

Titration - Lab 2

By William Critchley

Contents

1. Title page
2. Contents
3. Introduction
4. Method and materials
6. Results
7. Discussion
8. Conclusion
9. References

Introduction

A titration is a neutralisation reaction, this is where an acid and base react to form a salt and water the ones used here is shown in figure 1.

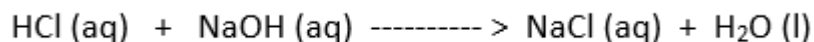


Figure 1

They are used for determining the molarity of a substance. This is done by finding the exact point of neutralisation when the number of moles in one substance matches the number of moles in the other, the number of moles in one of these is known. This point is shown by an indicator that changes colour in a neutral solution. The concentration of the unknown solution can be calculated from the volume used of the unknown solution along with the volume and concentration of the known solution.

The independent variable will be volume of NaOH added and the dependant variable will be the colour of the final solution, with everything else being control variables [1]

The equations used will be

- $M_a V_a = M_b V_b$
- $M = \frac{n}{v}$

Method and Materials

Materials and Equipment required:

- One burette, attached to a burette stand with clamp
- Pipette
- Pipette filler
- Erlenmeyer (conical) flasks
- Small funnel to fill the burette
- Plastic pipette
- Wash bottle with deionised water
- Graduated cylinder
- White paper to compare colour of solution
- Beaker for the waste
- 80 mL of **standard** NaOH (sodium Hydroxide) solution, $M_B = 0.1026 \text{ mol/L}$ in a labelled beaker
- 80 mL HCl (hydrochloric acid) solution with an unknown concentration in a labelled beaker
- Phenolphthalein indicator (colourless in acidic solution, pink in basic solution)

PPE required:

- Lab Coat
- Goggles
- Nitrile gloves
- Any loose items/hair removed or tied back

Method:

1. Wash all glassware
 - a. Wash the pipette first with deionised water and then HCL both if which are discarded
 - b. Wash the Burette again with ionised water and then NaOH and then discarded
 - c. Wash the conical flasks with deionised water
2. Fill the burette with NaHO and then record the initial level, after this remove the funnel as it can drip and affect results
3. Fill the three cleaned conical flasks with 25 mL of HCl

4. Add a few (3-4) drops of Phenolphthalein indicator and 10 mL of deionised water to each flask and mix
5. Open the tap on the burette slowly while swirling the flask until it starts to change to a vibrant pink, shut the valve then record the value of NaOH used
6. Refill the NaOH and record the starting level, then begin another titration but this time stop the flow about 3-5 mL higher than the previous result
7. Then slowly drip the NaOH into the flask and attempt to stop it when the solution in the flask has a very pale pink but there must be a pink tint and record this value
8. Repeat steps 6 and 7 until results vary less than 0.1 mL from each other

Results

Flask	1 (rough titration)	2	3	4
V (HCl) (mL) from pipette	25.00	25.00	25.00	
Initial Burette reading (mL)	0.02	7.7	27.0	
Final Burette reading (mL)	19.60	27.00	46.4	
V (NaOH) (mL)	18.98	19.3	19.4	
Moles of NaOH	1.95×10^{-3}	1.98×10^{-3}	1.99×10^{-3}	
Moles of HCl	1.95×10^{-3}	1.98×10^{-3}	1.99×10^{-3}	
Molarity of HCl	0.078 M	0.0792 M	0.0796 M	

Our key finding was that the HCl had a molarity of approximately 0.0794 after averaging our two precise titrations, we only undertook two precise ones as the total volume of HCl used was within 0.1 mL of each other thereby complying with the final instruction set out in the method.

To calculate the molarity we took the fact the the solution had changed colour as a sign that the number of moles in both the NaOH and HCL was the same, this was then plugged into the equation $M = \frac{n}{v}$ and $M_a V_a = M_b V_b$.

Discussion

This experiment shows that with very basic equipment it is possible with relative accuracy to predict the potential concentration of a solution by using only volume and the known concentrations of another solution. This could potentially be used in the detection and neutralisation of explosive compounds as if its chemical properties can be established eg the ratio of wax to RDX in PE8 plastic explosive you can estimate how powerful a potential blast would be and compare different suppliers' formulae for potential use cases eg more explosive vs wax used in a warhead that needs the highest yield for the smallest space.

It relates to current literature in the way it is a basic test that can be used in a huge range of fields e.g., geochemistry, petrochemical industry, pharmacy and many more.

I believe the main limitation in this test is that it provides quantitative data from a qualitative test, whether the solution has changed colour, this opinion will change depending on the eyesight of the person doing the test along with other human error eg leaving the funnel in the burette allowing extra drops to fall in affecting the reading or incorrectly reading the meniscus.

Conclusions

Overall the experiment achieved what it set out to by calculating the molarity of a solution which has an unknown number of moles, it came to a precise conclusion and is easily repeatable. Ways it could be improved would be using a refractometer to test when the solution is changing colour more accurately, potential future research could lead in the directions of explosives analysis and breakdown by identifying a compounds properties by its concentration and then ways it could be used, disposed of or classified.

References

[1] The editors of encyclopaedia britannica (March 8th 2024), "titration." Encyclopedia Britannica [online], Available: <https://www.britannica.com/science/titration>

[2]