Daisia Frank

CHEM 1121

Dr. Reed

July 31, 2016

Determining the Identity of an Unknown Weak Acid Lab Report

Introduction:

In this experiment, a weak acid's identity was determined using the method of titration for weak acids. The titration was performed with standard sodium hydroxide solution. In order to do this, the titration had to be monitored by an indicator or pH meter. A pH meter and LoggerPro software on a computer were used to determine the equivalence point of the titration.

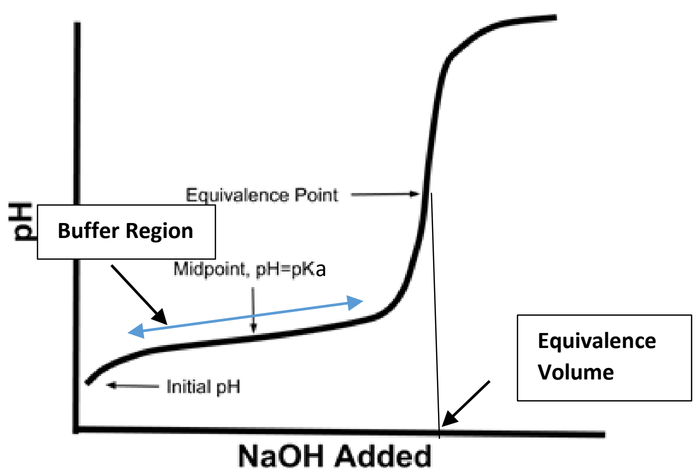


Figure 1: Titration of 0.1M of acid by 0.1 M NaOH (Just shown for illustration purposes) (1)

The equivalence point is the point where enough titrant (NaOH) has been added to the analyte (unknown weak acid) that results in the analyte being neutralized. Using this equivalence point, the acid disassociation constant, Ka can then be determined for the unknown acid titrated. Finally, the identity of the unknown acid can be concluded. For the dissociation of any weak acid, HA (2):

$$HA(aq) \rightarrow H^+(aq) + A^-(aq) \qquad \text{Eq.1}$$

When a weak acid dissolves in water an equilibrium is established. When the reaction is at equilibrium the total concentrations of each reagent are constant and the acid dissociation constant, K_a can be calculated:

$$K_a = \frac{[H^+][A^-]}{[HA]} \qquad \text{Eq. 2}$$

The Ka should be a very small number because weak acids don't disassociate completely and a large Ka value indicates greater dissociation. To solve for $[H^+]$:

$$[H^+] = \frac{K_a[HA^-]}{[A^-]} \qquad \text{Eq. 3}$$

Since Ka values are so small using pKa values are more beneficial to scientists as it allows them to use whole numbers (pKa = -logKa). Titration curves happen due to the molar component of the titrant and anylate. When slowly adding the base to the weak acid solution the graph exponentially increases. Then, when the number of moles of base equals the number of moles of weak acid present, a sharp change (increase) in the curve of the graph can be observed:

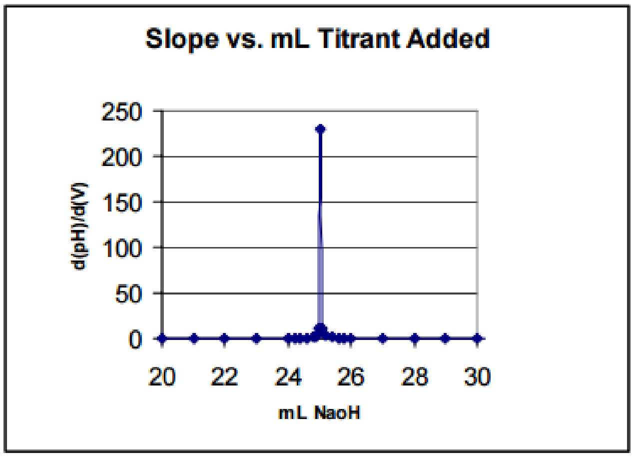


Figure 2: Plot of slope, ΔpH/ΔV, vs. mL NaOH based on Figure 1 titration (Numbers aren't accurate) (2)

After the sharp change in the curve, any base added just increases the pH and the graph eventually levels off. The graph can also be used to calculate the moles of acid present. The number of moles of acid to base is assumed to be 1:1, so the volume and concentration of added base can be determined. Finally, the identity of the unknown acid can be determined by estimating the pKa and calculating the molar mas of the acid based on the quantity of solution measured.

