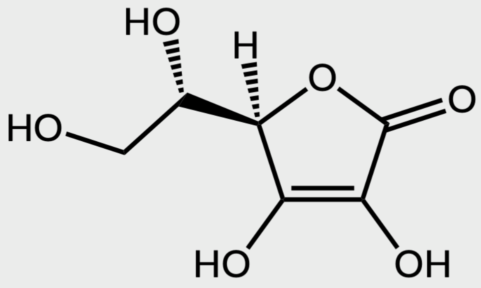
EXPERIMENT 4

QUANTITATIVE DETERMINATION OF VITAMIN C

CHEMISTRY 134L // SPRING 2020

Purpose

To determine the mass of vitamin C (ascorbic acid) in a commercial tablet.



$C_6H_8O_6$

Method

Like last week, we will use volumetric titrations.

Ascorbic acid is a reductant. As such, it undergoes oxidation in the presence of triiodide (I_3^-) via:

$$C_6H_8O_6\ (aq) + I_3^-\ (aq) \rightarrow C_6H_6O_6\ (aq) + 3\ I^-\ (aq) + 2\ H^+\ (aq)$$

oxidation

Problem → No triiodide salts are commercially available.

Solution → We can make I_3^- readily in the lab.

$$IO_3^- \ (aq) + 8\ I^- \ (aq) + 6\ H^+ \ (aq) \rightarrow 3\ I_3^- \ (aq) + 3\ H_2O\ (l)$$

Procedural Outline

The main idea in the titrimetric determination of ascorbic acid is to:

First, make an excess of I_3^- using IO_3^- *in the presence of ascorbic acid*.

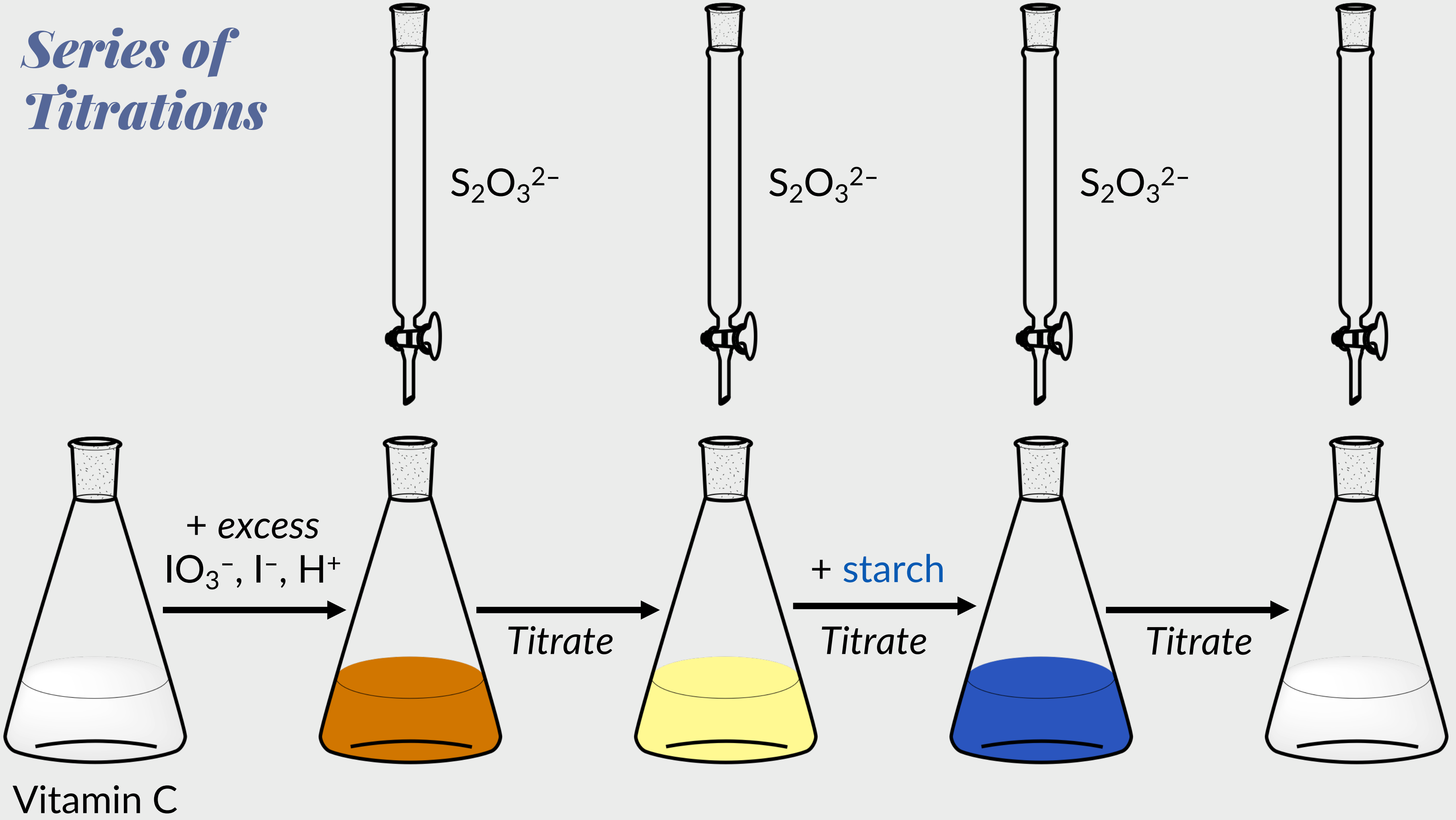
$$IO_3^- (aq) + 8\ I^- (aq) + 6\ H^+ (aq) \rightarrow 3\ I_3^- (aq) + 3\ H_2O\ (l)$$
$$C_6H_8O_6 (aq) + I_3^- (aq) \rightarrow C_6H_6O_6 (aq) + 3\ I^- (aq) + 2\ H^+ (aq)$$

