

# Determination unknown acid and averageweigh a sample



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## Determination of the Equivalent Mass and pKa of Unknown Acid

**Purpose-** To identify an unknown acid using titration to figure out pKa based on the equivalent mass

**Procedure-Part 1: Standardization of NaOH** Get a sample of dried potassium hydrogen phthalate and use a very sensitive balance (to .001) to weigh .4-.6 grams of it onto a weigh boat, making sure to accommodate for the weight of the boat on your balance. Using distilled water, wash the KHP into an Erlenmeyer flask and add 40 ml of distilled water after that.

Then swirl the flask until the KHP is dissolved. Rinse a buret with tap water and then rinse 3 times with NaOH. Fill the buret with measured NaOH solution. Open the stopper for a short time and shake the buret vertically to make sure there aren't any air bubbles. Add 3 drops of Phenolphthalein to the acid in the Erlenmeyer flask and then titrate with the NaOH until the solution turns pink or purple and stays that color for 15 or more seconds. Record the volume of NaOH that you use to the nearest .

01 mL. Repeat this two more times, using slightly more acid each time.

Calculate average molarity of the NaOH solution.

**Part 2: Determination of the Equivalent Mass of an Unknown Acid** Weigh a sample of the unknown acid (.3-.4 grams)

on a sensitive balance. Dissolve the acid in distilled water and add 3 drops of phenolphthalein, titrating with base (NaOH) like in part 1.

Repeat part 2 one more time, this time choosing an amount of the unknown acid that will require about 45 mL of NaOH.

**Determination of the pKa of the Unknown Acid and Average** Weigh a sample of the unknown acid that will

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need about 40 mL of NaOH to titrate. Dissolve the sample in 100 mL of distilled water.

Set up a pH meter and calibrate it with a buffer solution. Then rinse the electrode with distilled water. Put the beaker on a magnetic stirrer and clamp the pH electrode in the acid solution. Titrate with the NaOH solution, recording volume of the base and pH every mL until it gets closer to the equivalence point. As it gets closer, use smaller amounts. Keep titrating for 3mL beyond the equivalence point. Graph data with the pH on the y axis and volume of NaOH on the x axis.

Make it a large graph. Find and give pKa value(s), be sure to mark them on the graph. Calculate and state Ka value(s). To dispose, pour in the sink with a lot of water. Clean the buret as well with distilled water.

Data Tables-Standardization of NaOH: TrialMass of KHP (in g)Start (in mL)End (in mL)10. 546 0. 1124.

3720. 47918. 4238.

9030. 5343. 9827. 96Determination of the Equivalent Mass of an Unknown Acid: TrialUnknown acid mass (in g)Start (in mL)End (in mL)10. 343\*0. 420.

31\*50. 0 2. 2120. 3001. 7149.

80\*On this trial we had to refill the buret since we had to use more base for the titration than the buret had in it. The two sets of numbers stacked on each other separate each starting and ending point respectively. pH change

with titration: Mass of unknown acid used for Trial 3: . 267gNaOH

(mL)pHNaOH (mL)pHNaOH (mL)pH02. 43163. 30326. 8412. 44173.

48336. 9722. 47183.

84347. 0832. 50194. 75357.

2542. 53205. 2935. 57. 3752.

56215. 59367. 4962. 59225.

8036. 57. 6372. 63235. 95377. 8982.

67246. 0537. 58. 4592.

72256. 173810. 11 (Eq.)\*102. 76266.

2738. 510. 98112. 82276. 373911. 23122.

90286. 4739. 511.

48132. 97296. 564011. 62143. 05306.

6640. 511. 72153. 16316. 764111. 81\*Eq. = equivalence point (is a little off

due to error in gradual reduction of base added)Graph of pH vs volume of

NaOH required in titration: A: Stands for the volume required for the NaOH to react with one of the hydrogen ions.

B: Stands for the volume required for the NaOH to react with both of the hydrogen ions. C: Volume of NaOH needed to neutralize half of the first

hydrogen in the acid. D: Volume of NaOH needed to neutralize the all of the

first hydrogen and half of the second hydrogen in the acid. E: The pH when half of the first hydrogen is neutralized ( $pK_{a1} = 2.72$ ) F: The pH when half of the first hydrogen is neutralized ( $pK_{a2} = 6.66$ ) Calculations-Standardization of NaOH: Molarity for Trial one:  $1 \text{ mol H}^+ \cdot 0.$

$546 \text{ g} = 0.110 \text{ M} \cdot 204.22 \text{ g} \cdot 0.02426 \text{ L}$  Molarity for Trial two:  $1 \text{ mol H}^+ \cdot 0.$

$479 \text{ g} = 0.115 \text{ M} \cdot 204.$

$22 \text{ g} \cdot 0.02048 \text{ L}$  Molarity for Trial three:  $1 \text{ mol H}^+ \cdot 0.534 \text{ g} = 0.109 \text{ M} \cdot 204.$

