

# Analysis of brick cleaner

## Purpose

To find the percentage, by mass, of hydrogen chloride (present as hydrochloric acid) in brick cleaner.

## Materials

- 5 mL brick cleaner
- 100 mL of 0.100 M standard sodium carbonate solution
- 250 mL deionised water
- methyl orange indicator
- phenolphthalein indicator
- 250 mL volumetric flask
- 4 × 100 mL conical flasks
- small funnel
- 10 mL measuring cylinder
- 20 mL pipette
- pipette filler
- dropping pipette
- burette and stand
- white tile
- electronic balance
- safety glasses

## Safety

- *Wear safety glasses and a laboratory coat for this experiment.*
- *Brick cleaner contains a high concentration of hydrochloric acid. It can cause severe skin burns and must be handled with care. Mop up spills immediately, washing them away with copious amounts of water.*
- *Methyl orange may cause irritation to the skin and eyes. Avoid contact.*

## Procedure

1. Note the hydrogen chloride content of the brick cleaner as specified by the manufacturer.
2. Weigh the 250.0 mL volumetric flask. Record the result.
3. Use a 10 mL measuring cylinder (or a burette set up in the fume hood) to accurately pour 10.0 mL of concentrated brick cleaner into the 250.0mL volumetric flask, avoiding spillages.
4. Reweigh the volumetric flask and its contents. Record the result.
5. Half fill the volumetric flask with deionised water. Stopper the flask and turn it upside down *carefully* several times to mix the solution thoroughly. (THIS IS ALL COMPLETED IN FUME HOOD).
6. Fill the volumetric flask to the mark with more deionised water. Stopper and mix the solution thoroughly.
7. Use a 20 mL pipette to place 20.00 mL aliquots of standard sodium carbonate solution into four 100 mL conical flasks.
8. Add two to three drops of indicator to each conical flask. Set one flask aside to act as a control in colour matching.
9. Rinse the burette and fill with diluted solution of brick cleaner (using small funnel) and record the initial level of the solution in the burette to two decimal places.
10. Titrate the sodium carbonate solution until the end point is reached. Record the final burette reading and calculate the volume of the titre.
11. Repeat the titration until three concordant titres are achieved.

## Theory

Brick cleaner contains concentrated hydrochloric acid as the active ingredient. The acid reacts with the basic components of concrete and so enables concrete to be removed from brickwork. To analyse brick cleaner, a sample is diluted (since the original acid is highly concentrated) and titrated against a standard solution of a base, sodium carbonate.

Results. *Sample results*

Mass of empty 250 mL flask volumetric flask (g) 122.25g

Mass of empty volumetric flask and brick cleaner contents (g) 134.90 g

Burette reading	Trial 1	Trial 2	Trial 3	Trial 4
Start (mL)	0.25	18.50	5.00	2.00
Finish (mL)	18.50	36.77	23.19	22.90
Total added (mL)	18.25	18.27	18.19	20.90

Average titre (mL) 18.24

Calculations

- Write a balanced chemical equation for the reaction between  $\text{Na}_2\text{CO}_3$  and HCl. Include states.  $\text{Na}_2\text{CO}_3(\text{aq}) + 2\text{HCl}(\text{aq}) \rightarrow 2\text{NaCl}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$
- Calculate the amount, in mol, of  $\text{Na}_2\text{CO}_3$  present in each conical flask.  
*Calculate the average titre using only concordant results.*  
 $n_{\text{sodium carbonate}} = C \times V = 0.100 \times 0.0200 = 2.00 \times 10^{-3}$
- Calculate the amount, in mol, of HCl present in the average titre.  
 $2 \times 2.00 \times 10^{-3}$   
 $\Rightarrow 4.00 \times 10^{-3}$
- Calculate the amount, in mol, of HCl present in the volumetric flask  
 $(250 / 18.24) \times 4.00 \times 10^{-3}$   
 $\Rightarrow 0.0548$
- Calculate the mass of HCl present in the volumetric flask.  
 $0.0548 \times 36.5 = 2.00 \text{ grams}$
- Calculate the concentration of HCl in the sample in % w/w.  
 $\text{Mass of sample} = 134.90 - 122.25 = 12.65 \text{ g}$   
 $(2.00 \text{ g} / 12.65) \times 100 = 15.8\%$
- Calculate the concentration of HCl in the sample in:  
- %w/v  
 $(2.00 / 10 \text{ mL}) \times 100 = 20 \% \text{w/v}$   
mol/L  
 $\text{Find the mol of acid in 10 mL (0.010L)} = 2.00 / 36.5 = 0.0548 \text{ mol}$   
 $\Rightarrow 5.5 \text{ M}$

