Laboratory Concepts Frequently Tested

Gravimetric Analysis

An unknown concentration of lead (II) ions are dissolved in water. In order to determine the concentration, 0.05M sodium chloride is added until all the white precipitate stops precipitating. The NaCl is added in three different times. Each addition is 12 mL. After each addition of NaCl, the student waits 5 min before adding the second and finally 3rd NaCl solution. After a period of time the precipitate is filtered and dried.

Data:
Volume of lead ions: 24mL
Volume of NaCl added
- 12mL
- 12mL
- 12 mL

Mass of filter paper: 2.0g
mass of filter paper and lead (II) chloride: 2.9g

Video answer

Analysis:

1. Write out the chemical reaction talking place here. $PbNO_3 + NaCl \rightarrow PbCl_{2(s)} + NaNO_3$

2. Determine the molarity of the original lead (II) ions in the original solution.

   a. (the following questions are to walk you through #2, try it without these questions first)
      i. How many moles of solid lead (II) chloride are present in the filter?
      $2.9 - 2.0 = 0.9g \cdot \frac{1\ mol}{277.85} = 0.0032\ mol$
      ii. Determine the moles of lead present in the lead (II) chloride by stoichiometry or via percent composition.
      $0.0032\ mol\ PbCl_2 \cdot \frac{1}{1} = .0032 \cdot Pb$
      iii. Using the moles of lead ions, determine the concentration of the original solution using original moles and original volume.
      $\frac{.0032\ Pb}{.024\ L} = 0.134M$

3. Some of the solid slipped through the filter as you filtered. How will this affect the calculated concentration of the original solution.

$\frac{.0032}{.024L} = \downarrow = 0.134 \downarrow$

General Titration

A student is looking to determine the percent composition of Iron in a sample of a iron containing rock. The iron is titrated against a standardized $KMnO_4$ solution.

1. Relative to the lab, determination of iron percent by mass, you titrated a trial and collected the data below.

$8H^+ + MnO_4^- + 5Fe^{2+} \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$

	Trial 1	Trial 2	Trial 3
Mass of Iron unknown sample	.25g	.25	.25
Volume of iron dissolved sample	50mL	50mL	50mL
Concentration of $KMnO_4$	0.0196M	0.0196	0.0196
Volume of $KMnO_4$ titrated	22mL	23mL	29mL

I am using Trial 1

a. Determine the moles of <u>Iron</u> titrated in the sample.

$M \cdot L = mol$

$.022 \cdot .0196 = 0.000431 \cdot \frac{5}{1} = .00215$ mol

b. Determine the percent mass of the iron in the original sample.

$.00215 \cdot 55.84 = \frac{0.120g}{0.25g} \times 100 = 48\%$

c. If the sample was known to have a 12% what is the percent error?

$\frac{48-12}{12} = \times 100 = 300\%$

d. Which of the following errors could have caused the percent error you calculated in c?(circle)

- Student titrated past the equivalence point causing too much MnO_4^- to be added. Yes
- Sample of Iron contained an inert impurity at the time of weighing. No
- Extra water was added to the iron sample for purpose of dissolving it No

2. We titrated MnO_4^- which is starkly Purple. Why are we always looking for this color to reappear or to stick around or what does it mean in layman's terms what is means when you color remains. Explain. Indicates Fe is now Removed or Limiting.

3. We standardized the permanganate solution with the oxalate ion. The term standardize means to determine or verify the solutions concentration for use in a lab test. Other than the obvious reason for knowing the concentration, why is a standardization needed?

Substance could have decayed/gained water So conc. is Not the Same as past.

4. A student is titrating until the reaction turns pink/purple and ends up titrating way to long. How would this numerically affect the answer? Explain the cascading effect on the math. ↑ $KMnO_4$ ↑ Fe ↑ % Fe

<u>Hydrogen peroxide decomposed by the following reaction</u>: $2H_2O_{2(aq)} \rightarrow 2H_2O_{(g)} + O_{2(g)}$

1. ****10g of a 3% by mass hydrogen peroxide solution is decomposed at STP. Answer the following questions. The vapor pressure of H_2O is 23.8 mmHg)

   a. (1) The total pressure in the container is 1.0 ATM after the collection of gasses. What is the partial pressure of the O_2?