$22 \text{ g} \cdot 0.02398 \text{ L}$  Average Molarity:  $(0.$

$110 \text{ M} + 0.115 \text{ M} + 0.109 \text{ M}) = 0.$

111 M 3 Determination of the Equivalent Mass of an Unknown Acid: Equivalent

Mass Trial one:  $1x \cdot 0.343 \text{ g} = 0.111 \text{ M} \cdot .$

005148 L  $x = 60.0 \text{ g}$  Equivalent Mass Trial two:  $1x \cdot 0.300 \text{ g} = 0.111 \text{ M} \cdot .$

04809 L  $x = 56.2 \text{ g}$  Equivalent Mass three:  $1x \cdot 0.$

$267 \text{ g} = 0.111 \text{ M} \cdot .03800 \text{ L} = 63.3 \text{ g}$  Average Equivalent Mass:  $(60.0 \text{ g} +$

$56.2 \text{ g} + 63.$

$3 \text{ g}) = 59.8 \text{ g}$  3 Determination of the  $pK_a$  of the Unknown Acid and

average Equivalent Mass with standard deviation:  $pK_{a1} = 2.72$   $pK_{a2} = 6.$

$66$   $K_{a1} = 10^{-2.72} = 1.91 \cdot 10^{-3}$   $K_{a2} = 10^{-6.66} = 2.19 \cdot 10^{-7}$  Standard

deviation formula:  $(\sum (X_i - \bar{X})^2)^{1/2n}$  Standard deviation for equivalent mass in this

experiment:  $(60.$

0-59. 8)2 + (56. 2-59. 8)2 + (63. 3-59. 8)23 = 2. 90Discussion Questions (1-9)-1. What is equivalent mass? Why do we determine equivalent mass and not molecular mass? Equivalent mass is the mass at where an acid will dissociate to give 1 mole of Hydrogen ions.

We don't use molecular mass because it doesn't show you the difference between a monoprotic or polyprotic acid whereas equivalent mass lets you differentiate between the two because it tells you how many of the hydrogen ions react. Equivalent mass relates the combining abilities of atoms with each other. The molecular mass is irrelevant in this case, as our calculations are focused on the dissociation of ions. 2. What is a standard solution? This is where there's a solution where a known molarity is found using an experiment. 3. What is a titration? Titration is a way that you can find concentrations by adding a known volume of a standard solution (or titrant) to another solution, and then using an indicator or pH meter to determine equivalence point and when to stop adding the standard solution.

4. Why must the KHP and the unknown acid sample be dried? If they were not, how would the equivalent mass of the unknown change? Be specific, would it be too high, too low, or no change. Be sure you justify your answer. The KHP and unknown samples should be dried because then the masses that you measure on the sensitive balance will be closer to their actual weight and therefore proportional to the moles of the acid.

If the samples were not dried, the excess water would cause them to be heavier than they actually are, causing there to be less acid moles and less hydrogen ions, meaning that you also need less NaOH to titrate and the

equivalent mass will be too high due to the fact that there's less Hydrogen ions per unit of mass. 5. What is pH ? When the pH changes by one unit, how does the hydrogen ion concentration change? pH is the concentration of hydrogen ions in a solution.

As it changes one unit, the concentration of hydrogen ions changes by a factor of 10. 6. Why is the equivalence point not at a pH of 7? Justify your answer. The equivalence point does not have to have a pH of 7 because it only happens when there is an equal concentration for both the acid and the bases in the solution. The pH at the end actually depends on the major species ions that occur in the solution after the reaction which could be more on the acidic or more on the basic side.

7. What is  $K_a$ ? What does it mean? How is it determine through the titration curve?  $K_a$  is an equilibrium constant expression for acids. It is used for determining concentrations for an acid that will dissolve in the solvent.

You can use a graph that relates volume and pH to find the equivalence point. Then you can find the pH at which the solution is at half of what the equivalence point is and this is  $K_a$ . pH and  $K_a$  is equal, so using pH,  $K_a = 10^{-\text{pH}}$ . 8. Did your titration curve give any indication that your acid may have contained more than one ionizable hydrogen? Yes, there were two segments on the graph that looked like major inflection points which means that the acid may contain more than one ionizable hydrogen. 9. How many significant figures can you read from the buret? (How precisely can you read the buret?) How many significant figures can be read from the sensitive

balance? Why is it better to titrate with a volume of base that fills most of your buret? You can read to .

001 g (3 sig) with the sensitive balance and to . 01 (2 sig) mL with the buret.

It is better to titrate with a volume of base that fills most of the buret because there is less of a likelihood that it will be contaminated. Also having such a large amount of base makes it a lower chance that you will run out in the middle of a trial making it easier to measure also because it can be measured from the 0 mL mark leaving less chance of error.