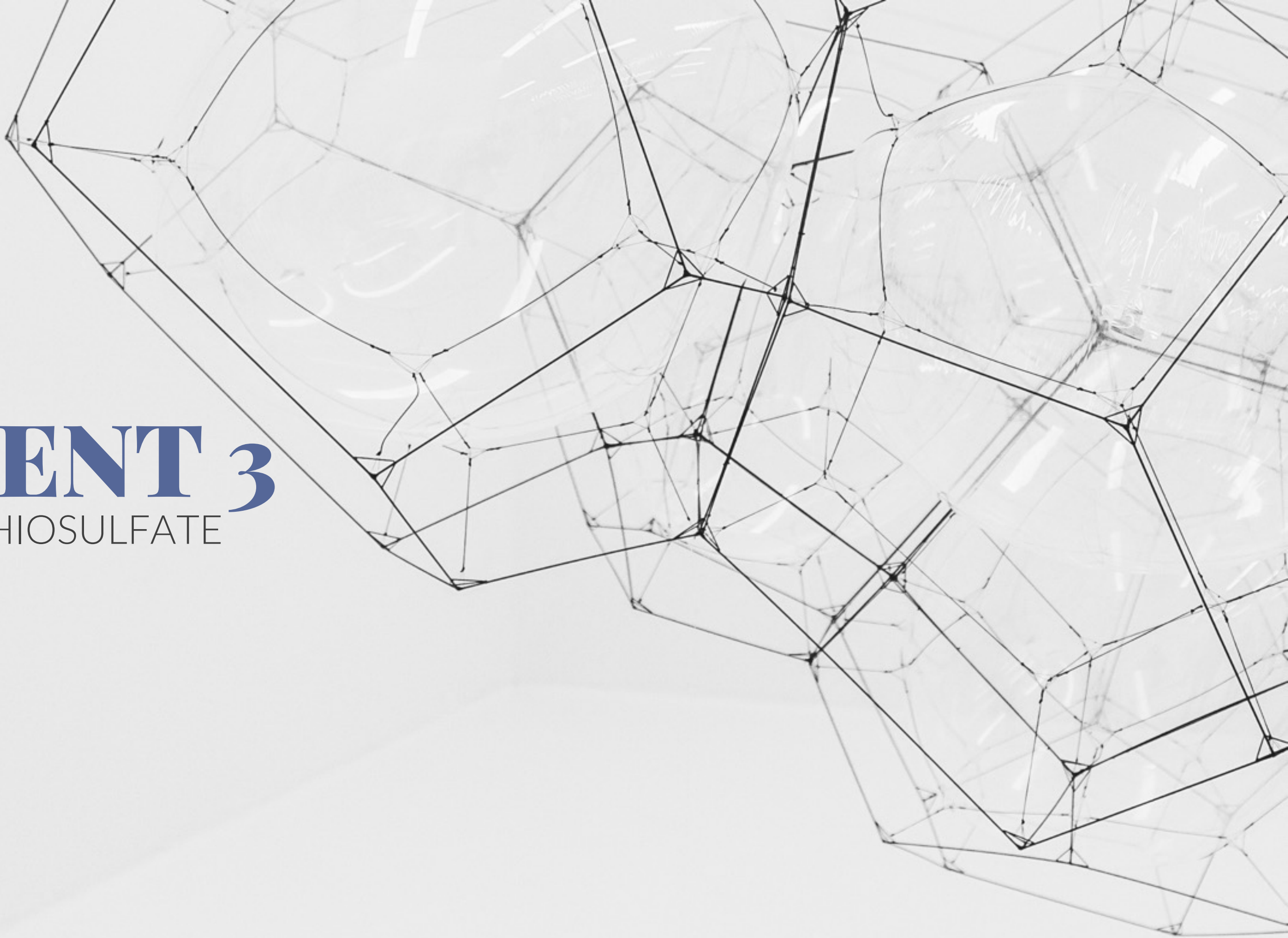
EXPERIMENT 3

STANDARDIZATION OF THIOSULFATE



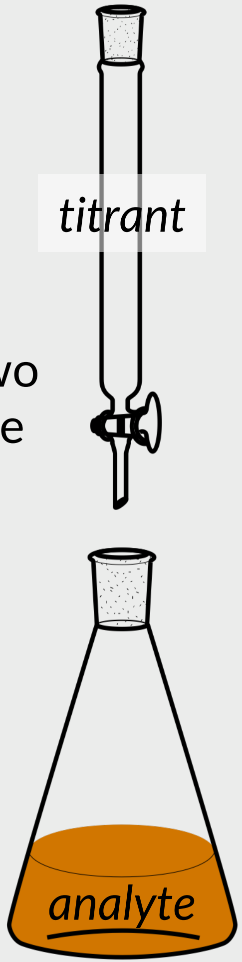
CHEMISTRY 134L // SPRING 2020

Method

Volumetric titration requires

- An analyte
- A titrant
- A reasonably fast reaction between the two
- A satisfactory indicator or detection device

Titrations can be used to determine the stoichiometry of a “new” reaction or the amount of an analyte if the stoichiometry is known.



Method

Titrations can be based on several types of reactions:

- Precipitation
- Acid-base neutralization
- Complex formation reactions
- Redox reactions

Among redox titrations, those based on I_2 (or I_3^-, triiodide) are popular because starch is an excellent indicator for I_2/I_3^-.

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

$$I_2 \, (aq) + 2\, S_2O_3^{2-} \, (aq) \rightarrow 2\, I^- \, (aq) + S_4O_6^{2-} \, (aq)$$

What is molarity?

In chemistry, molarity is a very useful way to express concentration.

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Volume of solution (L)}}$$

Given any two quantities, we can calculate the third.

