Quantities Package

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1. Calculate the following

   (a) Calculate the mass of Cl_2 that combines with 2.36 g of ~~Cl_2~~ *(I'm assuming this was an error and is H_2)* to form HCl in the following reaction
   $H_{2(g)} + Cl_{2(g)} \longrightarrow 2\,HCl_{(g)}$

   $$2.36 \text{ g } H_2 * \frac{1 \text{ mol } H_2}{2 * 1.01 \text{ g } H_2} * \frac{1 \text{ mol } Cl_2}{1 \text{ mol } H_2} * \frac{2 * 35.45 \text{ g } Cl_2}{1 \text{ mol } Cl_2}$$

   $$= 82.83 \text{ g } Cl_2$$

   $\therefore$ The mass required of Cl_2 to combine with 2.36 g of H_2 is 82.83 g.

   (b) What mass of $Al(OH)_3$ is formed when 7.5 g of H_2O reacts with excess of AlP? The balanced chemical equation is
   $AlP + 3\,H_2O \longrightarrow PH_3 + Al(OH)_3$

   $$7.5 \text{ g } H_2O * \frac{1 \text{ mol } H_2O}{2 * 1.01 + 16 \text{ g } H_2O} * \frac{1 \text{ mol } Al(OH)_3}{3 \text{ mol } H_2O} * \frac{26.98 + (16 + 1.01) * 3 \text{ g } Al(OH)_3}{1 \text{ mol } Al(OH)_3}$$

   $$= 10.82 \text{ g } Al(OH)_3$$

   $\therefore$ 10.82 g of $Al(OH)_3$ is formed with 2.36 g of H_2 and excess of AlP.

2. Given the following equation
   $Al_2(SO_3)_3 + 6\,NaOH \longrightarrow 3\,Na_2SO_3 + 2\,Al(OH)_3$

   (a) If you start with 16 g of $Al_2(SO_3)_3$ and 12.5 g of NaOH, determine the limiting reagent.

   What we will do is choose an arbitrary compound say, $Al_2(SO_3)_3$ and calculate the mass needed to completely react with $Al_2(SO_3)_3$ if it's less than the given mass of NaOH, then $Al_2(SO_3)_3$ is the limiting reagent, otherwise NaOH is the limiting reagent.

   Molar Mass of $Al_2(SO_3)_3 = 26.09 * 2 + (32.07 + 16 * 3) * 3 = 292.39$ g/mol
   Molar Mass of NaOH $= 22.99 + 16.00 + 1.01 = 40.00$ g/mol

   $$16 \text{ g } Al_2(SO_3)_3 * \frac{1 \text{ mol } Al_2(SO_3)_3}{292.39 \text{ g } Al_2(SO_3)_3} * \frac{6 \text{ mol NaOH}}{1 \text{ mol } Al_2(SO_3)_3} * \frac{40.00 \text{ g NaOH}}{1 \text{ mol NaOH}}$$

   $$= 13.13 \text{ g NaOH}$$

   $\therefore$ NaOH is the limiting factor as the required mass for a full reaction with $Al_2(SO_3)_3$ is greater than the given mass.

(b) Determine the mass of Na_2SO_3 produced.

As NaOH is the limiting reagent, we must calculate the mass of Na_2SO_3 with NaOH

Molar Mass of $Na_2SO_3 = 2 * 22.99 + 32.07 + 3 * 16.00 = 126.05$ g/mol

$$12.5 \text{ g NaOH} * \frac{1 \text{ mol NaOH}}{40.00 \text{ g NaOH}} * \frac{3 \text{ mol } Na_2SO_3}{6 \text{ mol NaOH}} * \frac{126.05 \text{ g } Na_2SO_3}{1 \text{ mol } Na_2SO_3}$$

$$= 19.70 \text{ g } Na_2SO_3$$

$\therefore$ The mass of Na_2SO_3 produced is 19.70 grams.

(c) Determine the mass of the excess reagent left over.

To calculate the mass of the excess reagent, we can calculate the mass used in the reaction with the limiting reagent.

$$12.5 \text{ g NaOH} * \frac{1 \text{ mol NaOH}}{40.00 \text{ g NaOH}} * \frac{1 \text{ mol } Al_2(SO_3)_3}{6 \text{ mol NaOH}} * \frac{292.39 \text{ g } Al_2(SO_3)_3}{1 \text{ mol NaOH}}$$

$$= 15.23 \text{ g } Al_2(SO_3)_3$$

Mass of excess reagent left over $= 16 - 15.23 = 0.77$ g $Al_2(SO_3)_3$
$\therefore$ The mass of excess reagent left over is 0.77 g of $Al_2(SO_3)_3$

(d) What is the percentage yield if 4.45 g of Na_2SO_3 was actually produced?

$$\text{Percentage Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} * 100\%$$

$$= \frac{4.45 \text{ g } Na_2SO_3}{19.70 \text{ g } Na_2SO_3} * 100\%$$

$$= 23\%$$

$\therefore$ The percentage yield is 23% if 4.45 g of Na_2SO_3 was actually produced.

3. A student conducts and experiment involving the following balanced chemical equation

$H_3PO_4 + 3\,KOH \longrightarrow K_3PO_4 + 3\,H_2O$

What is the percentage yield if the student obtains 49.0 g of K_3PO_4 when she combines 67.0 g of H_3PO_4 with 62.0 g of KOH?

Molar Mass of $H_3PO_4 = 3 * 1.01 + 30.97 + 4 * 16.00 = 98.00$ g/mol

Molar Mass of KOH $= 39.10 + 16.00 + 1.01 = 56.11$ g/mol

Molar Mass of $K_3PO_4 = 3 * 39.10 + 30.97 + 4 * 16.00 = 212.27$ g/mol

We must first find the limiting factor, then we can use the the limiting reagent to calculate the theoretical yield, which will be used to calculate the percentage yield.

Using a different method than 2a), we can calculate the limiting factor by calculating the mole of each compound, and whichever is less is the limiting factor.

$$67.0 \text{ g } H_3PO_4 * \frac{1 \text{ mol } H_3PO_4}{98.00 \text{ g } H_3PO_4} * \frac{1 \text{ mol } K_3PO_4}{1 \text{ mol } H_3PO_4} = 0.68 \text{ mol } K_3PO_4$$

$$62.0 \text{ g KOH} * \frac{1 \text{ mol KOH}}{56.11 \text{ g KOH}} * \frac{1 \text{ mol } K_3PO_4}{3 \text{ mol KOH}} = 0.37 \text{ mol } K_3PO_4$$

$\therefore$ The limiting reagent is KOH and we will calculate the theoretical yield with KOH
As we already know 62 g of KOH is 0.37 mol of K_3PO_4 we will continue from there.

$$0.37 \text{ mol } K_3PO_4 * \frac{212.28 \text{ g } K_3PO_4}{1 \text{ mol } K_3PO_4} = 78.54 \text{ g } K_3PO_4$$

$\therefore$ The theoretical yield is 78.54 g of K_3PO_4

$$\text{Percentage Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} * 100\%$$

$$= \frac{49.0 \text{ g } K_3PO_4}{78.54 \text{ g } K_3PO_4} * 100\%$$

$$= 62\%$$

$\therefore$ The student's percentage yield is 62.