EXPERIMENT 4

TITRATION OF AN UNKNOWN ACID

The reaction of an acid and a base to form a salt and water is known as neutralization. In this experiment you will titrate an known amount of KHP with an unknown molarity of NaOH. You will then be able to determine the molarity of the NaOH. Once it is confirmed that this initial titration was done correctly you will be asked to titrate a known mass of an unknown acid. The reaction of an acid and a base forms water according to the following reaction,

$$HCl + NaOH \rightarrow Na^{+} + Cl^{-} + H_2O$$

When the number of moles of acid equal the number of moles of base the solution is said to be neutralized. This does not always mean that the solution is neutral (pH = 7), except for the special case where we are using strong acids and bases. For weak acids and bases the solution will be either slightly basic or acidic.

EXPERIMENT: Make 500 mL of approximately 0.10 M NaOH by taking pouring about 10 mL of 6 M NaOH into a Florence flask and adding about 500 mL of water. Exact amounts are not important. You will titrate this solution to determine the exact concentration.

Save this solution! You will need it for the next experiment.

Rinse a buret with two 5-10 mL portions of NaOH, and then fill the buret with NaOH. Open the tip of the buret and allow some of the NaOH to flow through it. This will fill the tip and remove bubbles that might be present. Make sure there are no bubbles in the tip. Add more NaOH if necessary and adjust the volume until the BOTTOM of the meniscus is at or just under the 0.00 mL mark at the top of the buret. Record this as the starting volume (s).

Place 0.600 to 0.700 grams of KHP in a 125 or 250 mL flask and add about 30 mL of distilled water and swirl to dissolve the KHP. Do not be concerned if all of the KHP does not initially dissolve. Add three drops of phenolphthalein to the flask and titrate KHP with your standardized NaOH to the pink phenolphthalein endpoint. Near the end-point the pink color of the indicator will begin to persist longer and longer while you swirl the flask. The end-point is found when the solution remains pink for at least 30 seconds. This pink color should be barely detectable. Allow a minute or so to elapse, then record the final volume of the NaOH.

Repeat the titration. Your two values of NaOH concentration should agree to within +/- 0.005 M. If they do not, repeat the experiment until two values agree to within +/- 0.005 M.

CALCULATIONS PART I

Calculate the molarity of the NaOH. This is done by first calculating the number of moles of KHP used in the titration. In all neutralizations the number of moles of acid must equal the number of moles of base,

1) moles KHP = moles NaOH

Begin by calculating the mole of KHP use in your titration by dividing the mass you used the the formula weight of the KHP (204.227 g/mol). Once you have determined the moles of NaOH, the moles of HCl present is automatically known. The molarity of the HCl can now be determined by the definition of molarity.

2) Moles of KHP = Grams of KHP/ 204.227 g/mol KHP

The molarity of the NaOH is determined by dividing the moles of KHP by the volume of NaOH used.

3) Moles = (mole/liter) x (liters) = Molarity x Volume

now since the moles of KHP and NaOH must be equal we can write,

4) Moles KHP = Molarity NaOH x Volume NaOH so that,

5) Moles KHP/Volume NaOH = Molarity NaOH

Using this final formula to calculate the concentration of your NaOH (make sure you convert your volume to liters by dividing by 1000 mL/L). Report the value for the molarity of NaOH to the instructor to verify that you have correctly titrated the NaOH. If you have done this correctly, you will then receive your unknown acid.

Mark your flask with the concentration of NaOH you have just determined and save it for next weeks experiment.

THE TITRATION OF AN UNKNOWN SOLID ACID;
CALCULATION OF EQUIVALENT MASS

EXPERIMENT: Rinse the two 125 mL flasks used in the first part of the experiment with de-ionized water and refill your buret with NaOH. Place 0.3-0.35 grams of your solid unknown acid in each flask, weighing to the nearest mg. Weigh the acid directly into the flask. Now add 30 mL of distilled water and swirl. Add three drops of phenolphthalein to each flask and titrate the unknown acid with your standardized NaOH to the pink phenolphthalein endpoint. Record the starting and final volumes of NaOH used in your titration.

