Week 6: Titration and Spectroscopy of Model Compounds

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Analysis Techniques

1. Gravimetric Analysis
2. Titration Analysis
3. Spectroscopic Analysis

Gravimetric Analysis

1. Dissolved model compound in nitric acid to break it into its separate components

$$Cu(NH_3)_4SO_4\ (s) \xrightarrow{HNO_3} Cu^{2+}\ (aq) + 4\ NH_3(aq) + {SO_4}^{2-}(aq)$$

2. Add barium nitrate to precipitate out the sulfate from the model compound

$$Ba(NO)_2(aq) \rightarrow Ba^{2+}(aq) + 2\ {NO_3}^{-}(aq)$$

$$Ba^{2+}(aq) + {SO_4}^{2-}(aq) \rightarrow BaSO_4(s)$$

Gravimetric Analysis

- The barium sulfate is the white powder collected last week on the filter paper on the funnel.
- Since we added barium nitrate until the precipitation was completed (no more of the white barium sulfate formed), we know that all of the sulfate from the (0.9 g – 1.1 g) sample of our compound is now in the precipitated barium sulfate (the white powder.
- We will use stoichiometry to relate the mass of the precipitated barium sulfate (the white powder) to the amount of sulfate in the model compound.

$$\text{g of } BaSO_4 \Rightarrow \text{mol of } BaSO_4 \Rightarrow \text{mol of } SO_4^{2-} \Rightarrow \text{g of } SO_4^{2-}$$
$$\Rightarrow \text{Mass \% of } SO_4^{2-} \text{ in model compound}$$

Titration analysis

- Hydrochloric acid reacts with ammonia in the acid base reaction below

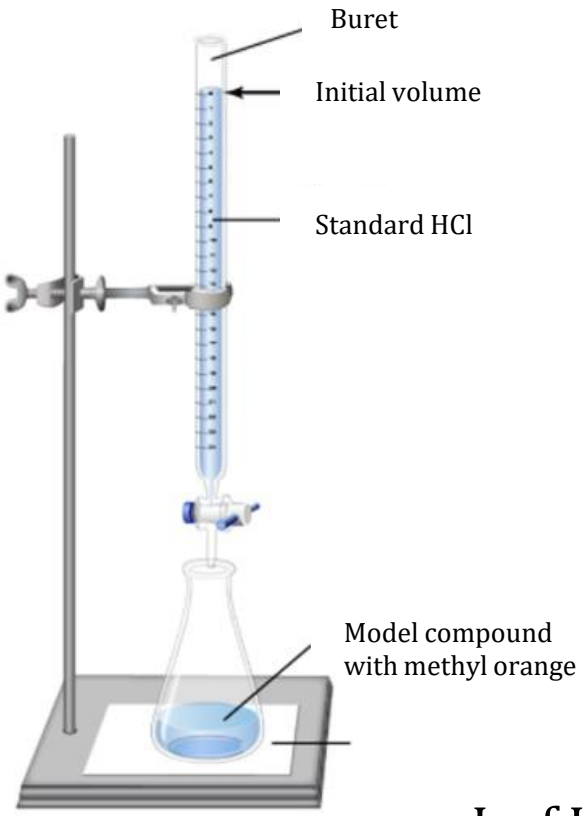
$$HCl(aq) + NH_3(aq) \rightarrow NH_4^+(aq) + Cl^-(aq)$$

- We will dissolve 0.100 g of the model compound in 30 mL of water, and then add HCl to the model compound to react with the complexed ammonia

