Assay for Phenol
Redox reaction

- Redox = reduction and oxidation
  - The reaction involves electron transfer from one reactant to another – the oxidation state of the elements has to be changed.

- $\text{Cu}^{2+} + \text{Zn} \rightarrow \text{Cu} + \text{Zn}^{2+}$
  - $\text{Cu}^{2+}$ gaining two electrons is oxidizing agent, being reduced.
  - $\text{Zn}$ losing two electrons is reducing agent, being oxidized.

- Faraday constant:
  - The unit of electric charge is coulombs (C).
  - One electron has $1.602 \times 10^{-19}$ C
  - One mole of electron has 96500 C of charge
    
    \[ F = 96500 \text{ C/mol} \]
Redox Titration

• Redox titration is based on the redox reaction (oxidation-reduction) between analyte and titrant.

\[
2 \text{S}_2\text{O}_3^{2-} + \text{I}_2 \rightarrow \text{S}_4\text{O}_6^{2-} + 2 \text{I}^-
\]

\[
+2e \ [2 \text{I}(0) \rightarrow 2 \text{I}(-1)]
\]

\[
-2e \ [4 \text{S}(+2) \rightarrow 4 \text{S}(+2.5)]
\]
Calculation in Lab

- 3 mol Br₂ → 1 mol Phenol
- 1 mol BrO₃⁻ (Primary standard, bromate) → 3 mol Br₂
- 1 mol Br₂ → 1 mol I₂
- 2 mol S₂O₃²⁻ (thiosulfate) → 1 mol I₂

Chemical Equations:

\[ \text{BrO}_3^- + 5 \text{Br}^- + 6 \text{H}^+ = 3 \text{Br}_2 + 3 \text{H}_2\text{O} \]

\[ \text{Br}_2 + 2 \text{I}^- = 2 \text{Br}^- + \text{I}_2 \]

\[ 2 \text{S}_2\text{O}_3^{2-} + \text{I}_2 = \text{S}_4\text{O}_6^{2-} + 2 \text{I}^- \]
Titration of the blank

- The volume of NaBrO₃ is $V_{\text{BrO}_3}$, the volume of thiosulfate standard used is $V_1^*$
- The mole amount of BrO₃⁻ is $V_{\text{BrO}_3} \times [\text{BrO}_3^-]$
- Br₂ produced is $3 \times V_{\text{BrO}_3} \times [\text{BrO}_3^-]$ mmol
- I₂ produced is $3 \times V_{\text{BrO}_3} \times [\text{BrO}_3^-]$ mmol
- Thiosulfate needed to titrate produced I₂ is $2 \times 3 \times V_{\text{BrO}_3} \times [\text{BrO}_3^-]$ mmol
- The concentration of thiosulfate solution is $6 \times V_{\text{BrO}_3} \times [\text{BrO}_3^-] / V_1^*$ mmol
Titration of the sample

- The volume of thiosulfate standard used is $V_2^*$
- The mole amount of thiosulfate used is
  
  $$[6 \times V_{\text{BrO}_3} \times [\text{BrO}_3^-]/V_1^*] \times V_2^* \text{ mmol}$$
- The amount of I$_2$ is the solution is
  
  $$0.5 \times [6 \times V_{\text{BrO}_3} \times [\text{BrO}_3^-]/V_1^*] \times V_2^* = [3 \times V_{\text{BrO}_3} \times [\text{BrO}_3^-]/V_1^*] \times V_2^* \text{ mmol}$$
- The excess amount Br$_2$ remained is
  
  $$[3 \times V_{\text{BrO}_3} \times [\text{BrO}_3^-]/V_1^*] \times V_2^* \text{ mmol}$$
- Total amount of Br$_2$ produced is
  
  $$3 \times V_{\text{BrO}_3} \times [\text{BrO}_3^-] \text{ mmol}$$
- The amount of Br$_2$ used to react with Phenol is
  
  $$3 \times V_{\text{BrO}_3} \times [\text{BrO}_3^-] - [3 \times V_{\text{BrO}_3} \times [\text{BrO}_3^-]/V_1^*] \times V_2^* \text{ mol}$$
- The amount of Phenol titrated is
  
  $$\frac{3 \times V_{\text{BrO}_3} \times [\text{BrO}_3^-] - [3 \times V_{\text{BrO}_3} \times [\text{BrO}_3^-]/V_1^*] \times V_2^*}{3} = V_{\text{BrO}_3} \times [\text{BrO}_3^-] - [V_{\text{BrO}_3} \times [\text{BrO}_3^-]/V_1^*] \times V_2^* \text{ mmol}$$