Chemistry 11

Unit 7 : Stoichiometry

Name:__________ **Block:_____**

Intro to Stoichiometry - *Calculating with Chemical Change*

The reaction between phosphoric acid, H_3PO_4, and potassium hydroxide, KOH, can produce three different products:

different molar ratio

$1\ H_3PO_4 + 1\ KOH \rightarrow KH_2PO_4 + H_2O$

$1\ H_3PO_4 + 2\ KOH \rightarrow K_2HPO_4 + 2\ H_2O$

$1\ H_3PO_4 + 3\ KOH \rightarrow K_3PO_4 + 3\ H_2O$

water always a product. all different products.

Each of the products KH_2PO_4, K_2HPO_4 and K_3PO_4, has different properties and different uses.

For example, KH_2PO_4 is used in baking powder K_2HPO_4 is used in some fertilizers and antifreezes, and K_3PO_4 is used in liquid soaps.

The products of this chemical reaction are based on the Molar Ratio of the reactants of H_3PO_4 and KOH used.

Stoichiometry (*stoicheion* meaning "element" and *metron* meaning "measure"): The relationship between the amounts of the reactants used, and the amounts of products produced. * quantitatively relate reactants : products

With stoichiometry, we can predict the amount of a specific product created when a given amount of reactant is used.

Example: $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$ — synthesis rxn

How does one state the chemical reaction equation above? It turns out that there are actually two ways:

"Two moles (molecules) of hydrogen react with one mole (molecule) of oxygen to produce two moles (molecules) of water."

Coefficients represent a ratio... ratio can be moles or molecules.

In chemistry we will usually think in terms of MOLES rather than molecules

b/c its nearly impossible to measure/weigh molecules.

The mole ratios of coefficients in the balanced reaction equation gives us the mole conversion factors: (4 numbers)

mole ratio:
- $2\ mol\ H_2 : 1\ mol\ O_2$
- $2\ mol\ H_2 : 2\ mol\ H_2O$
- $1\ mol\ O_2 : 2\ mol\ H_2O$

conversion factors:
- $\frac{2\ mol\ H_2}{1\ mol\ O_2}$ or $\frac{1\ mol\ O_2}{2\ mol\ H_2}$
- $\frac{2\ mol\ H_2}{2\ mol\ H_2O}$ or $\frac{2\ mol\ H_2O}{2\ mol\ H_2}$
- $\frac{1\ mol\ O_2}{2\ mol\ H_2O}$ or $\frac{2\ mol\ H_2O}{1\ mol\ O_2}$

EXAMPLE: Consider the reaction equation $N_2 + 3\ H_2 \rightarrow 2\ NH_3$.

How many molecules of N_2 are required to react with 15 molecules of H_2?

Since 1 molecule of N_2 reacts with 3 molecules of H_2

Then, 1 molecule N_2 : 3 molecules H_2 ← molar ratio

$$\frac{15\ \text{molecules}\ H_2}{} \left| \frac{1\ \text{molec.}\ N_2}{3\ \text{molec.}\ H_2} \right. = \underline{\ 5\ }\ \text{molecules}\ N_2$$

IMPORTANT: Use completely–labelled units (eg. "molecule N_2" not just "molecule") so you know which coefficient goes on top and which goes on the bottom of the conversion factor.

We can use these **conversion factors** to move from moles of one species to moles of another.

Example Suppose that 1.50 moles of aluminum were produced during a reaction between zinc and aluminum chloride. How many moles of zinc reacted?

$2\,AlCl_{3(aq)} + 3\,Zn_{(s)} \rightarrow 2\,Al_{(s)} + 3\,ZnCl_{2(aq)}$

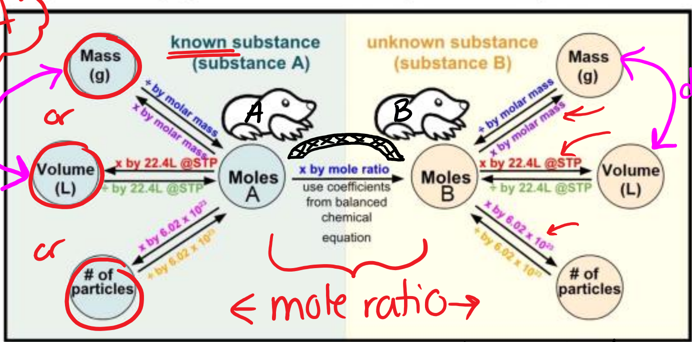
$1.50\text{ mol Al} \times \frac{3\text{ mol Zn}}{2\text{ mol Al}} = 2.25\text{ mol Zn}$

The Mole Bridge

As we have seen earlier, you can convert between the different species in the chemical reaction equation. To do this, however, you must get your substances into ___MOLES___: **Only moles can cross the mole bridge!**

Using the mole bridge, you can *convert* between any of the following:

- a reactant and a product
- a reactant and a reactant
- a product and a product



Example 1 If 428.5 g of wood were combusted, then what mass of water would be expected to form?

$1\,C_6H_{12}O_6 + 6\,O_2 \rightarrow 6\,H_2O + 6\,CO_2$

$428.5\text{ g }C_6H_{12}O_6 \times \frac{1\text{ mol }C_6H_{12}O_6}{180.0\text{ g }C_6H_{12}O_6} \times \frac{6\text{ mol }H_2O}{1\text{ mol }C_6H_{12}O_6} \times \frac{18.0\text{ g }H_2O}{1\text{ mol }H_2O} = 257\text{ g }H_2O$

Example 2 If 100.0 mL of 1-pentanol were combusted then what volume of CO_2 would form, given that the volume would be determined under conditions of STP? (note: $d_{\text{1-pentanol}} = 0.881$ g/mL)

$2\,C_5H_{12}O_{(l)} + 15\,O_{2(g)} \rightarrow 10\,CO_{2(g)} + 12\,H_2O_{(g)}$

volume (A) → (density) mass (A) → moles (A) → moles (B) → (22.4L @ STP) volume (B)

100.0 mL $C_6H_{12}O$	0.881 g $C_6H_{12}O$			
	1 mL $C_5H_{12}O$			

Example 3 What mass of C_3H_8 is required to produce 100.0g of H_2O?

$\underline{1}\ C_3H_8 + \underline{5}\ O_2 \longrightarrow \underline{3}\ CO_2 + \underline{4}\ H_2O$

? g C_3H_8 unknown

known 100.0g

mass H_2O → moles H_2O → moles C_3H_8 → mass C_3H_8

100.0g H_2O	1 mol H_2O	1 mol C_3H_8	44.0g C_3H_8	= 61.1 g C_3H_8
	18.0g H_2O	4 mol H_2O	1 mol C_3H_8	
	molar mass	mole ratio		

$$\frac{(100.0)(44.0)}{(18.)(4)}$$