Stoichiometry Worksheet

I. ONE REACTANT IN EXCESS – COMBUSTION

You burn an excess of butane (C_4H_{10}) in a limited amount of oxygen (O_2). If 67.2 L of CO_2 gas is formed, what volume of oxygen gas was present at the start of the reaction?

STEP 1: Balance the reaction:

$$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$$

STEP 2: Use a molar conversion to convert quantity of product given to moles:

$$67.2\ \text{L}\ CO_2 * \frac{1\ \text{mol}\ CO_2}{22.4\ \text{L}\ CO_2} = 3\ \text{mol}\ CO_2$$

STEP 3: Use a molar ratio to calculate the moles of reactant that I'm asking about:

$$3\ \text{mol}\ CO_2 * \frac{13\ \text{mol}\ O_2}{8\ \text{mol}\ CO_2} = 4.875\ \text{mol}\ O_2$$

STEP 4: Use a molar conversion to convert moles of reactant to the units I ask for:

$$4.875\ \text{mol}\ O_2 \left(\frac{22.4\ \text{L}\ O_2}{1\ \text{mol}\ O_2}\right) = 109.2\ \text{L}\ O_2 = \boxed{109\ \text{L}\ O_2}$$

II. ONE REACTANT IN EXCESS – SINGLE DISPLACEMENT

14 g of lithium is combined with excess K_2SO_4. What is the mass of the new ionic compound that is formed? How do you know that this reaction will take place?

STEP I: Balance the reaction:

$$2\ Li + K_2SO_4 \rightarrow Li_2SO_4 + 2\ K$$

Reaction occurs because Li is higher up than K on the activity series.

STEP 2: Use a molar conversion to convert quantity of reactant given to moles:

$$14\ \text{g Li} * \frac{1\ \text{mol Li}}{7\ \text{g Li}} = 2\ \text{mol Li}$$

STEP 3: Use a molar ratio to calculate moles of product that I'm asking about:

$$2\ \text{mol Li} * \frac{1\ \text{mol}\ Li_2SO_4}{2\ \text{mol Li}} = 1\ \text{mol}\ Li_2SO_4$$

STEP 4: Use a molar conversion to convert moles of product to units that I ask for:

$$1\ \text{mol Li2SO4} * \frac{110\ \text{g}\ Li_2SO_4}{1\ \text{mol}\ Li_2SO_4} = \boxed{110\ Li_2SO_4}$$

III. ONE REACTANT IN EXCESS – DOUBLE DISPLACEMENT

You combine 50.0 mL of a 20.0 M solution of $MgCl_2$ with excess $AgNO_3$ solution. What is the mass of solid precipitate that is formed? How do you know that this reaction will happen?

STEP 1: Balance the reaction. Show which compounds are (aq) and which are (s).

$$MgCl_{2\ (aq)} + 2\ AgNO_{3\ (aq)} \rightarrow Mg(NO_3)_{2\ \ (aq)} + 2\ AgCl_{\ (s)}$$

STEP 2: Use a molar conversion to convert the quantity of reactant given to moles:

$$50\ mL\ of\ 20M\ MgCl_2 = 0.05\ L\ of\ 20M\ MgCl_2$$

$$0.05\ L * \frac{20\ mol\ MgCl_2}{1\ L} = 1\ mol\ MgCl_2$$

STEP 3: Use a molar ratio to convert moles of reactant to moles of product I'm asking about:

$$1\ mol\ MgCl_2 * \frac{2\ mol\ AgCl}{1\ mol\ MgCl_2} = 2\ mol\ AgCl$$

STEP 4: Use a molar conversion to convert moles of product to the units that I ask for:

$$2\ mol\ AgCl \quad \frac{143\ g\ AgCl}{1\ mol\ AgCl} = \boxed{248\ g\ AgCl}$$

IV. **FIND LIMITING REACTANT – COMBUSTION**

You burn 35.2 g pentanol ($C_5H_{12}O$) in 44.8 L of oxygen gas (O_2) at STP. What is the volume of water vapor formed?

STEP 1: Balance the reaction:

$$2\ C_5H_{12}O + 15\ O_2 \rightarrow\ 10\ CO_2 + 12\ H_2O$$

STEP 2a & 2b: Use molar conversions to convert the quantities of reactants given to moles of reactants:

2a: 35.2 g $C_5H_{12}O$ $\left(\frac{1 \text{ mol } C_5H_{12}O}{88 \text{ g } C_5H_{12}O}\right)$ = 0.4 mol $C_5H_{12}O$

2b: 44.8 L O_2 $\left(\frac{1 \text{ mol } O_2}{22.4 \text{ L } O_2}\right)$ = $\boxed{2 \text{ mol } O_2}$ ← limiting reactant

STEP 3a: Use your first molar ratio to determine which reactant is limiting. Once you have figured this out, go back and circle the limiting reactant in step 2.

Pick 0.4 mol $C_5H_{12}O$ $\left(\frac{15 \text{ mol } O_2}{2 \text{ mol } C_5H_{12}O}\right)$ = 3 mol O_2 are needed to react fully with 0.4 mol $C_5H_{12}O$

or pick 2 mol O_2 $\left(\frac{2 \text{ mol } C_5H_{12}O}{15 \text{ mol } O_2}\right)$ = 0.267 mol $C_5H_{12}O$ are needed to react fully with 2 mol O_2

STEP 3b: Now that you know which is limiting reactant, use your second molar ratio to determine how much of the product that I'm asking about will form.

