Experiment 6 (28-11-08)

Analysis of Chlorine in Commercial Bleaching Solutions

Objective

To determine the molarities of sodium chlorate (I) in two brands of bleach solution by titration.

Theory

Reaction between chlorate (I) and iodide ions with the present of sulphuric acid:

$$ClO^-_{(aq)} + 2I^-_{(aq)} + 2H^+_{(aq)} \rightarrow Cl^-_{(aq)} + I_{2\,(aq)} + H_2O_{(l)}$$

Reaction between hypochlorite ions and iodine:

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

Procedures

a. Determine the total volume of bleach in the commercial bottles provided.
b. Note the price of the sample.
c. Wash a 25.0 cm^3 pipette with distilled water and then with the bleach solution.
d. Pipette 25.0 cm^3 of the bleach into a 250.0 cm^3 of volumetric flask.
e. Make up to the graduated mark of the volumetric flask.
f. Stopper the flask and invert it several times in order to mix the contents well.
g. Label the flask.
h. Wash a burette with distilled water and then with standard sodium hypochlorite solution.
i. Pour the sodium hypochlorite solution into the burette and ensure the tip of burette is filled.
j. Record the initial burette reading.
k. Pipette 25.0 cm^3 of the diluted bleach into a conical flask.
l. Add 10 cm^3 of KI solution and 10 cm^3 of 1 M sulphuric acid into the flask.
m. Run the solution from the burette into the conical flask, swirling the flask all the time.
n. Stop the titration when the colour of solution in the conical flask just becomes pale yellow.
o. Add 3 cm^3 of starch indicator.
p. Run the solution slowly form the burette until the solution in the flask turns from dark blue to colourless.
q. Record the final burette reading.
r. Repeat steps(a)-(q) three more times.
s. Repeat steps(a)-(r) with another brand of bleaching solution.

Results

	Brand Name of Bleach	
	Clorox	Kao
Total volume of bleach (cm^3)	2840	600
Price ($)	20	7.20

Brand Name of bleach : Clorox vs 0.1M $Na_2S_2O_3$

	1	2	3
Final burette reading (cm^3)	4.60	8.70	2.20
Initial burette reading (cm^3)	43.60	47.60	40.90
Volume of $Na_2S_2O_3$ added (cm^3)	39.00	38.90	38.70
Mean volume = $(39.00 + 38.90 + 38.70) / 3$ = 38.87 cm^3			

Brand Name of bleach : Kao vs 0.1M $Na_2S_2O_3$

	1	2	3
Final burette reading (cm^3)	10.00	1.40	25.30
Initial burette reading (cm^3)	33.80	25.30	49.00
Volume of $Na_2S_2O_3$ added (cm^3)	23.80	23.90	23.70
Mean volume = $(23.80 + 23.90 + 23.70) / 3$ = 23.80 cm^3			

Calculations

Clorox

No. of mole of $S_2O_3^{2-}$ = $38.87 \times 10^{-3} \times 0.1$ = 3.89 x 10^{-3} mol

By equation, no of moles of $S_2O_3^{2-}$: I_2 = 2 : 1

$\therefore$ no. of moles of I_2 liberated = $\frac{3.89 \times 10^{-3}}{2}$ = 1.944 x 10^{-3} mol

By equation, no of moles of I_2 : ClO^- = 1 : 1

$\therefore$ no. of moles of ClO^- = 1.944 x 10^{-3} mol

No. of mole of ClO^- in the original bleach solution = 1.944 x 10^{-3} x $\frac{250}{25}$ = 0.01944 mol

Molarity = $\frac{0.01944}{25 \times 10^{-3}}$ = 0.7774 M

Price per mole = $\frac{20}{0.01944 \times \frac{2840}{25}}$ = \$9.056 mol^-

Kao

No. of mole of $S_2O_3^{2-}$ = $23.80 \times 10^{-3} \times 0.1$ = 2.380 x 10^{-3} mol

By equation, no of moles of $S_2O_3^{2-}$: I_2 = 2 : 1

∴ no. of moles of I_2 liberated = $\frac{2.380 \times 10^{-3}}{2}$ = 1.190 x 10^{-3} mol

By equation, no of moles of I_2 : ClO^- = 1 : 1

∴ no. of moles of ClO^- = 1.190 x 10^{-3} mol

No. of mole of ClO^- in the original bleach solution = 1.190 x 10^{-3} x $\frac{250}{25}$ = 0.01190 mol

Molarity = $\frac{0.01190}{25 \times 10^{-3}}$ = 0.4760 M

Price per mole = $\frac{7.20}{0.01190 \times \frac{600}{25}}$ = \$25.21 mol^-

Conclusion

Price per mole of Clorox bleaching solution is \$9.056 mol^- and that of Kao bleaching solution is \$25.21 mol^-.

Discussion

Sources of errors

- Chlorine presented in the bleaching solution may oxidize iodide ions to iodine; more iodine is formed than expected.
- ClO^- ions may be decomposed into Cl^- ions and oxygen gas.
- Iodine is volatile; it may be lost to the surroundings.
- Starch solution is not fresh because it is oxidized. It loses its function.

Suggestion for the improvement

- Keep the bleach solution away from sunlight.
- Start titration immediately after adding potassium iodide solution and sulphuric acid into the diluted bleach solution.
- Starch solution should be freshly prepared before used.

Question

1. Clorox is the 'best' buy as it is relatively cheaper than Kao for 1 mole of sodium chlorate (I), which is the basis of commercial bleaches.
2. Sulphuric acid is used to provide hydrogen ions for the reaction between chlorate (I) and iodide ions.
3. First, when bleaching solution is put under sunlight, ClO^- ions may be decomposed into chloride ions and oxygen gas.

$$2ClO^-_{(aq)} \rightarrow 2Cl^-_{(aq)} + O_{2\,(g)}$$

Second, bleaching solution may react with carbon dioxide in air. Chlorate (I) ions in bleaching solution can react with carbon dioxide in air to form carbonate, water and chlorine gas.

$$2ClO^-_{(aq)} + CO_{2(g)} \rightarrow CO_3^{2-}{}_{(aq)} + H_2O_{(l)} + Cl_{2(g)}$$