ACID BASE TITRATION

OBJECTIVES

1. To demonstrate the basic laboratory technique of titration
2. To learn to calculate molarity based on titrations

INTRODUCTION

Molarity (M) or molar concentration is a common unit for expressing the concentration of solutions. It is defined as the number of moles of solute per liter of solution (or millimoles of solute per milliliter of solution).

The concentration of a basic solution can be determined by titrating it with a volume of a standard acid solution (of known concentration) required to neutralize it. The purpose of the titration is the detection of the equivalence point, the point at which chemically equivalent amounts of the reactants have been mixed. The amount of reactants that have been mixed at the equivalence point depends on the stoichiometry of the reaction.

In the neutralization reaction of HCl and NaOH, the equivalence point occurs when one mole of HCl reacts with one mole of NaOH. However, in the reaction of H_3PO_4 and NaOH, the equivalence point occurs when one mole of H_3PO_4 reacts with 3 moles of NaOH.

$$HCl \ + \ NaOH \ -----> \ NaCl \ + \ H_2O \qquad\qquad (1)$$

$$H_3PO_4 \ + \ NaOH \ -----> \ Na_3PO_4 \ + \ 3\ H_2O \qquad\qquad (2)$$
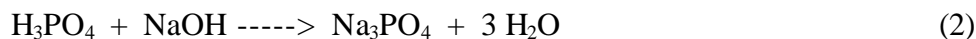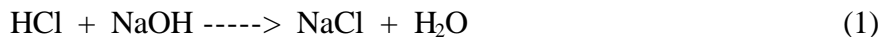
For example, the titration of 16.00 mL of 0.184 M HCl requires 25.00 mL of a NaOH solution. To find the molarity (molar concentration) of the NaOH solution:

$$0.01600 \text{ L HCl} \ \ x \ \ \underline{\frac{0.184 \text{ moles HCl}}{1 \text{ L solution}}} = 0.00294 \text{ moles HCl} \qquad\qquad (3)$$

$$0.00294 \text{ mol HCl} \ \ x \ \ \underline{\frac{1 \text{ mole NaOH}}{1 \text{ mole HCl}}} = 0.00294 \text{ moles NaOH} \qquad\qquad (4)$$

$$\frac{0.00294 \text{ moles NaOH}}{0.02500 \text{ L NaOH}} = 0.118 \text{ M NaOH} \qquad\qquad (5)$$

To determine when neutralization occurs, an indicator such as phenolphthalein can be used. An indicator is a substance which undergoes a distinct color change at or near the equivalence point. The point at which the indicator changes color and the titration is stopped is called the endpoint. Ideally, the endpoint should coincide with the equivalence point. Phenolphthalein is colorless in acidic solution and reddish violet in basic solution.

PROCEDURE

   In this experiment, you will determine the molarity of the NaOH solution which has been previously prepared in Experiment 8. You will do this by using the NaOH solution as a titrant and titrate standard acid solution until you reach the endpoint.

   Two standard acid solutions (HNO_3 and H_2SO_4) of 0.105 M will be available. The volumes of NaOH required to neutralize the acid solution will be tabulated and compared.

   Rinse the 50 mL buret three times with deionized water, and then twice with about 5 mL of the sodium hydroxide solution. Clamp the buret in position and fill the buret to just above the zero mark with the basic solution. Be sure to let any bubbles out of the tip of the buret. Bring the NaOH solution meniscus down to or below the zero mark, read, and record the buret reading to the nearest 0.02 mL.

   Use a graduated cylinder to add 20.0 mL portions of the standard acid solution to each of three clean Erlenmeyer flasks. Add 2-3 drops of phenolphthalein (PTH) to each flask. Set one flask under the buret, and add sodium hydroxide slowly, swirling the flask constantly. As you approach the endpoint, a pink spot, indicating a local excess of the titrant, will grow in size. Slow down the rate of addition of sodium hydroxide when a pink color begins to persist momentarily outside the place where the solutions mix. Proceed dropwise from this point. Before the endpoint is reached, a temporary pink color will be seen where the NaOH drop hits the bulk solution. Stop as soon as the first permanent pale pink color appears. This is the endpoint. Read the buret to the nearest 0.02 mL and record the reading. Repeat with the other two flasks. Calculate the molarity of the NaOH solution separately for each titration.

ACID BASE TITRATION
LABORATORY REPORT

NAME:_____

DATE:_____

FORMULA OF ACID USED:_____

Write the balanced equation to represent this neutralization reaction.

	<u>Trial 1</u>	<u>Trial 2</u>	<u>Trial 3</u>
Volume of acid used	_____	_____	_____
Molarity of acid used	_____	_____	_____
Initial buret reading	_____	_____	_____
Final buret reading	_____	_____	_____
Volume of NaOH used	_____	_____	_____
Molarity of NaOH sol'n	_____	_____	_____

AVERAGE MOLARITY OF NaOH _____

Class results:	HNO_3	H_2SO_4
Volume of NaOH used	_____	_____
	_____	_____
	_____	_____

Show a sample calculation of NaOH molarity:

QUESTIONS

1. HNO_3 and H_2SO_4 have the same molarity. Why did H_2SO_4 require about twice the volume of NaOH solution for the titration?

2. Explain the effect of each of the following sources of error on the molarity of NaOH as determined in this experiment stating whether the concentration of NaOH obtained would be too high or too low.

   a. The buret is contaminated with an acid solution.

   b. The buret contains a large air bubble in the tip, which disappears in the course of the titration.

   c. A small volume of the acid solution is spilled when you transfer it into the Erlenmeyer flask.

3. Using the molarity of the NaOH solution obtained from your titration, calculate the molarity of a 26.0 mL of CH_3COOH solution that requires 32.50 mL of NaOH to reach the endpoint.