## Questions

- 1. State 2 possible sources of error, based on the procedure used, other than human mistakes that could be responsible for significant uncertainty in the final result for the percentage composition.**

*A human error, or mistake, is an unintended action or omission by the person conducting the experiment. These are often random, avoidable, and result from inattention, lack of experience, or misunderstanding. They typically do not follow any consistent pattern and can vary in each trial. Errors in Titration: May be systematic or random, arising from the experimental design, procedure, or external factors, such as temperature which may impact the volume of titrant or sample delivered. Systematic errors are consistent and reproducible, while random errors are unpredictable and vary across trials.*

**Any two of the following but not limited to these.**

- **The procedure specifies the wrong indicator:** Using phenolphthalein will cause overshooting of the endpoint thus leading to a calculated concentration that is higher than is actually in the sample.
- **Parallax Error:** When reading the volume on the burette, if the observer's eye is not level with the meniscus, a parallax error can occur. This can cause the recorded volume to be slightly higher or lower than the actual volume, leading to inaccurate titration results. If the observer's eye is constantly positioned at the exact spot every reading then it becomes a systematic error, which cancels when taking the difference between two readings of a burette.
- **Side reactions which may react with the titrant** – The presence of a secondary acid in the sample mixture that reacts with the titrant (base).
- **The method specifies the use of a base that is not a primary standard, eg NaOH.**

- 2. Give two examples of human error (mistakes)**

- **Incorrect use of equipment. For example:**
  - Not filling the volumetric flask to the mark by overshooting or undershooting the mark.
  - Inaccurate measurement of reagents when the experimenter fails to measure the volumes accurately, such as by not properly reading the meniscus in the pipette or burette.
- **Endpoint Determination:** Misjudging the endpoint of the titration is a common source of error. If the colour change of methyl orange, indicating the endpoint, is not observed correctly, it can result in either overshooting or undershooting the actual endpoint, leading to inaccurate measurements of the amount of titrant used.
- **Inadequate Cleaning of Apparatus:** If the burette, pipette, or flask are not properly cleaned before use, residual chemicals from previous experiments could contaminate the solution, altering the reaction and resulting in errors in the titration process. If the wrong apparatus is washed with water dilution can occur
- **Spilling of sample solution as it is delivered into the conical flask.**
- **Leaving the funnel on top of the burette while conducting the titration. These may cause titrant to drip from the funnel into the burette.**
- **Incomplete mixing or failure to mix the solution in the conical flask whilst titrating:** During the titration process, if the solution in the flask is not thoroughly mixed after each addition of titrant, it can result in localized concentrations of the titrant, leading to an inaccurate determination of the endpoint. This can cause inconsistencies in the titration results.
- **Misreading the Burette:** If the person conducting the titration misreads the burette scale due to parallax error or distraction, they may record an incorrect volume of titrant, leading to an inaccurate concentration calculation.

● **Parallax Error:** When reading the volume on the burette, if the observer's eye is not level with the meniscus, a parallax error can occur. This can cause the recorded volume to be slightly higher or lower than the actual volume, leading to inaccurate titration results.

3. Apparatus should be cleaned and rinsed before use. What would you use to rinse the:
- burette **Titrant solution**
  - conical flask before use? **Distilled water**

4. The volumetric flask was washed and rinsed with pure water. Some of this water remained in the flask when it was weighed in step 2. Explain what effect this would have on the final calculated percentage by mass.

**No impact on the final result. The mass of the brick cleaner can still be determined as the mass of the volumetric flask, before and after addition of brick cleaner is accurately known.**

5. Give two reasons why a diluted solution of the brick cleaner was prepared in steps 2 -6 for later use in the titrations.

