

Titration Lab Report

Libby Jones

L4 OME

ACDB4011

08/03/2023

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Objective of the Laboratory Exercise

Overview of Titration:

This titration experiment is a process of chemical analysis, it is used to determine an unknown concentration of an acid solution. By adding in calibrated measurements of a known alkaline solution to a precise measured volume of an acid-based solution that contains an indicator. The result is to make each solutions quantity of moles equal to the other. Once a state of equilibrium has been reached, it is known that an acid-base neutralization reaction has taken place. Although it is important to be aware of the many variations of the titration experiment.

Main Tasks/Learning Outcomes:

After one might take part in a titration experiment, they will be able to.

- Adhere to the relevant health and safety requirements for the lab test.
- Familiarise with apparatus, chemicals and procedures.
- Be able to identify the equipment for the titration experiment.
- Describe basic steps to follow for a successful titration experiment.
- Explain why the titration experiment is needed.
- Explain the role indicator plays in this experiment.
- Use the results to calculate concentration of a solution of HCL (hydrochloric acid), using a standard solution of NaOH (sodium hydroxide).

Theory

Concept

The concept of titration is to determine the concentration of a solution that is unidentified, this solution is referred to as an analyte. To achieve this a solution of known concentration is used. The known solution is referred to as a titrant. Often the titrant is added through calibrated measurements to ensure precision of volume is being added to the analyte and indicator solution until visual presence is known of the indicator, signalling that the reaction has reached its end point. At this stage equilibrium is reached between the titrant and analyte solution as enough titrant has been added, meaning the solution has been neutralized and the moles within the analyte are equal to the moles of the titrant. From these results one may then calculate the molarity of the analyte and the moles of each solution, if correct the calculations will give the same resulting answer.

Chemical equation

This chemical equation contains an acid which is HCl (hydrochloric acid) and the base which is NaOH (sodium hydroxide). When the acid and base react, they form table salt although the technical name would be NaCl (sodium chloride) and H₂O (Water).



OME Application

Titration can be applied to Ordnance, munitions and explosives through a chemical reaction called oxidation-reduction reaction. This is where the electrons transfer between each of the reacting subshells. All electron transfers occur along with a change in the oxidation state of the reactants. Redox is a chemical reaction in which the oxidation states are substrate to either change an increase or decrease to the oxidation state, This is the gain or the loss of electrons. When redox titration occurs with transition metals this can display colourful variable oxidation states. The colour changes are sharp and so you do not need an indicator as the colour will indicate when the oxygen reaction state has reached its endpoint. Examples of this would be combustion (Burning), it gains oxygen atoms, and a fuel reacts with this releasing energy. Applying this to OME would be explosive or rapid combustion the display of fire works or other types of explosives. [1] [2]

Chemicals and Equipment

Equipment used,

- Beaker for waste.
- Erlenmeyer (conical) flask.
- White tile.
- Small funnel.
- 10ml pipette with pipette filler.
- 50ml burette.
- Burette stand and clamp.

Chemicals used,

- 100ml of standard sodium hydroxide (NaOH) solution.
- 100ml of sulfuric acid (HCL) solution.
- Phenolphthalein (indicator).
- H₂O (decontamination control).

Procedure

To obtain more accurate results, ensuring cleanliness is vital for no cross-contamination. Thoroughly wash the pipette, burette and Erlenmeyer flask. Once completed begin filling the burette with the NaOH solution until the meniscus is at zero level, no air bubbles should be trapped while doing this. After doing this use the pipette to place 25mL of HCl solution into the flask. Afterwards add 3 – 4 drops of phenolphthalein indicator into the flask and mix carefully. Following this open the burette tap to allow the NaOH solution into the flask. While this is happening gently swirl the flask until the solution turns pink. Once solution is pink record the reading. Complete the above again to gain another reading. Then for the second part of the experiment the NaOH must be run into the indicator mixture until its within 2 mL of what the titration was previously. When this point has been reached set the base to a slower rate, so they can easily read the HCl that is needed to neutralise the solution. At this point take a reading and then complete the above again and ensure 2 results are within 0.06 of each other or 3 results are within 0.10.

Observations of Data

In each observation the upmost consistency and accuracy were maintained. As an example, the HCL was measured and added each time through a pipette this was to ensure precise measurements of the volume rather than a measuring cylinder. This way it gives accuracy to all trials so that the results are consistent to each other. This is represented in figure 1 titration data sheet. If correct results have been obtained and neutralization has taken place leaving the mixed solutions of alkaline and acid in a state of equilibrium, this means that there is the same amount of concentration. The molarity will be balanced for each, this can then be checked if your results are the same for calculating the moles of both HCL and NaOH in all individual tests. This is represented in Table 1.

Calculations

(Figure 1)

STUDENT'S NAME: Libby Jones
 PARTNERS' NAMES: Emalie Halifax

TITRATION DATA SHEET

Molarity of the standard base solution: $M_{\text{NaOH}} = \underline{0.1002 \frac{\text{mol}}{\text{L}}}$

