12 pH-Titration of Strong Acids with Strong Bases

Purpose: A strong acid solution is titrated with a strong base solution. A titration curve is then used to determine the endpoint and find the concentration of the unknown acid solution.

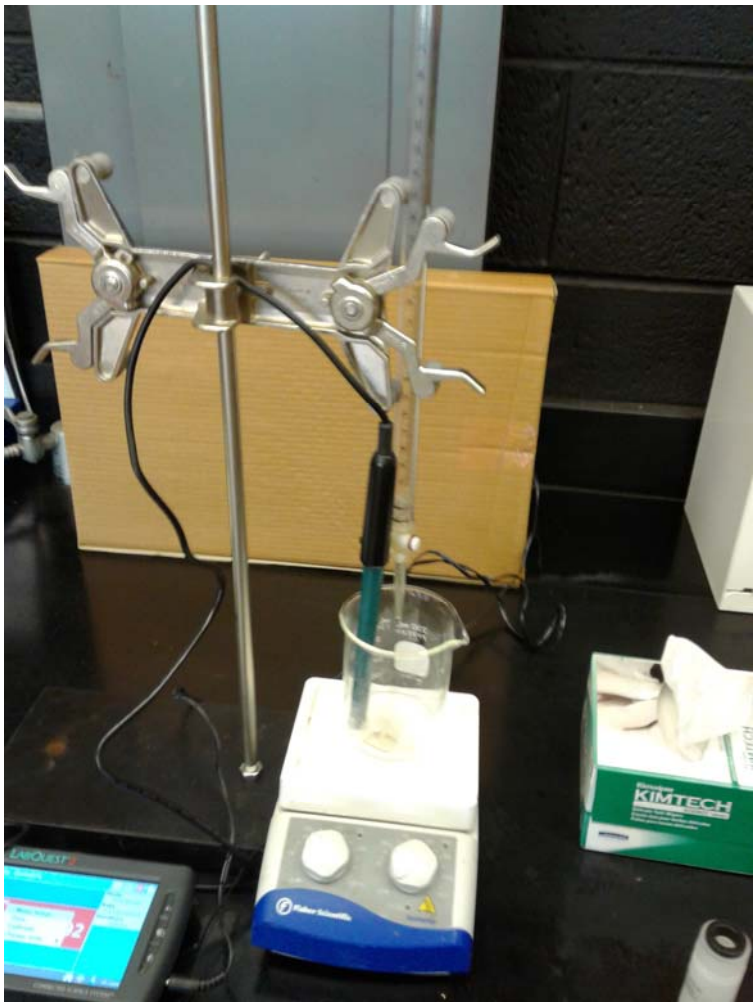
Introduction

A digital pH-meter will be used to follow the titration of hydrochloric acid, HCl(aq) with sodium hydroxide, NaOH(aq).

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O$$

The pH titration is performed by adding small amounts of standard NaOH to HCl of unknown concentration. A standard solution is one with known concentration. The pH is recorded and then plotted vs. the volume of NaOH added to the HCl solution. The result of this plot is an "S" shaped curve. The middle of the "S" is the point when moles of acid are equivalent to moles of base. From the equivalence point, also known as the endpoint, the concentration of the unknown acid, HCl, can be found.

Apparatus:



Procedure:

Titration of Unknown HCl with Standard (Known) NaOH

1. Place about 200 mL of standard NaOH solution in a clean, 250 mL Erlenmeyer flask. Record the molarity of the NaOH(aq).

2. Clean a 50 mL burette thoroughly with tap water, then rinse it with several small portions of the standard NaOH solution, being sure to run some solution through the tip.

3. Using the funnel, fill the burette above the '0' mL mark, then lower the meniscus back to '0'.

4. Using a volumetric pipette and a pipette pump measure 25.00 mL of unknown HCl solution into a 150 mL beaker. Place the beaker on a stir plate and clamp the electrode so that it is supported in the solution. Your instructor will assemble a sample set-up.

5. Place a magnetic stir bar in the beaker so that it does not touch the electrode while stirring. *(When electrode is not in use for more than a few minutes, return to storage bottle.)*

6. Add 5 drops of phenol red or phenolphthalein indicator to the HCl solution.

7. Place the burette just inside the beaker as shown in the figure so that the burette will drip directly into the solution.

8. Trial run: Add NaOH in roughly 2 mL volumes until the endpoint is reached, that is, when the phenol red changes from yellow (acidic) to red (basic) or the phenolphthalein from colorless (acidic) to pink (basic). Record the approximate volume of NaOH used to reach this point. The purpose of the trial run is to find the approximate end point so you will know when to slow down during your careful run (next step). The trial run should take only a minute or two.
Note: The equivalence point for a strong acid vs. strong base titration occurs at pH = 7.

9. Careful run: Add NaOH gradually (1 mL at a time) until you approach within 1 mL of the estimated endpoint. Then proceed much more slowly drop by drop. After the endpoint is reached, measure 5-10 more points adding 1 mL of NaOH at a time, to see the titration curve leveling off again.
Note: With practice you should be able to deliver half drops near the end point.

