Experiment 6

Acid Base Titration

Summary (from the Lab Manual and the Techniques Tutorial)

Volumetric analysis (VA) is a quantitative analytical process based on measuring volumes. The most common form of VA is the titration, a process whereby a **standard solution** of known concentration is chemically reacted with a solution of unknown concentration in order to determine the concentration of the unknown. In the first part of this experiment KHP (the standard) is reacted with sodium hydroxide (concentration unknown) until the reaction between the two compounds reaches completion (called the "end-point" of the titration). The endpoint occurs when the first **pale** pink colour appears in the colourless solution and stays (upon swirling) for 30 – 60 seconds. Once the sodium hydroxide solution has been standardized, it can then be used to standardize a hydrochloric acid solution of unknown concentration.

Measurements in VA must be **accurate to at least 4 significant digits** to ensure correct results. As you perform each step in this experiment, think about whether every instrument you use fulfills this requirement. Make sure that you **maintain this level of accuracy** when transferring reagents from one container to another.

Each titration will be performed on a 25.00mL sample of solution (the 25.00 mL pipet is the only one available in the lab). Think about the following requirements to ensure accuracy of the titrations:

- The volume of the titrant used in the titration should be at least 10.00mL (why?)
- In a titration, the most accurate results are obtained when similar volumes of the titrant and titrated sample are used (what would be an ideal volume of the titrant?)
- The capacity of a buret is 50.00mL. If the buret needs to be re-filled during the titration, an additional opportunity for introducing an error is created.
- If the concentrations of the titrant and the titrated sample are very different, and a 25.00mL sample is used, how would you ensure that the volume of the titrant is about 25 mL?
    - If the solution of the unknown (HCl) needs to be diluted, the dilution should be performed with quantitative precision (using a pipet and a volumetric flask). Why?
    - If the solution of the NaOH needs to be diluted for the purpose of standardization with the KHP standard, that dilution should be done with a graduated cylinder (quantitative dilution is not required) Why?

Problem 1

Using the Virtual Laboratory design and perform an experiment to determine the concentration of the unknown HCl solution to four significant figures. The concentrations of the HCl and NaOH are ~ 0.1M and ~ 1M, respectively. Solid KHP is provided.

- Preparation of the standard KHP solution

  (a) Toggle the Transfer Bar to Precise Transfer (Tools→Transfer Bar→Precise Transfer). Since we are working in the Precise Transfer mode, we will prepare the standard solution directly in a volumetric flask, and not following the accurate laboratory technique.
  (b) Retrieve the KHP container and a volumetric flask. Pour the calculated amount of KHP into the flask, by typing the mass of KHP with four decimal places into the Transfer Bar below the workbench. Retrieve distilled water and add 50mL of it to the volumetric flask. Check the volume of solution in the information window on the right. Use it as a guide to determine how much water to add to fill up the volumetric flask to the mark. The standard solution is now ready to use.

- Titrations

  This problem should be done with the Transfer Bar toggled to Significant Figures Transfer (Tools→Transfer Bar→Significant Figures) to ensure the choice of appropriate glassware. In this mode the Transfer Bar below the workbench will accept only values that reflect the accuracy of the glassware being used. For example:

  - When you transfer a solution from a 25 mL pipet, type 25.00.
  - Use a disposable pipet to deliver about 0.2mL phenolphtalein for each titration.
  - When you attempt to pour a solution directly from an Erlenmeyer flask, type 40 and you will only be able to transfer 40+/- 10 mL (do it to fill your buret).

  The **Solution Info** window on the right will show only an approximate volume in the recipient flask. All volumes used in calculations should be read directly in the detailed view of the glassware on the workbench (you will see a scale when your buret is highlighted).

  Once you have prepared a sample for a titration you may duplicate it as many times as you want to avoid repeated preparation of the same solution. Right click on the solution and highlight "duplicate". Right click again to rename your sample (Sample 1).

  Check your results using the Precise Transfer mode.

For the Experimental Design sheet, outline your procedure and list the glassware used in each step. If in any step you diluted the reagents provided, what glassware did you use, and why?

Problem 2

Using the Virtual Laboratory, design an experiment to determine the concentration of the unknown HCl solution to four significant figures. The concentrations of the HCl and NaOH are ~ 1M and ~ 0.1M, respectively. Solid KHP is provided (prepare the standard solution as per Problem 1). If you feel confident in your ability to choose correct glassware, use the "Precise Transfer Mode" for the titration. Also note that the HCl and NaOH concentrations are different from Problem 1.

For the Experimental Design sheet, outline your procedure and list the glassware used in each step. If in any step you diluted the reagents provided, what glassware did you use, and why?

Problem 3

Using the Virtual Laboratory, design an experiment to quickly determine which of the two reagents, HCl or NaOH, is 10 times more concentrated than the other. Then follow the procedure you have devised for Problem 1 or Problem 2, whichever is appropriate in the current scenario, to determine the concentration of the unknown HCl solution to four significant figures.

If you feel confident in your ability to choose correct glassware, use the "Precise Transfer Mode" for the titration.

Virtual Lab – Experiment 6

Data Sheet

Use this sheet to record your data, observations and answers. You may use this sheet in the lab.

Exp6 Problem 1

Procedure

1. Write the steps you used to determine the concentration of the unknown HCl solution. List the glassware used in each step.

2. If you diluted any of the reagents list the glassware you used to do it. Explain the reasons for using the glassware.

Data Tables

Prepare a table(s) of the data you collected. Be sure to add a title to your table and include units of measurement and significant figures.

Calculations

Show how you calculated the concentrations of NaOH and HCl.

Conclusion: The concentration of NaOH _____ HCl _____

Exp6 Problem 2

Procedure

1. Write the steps you used to determine the concentration of the unknown HCl solution. List the glassware used in each step.

2. If you diluted any of the reagents list the glassware you used to do it. Explain the reasons for using the glassware.

Data Tables

Prepare a table(s) of the data you collected. Be sure to add a title to your table and include units of measurement and significant figures.

Calculations

Show how you calculated the concentrations of NaOH and HCl.

Conclusion: The concentration of NaOH _____ HCl _____

Exp6 Problem 3

Procedure

1. Write the steps you used to determine which of the reagents, HCl or NaOH, is ten times more concentrated than the other. List the glassware required for this task.

2. State whether you used Problem 1 or Problem 2 procedure to determine the concentration of the unknown HCl solution.

Conclusion: The concentration of NaOH _____ HCl _____