1. Acid - Base Titration: Reaction of NaOH with HCl

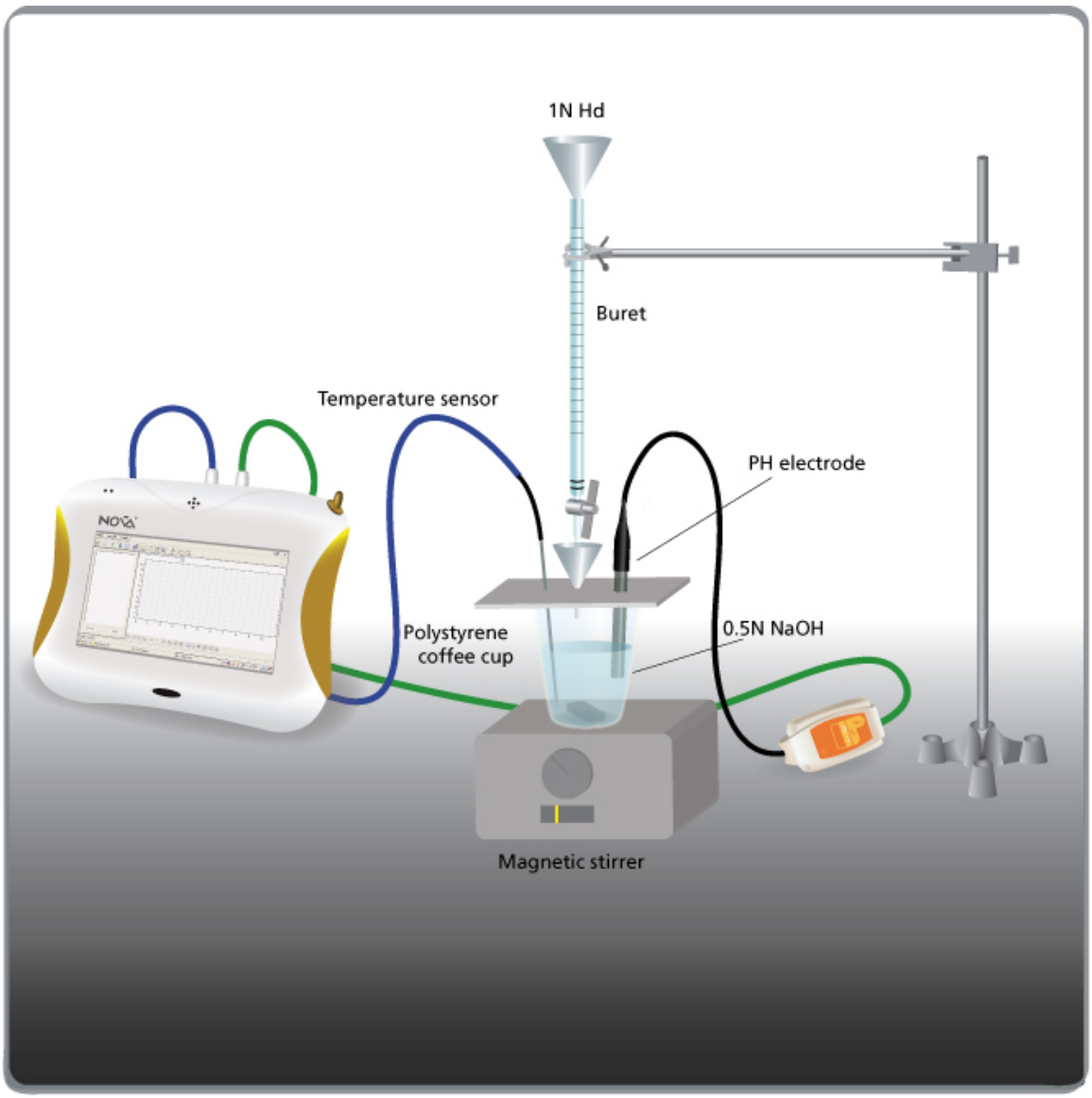

Figure 1

Introduction

In aqueous solutions, addition of bases to water leads to an increase in the pH of the solution, while the addition of acids leads to a decrease in the pH. The changes in the pH can be followed using either specific dyes, called indicators, or a pH electrode. Acids and bases neutralize, or reverse, the action of one another. By adding a known amount

of acid to a basic solution, until it completely reacts with it, the amount of the base can be determined. This procedure is called: Acid - Base Titration. During neutralization, acids and bases react with each other to produce ionic substances, called salts.

In this experiment, changes in pH and temperature, occurring while an acid (hydrochloric acid) is added to a base (sodium hydroxide) solution, are followed using a pH electrode and a Temperature sensor.

Equipment

- Nova5000
- A pH electrode
- A Temperature sensor (-25 °C to 110 °C)
- A polystyrene coffee cup
- 50 ml buret pipette
- A glass funnel
- 2 g NaOH
- 100 ml NHCl solution
- Magnetic stirrer

Equipment Setup Procedure

1. Launch MultiLab.
2. Connect the pH electrode to Input 1 (I/O-1) of the Nova5000.
3. Connect the Temperature sensor to Input 2 (I/O-2) of the Nova5000.
4. Assemble the equipment as illustrated in Figure 1.
5. Click **Setup**  on the main toolbar and program the data logger according to the setup specified below.

