Experiment 6
Redox Titration

Iodine Titrations

Objective:

Determination the concentration of Sn^{2+} in an unknown sample using back titration

**An oxidation-reduction (redox) reaction is a type of chemical reaction that involves a transfer of electrons between two species.

**An oxidation-reduction reaction is any chemical reaction in which the oxidation number of a molecule, atom, or ion changes by gaining or losing an electron.

I^-: Iodide ion

IO_3^-: Iodate ion

I_3^-: triiodide ion

$$I_2 + 2e^- \longleftrightarrow 2I^-$$

- The reaction is reversible
- I_2 is the oxidizing agent and I^- is the reducing agent

- Analyte in iodine titration can be

➢ oxidizing agent: example $Fe^{3+} + 2I^- \longrightarrow I_2 + Fe^{2+}$

$$I_2 + 2S_2O_3 \longrightarrow S_4O_6^{2-} + 2I^-$$

➢ reducing agent: example $S^{2-} + I_2 \longrightarrow S_4O_6^{2-} + 2I^-$

a) Standardization of $S_2O_3^{2-}$ using KIO_3 as primary standard

Reduction equation: $6\,H^+ + IO_3^- + 5e^- \longrightarrow 1/2\,I_2 + 3\,H_2O$

Oxidation equation: $5\,I^- \longrightarrow 5/2\,I_2 + 5e^-$

Net equation: : $6\,H^+ + IO_3^- + 5\,I^- \longrightarrow 3\,I_2 + 3\,H_2O$

Reduction equation: $I_2 + 2e^- \longrightarrow 2I^-$

Oxidation equation: $2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2e^-$

Net equation $I_2 + 2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2\,I^-$

$$M\,KIO3 = \frac{\frac{m}{Mw}}{v}, \qquad v = 0.1\,L$$

Number of moles I_2 = $(M \times V)KIO_3 \times 3$

Number of moles $I_2 \times 2 = (M \times V)\,S_2O_3^{2-}$

- Standard Solution: KIO_3
- Analyte: Sn^{2+}
- Excess reactant: Iodine
- Titrant: $Na_2S_2O_3$
- Indicator: Iodine (self indicator) through the appearance or disappearance of color (deep brown → orange → yellow → colorless
- If $[I_2]$ less than $4*10^{-5}$ M add starch to give dark blue color with iodine

- End point detection:

Red-brown color due to I_3^- $\xrightarrow{\text{titration with } S_2O_3^{2-}}$ yellow $\xrightarrow{\text{adding starch}}$ blue $\xrightarrow{\text{titration with } S_2O_3^{2-}}$ colorless

- Starch is used to detect iodine concentration down to 2×10^{-5} mol/L

Reactions:

$$Sn^{2+} + I_2 \rightarrow Sn^{4+} + 2I^-$$

$$KIO3 + 5KI + 6HCl \rightarrow 3H_2O + 3 I_2 + 6KCl$$

b) Standardization of iodine using $S_2O_3^{2-}$:

$$I_2 + 2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2\,I^-$$

$$(M \times V)\,I_2 \times 2 = (M \times V)\,S_2O_3^{2-}$$

c) Determination of tin in an unknown sample (back titration):

$$I_2 + Sn^{2+} \longrightarrow Sn^{4+} + 2I^-$$

$$I_2 + 2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2I^-$$

Total number of moles iodine = number of moles iodine react Sn^{2+} + number of moles iodine react $S_2O_3^{2-}$

$$(M \times V)\,I_2 = (M \times V)\,Sn^{2+} + (M \times V)\,S_2O_3^{2-}/2$$

- Back titration is used instead of direct titration because the reaction between I_2 and Sn^{2+} is slow