CALCULATIONS PART II

The equivalent mass is similar to the molecular mass except that instead of measuring grams/mole it measures grams/moles of H^+. For example lets take a look at some common acids,

ACID	# H^+	MOLECULAR MASS	EQUIVALENT MASS
HCl	1	36.45 g/mole	36.45 g/mole H^+
H_2SO_4	2	98.0 g/mole	49.0 g/mole H^+
H_3PO_4	3	98.0 g/mole	32.6 g/mole H^+

Here we see that the equivalent mass is the molecular mass divided by the number of moles of H^+ present in the acid. This means that 36.45 g of HCl, 49.0 g H_2SO_4, and 32.6 g H_3PO_4 all contain 1 mole of H^+ (hence the term equivalent mass). In this experiment you can calculate the equivalent mass of your unknown acid by calculating the moles of H^+ present per gram of unknown acid.

6) Mole of H^+ in Unknown = Molarity NaOH x Volume NaOH (see 1 - 5 above)

7) Eq. Mass of Unknown = Grams of Unk./Moles of H^+ in Unk.

Calculate the equivalent mass of the acid in each reaction flask. In your results report the average equivalent mass of your acid.

Read This!

Significant figures are particularly important in this lab. A buret can be read to within 0.01 mL so instead of writing 0 mL as your starting point it should be 0.00 mL. When you read the buret you should always write down all the digits even if they are zeros. For example 25.1 mL should be written as 25.10. This gives you four significant numbers in the volume.

The same is true for the mass. The balance gives you numbers to within 0.001 gram so all of these numbers should be written down. Therefore if you weigh out 0.326 grams of unknown acid you know the mass to three significant figures.

Since you know the volume to four significant figures and the mass to three significant figures, all of the math that you do on **these numbers should be reported to three significant figures**. Do not round. And remember, if you get an equivalent mass that is less than 1 g/eq, you have done something wrong (if you don't know why, ask me).

Name_______________ Date______________

TITRATION OF AN UNKNOWN ACID
(WORKSHEET)

OBJECTIVE:

PROCEDURE: Standardize a solution of NaOH by titrating it with a known amount of KHP. Use this NaOH to titrate a sample of an unknown acid and calculate its equivalent mass.

DATA:
Standardization of NaOH

Mass of KHP	Volume of NaOH (mL)	Moles of KHP	Moles of NaOH	Molarity of NaOH
#1				
#2				
#3				

Average Concentration of NaOH _______________

Titration of Unknown Acid #

Mass of unknown acid (g)	Volume of NaOH (mL)	Moles of H^+ in acid	Equivalent mass of acid
	start		
	finish		
	s		
	f		
	s		
	f		
	s		
	f		

CALCULATIONS:

RESULTS:

The average equivalent mass of unknown acid # ______ = __________ g acid/mole H^+

CONCLUSION:

SOURCES OF ERROR:

QUESTIONS
[Show all Work]

1) Why doesn't it matter how much water you put into the reaction flask?

2) If a bubble of air goes through the tip of the buret which contains NaOH will the reported molarity of HCl be too high or too low? Why?

3) Why is it necessary to titrate to a faint pink, rather than a dark pink endpoint?

4) Calculate the molarity of an H_2SO_4 solution if 20 mL of 0.50 M NaOH exactly neutralizes 40 mL of the H_2SO_4 solution.

5) If 20 mL of a 0.100 M NaOH solution are required to titrate 0.25 grams of an unknown acid, what is the equivalent mass of the acid? If the acid actually contains 3 moles of H^+ per mole of acid what is the molecular mass of the acid?

6) If 20 mL of NaOH solution are required to neutralize 15 mL of 0.40 M HCl, and 20 mL of the same NaOH solution are required to neutralize 30 mL of a sulfuric acid solution. What is the molarity of the H_2SO_4?