↓

Second, titrate the *remaining* I_3^- with thiosulfate ($S_2O_3^{2-}$) using starch indicator.

$$I_3^- (aq) + 2\ S_2O_3^{2-} (aq) \rightarrow 3\ I^- (aq) + S_4O_6^{2-} (aq)$$

Series of Titrations



An Example

In an experiment, a standard KIO_3 solution was prepared by dissolving 0.6789 g KIO_3 in a 200 mL volumetric flask. Then, to 0.500 g of a commercial vitamin C tablet (of total mass 1.12 g), 10.00 mL of the standard KIO_3 was added, along with excess KI and HCl. The resulting solution was then titrated with a 0.0500 M $Na_2S_2O_3$ using starch indicator. The blue to colorless end point was reached when 4.50 mL of the thiosulfate solution had been added. What is the mass % of vitamin C in the tablet?

$$\left\{\begin{array}{l} IO_3^- (aq) + 8\, I^- (aq) + 6\, H^+ (aq) \rightarrow 3\, I_3^- (aq) + 3\, H_2O (l) \\ C_6H_8O_6 (aq) + I_3^- (aq) \rightarrow C_6H_6O_6 (aq) + 3\, I^- (aq) + 2\, H^+ (aq) \\ I_3^- (aq) + 2\, S_2O_3^{2-} (aq) \rightarrow 3\, I^- (aq) + S_4O_6^{2-} (aq) \end{array}\right.$$

$$n_{S_2O_3^{2-}} = [S_2O_3^{2-}] \times V_{\text{buret}} = \frac{0.0500 \text{ mol } S_2O_3^{2-}}{1 \text{ L}} \times 0.00450 \text{ L} = 2.25_0 \times 10^{-4} \text{ mol } S_2O_3^{2-}$$

$$n_{IO_3^-} = [IO_3^-] \times V_{\text{pipetted}} = \left(\frac{0.6789 \text{ g KIO}_3}{214.001 \text{ g/mol}} \times \frac{1}{0.2000 \text{ L}}\right) \times (0.01000 \text{ L}) = 1.586_2 \times 10^{-4} \text{ mol } IO_3^-$$

$$n_{I_3^- \text{ consumed}} = 3 \times n_{IO_3^-} - \frac{1}{2} n_{S_2O_3^{2-}} = 3 \times 2.25 \times 10^{-4} \text{ mol} - \frac{1}{2} \times 1.586_2 \times 10^{-4} \text{ mol} = 3.63_4 \times 10^{-4} \text{ mol } I_3^-$$

$$n_{\text{VitC}} = n_{I_3^- \text{ consumed}} = 3.63_4 \times 10^{-4} \text{ mol VitC}$$

$$m_{\text{VitC}} = n_{\text{VitC}} \times (\text{Molar Mass}) = 3.63_4 \times 10^{-4} \text{ mol VitC} \times \frac{176.14 \text{ g}}{1 \text{ mol VitC}} = 6.40_0 \times 10^{-2} \text{ g}$$

$$\text{Mass \%} = \frac{m_{\text{VitC}}}{m_{\text{tablet-piece}}} \times 100\ \% = \frac{6.40_0 \times 10^{-2} \text{ g}}{0.500 \text{ g}} \times 100\ \% = 12.8\ \%\ \{3 \text{ sig figs}\}$$