Part 4. Iron Content Determination by Visible Spectrophotometry

Known: Absorbance of the $Fe(phen)_3^{2+}$ sample, A
Molar absorptivity for $Fe(phen)_3^{2+}$ at 510 nm, ε ($M^{-1}cm^{-1}$)
Dilution factors
Pathlength, l = 1 cm
Mass of the complex iron sample (g)

To be determined: Moles of Fe^{3+} per gram of sample (mole/g)

Calculations:

1. $\text{M}(\text{Fe(phen)}_3^{2+}) = \frac{A}{\varepsilon l}$ (mole/L)
2. Total dilution factor = $5 \times 5 \times X$, where X is your final dilution
3. $\text{M}_{\text{original}}(\text{Fe}^{3+}) = \text{M}\ (\text{Fe(phen)}_3^{2+}) \times$ Total dilution factor
4. In 25 ml of solution: $\text{moles Fe}^{3+} = \text{M}_{\text{original}}(\text{Fe}^{3+}) \times 0.025\ \text{L}$
5. $\text{Moles Fe}^{3+}/\text{g sample} = \frac{\text{moles Fe}^{3+}}{\text{mass of sample (g)}}$

$K_xFe_y(C_2O_4)_x{\cdot}zH_2O$ Molecular Formula Determination

Known: Moles of $C_2O_4^{2-}$ per gram of sample (mole/g sample)
Moles of K^+ per gram of sample (mole/g sample)
Moles of Fe^{3+} per gram of sample (mole/g sample)
$y = 1$

To be determined: x and z

Calculations:

1. $\frac{x}{y} = \frac{\text{moles of C}_2\text{O}_4^{2-}/\text{g sample}}{\text{moles of Fe}^{3+}/\text{g sample}} \Rightarrow x - ?$
2. g Fe^{3+}/g sample = moles Fe^{3+}/g sample $\times$ MW (Fe)
3. g $C_2O_4^{2-}$/g sample = moles $C_2O_4^{2-}$/g sample $\times$ MW ($C_2O_4^{2-}$)
4. g K^+/g sample = moles K^+/g sample $\times$ MW (K)

5. g H_2O/g sample = 1.000 g – g Fe^{3+}/g sample – g $C_2O_4^{2-}$/g sample – g K^+/g sample

6. $$\text{mole } H_2O\text{/g sample} = \frac{\text{g } H_2O\text{/g sample}}{\text{MW } (H_2O)}$$

7. $$\frac{z}{y} = \frac{\text{moles of } H_2O \text{ / g sample}}{\text{moles of } Fe^{3+} \text{ / g sample}} \qquad \Rightarrow \quad z - ?$$

Determination of the Theoretical Yield and Percent Yield of $K_xFe_y(C_2O_4)_x{\cdot}zH_2O$

Chemistry involved:

$$Fe(NH_4)_2(SO_4)_2{\cdot}6H_2O + H_2C_2O_4 \rightarrow FeC_2O_4{\cdot}2H_2O + (NH_4)_2SO_4 + H_2SO_4 + 4\,H_2O \qquad (1)$$

$$a\,FeC_2O_4{\cdot}2H_2O + b\,H_2C_2O_4 + c\,H_2O_2 + d\,K_2C_2O_4 \rightarrow e\,K_x[Fe_y(C_2O_4)_x]{\cdot}zH_2O \qquad (2)$$

Note: Equation (2) has to be balanced before you start working on these calculations.

Known: Actual yield of the product (g)
Mass of the starting material, $Fe(NH_4)_2(SO_4)_2{\cdot}6H_2O$ (g)

Assume $Fe(NH_4)_2(SO_4)_2{\cdot}6H_2O$ to be the limiting reactant in reaction (1)
Assume $FeC_2O_4{\cdot}2H_2O$ to be the limiting reactant in reaction (2)

To be determined: Theoretical yield (g) and Percent yield (%)

Calculations:

1. $$\text{Moles } Fe(NH_4)_2(SO_4)_2{\cdot}6H_2O = \frac{\text{mass of } Fe(NH_4)_2(SO_4)_2{\cdot}6H_2O \text{ (g)}}{\text{MW } (Fe(NH_4)_2(SO_4)_2{\cdot}6H_2O)}$$

2. Moles $FeC_2O_4{\cdot}2H_2O$ = Moles $Fe(NH_4)_2(SO_4)_2{\cdot}6H_2O$ (determined from the stoichiometry of equation 1)

3. Determine moles of $K_x[Fe_y(C_2O_4)_x]{\cdot}zH_2O$ from moles of $FeC_2O_4{\cdot}2H_2O$ using the stoichiometry of equation (2)*

4. Theoretical yield (g) = Moles $K_x[Fe_y(C_2O_4)_x]{\cdot}zH_2O \times$ MW ($K_x[Fe_y(C_2O_4)_x]{\cdot}zH_2O$)

5. $$\text{Percent yield} = \frac{\text{actual yield (g)}}{\text{theoretical yield (g)}} \times 100\%$$

* If you are unable to balance equation (2) due to the erroneous molecular formula determination, leave equation (2) unbalanced and use a 1-to-1 molar ratio of $FeC_2O_4{\cdot}2H_2O$ to $K_x[Fe_y(C_2O_4)_x]{\cdot}zH_2O$ at this step.