23-5 Gravimetric Measurement of Phosphorus in Plant Food

Nutrients in plant foods—nitrogen, phosphorus, and potassium—are indicated on the label by three numbers, such as 15-30-20. This notation means that the fertilizer contains 15 wt % N, 30 wt % P_2O_5, and 20 wt % K_2O. (This is a fictitious notation. Phosphorus is not in the form P_2O_5 and potassium is not in the form K_2O in the fertilizer.)

This experiment[13] measures the phosphorus content of plant food by the reaction

$$\underset{\text{From plant food}}{HPO_4^{2-}} + NH_3 + Mg^{2+} + 6H_2O \longrightarrow \underset{\text{FM 245.41}}{MgNH_4PO_4 \cdot 6H_2O(s)} \quad (23\text{-}3)$$

The experiment is not as accurate as others in this book, but it can be carried out with tap water and chemicals from the grocery store. The product is dried at room temperature to avoid loss of water of crystallization above 40°C. In more accurate determinations of phosphate, the solid $MgNH_4PO_4 \cdot 6H_2O$ is *ignited* (heated strongly) and decomposes to $Mg_2P_2O_7$. Read Sections 6-1 to 6-3 for this experiment.

Reagents

Epsom salts: $MgSO_4 \cdot 7H_2O$ (FM 246.52), 5–15 g/student

Ammonia: (200 mL/student) Use aqueous ammonia from the grocery (~4 wt % NH_3) or prepare 4.0 wt % NH_3 (= 2.3 M) by diluting 160 mL of concentrated (28 wt %) NH_3 up to 1.0 L in the hood.

Isopropyl alcohol: Each student needs 100 mL of rubbing alcohol.

Harris, 2nd Edition, pp. 499-500

Procedure

1. Weigh 10 to 11 g of commercial plant food to the nearest 0.01 g and dissolve it in 140 mL of water in a 250-mL beaker. Stir the mixture well and filter it (Figures 2-14 and 2-15) into a 1-L beaker to remove insoluble residue. A coffee basket filter can be used instead of laboratory filter paper. Rinse the 250-mL beaker twice with 5-mL portions of water and pour the washings through the filter into the 1-L beaker.

2. From the plant food label, estimate how many moles of phosphorus are in the solid that you weighed. (The middle number of the label gives the wt % of P_2O_5 (FM 141.94).) Calculate how many grams of Epsom salts ($MgSO_4 \cdot 7H_2O$, FM 246.52) are required for a 50% molar excess of Mg^{2+} for Reaction 23-3. Dissolve the required amount of Epsom salts in water, using 10 mL of H_2O per gram of $MgSO_4 \cdot 7H_2O$, and pour the resulting solution into the filtered plant food solution.

3. In a fume hood or a well-ventilated area, gradually add 200 mL of ammonia solution (measured with a beaker) to the plant food solution while stirring well with a glass rod. Allow the white precipitate to stand for at least 15 min.

4. Collect the precipitate by filtering through two layers of fluted filter paper or two layers of coffee filters. Then add 50 mL of isopropyl alcohol to the 1-L beaker and swirl to dislodge particles of solid. Pour the mixture over the precipitate in the filter and allow the liquid to drain. Repeat the process once more with another 50 mL of alcohol.

5. Spread the filter paper on several layers of paper towel to dry overnight, protected from dust. The next day, use a spatula to break up lumps. Then allow an additional day of drying, so that the solid is a free-flowing powder.

6. Weigh an empty 250-mL beaker. Scrape the solid from the filter into the beaker and weigh the beaker again to find the mass of solid precipitate. To be certain that the product is dry, allow the beaker to stand for at least another day protected from dust and weigh it again. If successive weighings agree to within ±0.1 g, the product is dry enough.

7. From the mass of dry product, calculate the moles of product in Reaction 23-3 and the moles of phosphorus analyzed. From the moles of phosphorus, compute the moles of P_2O_5 and grams of P_2O_5 in the solid plant food. Report the wt % P_2O_5 in the plant food. Pool the class results to find the mean and standard deviation for the wt % P_2O_5 in each type of plant food analyzed. Compare the class results to the package labels.