Limiting Reagent in a Synthesis

Synthesis of a coordination complex

- A complex ion consists of a central metal ion that has molecules or anions (ligands) attached to it to form a large ion.
  Also present are the ions (of opposite charge) needed to form a salt. The salt is the coordination complex.

  In this case, the complex ion is $[Ni(C_2H_8N_2)_3]^{+2}$ and the counter ions are Cl^-. The salt is $[Ni(C_2H_8N_2)_3]Cl_2$ or more simply, $Ni(C_2H_8N_2)_3Cl_2$.

To identify the limiting reagent

- The reactant which is totally consumed during the reaction is the **limiting reagent.**
- The other reactant is present in EXCESS.
- By experimental observations, you will decide which reagent was in excess.
  - Observe color of the filtrate
    If pink-lavender, then excess ethylenediamine is present.
    If blue-purple, then excess Ni^{+2} is present.
  - Test the filtrate solution with acid-base indicator paper and observe.
    If strongly basic (turns paper blue-green to blue), then excess ethylenediamine is present.

To calculate the theoretical yield

- The theoretical yield is the amount of product predicted to be formed by the **limiting reagent**.
    - Calculate the moles of $NiCl_2 \cdot 6H_2O$ from the mass used and the molar mass.

$$\text{mol } NiCl_2 \cdot 6H_2O = \text{mass } NiCl_2 \cdot 6H_2O \times \left(\frac{1 \text{ mol } NiCl_2 \cdot 6H_2O}{237.69 \text{ g } NiCl_2 \cdot 6H_2O} \right)$$

    - Calculate how much $Ni(C_2H_8N_2)_3Cl_2$ in theory would be produced ***if*** $NiCl_2 \cdot 6H_2O$ is limiting reagent.

$$\text{mass} = \text{mol } NiCl_2 \cdot 6H_2O \times \left(\frac{1 \text{ mol } Ni(en)_3Cl_2}{1 \text{ mol } NiCl_2 \cdot 6H_2O} \right) \times \left(\frac{309.87 \text{ g } Ni(en)_3Cl_2}{1 \text{ mole } Ni(en)_3Cl_2} \right)$$

    - Calculate the moles of ethylenediamine from the %, density and volume and molar mass.

$$\text{mol en} = \left(\frac{25.0 \text{ g en}}{100 \text{ g soln}} \right) \times \left(\frac{0.950 \text{ g soln}}{\text{mL soln}} \right) \times (\text{mL soln}) \times \left(\frac{1 \text{ mol en}}{60.10 \text{ g en}} \right)$$

    - Calculate how much $Ni(C_2H_8N_2)_3Cl_2$ in theory would be produced ***if*** ethylenediamine is the limiting reagent.

$$\text{mass} = \text{mol en} \times \left(\frac{1 \text{ mol } Ni(en)_3Cl_2}{3 \text{ mol "en"}} \right) \times \left(\frac{309.87 \text{ g } Ni(en)_3Cl_2}{1 \text{ mole } Ni(en)_3Cl_2} \right)$$

- The smaller mass of $Ni(C_2H_8N_2)_3Cl_2$ is the *theoretical yield.* The reagent that led to this calculation is the **LIMITING REAGENT**.
- Did the experimental observations about Limiting Reagent agree with your calculations?

To calculate the percent yield:

- The percent yield is the ratio of the experimental or actual yield to the theoretical yield.
- Remember the theoretical yield is the mass as calculated using the Limiting Reagent as the known amount.

$$\left(\frac{\text{Experimental yield}}{\text{Theoretical yield}}\right) \times 100\% = \text{Percent Yield}$$