Standardize the thiosulfate solution

Primary standards: very stable, high purity, and have known molar mass

Commercially available hydrates of $Na_2S_2O_3$ are not primary standards because they may have *different* hydrates ($Na_2S_2O_3 \cdot xH_2O$).

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↓

KIO_3 is a primary standard. It can be used to standardize thiosulfate solutions.

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

Titrate the I_3^- with the thiosulfate ($S_2O_3^{2-}$) solution and starch indicator.

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

↓

Now we can determine the concentration of thiosulfate solution used.

Procedural Outline

Prepare a standard solution of KIO_3.

↓

Known accurate mass in a known volume of solution.

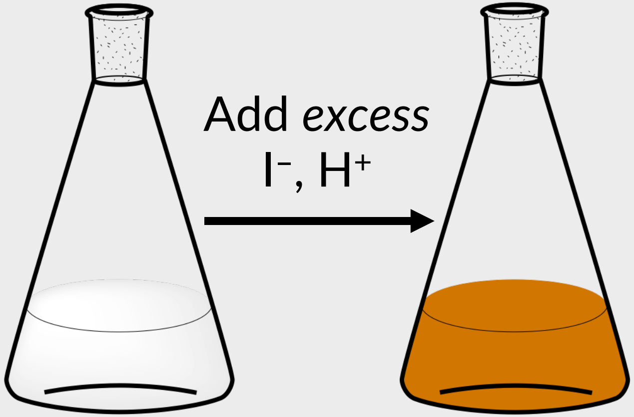
analytical balance — *volumetric flask*

$$[IO_3^-] = \frac{\text{moles } IO_3^-}{\text{volume solution}} = \frac{\text{mass } KIO_3}{\text{molar mass } KIO_3} \times \frac{1}{0.1000\ L}$$

Pipet a known accurate volume of this standard KIO_3 solution into an Eflask.

