HW17

Stoichiometric relationships. Stoichiometry is the study of the ratios in which chemical substances combine in reactions.

The number of moles in a given mass of a substance can be calculated using the equation

Number of moles (n) = mass of substance/ molar mass

$n = m/M$

Molar mass (M) numerically equal to molecular mass (M_r). The unit for M (molar mass) is g/mol or $gmol^{-1}$

Mass of substance (m) must be in grams.

The unit for moles is mol.

Example: sulfur, the atomic weight (A_r) of S can be found in the periodic table, A_r = 32.06

Molar mass of sulfur (M) 32.06 $gmol^{-1}$

This means 32.06 g of S contains 6.02×10^{23} sulfur atoms (1 mole of sulfur).

- An example of stoichiometry calculations
  Calculate how many grams of water and sulfur trioxide is needed to produce 100g of sulfuric acid according to the following chemical reaction:

$$SO_3 + H_2O \rightarrow H_2SO_4$$

	SO_3	H_2O	H_2SO_4
Molecular weight	80	18	98
Molar weight (g/mole)	80	18	98
Coefficients (moles reacting)	1	1	1
Known	?	?	100g
Number of moles to obtain the product and needed of reagents	1.02	1.02	100/98 = 1.02
Mass needed (g)	1.02(mole)x80(g/mole)=81.6(g)	1.02(mole)x18(g/mole)=18.36 (g)	

- If the coefficients of the reactions were different from 1 you must calculate the number of moles of the reactants needed for a given number of moles of the product. For example, in the following reaction of S and O_2, 2 moles of S reacts with 3 moles of O_2 to produce 2 moles of SO_3. Molar ration of $S:O_2:SO_3$ 2:3:2. To obtain 1 mole of SO_3 you need 1 mole of S and 3/2 moles of O_2. If you want to get 10 moles of SO_3 you will take 10 moles of sulfur and 15 moles of oxygen gas.

  $2S + 3O_2 \rightarrow 2SO_3$

- **Calculations involving Moles and Masses**

1. Coefficients in a chemical reaction indicate the molar ratio of reactants and products.

2. Work out the number of moles of anything you can.

3. Convert moles to the mass using n=m/M formula.

4. If a reactant is **in excess**, its mass **is not used** to determine product masses. The **limiting reactant** (completely consumed in the reaction) determines the mass of products. (if you need to find the limiting reactant, divide the number of moles of each reactant by its coefficient. The smallest number will give you the limiting reactant).

Example: $2H_2 + O_2 \rightarrow 2H_2O$ look at the coefficient, molar ratio $H_2:O_2:H_2O$ - 2:1:2

If we want the hydrogen and oxygen to react with each other completely and exactly we need to figure out the masses of H_2 and O_2 that correspond to the given ratio (2:1)

	H_2	O_2	H_2O
moles	2	1	2
Masses,g	$2mol \times 2gmol^{-1}=4g$	$1mol \times 32gmol^{-1}=32g$	$2mol \times 18gmol^{-1}=36g$
moles	20	10	20
Masses,g	40	320	360
moles	0.2	0.1	0.2
Masses,g	0.4	0.32	0.36

If we have 4g of hydrogen gas and 40 g of oxygen gas, we will have oxygen in excess, it will not be completely consumed in the reaction. In order to calculate the mass of water produced, we will use the information about hydrogen gas (4g) and ignore oxygen for our calculations. Remember, number of moles=mass/molar mass.

Look careful at our calculation from the class:

$n = \frac{m}{M}$ n = number of moles
m - mass in grams
M - Molar mass, g mol^{-1}

① Calculate the number of moles of magnesium atoms in 10 g of magnesium.

$$n = \frac{10\ g}{24.31\ g \cdot mol^{-1}} = 0.4110\ mol$$

$m = n \cdot M$

Calculate the mass of 0.3800 mol CH_3COOH:

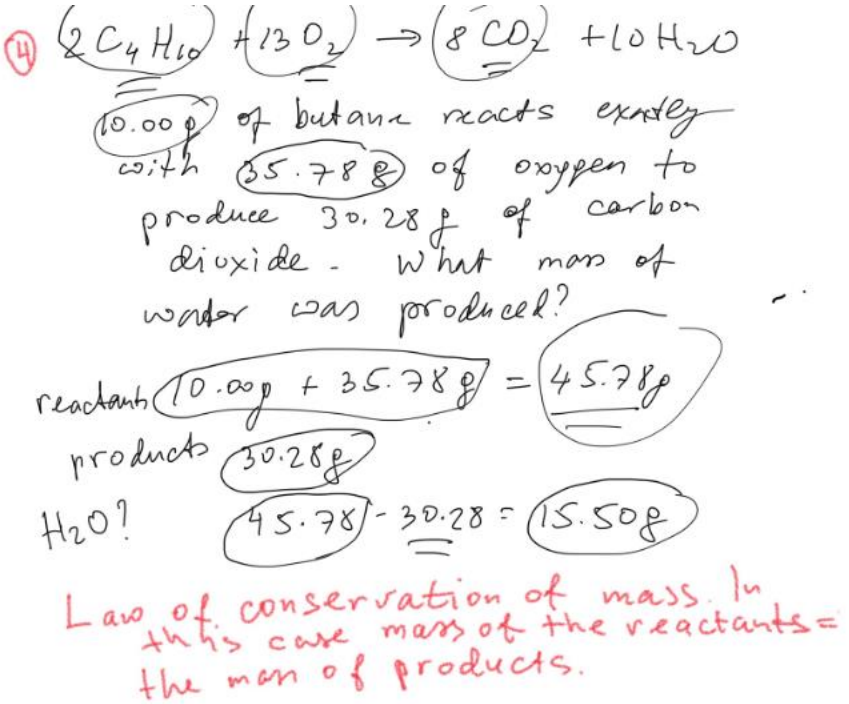
$M = 12 \cdot 2 + 16 \cdot 2 + 4 = 24 + 32 + 4 =$
$= 60$

$m = M \cdot n$
$m = 60 \times 0.38 = 22.828$

②

Compound	Molar mass (g mol^{-1})	mass (g)	Number of moles (mol)
H_2O	18.02	9.01	0.500
CO_2	$12 + 16 \cdot 2 = 44$	5	$\frac{5}{44} = 0.11$
H_2S	$2 + 32 = 34$	$34 \times 0.1 = 3.4$	0.100
NH_3	$14 + 3 = 17$	$17 \times 3.50 = 59.5$	3.50

$n = \frac{m}{M}$
$n = \frac{9.05}{18.02} = 0.5$



Questions

1. $4Na + O_2 \rightarrow 2Na_2O$ Figure out the mass of sodium in grams that will react exactly with 3.2 g of oxygen gas.
2. How many moles of hydrogen gas are produced when 0.4 mol of sodium react with excess of water

   $2Na + 2H_2O \rightarrow 2NaOH + H_2$

3. How many moles of O_2 react with 0.01 mol C_3H_8?

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

4. Calculate the mass of arsenic(III) chloride produced when 0.15 g of arsenic reacts with excess chlorine

   $2As + 3Cl_2 \rightarrow 2AsCl_3$