Part 2. Standard Iron Solution Calculations

Dilution calculations: $V_1M_1 = V_2M_2$,
where M_1 and M_2 are the molarities of the original concentrated and the final dilute solutions and V_1 and V_2 are the volumes of the original concentrated and the final dilute solutions

Calculations:

1. Convert g/L into a mole/L concentration for the standard Fe^{2+} solution

2. Calculate the molarity of the stock $Fe(phen)_3^{2+}$ solution prepared from the standard Fe^{2+} solution using the stoichiometry of the following equation:

   $$Fe^{2+} (aq) + 3\ phen\ (aq) \rightarrow Fe(phen)_3^{2+} (aq)$$

3. Calculate the molarities of the five standard $Fe(phen)_3^{2+}$ solutions prepared from the stock $Fe(phen)_3^{2+}$ solution

Part 4. Iron Content Determination by Visible Spectrophotometry

Beer's law: $A = \varepsilon\, l\, c$

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)

Moles of Fe^{3+} per gram of sample (mole/g) – ?

Calculations:

1. $M\,(Fe(phen)_3^{2+}) = \dfrac{A}{\varepsilon l}$ (mole/L)

2. Total dilution factor = $5 \times 5 \times X$, where X is your final dilution

3. $M_{original}\,(Fe^{3+}) = M\,(Fe(phen)_3^{2+}) \times$ Total dilution factor

4. In 25 ml of solution: moles $Fe^{3+} = M_{original}\,(Fe^{3+}) \times 0.025\,L$

5. $\text{Moles } Fe^{3+}/\text{g sample} = \dfrac{\text{moles } Fe^{3+}}{\text{mass of sample (g)}}$

$K_xFe_y(C_2O_4)_x \cdot zH_2O$ 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)
$y = 1$

x – ? and z – ?

Calculations: 1. $C_2O_4^{2-} : Fe^{3+} = \dfrac{\text{moles of } C_2O_4^{2-} / \text{g sample}}{\text{moles of } Fe^{3+} / \text{g sample}} \Rightarrow x - ?$

2. g Fe^{3+}/g sample = moles Fe^{3+}/g sample × MW (Fe)

3. g $C_2O_4^{2-}$/g sample = moles $C_2O_4^{2-}$/g sample × MW ($C_2O_4^{2-}$)

4. g K^+/g sample = moles K^+/g sample × 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. $\text{mole } H_2O/\text{g sample} = \dfrac{\text{g } H_2O/\text{g sample}}{\text{MW } (H_2O)}$

7. $H_2O : Fe^{3+} = \dfrac{\text{moles of } H_2O / \text{g sample}}{\text{moles of } Fe^{3+} / \text{g sample}} \Rightarrow z - ?$

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

Chemistry involved:

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

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

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

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

theoretical yield (g) – ? and percent yield (%) – ?

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

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 stoichiometry of equation (2)*

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

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

* If you were unable to balance equation (2) due to the erroneous molecular formula determination, use a 1-to-1 molar ratio of $FeC_2O_4 \cdot 2H_2O$ to $K_x[Fe_y(C_2O_4)_x] \cdot zH_2O$ to complete the theoretical yield calculation.