FLINN SCIENTIFIC

Name_____

# Pre-Lab Homework Assignment

Complete the following homework set and write a lab procedure to be approved by your instructor prior to performing the lab. Along with your procedure, you will turn in any graphs or figures you were asked to create in this homework set, and answers to the questions. Use a separate sheet of paper if needed.

**Introduction to Acids and Bases**

1. Define and provide an example list of common strong acids and bases and weak acids and weak bases.

2. See the particulate models in Figure 2 to answer questions *a*–*d*.

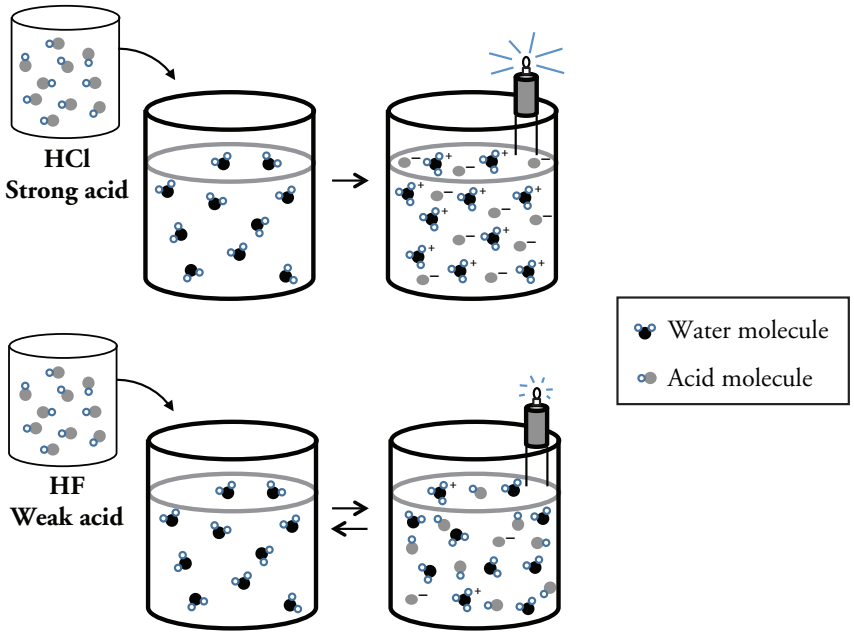


**Figure 2.**

*a.* Write the chemical reactions taking place.

*b.* Identify conjugate pairs by labeling the reactants and products as acids or bases.

*c.* Which chemical reaction illuminates the light bulb the brightest? Which light bulb is dimmer? Explain.

*d.* Write the equilibrium constant expression, $K_a$, for each and predict the relative magnitudes of $K_a$. Describe what structural factors influence dissociation and, thus, the $K_a$ value.

3. Draw a similar particulate model from question 2 for an aqueous solution of 0.01 *M* ammonia.

4. Answer *a–e* regarding the relationships between $[H^+]$, $[OH^-]$, and pH.

   *a.* Water may behave as an acid or a base, $H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$, where the equilibrium constant, $K_w$, equals $1 \times 10^{-14}$ at 25 °C. Write the equilibrium expression.

   *b.* What are the concentrations of $[H^+]$ and $[OH^-]$ from 4*a*?

   *c.* Calculate the pH of 0.10 *M* HCl and 0.10 *M* $CH_3COOH$. Show your work. *Hint:* $pH = -\log[H^+]$

   *d.* Seek out education resources and observe the pH values of common acids and bases, both strong and weak. Can a weak acid and a strong acid have the same pH?

   *e.* Go back to question 3. Write the equilibrium constant expression, calculate it, and calculate the pH. Show your work. *Hint:* $K_a$ for ammonium ion is $5.69 \times 10^{-10}$.

**Neutralization Reactions**

5. Acids and bases go to completion via neutralization reactions, thus titrations are applicable. Refer to educational resources and provide an example of the chemical reactions for the solutions in *a–c*.

   *a.* A mixture between a strong acid and a strong base.

*b.* A strong base mixed with a weak acid.

*c.*A strong acid mixed with weak base.

**Design a Titration Experiment**

6. A student has to design a titration experiment to determine the concentration of an unknown acid. Answer questions *a–f*.

*a.* See Figure 3. Label the equipment the stu[illegible]itration. Write answers next to the blanks.