   $760 - 23.8 = 736.2$ mmHg

   (0.968 atm)

34g/mol

b. (1) What is the total mass of H_2O_2 present in the solution? (show work below)

c. (2) What would be total volume of Oxygen produced? (show work below)

b) $10g \cdot 0.03 = \boxed{.3g}$

c) $.3g \cdot \frac{1\ mol}{34\ g} = 0.0088\ mol \cdot \frac{1}{2} = 0.0044\ mol \cdot \frac{22.4L}{1\ mol}$

0.197L

2. (1) What was the purpose of the iron ions in this reaction?

Catalyst

3. If the Iron was used in the reaction and iron is orange/yellow, then why do we not see that color disappear over the course of the reaction?

Catalyst Not Consumed

4. A student runs this experiment and some of the water spills and is not recorded. How effect will this error cause on the outcome of the % H_2O_2? (be specific on the error)

$PV = nRT$ $n = \frac{PV}{RT}$ ↓ n↓ %↓

Empirical formula

A 2.500 g copper strip has Iodine added and heated causing a reaction to take place. After the reaction took place it was massed at 2.59g. The chemical is cleaned off and re-massed at 2.45g.

1. What is the empirical formula given this data? *Show all work*

mass Cu: $2.50 - 2.45 = 0.05g / 63 = .000787$

mass I: $2.59 - 2.50 = 0.09g / 126g = .000709$

CuI

Cu = .000787/.000709 ≈ 1

I = .000709/.000709 = 1

2. What color is iodine vapor?

Purple

3. I have seen many strips that were not fully cleaned of copper iodine mixture, how would this error affect the *empirical formula*? This is an error; your job is to explain how this error effects answer.

affects 3rd weight

Mass Cu: $2.50 - 2.45 = 0.05$

error ↑ too small

5. A student, working very hard, over cleans the copper strip prior to the last massing causing lots of copper to be removed that did not react. How will this affect the *empirical formula*?

Cu↑ I↓

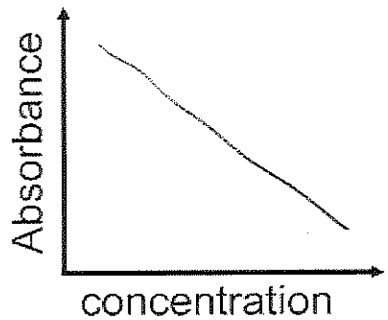
opposite of previous

Cu↑ I↓

Beer's Law

Copper is a component of Brass. The quantity of Copper, in brass, was measured by first reacting the brass with nitric acid (HNO_3) then measured the quantity of light that passed through the sample. The light that passes through the substance can be measured in % Transmittance or Absorbance (opposite of Transmittance. (They are inversely proportional but Absorbance is not a percentage so not on a 100 scale.) A series of known copper solutions were tested for absorbance and plotted to create a linear relationship. This linear relationship is represented by: Y = 32x + .0032

1. Answer the following questions relative to the lab.
   a. (1) Actual mathematical relationship is provided above. Below you are provided with a blank graph. ROUGHLY sketch what this graph might look like. (only draw the line, do not scale it... very rough)



   b. (2) If the unknown solution has an absorbance of 16.01 what is the concentration of copper in the solution? $16.01 = 32x + 0.0032$
      $x = 0.5M$

2. A student claims: Since the solution of copper is blue we should use blue light to shine into the solution. Justify or nullify this claim.

   use light absorbed Not Reflected.

3. Beer's Law is a very useful tool to determine the concentration of stuff. Give one example where Beer's law might <u>not</u> be the best technique to determine a concentration.

   Clear liquid / Solids?

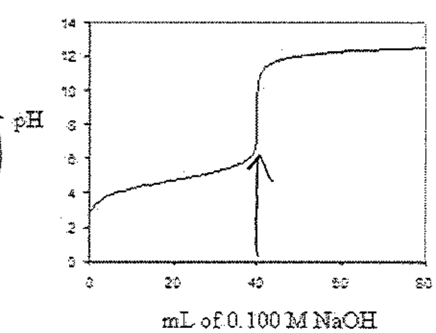
4. The amount of light absorbed by a sample that is actually traveling through the sample is governed by this formula:
   A = Absorbance
   € = constant specific to the substance
   c = concentration
   l = ?
   What does the "l" stand for in this formula?

$$A = \epsilon l c$$

   length of container

<u>Acid base Titration</u>

You are charged with the task of determining the concentration of an acid. The student measured out 30mL of acid with a beaker. The burette was rinsed once with water and then filled the burette with 0.100M NaOH. The pH was monitored, and the following graph was produced.



1. *** What is the [Unknown acid]?

