Study Guide: Chemical Quantities, Mole Concepts and Stoichiometry

Chemical Quantities: Use the factor label ("fence post") method to convert the following:

275 mm = 27.5 cm   15 g = 15,000 mg   3 hrs = 10,800 sec.

27.5 $\frac{275\text{ mm}}{} \cdot \frac{1\text{ cm}}{10\text{ m}}$ =   15 ... $\frac{15\text{ g}}{} \cdot \frac{1000\text{ mg}}{1\text{ g}}$ $\frac{3\text{ hrs}}{} \cdot \frac{60\text{ min}}{1\text{ hr}} \cdot \frac{60\text{ sec}}{1\text{ min}}$

Mole and Avogadro's number: Use Avogadro's number (6.02×10^{23}) to determine the number of moles or particles in each of the following:

3.4×10^{26} molecules PCl_3 = 5,647.8 mol $\frac{3.4 \times 10^{26}\text{ molecules}}{} \cdot \frac{1\text{ mol}}{6.02 \times 10^{23}\text{ molecules}}$

1.5 moles H_2O = 9.03×10^{23} molecules $\frac{1.5\text{ moles } H_2O}{} \cdot \frac{6.02 \times 10^{23}\text{ molecules}}{1\text{ mol } H_2O}$

0.75 moles Zn = 4.52×10^{23} atoms $\frac{0.75\text{ moles Zn}}{} \cdot \frac{6.02 \times 10^{23}\text{ atoms}}{1\text{ mol Zn}}$

2.0 moles NaCl = 1.2×10^{24} formula units $\frac{2.0\text{ mol NaCl}}{} \cdot \frac{6.02 \times 10^{23}\text{ formula units}}{1\text{ mol NaCl}}$

15 moles CO_2 = 2.7×10^{25} atoms $\frac{15\text{ mol } CO_2}{} \cdot \frac{6.02 \times 10^{23}\text{ molecules}}{1\text{ mol } CO_2} \cdot \frac{3\text{ atoms}}{1\text{ molecule}}$

Mole and Mass: Determine the number of moles or grams in each of the quantities below.

74 g of KCl = 1.0 moles   1.70 moles of $KMnO_4$ = 268.6 g

$\frac{74\text{ g KCl}}{} \cdot \frac{1\text{ mol KCl}}{74.6\text{ g KCl}}$ $\frac{1.70\text{ mol } KMnO_4}{} \cdot \frac{158\text{ g } KMnO_4}{1\text{ mol } KMnO_4}$

Mole and Volume: For gases at STP (0°C and 1 atm), one mole occupies a volume of 22.4 L. What volume will the following quantities of gases occupy at STP?

1.75 moles CO_2 = 39.2 L   28.0 g of N_2 = 22.4 L

$\frac{1.75\text{ mol}}{} \cdot \frac{22.4\text{ L } CO_2}{1\text{ mol } CO_2}$ $\frac{28.0\text{ g } N_2}{} \cdot \frac{1\text{ mol } N_2}{28\text{ g } N_2} \cdot \frac{22.4\text{ L } N_2}{1\text{ mol } N_2}$

Molar Mass and Density

What is the molar mass of a gas with a density of 85.3 g/L? $\frac{85.3\text{ g}}{\text{L}} \cdot \frac{22.4\text{ L}}{1\text{ mol}} = 1910.7$

Mixed Mole Problems

What is the mass of a sample of NH_3 that takes up 75 liters at STP?

$\frac{75\text{ L } NH_3}{} \cdot \frac{1\text{ mol } NH_3}{22.4\text{ L } NH_3} \cdot \frac{17\text{ g } NH_3}{1\text{ mol } NH_3} = 56.9\text{ g } NH_3$

A 5.0 g sample of O_2 is in a container at STP. What volume is the container?

$\frac{5.0\text{ g } O_2}{} \cdot \frac{1\text{ mol } O_2}{32\text{ g } O_2} \cdot \frac{22.4\text{ L } O_2}{1\text{ mol } O_2} = 3.5\text{ L } O_2$

Gram Formula Mass: Determine the gram formula mass (mass of one mole) of each compound below.

H_2CO_3 62 g $Zn_3(PO_4)_2$ 386.2 g

$(2 \times 1) + 12 + (3 \times 16) =$ $(3 \times 65.4) + (2 \times 31) + (8 \times 16) =$

Percent Composition: Determine the percent composition for each of the following compounds.