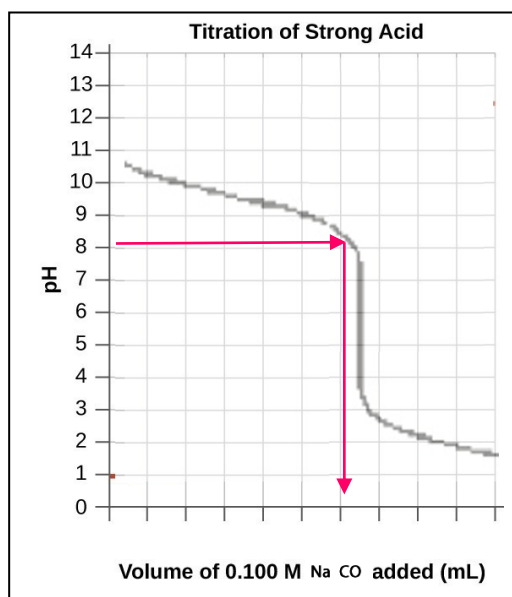
**The two of the below options but not limited to these.**

● **Improves Accuracy:** A diluted solution requires a larger volume of titrant to reach the endpoint, which improves measurement accuracy. Small errors in titrant volume have less impact on the final result when larger volumes are used.

● **Avoids Burette Refilling during the titration:** Diluted solutions require a greater volume of titrant, which reduces the need for frequent refilling of the burette during titration. This makes the process more efficient and less prone to interruptions, which could introduce errors.

6. Methyl orange was the chosen indicator. It changes colour at pH = 3.1 to 4.5 but determining the correct colour is difficult. Phenolphthalein indicator has a very distinct colour change from pink in basic to clear in acidic solutions. The colour change occurs at pH = 8 to 10.

- a. Draw a pH curve for the reaction between  $\text{Na}_2\text{CO}_3$  and HCl in the space provided on the right.



- a. Is phenolphthalein a suitable indicator for this titration? Justify your answer with reference to the pH curve drawn as the answer to question a. above and give the appropriate colour change.

**Phenolphthalein is pink in basic solution and turns clear at pH below 8.0.**

**Using the pH curve drawn as the solution to question a. Phenolphthalein will turn from pink to clear at pH 8. This is just before the equivalence point, which lies on the steep part of the pH curve and as such the volume of titrant added to achieve the end point may not reflect accurately the volume needed to achieve the equivalence point.**

7. Differentiate between the terms 'equivalence point' and 'end point' in a volumetric analysis using your experiment to illustrate the difference.

*The equivalence point represents the exact stoichiometric ratio between the reacting species according to the balanced chemical equation. It is the point where the titration should ideally stop. The endpoint is the practical point at which the titration is stopped. This occurs via a visual cue, typically when an indicator changes colour. It is ideally very close to the equivalence point, but not always the same.*

8.  $\text{Na}_2\text{CO}_3$  is described as a "**primary standard**" while the  $\text{Na}_2\text{CO}_3$  solution used in the experiment is said to be a "standard solution"?

- a. Explain what these two terms means to clearly show the difference between them?

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*A primary standard is a highly pure, stable, and non-hygroscopic chemical substance that can be used to prepare a standard solution with a known concentration. It must have a known and constant composition, and its purity should be well-established.*

*A standard solution is a solution of known concentration, which is used in titrations to determine the concentration of an unknown solution. It is prepared either by dissolving a primary standard in a solvent (usually water) or by standardizing a solution against a primary standard where you're essentially preparing a standard solution with a known and accurate concentration with which to titrate the unknown solution with.*

- b. What three characteristics should a compound have to be considered as a primary standard.

- *High Purity: The substance must be very pure, with no impurities that could affect the accuracy of measurements.*
- *Stability: It should be stable over time, not absorbing moisture or reacting with air.*
- *Known Composition: The exact chemical composition of the primary standard must be well-defined.*
- *Large Molar Mass: A higher molar mass minimizes weighing errors, as a small weighing error will have a smaller impact on the number of moles.*

*Example:*

- *Sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) for acid-base titrations.*