2 mol O_2 $\left(\frac{12 \text{ mol } H_2O}{15 \text{ mol } O_2}\right)$ = 1.6 mol H_2O

STEP 4: Use a molar conversion to convert moles of product to the units that I ask for:

1.6 mol H_2O $\left(\frac{22.4 \text{ L } H_2O}{1 \text{ mol } H_2O}\right)$ = 35.84 L H_2O gas = $\boxed{35.8 \text{ L } H_2O \text{ gas}}$

V. **FIND LIMITING REACTANT – SINGLE DISPLACEMENT**

You heat 54.6 g of Potassium (K) with 107.2 g copper (II) chloride ($CuCl_2$). What is the mass of the new ionic compound that will form? How do you know this reaction will happen?

STEP 1: Balance the reaction:

$$2\ K + CuCl_2 \rightarrow 2\ KCl + Cu$$

Reaction will occur because K is higher up than Cu on the activity series.

STEP 2a & 2b: Use molar conversions to convert the quantities of reactants given to moles of reactants:

2a: $54.6\text{ g K} \left(\frac{1\text{ mol K}}{39\text{ g K}}\right) = \boxed{1.4\text{ mol K}} \leftarrow$ limiting reactant

2b: $107.2\text{ g } CuCl_2 \left(\frac{1\text{ mol } CuCl_2}{134\text{ g } CuCl_2}\right) = 0.8\text{ mol } CuCl_2$

STEP 3a: Use your first molar ratio to determine which is the limiting reactant. Once you figure this out, go back and circle the amount of limiting reactant that you have from step 2.

Pick $1.4\text{ mol K} \left(\frac{1\text{ mol } CuCl_2}{2\text{ mol K}}\right) = 0.7\text{ mol } CuCl_2$ needed to react fully with 1.4 mol K

Or pick $0.8\text{ mol } CuCl_2 \left(\frac{2\text{ mol K}}{1\text{ mol } CuCl_2}\right) = 1.6\text{ mol K}$ needed to react fully with 0.8 mol $CuCl_2$

STEP 3b: Now that you know which is limiting reactant, use your second molar ratio to determine how much of the product that I'm asking about will form.

$$1.4\text{ mol K} \left(\frac{2\text{ mol KCl}}{1\text{ mol K}}\right) = 2.8\text{ mol KCl}$$

STEP 4: Use a molar conversion to convert moles of product to the units that I ask for:

$$2.8\text{ mol KCl} \left(\frac{75\text{ g KCl}}{1\text{ mol KCl}}\right) = 210\text{ g KCl} = \boxed{2.10*10^2\text{ g KCl}}$$

V. **FIND LIMITING REACTANT – DOUBLE DISPLACEMENT**

You combine 250 mL of a 4.00 M solution of K_3PO_4 with 50.0 mL of a solution of 10.0 M $MgCl_2$. What is the mass of precipitate that is formed? How do you know that a reaction has occurred?

STEP 1: Balance the reaction:

$$2\ K_3PO_{4\ (aq)} + 3\ MgCL_{2\ (aq)} \rightarrow 6\ KCL_{\ (aq)} + Mg_3(PO_4)_{2\ (s)}$$

Reaction will occur because ionic compounds of Mg^{2+} and PO_4^{3-} are insoluble.
Therefore a phase change has occurred from when these ions where in soluble compounds
(Mg^{2+} with Cl^- and PO_4^{3-} with K^+).
Find this information on your solubility chart.

STEP 2a & 2b: Use molar conversions to convert the quantities of reactants given to moles of reactants:

2a: $250\ mL\ K_3PO_{4\ (aq)} \left(\frac{1\ L}{10^3\ mL}\right) * \left(\frac{4\ moles}{1\ L}\right) = 1\ mol\ K_3PO_4$

2b: $50\ mL\ MgCl_{2\ (aq)} \left(\frac{1L}{10^3\ mL}\right) * \left(\frac{10\ moles}{1\ L}\right) = \boxed{0.5\ mol\ MgCl_2}$ ← limiting reactant

STEP 3a: Use your first molar ratio to determine which is the limiting reactant. Once you figure this out, go back and circle the amount of limiting reactant that you have from step 2.

Pick $0.5\ mol\ MgCl_2 \left(\frac{2\ mol\ K_3PO_4}{3\ mol\ MgCl_2}\right) = 0.333\ mol\ K_3PO_4$ needed to react fully with $0.5\ mol\ MgCl_2$

Or pick $1\ mol\ K_3PO_4 \left(\frac{3\ mol\ MgCl_2}{2\ mol\ K_3PO_4}\right) = 1.5\ mol\ MgCl_2$ needed to react fully with $1\ mol\ K_3PO_4$

STEP 3b: Now that you know which is limiting reactant, use your second molar ratio to determine how much of the product that I'm asking about will form.

$$0.5\ mol\ MgCl_2 \left(\frac{1\ mol\ Mg_3(PO_4)_2}{3\ mol\ MgCl_2}\right) = 0.167\ mol\ Mg_3(PO_4)_2$$

STEP 4: Use a molar conversion to convert moles of product to the units that I ask for:

$$0.167\ mol\ Mg_3(PO_4)_2 \left(\frac{265\ g\ Mg_3(PO_4)_2}{1\ mol\ Mg_3(PO_4)_2}\right) = 44.24\ g\ Mg_3(PO_4)_2 = \boxed{44\ g\ Mg_3(PO_4)_2}$$