Advanced Placement Chemistry ***Name*** _____

Laboratory Activity IV Introduction: Standardization of NaOH solution and Determination of Molarity of Acetic Acid in Commercial Vinegar

Objectives

- Standardize a solution for use in titration
- Determine the molarity of a commercial vinegar solution

Background

In your initial titration – mainly performed to determine how to stop the titration and perform calculations – you used a solution of NaOH provided to you, and the molarity of that solution was told to you as 0.100-molar. All of the calculations were performed as if the molarity of that solution was, indeed, 0.100-molar.

However, we typically would like to test our titrant to ensure that it has a more determinate molarity than that more loosely-calculated from calculations using the mass of NaOH used to prepare a solution. We can do this by ***standardizing*** the solution, or determining its molarity with great certainty. This is accomplished by titrating the prepared base (the molarity of which is at this point only known approximately) with a ***primary standard***[1]. Do not be alarmed – this is not difficult! It is simply reacting the base with a substance that has the characteristics listed in the footnote below to ensure that we can obtain the most accurate molarity of our prepared base. In fact, the calculations involved are identical to those used in the first titrations we have done, except that now we are determining the molarity of the titrant, so everything is kind of conceptually "reversed" in the standardization. We use a fairly typical standard, ***potassium hydrogen phthalate*** – also called ***KHP***. A recommended mass of KHP might be between 0.800 g and 1.00 g per trial.

Determine the molarity of the NaOH from the mass of KHP used and the volume of NaOH required to reach the equivalence point. Once completed, average the three values of NaOH molarity obtained and take this to be the molarity of the NaOH solution. If any determination of molarity varies by more than 1% from the average value, please run additional trials until you have three that do not vary from the average by more than 1%. Remember to use only one sample of NaOH for standardization and subsequent vinegar determinations – you are standardizing the solution to ensure that it is known with certainty; thus, you cannot change solutions during the activity.

Once standardized, the NaOH solution can be used with three trials of commercial vinegar.

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[1] *KHP readily absorbs moisture from the atmosphere – thus, you must obtain a sample of this standard, mass the sample and dissolve it in water in relatively little time. Moreover, you must NOT leave the bottles open for a time longer than needed to obtain a sample of KHP. The samples are heated before use (by the instructor) to drive off any absorbed moisture. A good primary standard should:*

- *be of high purity*
- *remain unchanged in air during massing and remain stable during storage*
- *have a high molar mass to reduce massing errors*
- *react with the solution to be standardized in a direct, well-defined reaction*

Please note that all data should be recorded to the appropriate number of significant digits based upon the tools used for the determination of the data. Also, when performing titrations, we record the initial and final buret readings, and we use the change in volume when calculating with the data. I have provided a data sheet on which you can record data for this initial standardization activity – you will prepare your own later in the week when we standardize potassium permanganate solution for use in your first oxidation-reduction titration.

This data should be recorded in the lab notebook – not on this page.

KHP Standardization Data

	Mass KHP, g	Mol KHP, mol	Initial Buret Reading, mL	Final Buret Reading, mL	Volume NaOH Used, mL
TRIAL 1					
TRIAL 2					
TRIAL 3					
TRIAL 4, if needed					
TRIAL 5, if needed					

	Mol NaOH Used	NaOH Molarity Calculation, M_x
TRIAL 1		
TRIAL 2		
TRIAL 3		

Average NaOH Molarity, M_y	

Variation From Average

[repeat a 4th or more Trial if any Trials are > 1% difference than the average]

$$\%\ difference = \frac{|M_x - M_y|}{M_y}$$

Commercial Vinegar Concentration Data

	Molarity NaOH, *M*	Volume Vinegar, mL	Initial Buret Reading, mL	Final Buret Reading, mL	Volume NaOH Used, mL
TRIAL 1					
TRIAL 2					
TRIAL 3					

	Mol NaOH Used	Vinegar Molarity Calculation
TRIAL 1		
TRIAL 2		
TRIAL 3		

Average Vinegar Molarity, *M*	

Follow-up and Discussion for this activity will be combined with that for the oxidation-reduction titration of iron(II) solution with standardized permanganate solution.

Practice Items

$$HC_8H_4O_4^- + OH^- \rightarrow HOH + C_8H_4O_4^{2-}$$

The reaction KHP and NaOH is represented by the net ionic equation above.

A student obtained three samples of KHP with which to standardize a NaOH solution to be used later for titration of a vinegar solution. The standardization titration provided the following data:

Trial	Mass KHP used, g	Volume NaOH used, mL
Trial 1	0.6570	12.870
Trial 2	0.7040	13.900
Trial 3	0.6890	13.440

Determine the molarity of the NaOH solution using each of the Trials above and the average of all three.

Do any of the Trial calculations vary by more than 1.00% from the average determination? Show work to support your answer.

A 4.56 mL sample of commercial vinegar was placed in a beaker and diluted to about 25 mL. Phenolphthalein was added as an indicator. The vinegar (acetic acid) / NaOH reaction is represented by the equation below.

$$CH_3COOH(aq) + NaOH(aq) \rightarrow NaCH_3COO(aq) + HOH(l)$$

The indicator changed to pink when 16.64 mL of standardized NaOH(aq) was added. Determine the molarity of the commercial vinegar.

Determine the percent by mass acetic acid of the commercial vinegar sample – assume the density of vinegar to be that of water, or 1.00 g/mL. (It might be 0.96 g/mL to 1.01 g/mL – but hey, let's simplify this a bit!)