<u>Equipment/ Chemicals:</u>

- Unknown Weak Acid
- 50 ml 0.10 M KCl
- 100 ml volumetric flask
- Buret
- Ring stand/ clamp
- pH Meter
- NaOH solution
- LabQuest Mini
- Drop Counter
- pH sensor
- Stir plate

Procedure:

About 1.3-1.4 grams of unknown acid "H" were weighed and dissolved in 50 ml of 0.10 M KCl solution in a 100-mL volumetric flask. Once all the solid was dissolved, the solution was diluted to the 100 mL mark with 0.10 M KCl. LabQuest Mini was connected to the computer and a drop counter was attached to a ring stand. A pH sensor was inserted into the opening in the drop counter. Once connected, the computer displayed information from both the drop counter and pH meter. A stir plate and magnetic stir bar were obtained. A buret was attached to a utility clamp and ring stand. The discharge opening was positioned 1 cm above the drop counter. A waste beaker was placed at the base of the stand and the buret was filled with about 25 ml of dH_2O. The lower stopcock was opened completely while the top one was opened until the flow of water was at a steady 1 drop a second. All of the water was dispensed and the lower stopcock was closed. The buret was then filled with about 75 ml of NaOH. To calibrate the drop counter, 9-10 ml of the solution were dropped into a 10-ml graduated cylinder and the exact amount of NaOH dispensed was imputed into the computer. In a 100 ml beaker 25 ml of dH_2O were poured in and using a volumetric pipette 25.00 ml of the unknown weak acid solution was poured in as well. The beaker was placed on the stir plate with a magnetic stir bar inside. The pH probe was positioned inside the beaker and the stir plate was turned on. The green arrow on the computer was pushed to start the titration and the lower stopcock was opened fully. The titration proceeded until 10 ml after the equivalence point. The data was saved and stored.

Calculations:

Calibration of Drop counter: 201 drops/ 8.9 ml = **22.58 drops/ ml**

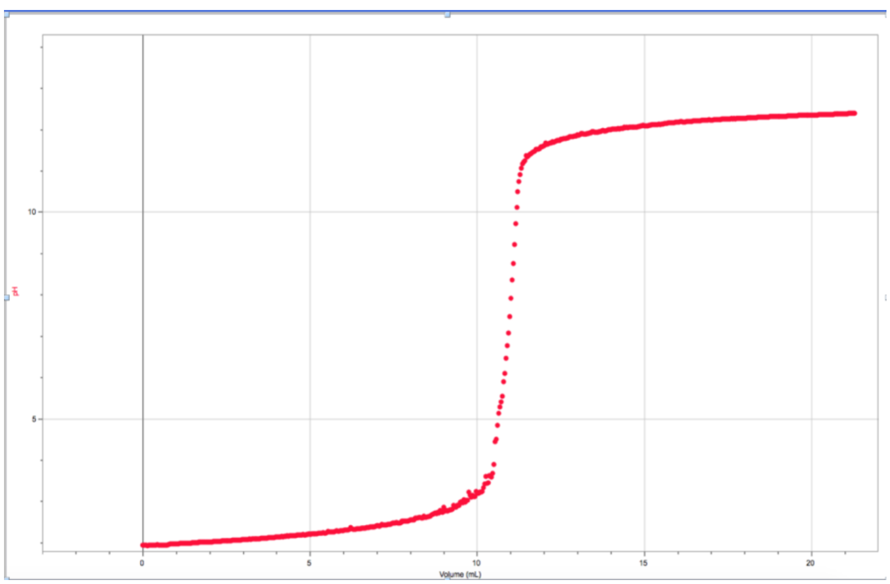
Molar Mass unknown acid = grams weighed/ moles calculated

