Name_________________________ Section_____________

Partner(s)______________________ Date______________

CONDUCTOMETRIC MEASUREMENTS

PRE-LAB QUERIES

1. Why did you get a difference in the voltage readings for the 0.01M acetic acid and 0.01M hydrochloric acid solutions using the “home-made” conductivity probe in the previous lab activity *An Investigation of Electrochemical Reactions*?

2. Complete the following neutralization reactions:

   HCl + NaOH →

   CH_3COOH + NH_3 →

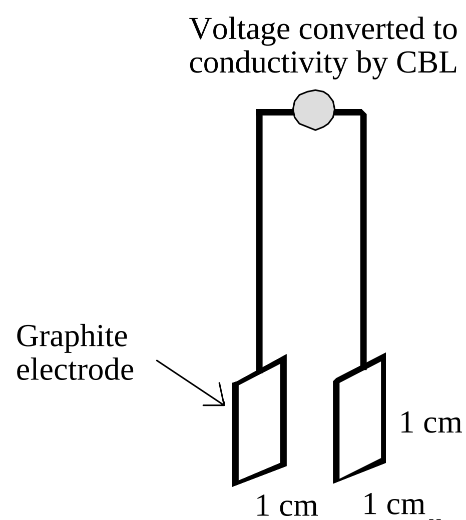
OBJECT

In this activity, the conductivity of solutions will be measured for the dilutions of strong and weak electrolytes, and a titration of a weak acid with a weak base will be performed. The measurement of the equivalence point of the weak acid-weak base titration, considered infeasible by potentiometric means, will be accomplished by graphical analysis. This activity will use Vernier Software conductivity probe along with the Texas Instrument (TI) Calculator-Based Laboratory (CBL) and TI-83 or TI-83 Plus calculator.

INTRODUCTION

The conductivity of a solution depends on the following factors in the specified manner:

1. directly on the surface area of the electrodes;
2. inversely on the distance between the electrodes;
3. directly on concentration of the ions in solution;
4. directly on the mobility of the ions; and
5. directly on the temperature.



Conductivity, in units of microsiemens per centimeter (μS/cm), is measured with a probe using graphite electrodes (fairly inert) with an alternating current used to prevent electrolysis. Earlier activities used steel paper clips. The paper clips corrode (oxidize) due to the applied direct current. With the Vernier conductivity probe, the first two factors listed above are held constant for all measurements. The conductivity probe can be calibrated with a conductivity standard for exact measurements or can be used to determine relative differences as applied in this activity. The probe also has automatic temperature compensation that corrects for any temperatures between 5-35^{o}C and references conductivities to 25^{o}C

Why is it critical not to change the spacing between the electrodes in a conductivity cell?

PROCEDURE

Set up the conductivity probe with the CBL and TI-83 calculator. The conductivity probe requires a DIN adapter, which is to be plugged into CH1 on the CBL. The calculator will need the Vernier Software program CHEMBIO loaded on it. Your instructor will provide the program. Use the link cable to link the CBL to your TI-83 calculator.

<u>General CBL and TI-83 Settings</u>

Use the **[PRGM]** on the TI-83 or **[APPS]** on the TI-83 Plus to select the program CHEMBIO. Select the "Set up probes" from the menu and follow the steps. Select the "use stored" calibration. After the probe is ready for use, select the "Collect data" option and choose the trigger/prompt. When the CBL has stabilized push the trigger button on CBL and then enter the x-variable (concentration or volume).

Experiment	Setting of range switch on probe	Set up choice in program
Part I - hydrochloric acid	0-20,000 μS/cm	5
Part I - acetic acid	0-2000 μS/cm	3
Part II - titration	0-20,000 μS/cm	5

How will conductivity change on dilution? Will the change be the same for HCl and CH_3COOH?

Now let's explore the behavior.

Part I - Dilution Behavior of Electrolytes

1. Obtain 25-30 mL of 0.010M HCl and measure its conductivity using the CHEMBIO program. Be sure that the opening for the graphite electrodes is completely covered by the solution. Dilute the 0.010M HCl by placing 25 mL of 0.010 M HCl into a graduated cylinder and bring the volume up to 50 mL with distilled water. Measure the conductivity.

   Repeat the dilution process four more times. After the last datum point, choose graph data to see the plot. Then press **[ENTER]** NO and QUIT. Use **[STAT]** EDIT to retrieve the lists of data (L_1 - concentration and L_2 - conductivity). Record the data in the table. Rinse the probe with distilled water.