A 9.14 g sample contains 4.77 g carbon, 1.19 g hydrogen, and 3.18 g oxygen.

% C 52.2 % H 13.0 % O 34.8

CaC_2O_4: %Ca 31.3 %C 18.7 %O 50 $CaC_2O_4 = 128.1g$

Ca $\frac{40.1}{128.1} \times 100$ C $\frac{24}{128.1} \times 100$ O $\frac{64}{128.1} \times 100$

Empirical Formula: What is the empirical formula (lowest whole number ratio) of the compounds below?

75% carbon and 25% hydrogen: CH_4

C $\frac{75g \mid 1mol}{\mid 12g} = 6.25mol / 6.25 = 1$

H $\frac{25g \mid 1mol}{\mid 1g} = 25mol / 6.25 = 4$

Calculate the empirical formula for a compound having 37.70% sodium, 22.95% silicon, and 39.34% oxygen. Na_2SO_3

Na $\frac{37.7g \mid 1mol}{\mid 23g} = 1.64 mol / 0.82 = 2$

Si $\frac{22.95g \mid 1mol}{\mid 28.1g} = 0.82 mol / 0.82 = 1$

O $\frac{39.34g \mid 1mol}{\mid 16g} = 2.45 / 0.82 = 3$

Molecular formula

The empirical formula of a compound is NO_2. Its molecular mass is 92 g/mol. What is its molecular formula? N_2O_4

$NO_2 = 46g$ $\frac{92g}{46g} = 2$

A compound is 54.5% carbon, 9.1% hydrogen, and 36.4% oxygen. Its molecular mass is 88 g/mol. What is its molecular formula? $C_4H_8O_2$

C $\frac{54.5g \mid 1mol}{\mid 12g} = 4.5mol / 2.3 = 2$

H $\frac{9.1g \mid 1mol}{\mid 1g} = 9.1 mol / 2.3 = 4$

O $\frac{36.4g \mid 1mol}{\mid 16g} = 2.3 mol / 2.3 = 1$

$C_2H_4O = 44g$ $\frac{88g}{44g} = 2$

Stoichiometry

Find the mass of sugar ($C_6H_{12}O_6$) required to produce 1.82 L of carbon dioxide gas at STP from the reaction described by the following equation. (Answer: 7.3 g $C_6H_{12}O_6$)

$$C_6H_{12}O_6 \rightarrow 2C_2H_6O + 2CO_2$$

$\frac{1.82L\ CO_2}{} \Big| \frac{1 mol\ CO_2}{22.4L\ CO_2} \Big| \frac{1 mol\ C_6H_{12}O_6}{2 mol\ CO_2} \Big| \frac{180g\ C_6H_{12}O_6}{1 mol\ C_6H_{12}O_6} =$

What mass of hydrogen peroxide (H_2O_2) must decompose to produce 0.77g of water according to the following reaction: $2H_2O_2 \rightarrow 2H_2O + O_2$ (Answer: 1.45 g H_2O_2)

$\frac{0.77g\ H_2O}{} \Big| \frac{1 mol\ H_2O}{18g\ H_2O} \Big| \frac{2 mol\ H_2O_2}{2 mol\ H_2O} \Big| \frac{34g\ H_2O_2}{1 mol\ H_2O_2} =$

Limiting Reagent: Identify the limiting reactant when 5.87 grams of $Mg(OH)_2$ reacts with 12.84 grams of HCl to form $MgCl_2$ and water. How much $MgCl_2$ is produced? (Answer: $Mg(OH)_2$ is the limiting reactant and only 9.6g of $MgCl_2$ can be produced). $1\ Mg(OH)_2 + 2HCl \rightarrow 1\ MgCl_2 + 2H_2O$

$\frac{5.87g\ Mg(OH)_2}{} \Big| \frac{1 mol\ Mg(OH)_2}{58.3g\ Mg(OH)_2} \Big| \frac{2 mol\ HCl}{1 mol\ Mg(OH)_2} \Big| \frac{36.5g}{1 mol\ HCl} = 7.35g\ HCl$ → have more HCl than needed

$Mg(OH)_2$ limiting reagent, HCl excess reagent

$\frac{5.87g\ Mg(OH)_2}{} \Big| \frac{1 mol\ Mg(OH)_2}{58.3g\ Mg(OH)_2} \Big| \frac{1 mol\ MgCl_2}{1 mol\ Mg(OH)_2} \Big| \frac{95.3g\ MgCl_2}{1 mol\ MgCl_2} =$