Chem 151 Pre-lab Practice 6
Exp 6: Preparation and Spectroscopy of Complex Ions

(see next page for answers)

A student, Joe, synthesized hexamminecobalt(III) chloride using the method in Exp 6 and wrote down the following amount of reactants:

Mass of NH_4Cl = 0.0711 g
Mass of $CoCl_2 \cdot 6H_2O$ = 0.1344 g
Volume of 3.0% H_2O_2 solution = 0.60 mL
An excess amount of aqueous ammonia (NH_4OH)

Joan obtained 0.1234 g of the product, hexamminecobalt(III) chloride. Follow the steps to calculation the percentage yield of Joan's synthesis.

1. Write down the reaction equation.

2. Calculate the number of moles of each reactant (except for NH_3 (aq), which is in excess).

   i) NH_4Cl

   ii) $CoCl_2 \cdot 6H_2O$

   iii) H_2O_2

3. What is the limiting reagent of Joan's procedure?

4. Calculate the theoretical yield (that is, the amount of expected product if the limiting reagent 100% reacts).

5. Calculate the percentage yield of Joan's synthesis. (% yield = $\frac{actual\ yield}{theoretical\ yield} \times 100\%$)

Answers of Pre-Lab Practice 6

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1. Write down the reaction equation.

   $CoCl_2 \cdot 6H_2O + ½H_2O_2 + NH_4Cl + 5\ NH_3 \rightarrow [Co(NH_3)_6]Cl_3 + 7\ H_2O$

2. Calculate the number of moles of each reactant (except for NH_3 (aq), which is in excess).

   a. NH_4Cl

   moles of NH_4Cl = $\dfrac{mass\ NH_4Cl}{molar\ mass} = \dfrac{0.0711\ g}{53.49\ g/mol} = .00132\ mol$

   b. $CoCl_2 \cdot 6H_2O$

   Moles of $CoCl_2 \cdot 6H_2O$ = $\dfrac{mass}{molar\ mass} = \dfrac{0.1344\ g}{237.9\ g/mol} = 5.65 \times 10^{-4}\ mol$

   c. H_2O_2

   In order to calculate the moles of H_2O_2, we have to find the mass of H_2O_2 in 0.60 mL of 3.0% H_2O_2 solution. Since the concentration of H_2O_2 in the solution is low, we can assume the density of the solution is similar to the density of water solvent (1.00 g/mL). Thus, the mass of H_2O_2 solution is 0.60 g. (Careful, this is NOT the mass of H_2O_2 because it is a 3.0% solution, not 100% H_2O_2).

   Mass of H_2O_2 = 3.0% × 0.60 g = 0.018 g.

   Moles of H_2O_2 = $\dfrac{mass}{molar\ mass} = \dfrac{0.018\ g}{34.0\ g/mol} = 5.3 \times 10^{-4}\ mol$

3. What is the limiting reagent of Joan's procedure?

   Be careful, the one with the fewest number of moles is NOT necessary the limiting reagent. Here, we have fewer moles of H_2O_2 than $CoCl_2 \cdot 6H_2O$, but one mole of $CoCl_2 \cdot 6H_2O$ needs only half mole of H_2O_2. Therefore, the limiting reagent is $CoCl_2$.

4. Calculate the theoretical yield.

   Always use the limiting reagent to calculate the theoretical yield. Since one mole of $CoCl_2 \cdot 6H_2O$ makes one mole of $[Co(NH_3)_6]Cl_3$, we have 5.65×10^{-4} moles of $[Co(NH_3)_6]Cl_3$.

   Theoretical yield = $5.65 \times 10^{-4}\ mol\ [Co(NH_3)_6]Cl_3 \times \dfrac{267.3\ g}{1\ mol\ [Co(NH_3)_6]Cl_3} = 0.151\ g$

5. Calculate the percentage yield of Joan's synthesis. (% yield = $\dfrac{actual\ yield}{theoretical\ yield} \times 100\%$)

   Percentage yield = $\dfrac{actual\ yield}{theoretical\ yield} \times 100\% = \dfrac{0.1234\ g}{0.151\ g} \times 100\% = 81.7\%$