

F.6A Lam Pik Sum (10)

Title: analysis of two commercial brands of bleaching solution

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Objective: to find out which of the two brands of bleach is cheaper base on their actual bleaching strength.

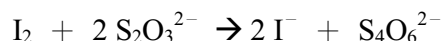
Introduction

Redox titration can be divided into two parts: in one half the reducing agent loses electrons and in other half the oxidizing agent gains electrons. The stoichiometric equation for a redox reaction may then derive using the fact that all the electrons lost by the reducing agent must be gained by the oxidizing agent.

In this experiment, we need to find out the cost of active ingredient per gram in two different brands of household bleaches in other to find out with bleach is cheaper. The two bleaches we use are KAO (\$13.9 for 1.5L) and Best Buy (\$11.9 for 2L).

Sodium hypochlorite forms the basis of most of commercial bleaches. In this analysis, the sodium hypochlorite is allowed to react with an excess of potassium iodide solution in the presence of acid, liberating iodine, which is then titrated against standard sodium thiosulphate solution.

Reactions involved: $\text{ClO}^- + 2 \text{I}^- + 2 \text{H}^+ \rightarrow \text{I}_2 + \text{H}_2\text{O} + \text{Cl}^-$



In this redox titration, potassium iodide in the acidic medium acts as a reducing agent is added to the bleach solution to generate the iodine by the reduction of the hypochlorite ions. The formed iodine is then back-titrated with sodium thiosulphate to reduce iodine to iodide ions while sodium thiosulphate is being oxidized in order to determine the amount of hypochlorite ions originally present.

When the brown colour of iodine fades as the end point approaches, a little amount of starch solution is added. Starch solution acts as an indicator is added to clarify the end point of the titration. Since starch forms a dark blue aqueous complex with iodine, the disappearance of the dark blue colour indicates that there is no iodine in the reaction mixture, that means the end point of the titration is reached.

Procedures

For each brand of bleach, carry out the following:

- 1) Both volumes and the prices of the bleaches were recorded.
- 2) 10 cm^3 of bleach was measured into a volumetric flask using a pipette.
- 3) Distilled water was added to the volumetric flask until reaching the graduation mark.
- 4) 25 cm^3 of this solution was pipetted into a 250 cm^3 conical flask.
- 5) $10\text{-}15 \text{ cm}^3$ of 1M potassium iodide solution was added to the conical flask.

- 6) 10-15 cm³ of 1M potassium iodide solution was added to the conical flask.
- 7) Standard sodium thiosulphate solution was added to the burette.
- 8) The initial reading on the burette was recorded
- 9) Standard sodium thiosulphate solution was run out from the burette to the conical flask until the colour of the solution in the conical flask changed from reddish brown to pale yellow..
- 10) Few drops of starch solution were added to the solution in the conical flask.
- 11) Standard sodium thiosulphate solution was run out from the burette to the conical flask until the colour of the solution in the conical flask changed from blue-black to colourless.
- 12) The final reading on the burette was recorded.
- 13) Titrations were repeated until the normal degree of consistency is obtained.

Data of results

Titration table of KAO bleach with KI and H₂SO₄ against standard 0.07676M

sodium thiosulphate

	Trial	1 st titration	2 nd titration	3 rd titration
Initial reading on the burette	15.5 cm ³	6.9 cm ³	5.6 cm ³	11.2 cm ³
Final reading on the burette	35.6 cm ³	26.8 cm ³	25.6 cm ³	31.1 cm ³
Volume of H ₂ SO ₄ used	20.1 cm ³	19.9 cm ³	20.0 cm ³	19.9 cm ³

Average volume of sodium thiosulphate used

$$= (19.9 + 20.0 + 19.9) \div 3$$

$$= 19.93 \text{ cm}^3$$

20.1 cm³ is rejected because this is just a trial.

Titration table of Best Buy bleach with KI and H₂SO₄ against standard 0.07676M

	<u>sodium thiosulphate</u>			
	Trial	1 st titration	2 nd titration	3 rd titration
Initial reading on the burette	7.4 cm ³	21.9 cm ³	3.8 cm ³	17.9 cm ³
Final reading on the burette	21.9 cm ³	36 cm ³	17.9 cm ³	32.1 cm ³
Volume of H ₂ SO ₄ used	14.5 cm ³	14.1 cm ³	14.2 cm ³	14.2 cm ³

Average volume of sodium thiosulphate used

$$= (14.1 + 14.2 + 14.2) \div 3$$

$$= 14.167 \text{ cm}^3$$

14.5 cm³ is rejected because this is just a trial.