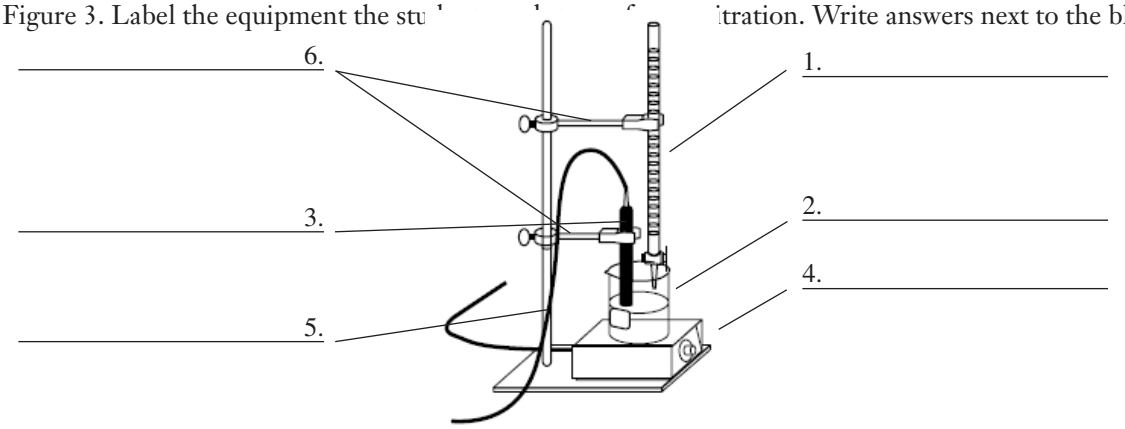


**Figure 3.**

*b.* The student performs a "rough" titration using beakers, beral-type pipettes, and a pH meter. The purpose is to determine the proper acid–base indicator in signaling the endpoint in the titration of various combinations of acids and bases. See the student's data table below. Fill in the table for the best indicator to use in each. *Note:* More than one indicator may apply.

| Acid | Initial pH | Base | Initial pH | Endpoint | Indicator |
|---|---|---|---|---|---|
| Acetic acid | 2.8 | Ammonia | 10 | 6.8 | |
| Acetic acid | 2.8 | Sodium hydroxide | 13 | 7.5 | |
| Hydrochloric acid | 1.0 | Ammonia | 10 | 5.5 | |
| Hydrochloric acid | 1.0 | Sodium hydroxide | 13 | 7.0 | |
| Nitric acid | 2.0 | Ammonia | 10 | 5.5 | |
| Nitric acid | 2.0 | Sodium hydroxide | 13 | 7.0 | |
| Sulfuric acid | <1.0 | Ammonia | 10 | 5.5 | |
| Sulfuric acid | <1.0 | Sodium hydroxide | 13 | 7.0 | |

| Indicator | Acid Form | Base Form | pH Transition Interval |
|---|---|---|---|
| Bromphenol blue | Yellow | Purple | 3.0–4.6 |
| Bromthymol blue | Yellow | Blue | 6.0–7.6 |
| Thymol blue | Yellow, (red to yellow)* | Blue | 1.2–2.8*, 8.0–9.2 |
| Phenolphthalein | Colorless | Pink | 8.2–10.0 |
| Thymolphthalein | Colorless | Blue | 9.3–10.5 |
| Methyl red | Red | Yellow | 4.4–6.2 |

*c.* After the "rough titration", the student gathered materials and performed a titration three times. Graph the students' titration data below of a weak acid (acetic acid) titrated with a strong base (0.10 M sodium hydroxide) utilizing a spreadsheet program. The student selected thymol blue as the indicator. Give a reason why this is a good indicator to use for this titration.

**Volume of Sample Titrated:** 25.0 mL acetic acid

| Volume NaOH, mL | pH |
|---|---|
| 0.00 | 2.88 |
| 5.00 | 4.15 |
| 10.00 | 4.58 |
| 12.50 | 4.76 |
| 15.00 | 4.93 |
| 20.00 | 5.36 |
| 24.00 | 6.14 |
| 24.90 | 7.15 |
| 25.00 | 8.73 |
| 26.00 | 11.29 |
| 30.00 | 11.96 |

*d.* On the generated titration plot from part *c*, using arrows, label the pH at half equivalence, the one half-equivalence point volume, the equivalence point volume, the pH at the equivalence point, and the end titration.

*e.* Calculate $K_a$.

*f.* Calculate the concentration of the acid (acetic acid).

7. Write a general step-by-step procedure to determine the concentration of an unknown acid or base. On lab day, your instructor will provide you with a titration curve to reproduce. The procedure should be written in the lab notebook to be used on the day of lab. *Helpful tips:*

*a.* Think safety, first. Make sure you have the proper PPE available to perform this lab. I.e. goggles, apron, and gloves.

*b.* Make a list of the equipment and glassware needed for this lab.

*c.* Number the steps in your procedure; remember to be as detailed as possible, from set-up to clean-up.

*d.* Draw necessary data tables in your notebook for data collection during the lab.

*e.* Be prepared to pick your acid and base on lab day to reproduce the given titration curve. Watch the amount of chemical volumes for the three trials—you don't want to run out!

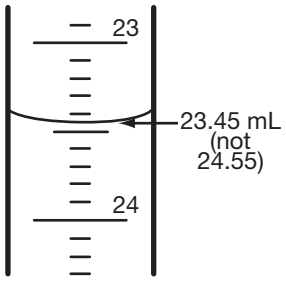


**Figure 4.**

*f.* To record the volume in a buret, read it from the top-down. A buret is marked every 0.1 mL and thus the volume may be estimated to two decimal places (see Figure 4).