0.3498/ 0.00264 = **132.48 grams/ mol**

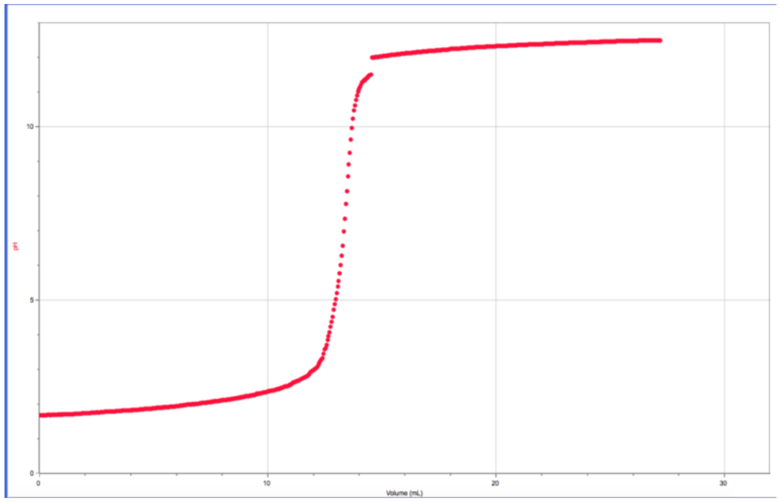
(Equivalence Volume) (Molarity Base) = mol OH^-

(0.01336 L)(0.1974 M) = 0.00264 moles of base

pKa = 0.5(Equivalence Volume) ← Midpoint of buffer region



Graph 1: Trial 1 Titration Curve



Graph 2: Titration Curve

Moles of Acid Used (grams)	1.399
Total Volume of Prepared Acid Sample	100 mL KCl
Concentration of Prepared Acid Sample (g/ ml)	0.02798 g/ ml
Concentration of Base	0.1974 M NaOH
Table 1: Concentrations and masses of acid and base samples (Unknown Acid: H)	

	Trial 1	Trial 2
Volume of Acid Titrated (mL)	25 ml	25 ml
Mass of acid titrated (g)	0.3498	0.3498
Equivalence Volume (V_e) (mL)	13.36	10.94
Moles of Base required for equivalence	0.00264	0.0022
Molar Mass of Unknown Acid	132.48	150.98
pKa of unknown acid	1.94	2.24
Table 2: Trials 1 and 2 data		

Average Molar Mass (g/mol)	141.73
Average pKa	2.09
Identity of Unknown Acid	Potassium Bisulfate
Table 3: Average Calculations and identity of unknown weak acid	

Identity percent error: 4.06%

Discussion:

The purpose of the experiment was to determine the identity of an unknown weak acid through titration. Titration is a process that involves a strong base as the titrant - for this experiment NaOH solution - and a weak acid as the anylate - in this experiment the identity is unknown. Given Unknown acid “H” and NaOH solution, a titration curve/ graph was plotted using LoggerPro. Figure 1 shows the equivalence point, which is near the middle of the sharp curve; the equivalence volume, which is the vertical line that corresponds to the volume for the equivalence point; the buffer region, which is the portion of the curve before the sharp curve; and pH= pKa which is close to the middle of the buffer region. The average equivalence volume was 12.15. The volume and molar concentration of the base (titrant) that was added was used to determine the moles of acid present:

Molar Mass unknown acid = grams weighed/ moles calculated

0.3498/ 0.00264 = 132.48 grams/mol

. The average molar mass was 141.73. Using the titration curve the pKa was found by finding the midpoint of the buffer region. The average pKa was 2.09 which is equivalent to the pH. This seems accurate because the solution is in fact acidic. Comparing the experimental molar mass to actual values of actual compounds, the identity of the unknown acid was determined to be Potassium Bisulfate. Some sources of error included accidentally stopping the graph for trial 2 for about 30 seconds, which is the reason there is a jump after the equivalence point in Graph 2. Additionally, miscalculations and misinterpretations of the graph could have led to inaccurate values. Overall, the experiment showed that titration is a beneficial process for determining the identity of an unknown weak acid and titration curves can provide a lot of information regarding its titrant and anylate, References:

(1)Enduring Understanding 6.C: Titration Curves. (2005-2016). Retrieved August 01, 2016, from http://www.softschools.com/notes/ap_chemistry/titration_curves/

(2) Department of Chemistry. (2010). *UCCS (University of Colorado at Colorado Springs) Chem 106 Laboratory Manual*. Cengage Learning. Retrieved July 31, 2016. http://www.uccs.edu/Documents/chemistry/nsf/106%20Expt6V-Titration2.pdf

(3) Department of Chemistry. (2016). *Austin Peay State University Revision F16 Lab Manual.* Cengage Learning. Retrieved July 31, 2016.