FLASK	1 rough titration	2	3	4
$V_{\text{HCl}}(\text{mL})$ from pipette	25 ml	25 ml	25 ml	25 ml
Initial burette reading	0.2 ml	17.25 ml	24.2 ml	21.4 ml
Final burette reading	17.25 ml	33.3 ml	40.4 ml	37.65 ml
$V_{\text{NaOH}}(\text{mL})$	17.05 ml	16.05 ml	16.2 ml	16.25 ml
moles of NaOH	$1.708 \times 10^{-3} \text{ moles}$	$1.608 \times 10^{-3} \text{ moles}$	$1.623 \times 10^{-3} \text{ moles}$	$1.628 \times 10^{-3} \text{ moles}$
Moles of HCl	$1.708 \times 10^{-3} \text{ moles}$	$1.608 \times 10^{-3} \text{ moles}$	$1.623 \times 10^{-3} \text{ moles}$	$1.628 \times 10^{-3} \text{ moles}$
Molarity of HCl	$6.832 \times 10^{-2} \text{ mol/L}$	$6.432 \times 10^{-2} \text{ mol/L}$	$6.492 \times 10^{-2} \text{ mol/L}$	$6.512 \times 10^{-2} \text{ mol/L}$

Accuracy

You should record pipette and burette readings to the nearest 0.05 cm³ (approximately one drop). Consecutive titrations should agree to within 0.10 cm³ and, you should repeat the titration until this is achieved.

(Table 1)

	1 Rough Titration	2 Rough Titration	3 Rough Titration	4 Rough Titration
Moles of NaOH	$C = 0.1002 \text{ mol L}^{-1}$ $n = ?$ $V = V_F - V_I$ $V = 17.05 - 0.2$ $V = 17.05 \times 10^{-3} \text{ L}$ $n = C \times V$ $n = 0.1002 \times 17.05 \times 10^{-3}$ <u>$n = 1.708 \times 10^{-3} \text{ Moles}$</u>	$C = 0.1002 \text{ mol L}^{-1}$ $n = ?$ $V = V_F - V_I$ $V = 33.3 - 17.25$ $V = 16.05 \times 10^{-3} \text{ L}$ $n = C \times V$ $n = 0.1002 \times 16.05 \times 10^{-3}$ <u>$n = 1.608 \times 10^{-3} \text{ Moles}$</u>	$C = 0.1002 \text{ mol L}^{-1}$ $n = ?$ $V = V_F - V_I$ $V = 40.4 - 24.2$ $V = 16.2 \times 10^{-3} \text{ L}$ $n = C \times V$ $n = 0.1002 \times 16.2 \times 10^{-3}$ <u>$n = 1.623 \times 10^{-3} \text{ Moles}$</u>	$C = 0.1002 \text{ mol L}^{-1}$ $n = ?$ $V = V_F - V_I$ $V = 37.65 - 21.4$ $V = 16.25 \times 10^{-3} \text{ L}$ $n = C \times V$ $n = 0.1002 \times 16.25 \times 10^{-3}$ <u>$n = 1.628 \times 10^{-3} \text{ Moles}$</u>
Moles of HCL	Moles of HCl = Moles of NaOH <u>$1.708 \times 10^{-3} \text{ Moles}$</u>	Moles of HCl = Moles of NaOH <u>$1.608 \times 10^{-3} \text{ Moles}$</u>	Moles of HCl = Moles of NaOH <u>$1.623 \times 10^{-3} \text{ Moles}$</u>	Moles of HCl = Moles of NaOH <u>$1.628 \times 10^{-3} \text{ Moles}$</u>
Molarity of HCL	$C = n / V$ $C = 1.708 \times 10^{-3} / 25 \times 10^{-3}$ $C = 0.06832 \text{ Mol L}^{-1}$ <u>$C = 6.832 \times 10^{-2} \text{ Mol L}^{-1}$</u>	$C = n / V$ $C = 1.608 \times 10^{-3} / 25 \times 10^{-3}$ $C = 0.06432 \text{ Mol L}^{-1}$ <u>$C = 6.432 \times 10^{-2} \text{ Mol L}^{-1}$</u>	$C = n / V$ $C = 1.623 \times 10^{-3} / 25 \times 10^{-3}$ $C = 0.06492 \text{ Mol L}^{-1}$ <u>$C = 6.492 \times 10^{-2} \text{ Mol L}^{-1}$</u>	$C = n / V$ $C = 1.628 \times 10^{-3} / 25 \times 10^{-3}$ $C = 0.06512 \text{ Mol L}^{-1}$ <u>$C = 6.512 \times 10^{-2} \text{ Mol L}^{-1}$</u>

Discussion of Results

Just as any type of titration, neutralisation titrations will always depend on the chemical reaction that occurs between the unknown solution and the standard reagent. Chemical equivalence is achieved by an instrument measurement or chemical indicator and once the colour of the solution changes to the specified colour this means that the titration has reached the final stage of the process. The methods used to obtain the results were as precise as possible. Overall, from the results and readings from the experiment It is clear to see that the protons moved from HCL to NaOH or HCL donated H^+ ions to the solution, which also means that NaOH gave OH^- ions to the solution.

Experimental errors:

- Some NaOH was lost during the experiment through splashing before the end point of titration was reached.
- Equipment may have not been washed thoroughly therefore could have been contaminated.
- Human error when taking the reading on the burette.
- Not taking the reading from the bottom of the meniscus

Conclusion

This experiment is conducted using basic equipment and relies heavily on visual detection. Although this proved to be quite precise. However, some human error is likely to occur through this which could have impacted the validity of the results. The results obtained by the process were as accurate as they could be and showed that moles acid = moles base. In the future this experiment's accuracy and precision could be improved by fitting the burette with a device that could consistently control the flow of NaOH solution. The use of a magnetic stir bar and stir plate would provide even and consistent distribution throughout the experiment. Overall the results obtained are satisfactory due to the two volumetric results of NaOH are within 0.06 of each other.

References

- [1] "BBC Bitesize," BBC, [Online]. Available:
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<https://www.studysmarter.us/explanations/chemistry/inorganic-chemistry/titrations/>.
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