Lab Session 7, Experiment 6: Acid-Base Titration

Molarity (M) and normality (N) are two means of expressing solute concentrations. Molarity is defined as moles of solute per liter of solution, and in a similar way, normality is defined as equivalents (eq) of solute per liter of solution. From these definitions we may write the following:

$$M = \frac{moles}{L} \text{, or by rearrangement,} \quad M \times L = moles$$

$$N = \frac{eq}{L} \text{, or by rearrangement,} \quad N \times L = eq$$

$$N = \frac{millequivalents \text{ (or meq)}}{mL} \text{, or by rearrangement,} \quad N \times mL = meq$$

In this experiment, we will consider only acid-base reactions. Your instructor will define the quantity of an acid that is an equivalent and the quantity of a base that is an equivalent. Let us stress here that one eq (or meq) of an acid reacts exactly with one eq (or meq) or a base. Whatever the number of eq (or meq) of acid, the same number of eq (or meq) of base will be consumed in the reaction. Thus,

$$meq_{acid} = meq_{base}$$

$$mL_{acid} \times N_{acid} = mL_{base} \times N_{base}$$

Assume that 20.00 mL of 0.3000 N acid requires 30.00 mL of base. Then,

$$N_{base} = \frac{mL_{acid} \times N_{acid}}{mL_{base}} = \frac{20.00 \times 0.3000}{30.00} = 0.2000 \text{ N}$$

Our assumed case may be stated as follows: The titration of 20.00 mL of 0.3000 N acid requires 30.00 mL of 0.2000 N base.

Titration is the precise measurement of the volume of one reagent required to react with a mass or volume of another reagent. As in the titration described above, the solution of base would be added from a burette to the acid until the acid is just neutralized. You will use the indicator phenolphthalein, which is colorless in acid and pink in base, to indicate when the acid is just neutralized. Two or three drops of phenolphthalein are added to the acid before the titration is begun. This colorless solution turns pink when, as a result of base addition from the burette, the solution changes from acidic to barely basic. When the color change appears, the burette is read to obtain the volume of base added.

6A Experiment

In this experiment, you will use a standardized NaOH solution to titrate against an aqueous acetic acid unknown in order to determine the normality of the acetic acid solution.

1. You will be provided with three chemicals:
    (1) An NaOH standard solution of known normality (approximately 0.21 N). The exact normality should be recorded in the data table.
    (2) Acetic acid, CH_3CO_2H, of unknown normality. This is to be prepared by the stockroom personnel by diluting 12 mL of concentrated acetic acid to one liter.
    (3) Phenolphthalein in a dropper bottle.

2. Clean and empty the burette, rinse with and then fill with the acetic acid.

3. Draw off three 15.00 mL samples of acetic acid into three Erlenmeyer flasks. You may use either size flask, 125 mL and/or 250 mL.

4. Add 2-3 drops of indicator to each sample.

5. Clean and empty the burette, rinse with and then fill with the NaOH solution.

6. Titrate each acid sample to the phenolphthalein end-point. Complete the data table below for each of the three titrations.

	Titrations				
	1	**2**	**3**		
N_{base}					
mL_{acid}					
mL_{base}				**Averages**	
N_{acid}				N_{acid}	
% deviation				% deviation	

6B Exercise

1. Calculate the grams of acetic acid in one liter of solution.

2. The density of the acetic acid solution is 1.00 g/mL. Calculate the percentage of acetic acid in the solution.

3. Give the equations for the neutralization of $HCl_{(aq)}$ and $CH_3CO_2H_{(aq)}$ with $NaOH_{(aq)}$.

Be sure to clean your burette and rinse it with deionized water before you return it to the hood.
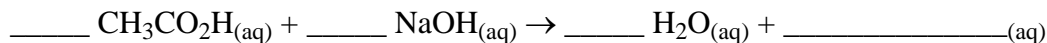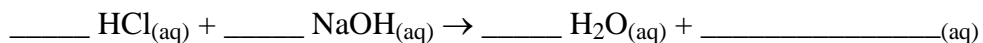
Report Form 6: Acid-Base Titration

Name_____

Partner_____Section #_____

6A Experiment

	Titrations				
	1	**2**	**3**		
N_{base}					
mL_{acid}					
mL_{base}				**Averages**	
N_{acid}				N_{acid}	
% deviation				% deviation	

6B Exercise

1. Grams of acetic acid in one liter of solution _____ g

2. Percentage of acetic acid in the solution _____ %

3. Balanced Neutralization equations

_____ $HCl_{(aq)}$ + _____ $NaOH_{(aq)} \rightarrow$ _____ $H_2O_{(aq)}$ + _____(aq)

_____ $CH_3CO_2H_{(aq)}$ + _____ $NaOH_{(aq)} \rightarrow$ _____ $H_2O_{(aq)}$ + _____(aq)

Note: In the above table, if N_1, N_2 and N_3 are the values of N_{acid} for the individual titrations,

Average $N_{acid} = \dfrac{N_1 + N_2 + N_3}{3}$

Defining N_{avg} = average N_{acid}, the % deviations for the individual titrations are

% D1 $= \dfrac{|N_1 - N_{avg}|}{N_{avg}}$ X 100,   % D2 $= \dfrac{|N_2 - N_{avg}|}{N_{avg}}$ X 100,   % D3 $= \dfrac{|N_3 - N_{avg}|}{N_{avg}}$ X 100

The average % deviation, therefore, is

Average % deviation $= \dfrac{\%D1 + \%D2 + \%D3}{3}$