**Titration Curves of Strong and Weak Acids and Bases (Revised, 5-23-18)**

***Objectives:***

\*to become familiar with the Vernier pH probe and accompanying software, using an “events with entry” file to generate titration curves,

\*to titrate a strong acid with a strong base, a weak acid with a strong base, a strong acid with a weak base, and a weak acid with a weak base,

\*to understand the difference between and compare the occurance of the equivalence point and the endpoint in your titrations, and

\*to compare the appearance and characteristics of the titrations curves for these four combinations.

***Procedure:***

1. Prepare a buret for titration using 0.10 M NaOH. (Fill the buret above the zero mark, then drain some titrant into a waste flask in order to fill the tip of the buret.) Record the initial volume on the buret. (Since this is an events with entry lab, it will be easiest to start your buret at zero.)
2. Plug in the power supply chord to the LabPro interface, connect the LabPro to the laptop using the USB cable and connect the pH probe to the LabPro. **NOTE:** The pH probe must be stored in a buffer solution to keep it from drying out. If ion selective electrodes are allowed to dry out, they will most likely be ruined, so always store them in their storage solution in an **upright** position.)
3. Open the ***Acid-Base Titration*** file (Chemistry with Vernier, **#24a**) on your computer.
4. Precisely measure about 8 mL of HCl into a 250 mL beaker. Add about 50 mL of distilled water and 3 drops of phenolphthalein to the beaker. (NOTE: Although adding water changes the concentration of the acid, it does NOT change the number of moles of acid, nor the initial volume, so therefore, the titration is unaffected.)
5. Set the beaker of analyte on a magnetic stirring base beneath your buret and add a magnetic stirring bar.
6. Remove the pH probe from its storage solution by loosening the compression cap and sliding the probe out of its container. Set the storage container aside in a location where you will not knock it over and spill the storage buffer. Rinse the probe with distilled water (use a squeeze bottle) and clamp the probe to your utility pole so that the probe is held upright in the beaker containing the analyte. Be sure the pH probe is off to the side and turn on the magnetic stirrer.
7. Click collect on the computer screen.
8. When the pH reading on the computer screen settles somewhat, click the KEEP button on the computer screen, and enter the initial volume as ***zero*** when prompted to do so. (Even if the buret is not reading zero at this point, you enter zero because you have not added any titrant to the analyte yet.
9. Slowly add enough titrant to the analyte beaker to raise the pH by about 0.15 units. Click Keep and record the new volume. (If the initial buret reading was ***not zero***, be sure to enter the ***volume of*** ***titrant dispensed*** by entering the ***difference*** between the current buret reading and the initial buret reading.)
10. Repeat step #9 until a pH of about 3.5 is reached, then change to drop by drop increments and continue to collect data points. Take note of the point closest to where the phenolphthalein changes color. Once the titration curve begins to level off, resume titrant increments which raise the pH by about 0.15 units and collect 3 or 4 more data points to complete this curve.
11. Format your graph (adjust window size accordingly, add a footer with your names, label the equivalence point, andpoint, etc.,) and print it.
12. Refill (or drain) your buret to an even 10.00 ml multiple (0, 10, or 20, not 30 or more) to begin the next titration.
13. Repeat steps 1-10 using 0.10M acetic acid (HC2H3O2) in place of HCl as the analyte.
14. Empty your buret into the ***reclaimed titrant*** container provided by your instructor.
15. Rinse the buret with a small amount (about 5 mL) of 0.10 M ammonia (NH3) two times. When rinsing the buret, be sure to run some of the rinsing solution through the spigot. Then refill the buret with the ammonia solution. Remember to refill the tip of the buret by draining some titrant through it.
16. Using the same process as described above, generate titration curves using (a) ammonia as titrant and HCl as analyte, and (b) ammonia as titrant and acetic acid as analyte.

***Data and Observations:*** Experiment performed on \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | NaOH & HCl | NaOH & HC2H3O2 | NH3 & HCl | NH3 & HC2H3O2 |
| Volume of Analyte (mL) |  |  |  |  |
| Initial Buret Vol (mL) |  |  |  |  |
| Titrant Vol when pH=7 |  |  |  |  |
| Titrant Vol @ Equiv. Pt. |  |  |  |  |
| Titrant Vol @ color chg |  |  |  |  |
| pH @ color change |  |  |  |  |
| Describe Color |  |  |  |  |
| Final Buret Vol (mL) |  |  |  |  |

Questions:

1. Label the titration curves below as to which one you think best represents a strong acid-strong base titration, which best represents a weak acid-strong base titration, which is strong-weak and which is weak-weak.
2. What is the ***theoretical*** difference between the equivalence point and the endpoint? Would you be able to distinguish between them if you were titrating with phenolphthalein, but without a pH probe? Would you be able to distinguish between them with a probe, but no phenolphthalein? What was the difference in volume (generally speaking) between your equivalence points and your endpoints?
3. Since the color change observed with phenolphthalein occurs at a pH of about 9, for which combination of strong and weak is it most appropriate to use phenolphthalein to approximate an equivalence point?
4. Science teachers often say that phenolphthalein is clear in acid or neutral solution and pink in a base. Is this oversimplification of the truth a major or minor oversimplification? Justify your answer by referring to the difference in volume that this can make in a particular kind of titration.
5. If the equivalence point is considered the center of the near vertical portion of the titration curve, do all of your equivalence points occur at the same pH?
6. Describe the different appearances of the four types of titration curves including the length of the vertical portion, the slopes of the beginning and ending portions, the appearance of the inflection points, etc.,
7. Write the equilibrium expressions for each of the four compounds used in this lab (not including phenolphthalein) and look up the Ka values of the acids and the Kb values of the bases. What general statements can you make regarding the extent of each reaction, the size of the equilibrium constant, and how these relate to acid-base strength.