Also, prepare a solution of $Na_2S_2O_3$ of a *not so accurate molarity.*

Series of Titrations

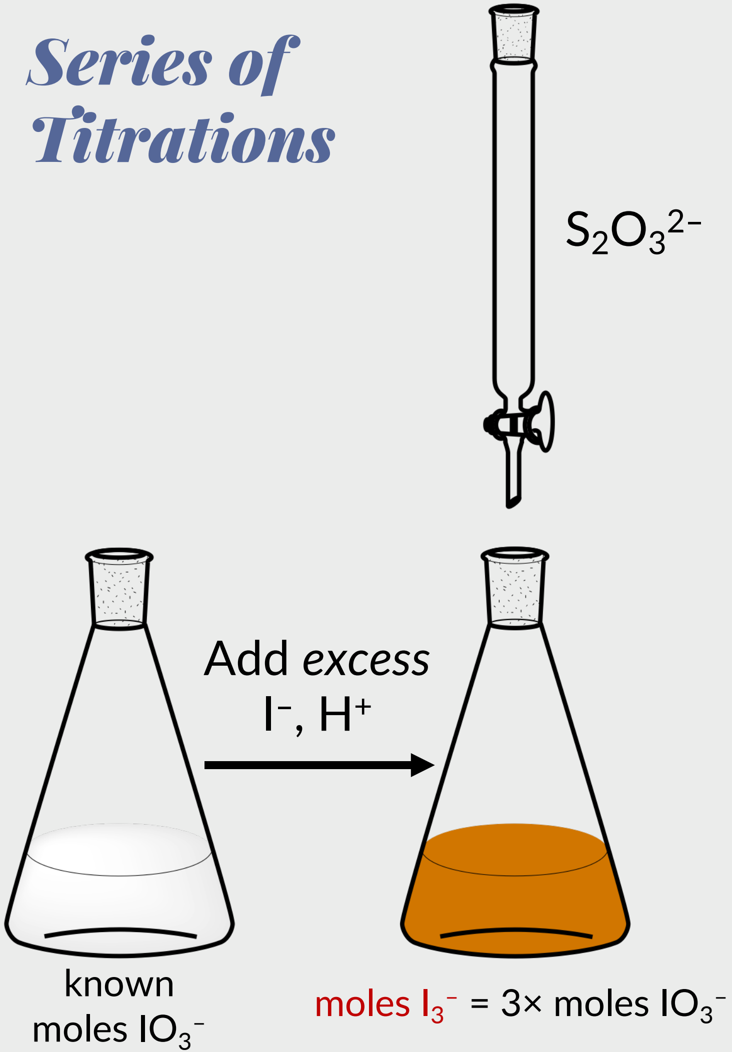


known moles IO_3^-

moles I_3^- = 3× moles IO_3^-

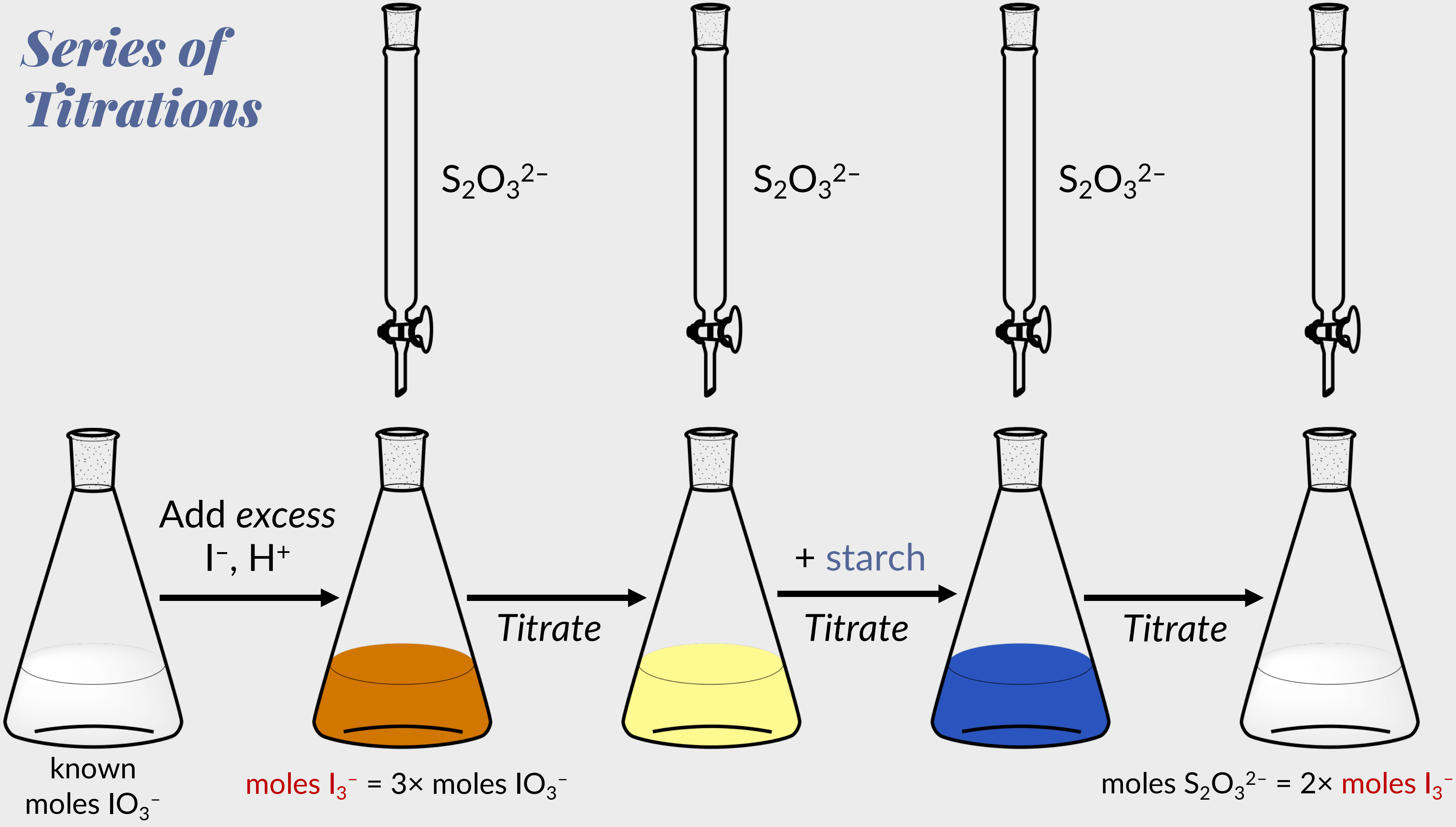
$$IO_3^- (aq) + 8\ I^- (aq) + 6\ H^+ (aq) \rightarrow 3\ I_3^- (aq) + 3\ H_2O\ (l)$$

