol C**

$\frac{1 \text{ mol H}}{1.01 \text{ g}} \times \frac{25 \text{ g}}{1} = $ **25 mol H**

$\frac{6.25}{6.25} = 1$　$\frac{25}{6.25} = 4$　E.F. = CH_4 (16)

32 →

Multiplier is 2 ⟹ **C_2H_8**

$2\ CH_4$ = 2 methane molecules

Gram to Gram Conversions

$2\ NaOH + H_2SO_4 \rightarrow 2\ H_2O + Na_2SO_4$

mole : mole ratios

How many grams of sodium sulfate will be produced if you start with 200 grams of sodium hydroxide and you have an excess of sulfuric acid?

$\frac{142 \text{ g } Na_2SO_4}{1 \text{ mol } Na_2SO_4} \times \left[\frac{1 \text{ mol } Na_2SO_4}{2 \text{ mol NaOH}}\right] \times \frac{1 \text{ mol NaOH}}{40 \text{ g NaOH}} \times \frac{200 \text{ g NaOH}}{1} = $ **355 g Na_2SO_4**

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$Pb(SO_4)_2 + 4\ LiNO_3 \rightarrow Pb(NO_3)_4 + 2\ Li_2SO_4$

How many grams of lithium nitrate will be needed to make 250 grams of lithium sulfate, assuming that you have an adequate amount of lead (IV) sulfate to do the reaction?

$$\frac{69\text{ g } LiNO_3}{1\text{ mol } LiNO_3} \times \frac{4\text{ mol } LiNO_3}{2\text{ mol } Li_2SO_4} \times \frac{1\text{ mol } Li_2SO_4}{110\text{ g } Li_2SO_4} \times \frac{250\text{ g } Li_2SO_4}{1} = \boxed{313.6\text{ g } LiNO_3}$$

Molar Volume Calculations (Gases Only)

(1 mole = 22.4 Liters)

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$

How many liters of hydrogen will be needed to make 350 liters of water vapor?

$$\frac{22.4\text{ L } H_2}{1\text{ mol } H_2} \times \frac{2\text{ mol } H_2}{2\text{ mol } H_2O} \times \frac{1\text{ mol } H_2O}{22.4\text{ L}} \times \frac{350\text{ L } H_2O}{1} = \boxed{350\text{ L } H_2O_g}$$

How many milliliters of oxygen will be needed to make the same amount of water vapor?

$$\frac{1000\text{ mL } O_2}{1\text{ L } O_2} \times \frac{22.4\text{ L}}{1\text{ mol}} \times \frac{1\text{ mol } O_2}{2\text{ mol } H_2O} \times \frac{1\text{ mol } H_2O}{22.4\text{ L } H_2O} \times \frac{350\text{ L } H_2O}{1} = \boxed{175{,}000\text{ mL } O_2}$$

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$2Cu_{(s)} + O_{2(g)} \rightarrow 2CuO_{(s)}$

How many grams of Copper (II) oxide will be formed from 10 liters of oxygen gas?

$\frac{80\text{ g CuO}}{1\text{ mol CuO}} \times \frac{2\text{ mol CuO}}{1\text{ mol }O_2} \times \frac{1\text{ mol }O_2}{22.4\text{ L }O_2} \times \frac{10\text{ L }O_2}{1} = 71.4\text{ L }O_2$

Particle Calculations - Avogadro

(1 mole = 6.022 x 10^{23} particles)

$H_2SO_4 + 2NaOH \rightarrow 2H_2O + Na_2SO_4$

How many water molecules will be formed from the reaction of 250 grams of NaOH?

$\frac{6.02\times10^{23}\text{ molec. }H_2O}{1\text{ mol }H_2O} \times \frac{2\text{ mol }H_2O}{2\text{ mol NaOH}} \times \frac{1\text{ mol NaOH}}{40\text{ g NaOH}} \times \frac{250\text{ g NaOH}}{1} = 3.76\times10^{24}\text{ molecules }H_2O$

How many moles of hydrogen atoms is that?

$\frac{2\text{ atoms H}}{1\text{ molecule }H_2O} \times \frac{3.76\times10^{24}\text{ molecules }H_2O}{1} = 7.525\times10^{24}\text{ atoms H}$

$\frac{1\text{ mol H atoms}}{12.04\times10^{23}\text{ atoms}} \times \frac{7.525\times10^{24}\text{ atom}}{1} = 6.25\text{ mol H atoms}$

$C_2H_{4(g)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 2H_2O_{(g)}$

How many oxygen atoms will be used to make 500 grams of water?

$\frac{2\text{ atoms O}}{1\text{ molecule }O_2} \times \frac{6.02\times10^{23}\text{ molecules}}{1\text{ mol }O_2} \times \frac{3\text{ mol }O_2}{2\text{ mol }H_2O} \times \frac{1\text{ mol }H_2O}{18\text{ g }H_2O} \times \frac{500\text{ g }H_2O}{1} = 5.02\times10^{25}\text{ atoms O}$

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Putting it All Together

1. A 5.0 g sample of CO_2 is in a container at STP. What volume is the container?

$$\frac{22.4\text{ L }CO_2}{1\text{ mol }CO_2} \times \frac{1\text{ mol }CO_2}{44\text{ g }CO_2} \times \frac{5.0\text{ g }CO_2}{1} = 2.55\text{ L }CO_2$$