Data Logger Setup

Sensors:

Input 1:	pH
Input 2:	Temperature (-25 °C to 110 °C)

Rate:

Every second

Samples:

2000 samples

Experimental Procedure

1. Prepare a polystyrene cover for the polystyrene coffee cup. The cover should be flat and larger than the circumference of the coffee cup (see Figure 1).
2. Pierce three holes in the cover: One for the pH electrode, one for the Temperature sensor and one for the glass funnel.
3. Add 50 ml 0.5 N NaOH solution to the coffee cup.
4. Place the coffee cup on a magnetic stirrer.
5. Place the cover on the cup.
6. Click **Run**  on the upper toolbar to begin recording data.
7. Wait until readings from the sensors are stable.
8. Start stirring the NaOH solution in the coffee cup.
9. Add, drop-by-drop, 1 N HCl solution from the buret to the cup, through the glass funnel.
10. Follow changes in pH and temperature registered on the monitor.
11. As the pH just starts to change, stop the flow of HCl. Find the volume of HCl added until that point.
12. Renew the flow of HCl. Follow pH changes very carefully.
13. Stop immediately the flow of HCl as the pH level stabilizes.

14. Save your data by clicking **Save**  on the upper toolbar.

Data Analysis

1. Use the First cursor  and Second cursor  to display the change in the pH obtained during the neutralization process.

   What was the initial pH value? The final value? The difference between the two values?

The Cursor: *You can display up to two cursors on the graph simultaneously.*

Use the first cursor to display individual data recording values, to select a curve or to reveal the hidden Y-axis.

Use two cursors to display the difference between two coordinate values or to select a range of data points.

To display the First cursor: *Double click on an individual data point or click First cursor*  *on the graph toolbar. You can drag the cursor with the mouse onto any other point on the plot, or onto a different plot. For finer cursor movements click* ***Forward***  *and* ***Backward***  *cursor.*

The coordinate values of the selected point will appear in the information bar at the bottom of the graph window.

To display the Second cursor: *Double click again anywhere on the graph area or click Second cursor*  *.*

The information bar will now display the difference between the two coordinate values.

To remove the cursors*: Click*  *to remove the Second cursor and click*  *to remove the First cursor.*

2. What was the volume of HCl added until the pH started to change? Compare it with the volume of HCl added until a complete neutralization of NaOH was achieved.
3. Use the graph cursors to find the time interval between the point of start of change in pH and the point of pH start of stabilization.

4. Use the graph cursors to display the change in temperature obtained in the process and the time needed to reach the final temperature value.
5. Calculate the heat of reaction: C- water capacity, ΔT - temperature change.

$$Q = mc\Delta T$$

Note: *Water specific heat capacity at 25 °C is 4.18 (J/g*°C).*

An example of the graph obtained in this experiment is shown below:

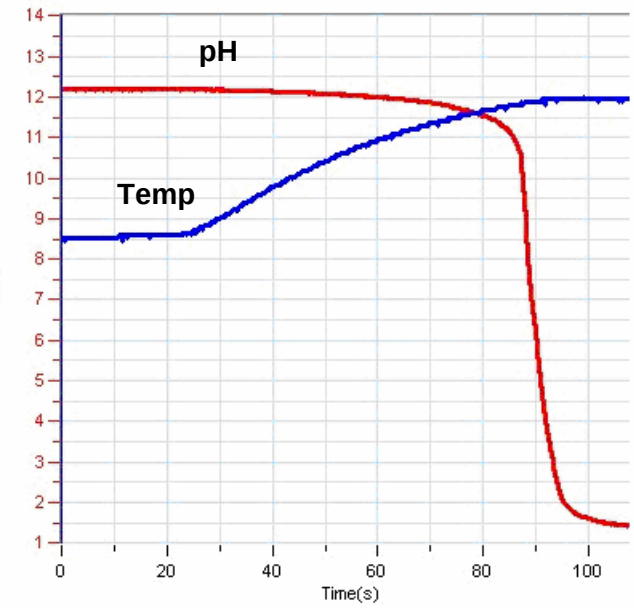

Figure 2

Questions

1. Did you observe a fast pH change? Explain the difference in the short time interval needed for the completion of the drastic changes of pH and that of the whole neutralization process.
2. Is the neutralization reaction an exothermic reaction? Base your conclusions on the experiment you performed.
3. Try to assume the results of acid - base reaction at different concentrations of NaOH added to the coffee cup. What will be the pH change in each case? What will be the extent of change in the temperature?
4. What will be the effect of reacting other acids (such as, for example, acetic acid) with NaOH?

Further Suggestions

1. React different concentrations of NaOH with a constant concentration of HCl.
2. Calculate unknown concentrations of the titrated NaOH (or HCl). This can be achieved by setting the flow of acid (or base) from the Buret pipette at a constant rate (from the time interval on X axis multiplied by the flow rate, the volume added, can be calculated).
3. Examine the effect of increasing the water and/or the surrounding temperature, on the reaction.
4. Perform Acid - Base reaction with different types of acids and/or bases: A weak acid with a strong base and vice versa.