   M . L = mol
   .1 .04 = .004 mol

   $.004 / .03 = \boxed{0.133M}$

2. Indicate if there were any mistakes that occurred as a result of the student's actions that could have affected the results of the lab. (there may be more than 1)

   Did Not Rinse burette with <u>Base</u>   others possible

3. Is the unknown acid weak or strong? Explain. Weak, equivalence is weak Base. So Conjugate is weak acid

4. Unknown to the students, a 2nd student added a little water to the acid beaker just prior to starting the titration but after the original 30 mL was measured. How will this affect the overall answer? Explain. No effect, $\frac{mol}{L} \leftarrow \text{Same}$ $\leftarrow .03$

5g Solid Na_2S is dissolved in 25mL of water and the pH is tested. $S^{-2} \rightarrow H_2S$

5. In what range might you find the pH? (0-2, 3-5,6-8,9-11,12-14)

Conjugate of weak acid

6. If you were to calculate the probable pH on paper, what piece of information might you need? $K_a = \frac{[X^-]\cdot[H^+]}{[\ ]} \rightarrow pH$

K value ← Need →

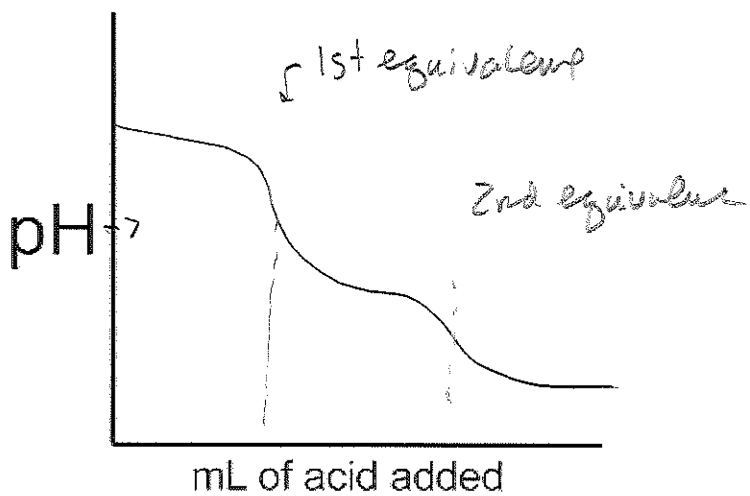
Conc. ← this we have

If you were to titrate this salt with .10HCl.

7. *** At what volume(s) might you expect to find an equivalence point(s)?

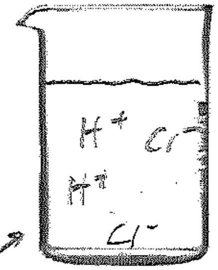
$5g \cdot \frac{1\ mol}{78g} = 0.064 mol$ $.1 = \frac{.064}{x}$ $x = 640\ mL$ x2 1282mL

8. Sketch below that would represent the neutralization titration if double the quantity of acid in #11 is added. (add sketch below)

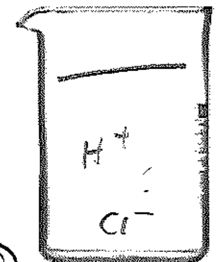


Acid Base Titration Analysis

1. 0.10M hydrochloric acid solution.
   a. Determine the pH. $-\log(.1) = 1$
   b. How would you describe the value of the Ka of hydrochloric acid? Very large
   c. Draw a picture of this solution 0.10M in the beaker provided.

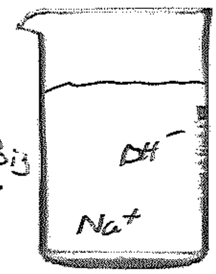


   d. Draw a picture of a 0.05M solution of HCl in the beaker provided.