10. Perform another careful run with a second sample of the same unknown HCl. If the careful runs are not very close to the same, see your instructor. If time allows, you could try a third careful run.

11. Plot the pH vs. the volume of NaOH added. Find the concentration of the unknown acid, using the equation $M_{NaOH}\ V_{NaOH} = M_{HCl}V_{HCl}$. (M is Molarity and V is Volume.)

Data and Results (pH titration)

Name(s) _____

Molarity of standard NaOH: _____ M. Code number/letter of unknown HCl: _____

Trial run: equivalence point: _____ mL NaOH

Careful Run

Titration 1				Titration 2			
NaOH (mL)	pH	NaOH(mL)	pH	NaOH(mL)	pH	NaOH(mL)	pH

Equivalence point 1: ..... mL NaOH. Equivalence point 2: ..... mL NaOH

Average of 1 & 2: ..... mL NaOH. Concentration of HCl: ..... M

Question:

1. Include plot with your data. What is the pH at the equivalence point?

Instructor's Guide
 # 12 pH titration NaOH vs HCl

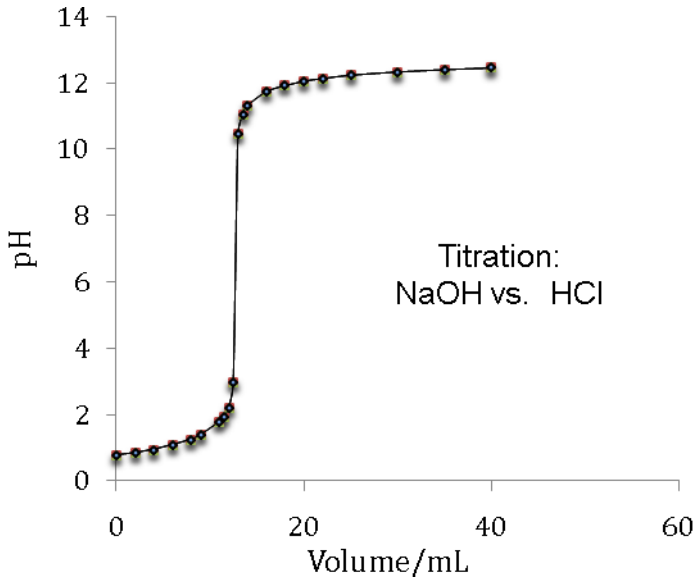
Molarity of standard NaOH: __*0.1*___ M. Code number/letter of unknown HCl: __*C*__
Careful Run

Titration 1				Titration 2			
pH	NaOH(mL)	pH	NaOH(mL)	pH	NaOH(mL)	pH	NaOH(mL)
0.77	*0*	*11.31*	*14*				
0.84	*2*	*11.73*	*16*				
0.94	*4*	*11.92*	*18*				
1.08	*6*	*12.05*	*20*				
1.25	*8*	*12.13*	*22*				
1.38	*9*	*12.23*	*25*				
1.54	*10*	*12.33*	*30*				
1.78	*11*	*12.4*	*35*				
1.93	*11.5*	*12.45*	*40*				
2.19	*12*	*12.53*	*50*				
2.98	*12.5*						
10.45	*13*						
11.05	*13.5*						

Equivalence point 1: *12.9* mL NaOH. Concentration of HCl: __*0.052*__ M

Question: **1.** Include plot with your data. What is the pH at the equivalence point?

pH = 7 at the equivalence point



Instructor's Guide
pH titration NaOH vs HCl (cont'd)

Time: 1 h

Equipment and Materials Per group:

Items	**Number**	**Comment**
0.1 M NaOH(aq)	2 L	includes trial run.
Labquest2	1	pH Electrode
250-mL Erlenmeyer flasks	1	for dispensing NaOH(aq) standard
25.00 mL pipettes	1	
pipette pumps	1	
Phenol red	3 per class	dropper bottles
150-mL beakers	1	
Kimwipes, box	1	
stir plates	1	
stir bars	1	
stir bar retriever	2 per class	
funnels (plastic)	1	to fill burettes
ring stands	1	
burettes	1	
burette holders	1	
wash bottles	1	distilled water
Waste bottle	1 per class	
Unknown HCl B & C	2 L	One of each. Unknown B is 0.104 M Unknown C is 0.052 M
Safety Glasses	1 per student	
Rubber gloves	1 box per class	

Ideas/ Information

Unknown HCl solutions could be prepared by adding concentrated HCl (12 M) to a volumetric flask and then diluting with distilled water to the mark on the flask.

Molarity mol/L	mL con. HCl for 1 L solution	mL con. HCl for 500 mL solution
0.052	4.34	2.17
0.104	8.68	4.34

Standard NaOH solution could be prepared by adding solid NaOH to a volumetric flask and then diluting with distilled water to the mark on the flask.

Molarity mol/L	g NaOH for 1 L solution	g NaOH 500 mL solution
0.1	4	2