Series of Titrations



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

Series of Titrations



An Example

In an experiment, 0.3456 g KIO_3 were dissolved in water and made up in a 100 mL volumetric flask. 10.00 mL of this was pipetted into a 250 mL Eflask and treated with excess KI and HCl. The resulting I_3^- was titrated with a $Na_2S_2O_3$ solution of unknown molarity using starch as indicator. The blue to colorless end point was reached when 16.45 mL of the thiosulfate solution had been added. What is $[S_2O_3^{2-}]$?

$$IO_3^- \,(aq) + 8\,I^- \,(aq) + 6\,H^+ \,(aq) \rightarrow 3\,I_3^- \,(aq) + 3\,H_2O\,(l)$$
$$I_3^- \,(aq) + 2\,S_2O_3^{2-} \,(aq) \rightarrow 3\,I^- \,(aq) + S_4O_6^{2-} \,(aq)$$

$$n_{IO_3^-} = [IO_3^-] \times V_{\text{pipetted}} = \left(\frac{0.3456 \text{ g KIO}_3}{214.001 \text{ g/mol}} \times \frac{1}{0.1000 \text{ L}}\right) \times (0.01000 \text{ L}) = 1.615_0 \times 10^{-4} \text{ mol IO}_3^-$$

$$n_{I_3^-} = 3 \times n_{IO_3^-} = 3 \times (1.615_0 \times 10^{-4} \text{ mol}) = 4.844_9 \times 10^{-4} \text{ mol I}_3^-$$

$$n_{S_2O_3^{2-}} = 2 \times n_{I_3^-} = 3 \times (4.844_9 \times 10^{-4} \text{ mol}) = 9.689_7 \times 10^{-4} \text{ mol S}_2\text{O}_3^{2-}$$

$$[S_2O_3^{2-}] = \frac{n_{S_2O_3^{2-}}}{V_{\text{buret}}} = \frac{9.689_7 \times 10^{-4} \text{ mol S}_2\text{O}_3^{2-}}{0.01645 \text{ L}} = 5.890 \times 10^{-2} \text{ M}$$

Notes

1. Work independently today.
2. Remove gloves when using analytical balance.

   Ask Robert or Mioy to clean up spills inside balance.
3. Use mini-balance for sodium thiosulfate.

   Make sure it is set to grams (g)!