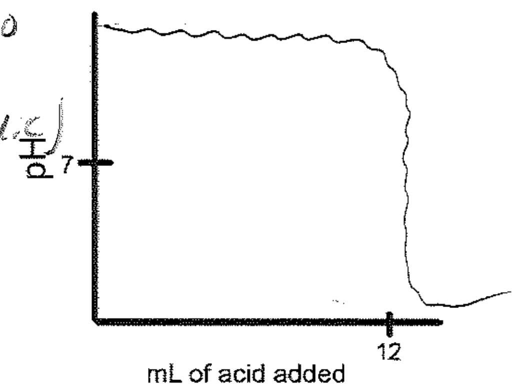


Video

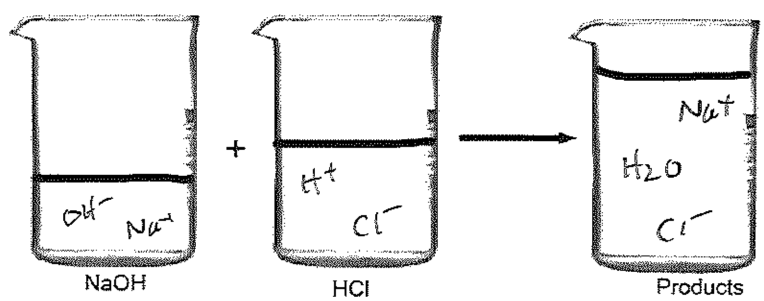
2. 0.5M NaOH
   a. Determine the pH of this solution. $-\log(.5) = 0.3$ $14 - .3 = 13.6$
   b. Justify or nullify the following statement: NaOH does not have a Kb value because it does not undergo hydrolysis. True, it has a Ksp but that is very Big too.
   c. Draw a picture of the basic solution in the beaker provided.



3. A pH meter and 10mL of 0.5M NaOH are placed in a beaker. 12mL of 0.5M HCl and 2 drops of phenolphthalein are added to a beaker. $HCl + NaOH \rightarrow NaCl + H_2O$
   a. Write the neutralization reaction. $H^+ + OH^- \rightarrow H_2O$
   b. Will the beaker be clear/pink/green?
   Start Pink (Basic) → go Clear (acidic)
   c. Sketch the relative pH graph for this reaction.



   d. In the three beakers below sketch the reactants and products.



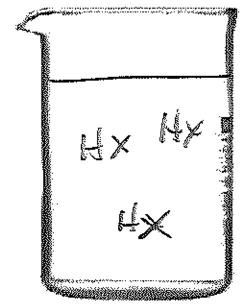
4. 0.5M Acetic acid, commonly used as a preservative in the food industry.

   a. The pka of acetic acid = 4.76.

      i. What does this pKa mean? at ½ equivalence pH = 4.76

      - acid stronger than Base [acid] = [Base]

      - general Buffer area 4.76



      ii. What is the ka of this acid?

      $10^{-4.76} = \boxed{1.73E-5}$

      iii. Determine the pH of this solution.

      $1.73E-5 = \frac{x^2}{.5}$ x = 0.0029 $-\log(\ ) = 2.53$

      iv. Draw a representative picture of the solution in the beaker provided.

      H+ and X− so small that Likely Not Shown.

5. Sodium acetate is the conjugate of acetic acid.

   a. What is the pKb of acetate. $\frac{1.0E-14}{1.73E-5} = 5.7E-10$

   pKa + pKb = 14

   b. What is the Kb of acetate? $-\log(\ ) = \boxed{9.23}$

   c. If you had a solution that had equal concentrations of acetic acid and sodium acetate, this solution would be (acidic, basic, neutral)?

   d. Calculate the actual pH of letter "c". 4.76 pKa

   82 g/mol

   $NaC_2H_3O_2$

6. A 50mL sample of 0.5M $HC_2H_3O_2$ has 1.025g of $NaC_2H_3O_2$ added to it.

   a. What is the concentration of the $C_2H_3O_2^{-1}$ ion? $1.025g \cdot \frac{1\ mol}{82\ g} = \frac{0.0125 mol}{.05 L}$

   0.25M

   b. What is the pH of this solution?

   $Ka = \frac{[X][H^+]}{[HX]}$ $1.73E-5 = \frac{.25\ X}{.5}$

   X = 3.4E-5 $-\log(\ ) = \boxed{4.46}$

7. A 50mL sample of .5M Acetic acid has 125mL of 0.1M NaOH added.

   a. Write the net ionic equation for this reaction.

   $HX + OH^- \rightarrow X^- + H_2O$

   b. Determine the number of moles of acetic acid and hydroxide before the reaction

   M · L = mol

   .5 · .05 = 0.025 mol   0.1 · .125 = .0125 mol

   c. Determine the new concentration of acetic acid and acetate ion after the reaction.

   .025   0

   −.0125   +.0125 $\frac{.0125\ left}{.175} = 0.071$

   Ka = [ ]

   d. Determine the pH of the solution after mixed.

   $Ka = \frac{.071\ [\ ]}{.071}$ −log Ka   pKa   4.76

   at ½ eq. 4.76

8. A 25mL of acetic acid with an unknown concentration is mixed with 0.5M NaOH. 20mL of the base is required to reach equivalence.

   a. The unknown is (more/less) concentrated then the known base?

