Analysis of Hypochlorite in Bleach
(Redox titrations are cool!)

This experiment allows you to determine the percentage (w/v) of active ingredient**,** **sodium hypochlorite** (NaOCl) in common commericial bleaches. We won't do it directly, but we will use some cool chemistry and we will be able (or should be able) to determine percentages pretty accurately.

THE CHEMISTRY: (for more a more detailed description see your lab manual)

$$OCl^-_{(aq)} + 2\,H^+_{(aq)} + 2\,I^-_{(aq)} \rightarrow I_{2(aq)} + Cl^-_{(aq)} + H_2O_{(l)} \quad [1]$$

$$2\,S_2O_3^{2-} + I_2 \rightarrow 2\,I^- + S_4O_6^{2-} \quad [2]$$

$$I_{2(aq)} + I^-_{(aq)} \rightarrow I_3^-{}_{(aq)} \quad \text{(occurs rapidly and completely)} \quad [3]$$

So when I^- is in excess:

$$2\,S_2O_3^{2-}{}_{(aq)} + I_3^-{}_{(aq)} \rightarrow 3\,I^-_{(aq)} + S_4O_6^{2-}{}_{(aq)} \quad [4]$$

$$I_3^-{}_{(aq)} + \text{starch} \rightarrow \text{deep-blue complex} \quad \text{(also occurs rapidly)} \quad [5]$$

Our problem: The analysis of OCl^- by titration with $S_2O_3^{2-}$ requires that we know the concentration of the $S_2O_3^{2-}$ solution. Unfortunately, **sodium thiosulfate** ($Na_2S_2O_3$) is not a primary standard, so we must standardize the sodium thiosulfate solution. A similar series of reactions is used for the standardization, only **potassium iodate** (KIO_3) is used to oxidize **iodide** (I^-) to **iodine** (I_2):

$$IO_3^-{}_{(aq)} + 5\,I^-_{(aq)} + 6\,H^+_{(aq)} \rightarrow 3\,I_{2\,(aq)} + 3\,H_2O_{(l)} \quad [6]$$

So we'll titrate a known amount of KIO_3 (the limiting reagent), in the presence of excess of I^-, with our $Na_2S_2O_3$ solution. Using the stoichiometry of reaction 6, we can calculate the I_2 generated (theoretically) and then using the stoichiometry of reaction 2 (this gives us moles $Na_2S_2O_3$ used in each titration) and the titration volumes we can calculate $[Na_2S_2O_3]$.

THE EXPERIMENT:

1) Standardize $S_2O_3^{2-}{}_{(aq)}$ ⇒ Solves problem.

The stoichiometry is important:

1 mole IO_3^- = 3 mole I_2 [6]
1 mole I_2 = 2 mole $S_2O_3^{2-}$ [2]

So after titrations are completed (volumes), you can find $[S_2O_3^{2-}]$.
You need at least 3 titration volumes within 0.05 mL.

2) Determine % NaOCl in bleach (w/v)

You need at least 3 titrations within 0.05 mL.

$[S_2O_3^{2-}]$ x titration vol. of $S_2O_3^{2-}$ = mole $S_2O_3^{2-}$

1 mole $S_2O_3^{2-}$ = 1/2 mole I_2 [2]
1 mole I_2 = 1 mole OCl^- (= mole NaOCl) [1]

Convert to mass NaOCl (g) (MW NaOCl = 74.44 g/mole)
Find (g/sample vol.) x 100%

sample vol. = 0.10 mL ⇒ 5.00 mL of orignal bleach solution/250.0 mL, so, stock bleach solution is 0.02 (or 1/50) of original bleach solution.
For each titration ⇒ 5.00 mL x 0.02 (or 5.00 mL/50) = 0.10 mL

SAMPLE CALCULATIONS:

1) Standardization of $Na_2S_2O_3$:

(0.2000 g KIO_3)(1 mole KIO_3/214.00 g/mole) = 9.346×10^{-4} mole KIO_3

You made up KIO_3 stock solution in a 100.0 mL volumetric flask and for each titration you used 5.00 mL of your stock solution

So…. for each titration you used 1/20 of your stock solution:

KIO_3 used in each titration = 9.346×10^{-4} mole KIO_3/20

KIO_3 used in each titration = 4.67×10^{-5} mole KIO_3

1 mole KIO_3 = 3 mole I_2 ⇒ 1.40×10^{-4} mole I_2
1 mole I_2 = 2 mole $Na_2S_2O_3$ ⇒ 2.80×10^{-4} mole $Na_2S_2O_3$

e.g. For a titration volume = 5.61 mL (from experimental data):

2.80×10^{-4} mole $Na_2S_2O_3$/ 0.00561 L = 0.0500 M $Na_2S_2O_3$

2) Analysis of Bleach (Clorox)

e.g. For a titration volume = 3.44 mL (from experimental data)

(0.00344 L $Na_2S_2O_3$)(.0500 mole/L $Na_2S_2O_3$) = 1.72×10^{-4} mole $Na_2S_2O_3$

1 mole $Na_2S_2O_3$ = 1/2 mole I_2 ⇒ 8.68×10^{-5} mole I_2
1 mole I_2 = 1 mole mole NaOCl ⇒ 8.68×10^{-5} mole NaOCl

mass NaOCl = (8.68×10^{-5} mole NaOCl)(74.44 g/mole) = 0.00640 g NaOCl
% NaOCl (w/v) = (0.00640 g NaOCl/0.10 mL bleach) x 100% = 6.40 % NaOCl

RMD (ppt) = (mean deviation/mean) x 1000