Calculation

KAO

In the titration, iodine in the reaction mixture react with the sodium thiosulphate as the following equation: $\text{I}^2 + 2\text{S}_2\text{O}_3^{2-} \rightarrow 2\text{I}^- + \text{S}_4\text{O}_6^{2-}$

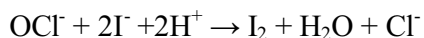
Mole ratio of I^2 to $\text{S}_2\text{O}_3^{2-}$ is 1: 2

As 19.93 cm³ of sodium thiosulphate is used,

$$\text{No. of mole of sodium thiosulphate} = 0.07676\text{M} \times 0.01993 \text{ dm}^3 = 0.0015298268 \text{ mol.}$$

$$\text{No. of mole of iodine} = 0.0015298268 \div 2 = 0.0007649134 \text{ mol.}$$

Iodine present in the reaction mixture is come from the reaction between bleach and potassium iodide and dilute sulphuric acid as the following equation:



Mole ratio of OCl^- to I_2 is 1:1

$$\text{No. of mole of diluted sodium hypochlorite (25 cm}^3) = 0.0007649134 \text{ mol.}$$

$$\begin{aligned} \text{No. of mole of diluted sodium hypochlorite (250 cm}^3) &= 0.0007649134 \times 10 \\ &= 0.007649134 \text{ mol.} \end{aligned}$$

$$\text{No. of mole of original sodium hypochlorite (10 cm}^3) = 0.007649134 \text{ mol.}$$

$$\begin{aligned} \text{Molarity of the original bleach} &= 0.007649134 \div 0.01 = 0.7649134 \text{ M} \\ &= 0.769 \text{ M (corr. to 3 sig. fig.)} \end{aligned}$$

$$\begin{aligned} \text{Mass of the sodium hypochlorite in 10 cm}^3 \text{ bleach} &= 0.007649134 \times (23+16+35.5) \\ &= 0.569860483 \text{ g} \end{aligned}$$

$$\begin{aligned} \text{Strength of the original bleach} &= 0.569860483 \div 0.01 \\ &= 56.9860483 \text{ g dm}^{-3} \\ &= 57.0 \text{ g dm}^{-3} \text{ (corr. to 3 sig. fig.)} \end{aligned}$$

Available bleach present in one bottle = 0.569860483×150

$$= 85.47907245 \text{ g}$$

$$= 85.5 \text{ g (corr. to 3 sig. fig.)}$$

Cost of bleach per gram = $\$13.9 \div 85.47907245 \text{ g} = \$ 0.163$ (corr. to 3 sig. fig.)

Best Buy

In the titration, iodine in the reaction mixture react with the sodium thiosulphate as the following equation: $\text{I}_2 + 2\text{S}_2\text{O}_3^{2-} \rightarrow 2\text{I}^- + \text{S}_4\text{O}_6^{2-}$

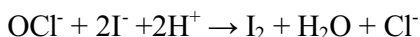
Mole ratio of I_2 to $\text{S}_2\text{O}_3^{2-}$ is 1: 2

As 14.167 cm^3 of sodium thiosulphate is used,

$$\begin{aligned}\text{No. of mole of sodium thiosulphate} &= 0.07676\text{M} \times 0.014167 \text{ dm}^3 \\ &= 0.00108745892 \text{ mol.}\end{aligned}$$

$$\text{No. of mole of iodine} = 0.00108745892 \div 2 = 0.00054372946 \text{ mol.}$$

Iodine present in the reaction mixture is come from the reaction between bleach and potassium iodide and dilute sulphuric acid as the following equation:



Mole ratio of OCl^- to I_2 is 1:1

$$\text{No. of mole of diluted sodium hypochlorite (25 cm}^3\text{)} = 0.00054372946 \text{ mol.}$$

$$\begin{aligned}\text{No. of mole of diluted sodium hypochlorite (250 cm}^3\text{)} &= 0.00054372946 \times 10 \\ &= 0.0054372946 \text{ mol.}\end{aligned}$$

$$\text{No. of mole of original sodium hypochlorite (10 cm}^3\text{)} = 0.0054372946 \text{ mol.}$$

$$\begin{aligned}\text{Molarity of the original bleach} &= 0.0054372946 \div 0.01 = 0.54372946 \text{ M} \\ &= 0.544 \text{ M (corr. to 3 sig. fig.)}\end{aligned}$$

$$\begin{aligned}\text{Mass of the sodium hypochlorite in 10 cm}^3\text{ bleach} &= 0.0054372946 \times (23+16+35.5) \\ &= 0.405078447 \text{ g}\end{aligned}$$

$$\begin{aligned}\text{Strength of the original bleach} &= 0.405078447 \div 0.01 \\ &= 40.50784477 \text{ g dm}^{-3} \\ &= 40.5 \text{ g dm}^{-3} \text{ (corr. to 3 sig. fig.)}\end{aligned}$$

Available bleach present in one bottle = 40.5078447×200

$$= 81.0156894 \text{ g}$$

$$= 81.0 \text{ g (corr. to 3 sig. fig.)}$$

Cost of bleach per gram = $\$ 11.9 \div 81.0156894 \text{ g} = \$ 0.147$ (corr. to 3 sig. fig.)