2. Obtain 25-30 mL of vinegar, 0.83M acetic acid, and measure its conductivity using the CHEMBIO program. Based on the behavior of HCl, **predict** the acetic acid conductivity when it is diluted in half (25 mL acid + 25 mL water). Perform the dilutions five times measuring the conductivity after each dilution. After the last datum point, choose graph data to see the plot. Then press **[ENTER]** NO and QUIT. Use **[STAT]** EDIT to retrieve the lists of data (L_1 - concentration and L_2 - conductivity). Record the data in the table. Rinse the probe with distilled water.

Part II - Titration of Acetic Acid in Vinegar with Ammonia

3. Place 15.0 mL vinegar in a 150 mL beaker and add 25 mL distilled water. Place the conductivity probe in the beaker and have the CHEMBIO program ready for measurement. Record the initial conductivity. From a buret, add the volumes of ammonia shown in the data table. Mix before triggering the conductivity reading! When finished, rinse probe with distilled water. Retrieve data as described above (L_1 - volume and L_2 - conductivity). Press 2nd HALT on the CBL to turn it off!

DATA

Part I - Dilution Behavior of Electrolytes

HYDROCHLORIC ACID		ACETIC ACID	
Concentration	**Conductivity**	**Concentration**	**Conductivity**
0.010M		0.83M	
0.0050		0.42	
0.0025		0.21	
0.0013		0.10	
0.00063		0.052	
0.00031		0.026	

Prediction for 0.42 M CH_3COOH conductivity: ___________

Part II - Titration of Acetic Acid with Ammonia

Volume	Conductivity	Volume	Conductivity
0		26	
2		28	
4		30	
6		32	
8		34	
10		36	
12		38	
14		40	
16		42	
18		44	
20		46	
22		48	
24		50	

RESULTS

1. Generate the following graphs of the data:
   a. conductivity vs. concentration of HCl
   b. conductivity vs. concentration of CH_3COOH
   c. conductivity vs. volume of NH_3

2. Explain the difference in conductivity behavior between the HCl and CH_3COOH.

3. Determine the equivalence point of the CH_3COOH - NH_3 titration. Calculate the concentration of ammonia assuming the vinegar is 0.83 M CH_3COOH.

CONCLUSIONS

Explain the behavior occurring during each section of the piece-wise function of the curve for the conductometric titration of CH_3COOH with NH_3.

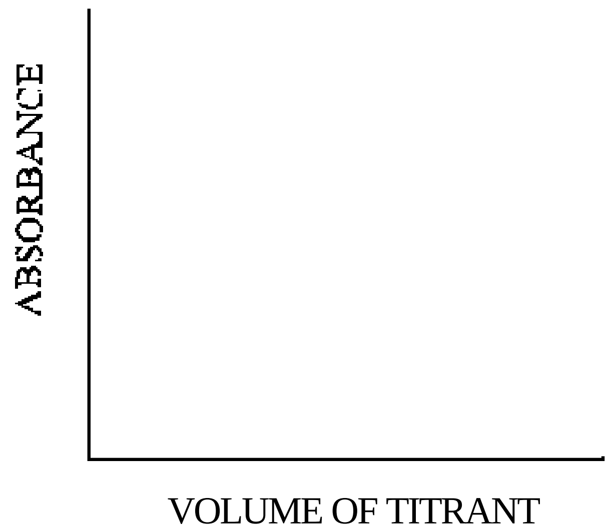
POST-LAB QUESTIONS

1. On your conductivity vs. concentration graph for acetic acid, sketch a dashed line/curve for the behavior of sugar, a non-electrolyte.

2. Suppose a spectrophotometric titration was performed as outlined by the general reaction below:

ANALYTE	+	TITRANT	→	PRODUCTS
intense color		colorless		colorless

Sketch a graph of absorbance vs. volume of titrant.



3. Why is the potentiometric titration of acetic acid with ammonia considered infeasible?

4. The old soda-acid fire extinguishers were pressurized by carbon dioxide to force the aqueous solution out onto the fire by the reaction below:

$$H_2SO_4(aq) + 2NaHCO_3(aq) \rightarrow Na_2SO_4(aq) + 2H_2O + 2CO_2(g)$$

Explain the warning found on the extinguisher: DO NOT USE ON ELECTRICAL FIRES!