$$Cu(NH_3)_4SO_4\ (s) \rightarrow Cu^{2+}(aq) + 4\ NH_3(aq) + SO_4^{2-}(aq)$$

$$HCl(aq) + NH_3(aq) \rightarrow NH_4^+(aq) + Cl^-(aq)$$

Titration analysis



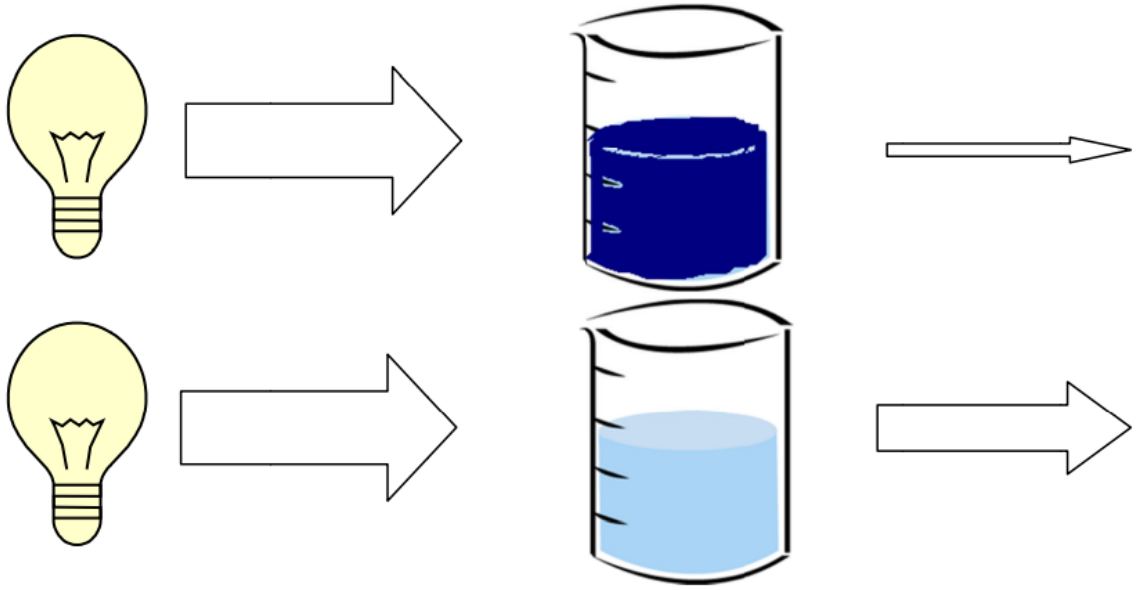
- Add HCl until it has reacted with all the NH_3 from the model compound
- This will be signaled by the color of the solution changing from yellow to orange
- Repeat this again

mL of HCl ⇒ mol of HCl ⇒ mol of NH_3 ⇒ g of NH_3

⇒ Mass % of NH_3 in model compound

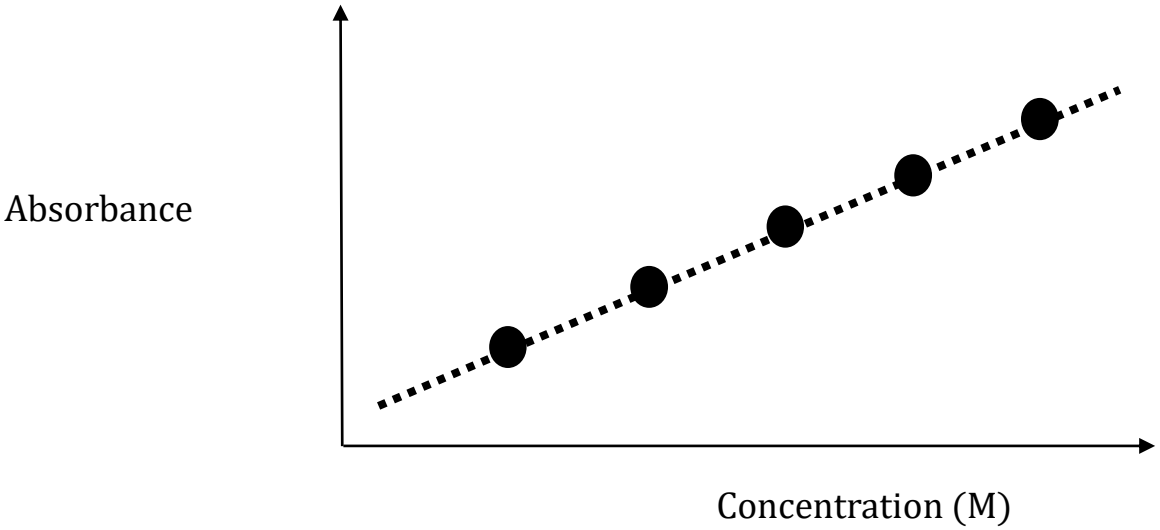
Spectroscopy analysis

- When light is shone on a solution, the light can either be by absorbed by the solute particles or be transmitted (make it through undisrupted).
- The more solute particles are present (higher concentration), the more likely the solute particles absorb the light



Spectroscopy analysis

- A spectrometer is a device which analyzes the amount of light that is absorbed by a sample
- We can relate the absorbance to concentration by making a standard curve like the one that we made relating density to mass % of sugar



Spectroscopy analysis

- We will use the standard curve to determine the copper concentration
- To make the standard curve we'll need to measure the absorbance of solution with known concentrations
- You'll prepare five solutions with varying concentrations of copper and measure their absorbance to get the information needed to make the standard curve
- You'll then measure the absorbance of the model compound and use the standard curve to relate that to the concentration of the model compound

mL of Cu ⇒ mol of Cu ⇒ g of Cu

⇒ Mass % of Cu in model compound

Finding the empirical formula

- You'll then use your mass percentages of copper, ammonia, and sulfate to determine the empirical formula of your model compound.
- Remember, that the formula should be $Cu(NH_3)_4SO_4$, so any deviations from this formula will be due to error in either the synthesis of the compound or analysis of the compound.