Conclusion

Best buy is cheaper than KAO as cost of bleach per gram of Best Buy is \$ 0.147 while cost of bleach per gram of KAO is \$ 0.163.

Discussion

1) Why potassium iodide is added to the bleach solution before dilute sulphuric acid?

If dilute sulphuric acid is first added to the bleach solution, the hypochlorite ions in the bleach solution will react with the hydrogen ions in the dilute sulphuric acid to form

Study Questions

- 1) Why the KI has to be present in excess? If a student use much less than the specified quantity, what effect would there be in his results?

KI has to be present in excess because we need to make sure that all the sodium hypochlorite is reacted with potassium iodide to give out iodine. If a student use much less than the specified quantity, potassium iodide may not be excess in the reaction and not all the sodium hypochlorite is reacted. Therefore the number of mole of sodium hypochloite presents cannot be calculated from the number of mole of iodine formed.

- 2) What is the function of the dilute sulphuric acid?

The equation of the reaction between the sodium thiosulphate and the potassium iodide is $\text{ClO}^- + 2\text{I}^- + 2\text{H}^+ \rightarrow \text{I}_2 + \text{H}_2\text{O} + \text{Cl}^-$.

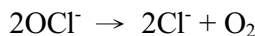
The equation shows that the reaction between sodium thiosulphate and potassium iodide need acid medium to proceed. H^+ , act as a catalyst, speed up the reaction.

- 3) Bleaching solution may be deteriorated for 2 reasons. One is the attack by CO_2 in air according to the reaction: $2\text{ClO}^- + \text{CO}_2 \rightarrow \text{CO}_3^{2-} + \text{H}_2\text{O} + \text{Cl}_2$

What is the other possible reason?

Sunlight is the other possible reason that makes bleaching solution deteriorated.

Bleach solution contains hypochlorite ions (OCl^-) as the active ingredient. The hypochlorite ions in bleach solution is not very stable and slowly decomposes:



The decomposition is speeded up by sunlight.

- 4) Why the starch indicator should not be added too early?

Starch will react with iodine to form a dark blue aqueous complex. If starch is added too early, starch may be combined with iodine too strongly. It is because the time for the combination of starch molecule with iodine molecule is longer, and the complex ion will be more stable. As a result, the iodine is combined too strongly with starch and cannot react with sodium thiosulphate to form iodine and indicate the end point.

- 5) Why are crystals of hydrated sodium thiosulphate though obtainable in a state of high purity, not used as a primary standard?

Primary standard is a solution of known concentration by dissolving known amount of solute in a given volume of solvent. It is because crystals of hydrated sodium thiosulphate are not stable under sunlight. Features of a primary standard include: high purity, low reactivity, low hygroscopicity and efflorescence, high solubility (if used in titration and high equivalent weight. In other words, primary standard solution will remain standard after a reasonable time elapsed. Crystals of hydrated sodium thiosulphate are not used as a primary standard because they are efflorescent (i.e. to release the water of crystallization in dry air) and deliquescent (i.e. to absorb water from moist air and to dissolve in the water absorbed). In other words, it is necessary to standardize the $\text{Na}_2\text{S}_2\text{O}_3$ solution. If the concentration of $\text{Na}_2\text{S}_2\text{O}_3$ is calculated based on the mass of hydrated sodium thiosulphate crystals and the volume of the solution, a significant error would be caused.

6) As the brown I^2/I^- solution becomes colourless at the end-point, why do we bother to add starch indicator in the titration?

The addition of starch indicator at the end-point is to check that whether there is any iodine still present in the solution. When this titration is near to the end-point, the I^2/I^- solution will become very pale yellow that we may wrongly judge it as colourless. The addition of starch solution can clearly show the presence or absence of iodine in the solution as starch will form a dark blue aqueous complex with iodine.

7) Why do thiosulphate ions only reacts with I^2 and not H^+ in the experiment?

Thiosulphate ions only react with I^2 and not H^+ in the experiment because I^2 is a stronger oxidizing agent than. Therefore thopsulphate ions is more likely to react with I^2 than H^+ .

8) Explain the action of bleaching.

Colour in most dyes and pigments is produced by molecules, such as beta carotene, which contain chromophores. Household bleach solution is a kind of oxidizing bleach due to the hypochlorite ions. They react with many organic and inorganic compounds. An oxidizing bleach works by breaking the chemical bonds that make up the chromophore. This changes the molecule into a different substance that either does not contain a chromophore, or contains a chromophore that does not absorb visible light.

End of Report