2. How many grams are there in 1.5 x 10^{25} molecules of CH_4?

$$\frac{16\text{ g }CH_4}{1\text{ mol }CH_4} \times \frac{1\text{ mol }CH_4}{6.02\times10^{23}\text{ molec.}} \times \frac{1.5\times10^{25}\text{ molecules}}{1} = 398.7\text{ g }CH_4$$

3. Look on Table I for the equation for the formation of ammonia gas. What volume of NH_3 at STP is produced if 25.0 g of H_2 is reacted with an excess of N_2?

$$N_2 + 3H_2 \rightarrow 2NH_3$$

$$\frac{22.4\text{ L }NH_3}{1\text{ mol }NH_3} \times \frac{2\text{ mol }NH_3}{3\text{ mol }H_2} \times \frac{1\text{ mol }H_2}{2.02\text{ g }H_2} \times \frac{25.0\text{ g }H_2}{1} = 184.8\text{ L }NH_3$$

4. How many milliliters of H_2O vapor will be formed from the combustion of 120 g of propane? (C_3H_8 is propane - look at Table I for the reaction.)

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

$$\frac{1000\text{ mL }H_2O}{1\text{ L }H_2O} \times \frac{22.4\text{ L }H_2O}{1\text{ mol }H_2O} \times \frac{4\text{ mol }H_2O}{1\text{ mol }C_3H_8} \times \frac{1\text{ mol }C_3H_8}{44\text{ g }C_3H_8} \times \frac{120\text{ g }C_3H_8}{1} =$$

$$244{,}363\text{ mL }H_2O$$

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5. If you can do this one, you can do ANYTHING! How many molecules of CO_2 will be formed from the combustion of 500 mg of propane? (C_3H_8 is propane - look at Table I for the reaction.) $C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$

$$\frac{6.02\times10^{23}\text{ molecules}}{1\text{ mol }CO_2} \times \frac{3\text{ mol }CO_2}{1\text{ mol }C_3H_8} \times \frac{1\text{ mol }C_3H_8}{44\text{ g }C_3H_8} \times \frac{1\text{ g }C_3H_8}{1000\text{ mg }C_3H_8} \times \frac{500\text{ mg }C_3H_8}{1} =$$

$$\boxed{2.05\times10^{22}\text{ molecules }C_3H_8}$$

$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$

Limiting Reagent & Theoretical Yield

6. A 2.00 g sample of ammonia is mixed with 4.00 g of oxygen. Which is the limiting reactant and how much excess reactant remains after the reaction has stopped?

$$\frac{30.0\text{ g NO}}{1\text{ mol NO}} \times \frac{4\text{ mol NO}}{4\text{ mol }NH_3} \times \frac{1\text{ mol }NH_3}{17.0\text{ g }NH_3} \times \frac{2.00\text{ g }NH_3}{1} = \boxed{3.53\text{ g NO}}$$

$$\frac{30.0\text{ g NO}}{1\text{ mol NO}} \times \frac{4\text{ mol NO}}{5\text{ mol }O_2} \times \frac{1\text{ mol }O_2}{32.0\text{ g }O_2} \times \frac{4.00\text{ g }O_2}{1} = 3.00\text{ g NO}$$

O_2 is the Limiting Reagent

$$\frac{17.0\text{ g }NH_3}{1\text{ mol }NH_3} \times \frac{4\text{ mol }NH_3}{5\text{ mol }O_2} \times \frac{1\text{ mol }O_2}{32\text{ g }O_2} \times \frac{4.00\text{ g }O_2}{1} = 1.70\text{ g }NH_3$$

$$2.00\text{ g }NH_3\text{ (original sample)} - 1.70\text{ g }NH_3 = \boxed{0.30\text{ g }NH_3}$$

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$$CuCl_2 + 2NaNO_3 \longrightarrow 2NaCl + Cu(NO_3)_2$$

7. If 15 grams of copper (II) chloride react with 20 grams of sodium nitrate, how much sodium chloride can be formed? What is the limiting reagent for the reaction? How much of the non-limiting reagent is left over (excess) in this reaction?

$$\frac{58\,g\,NaCl}{1\,mol\,NaCl} \times \frac{2\,mol\,NaCl}{1\,mol\,CuCl_2} \times \frac{1\,mol\,CuCl_2}{133\,g\,CuCl_2} \times \frac{15\,g\,CuCl_2}{1} = \boxed{13.1\,g\,NaCl}$$

$$\frac{58\,g\,NaCl}{1\,mol\,NaCl} \times \frac{2\,mol\,NaCl}{2\,mol\,NaNO_3} \times \frac{1\,mol\,NaNO_3}{85\,g\,NaNO_3} \times \frac{20\,g\,NaNO_3}{1} = 13.6\,g\,NaCl$$

$CuCl_2$ is the Limiting Reagent

$$\frac{85\,g\,NaNO_3}{1\,mol\,NaNO_3} \times \frac{2\,mol\,NaNO_3}{1\,mol\,CuCl_2} \times \frac{1\,mol\,CuCl_2}{133\,g\,CuCl_2} \times \frac{15\,g\,CuCl_2}{1} = \boxed{19.2\,g\,NaNO_3}$$

$20\,g\,NaNO_3$ (original sample) $- 19.2\,g\,NaNO_3 =$ **0.8 g remaining**

8. If 11.3 grams of sodium chloride are formed in the reaction, what is the percent yield of this reaction?

$$\%\,Yield = \frac{Part}{Whole}$$

$$= \frac{11.3\,g}{13.1\,g} \times 100$$

$$\boxed{= 86\%}$$