   Same mole = MV

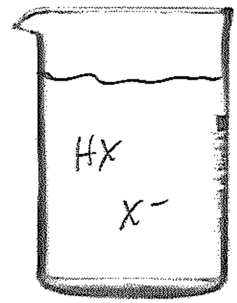
   larger vol

b. Determine the actual concentration of the acid.

$.5 \cdot 0.02L = .01mol \frac{1}{1} = .01/.025 = 0.4M$

c. How many mL of the NaOH will be required to reach the half equivalence. 10 mL

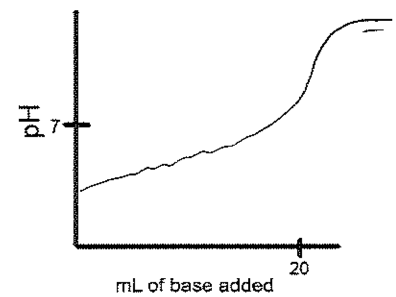
d. Draw a picture of this half equivalence in the beaker provided.



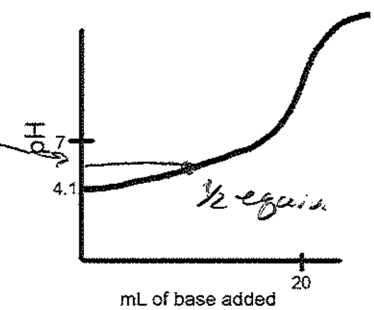
e. The half equivalence will be (acidic/base/neutral) justify.

Ka > Kb So Acid Stronger

f. Sketch the titration curve for this reaction. Conc = equal



9. 0.5g of an unknown solid acid is dissolved in 50mL of distilled water and titrated with 0.1M of NaOH. The titration curve is given. Answer the following questions.



a. Estimate the pKa of this acid. Little bigger then 4.1

b. Using the curve, determine the molar mass of the acid.

$\frac{.002mol}{.05L} = .04M$ $\quad .1 \cdot .02L = .002 mol \quad \frac{.5g}{.002} = 250 g/mol$

c. Using the curve determine the ka of the acid. → fill out I&E table

$HY + H_2O \rightleftharpoons H_3O^+ + X^-$

I .04 = 0 0

C −x = +x +x

E .04−x = x x

$10^{-4.1} = 7.9E{-5}\ H^+$

d. Using your concentration calculated, calculate the percent ionization.

$\frac{7.9E{-4}}{.04} \times 100 = 0.19\%$ ionized

$\boxed{1.58E{-7} = Ka}$ $\leftarrow \frac{(7.9E{-5})^2}{.04}$

10. 10mL of NH_3 is titrated with 0.1M HCl. The equivalence is reached after 8mL of acid.

a. Write the molecular reaction taking place. NH_3 = 1.8E-5

$NH_3 + HCl \rightarrow NH_4Cl$

b. Write the net ionic reaction taking place.

$NH_3 + H^+ \rightarrow NH_4^+$

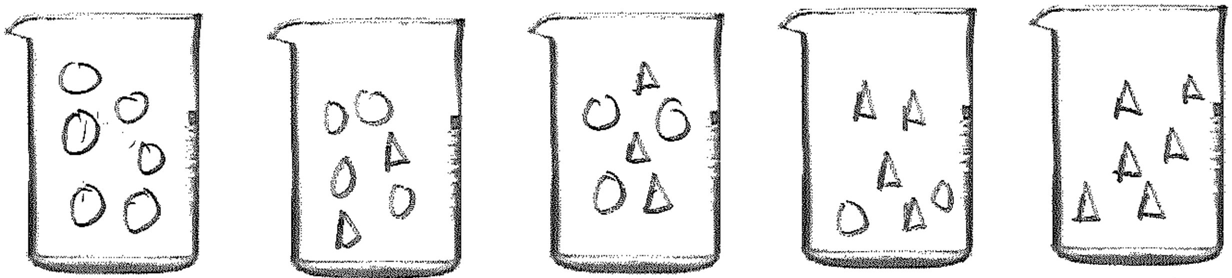
c. At 4 mL will the solution be (basic,acidic,neutral)?

d. At 8mL will the solution be (basic, acidic, neutral)?

Only NH_4^+

WEAK acid

e. To the best of your ability draw the following beaker at different times of the neutralization.



0 ml added | 2 ml added | 4 ml added | 8mL added | 10mL added

O = NH_3
Δ = NH_4^+