Workshop (Acid and Base Chemistry)

Acid Base Definitions

- **Arrhenius Acid** - The properties of an acidic solution are due to the presence of the H+(aq) ion
  Arrhenius Base - The properties of a basic solution are due to the presence of the OH–(aq) ion
- **Brønsted–Lowry Acid** - proton donor
  Brønsted–Lowry Base - proton acceptor
  - **Conjugate Acid–Base Pair**
  - Any two substances related to each other by the transfer of a proton can be considered a conjugate acid–base pair.

Neutralization Reaction

- When an acid reacts with a base, a *neutralization* reaction occurs
  - The H+ from the acid reacts with the OH- from the base to form water.
  - $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

pH, pOH, $[H^+]$, and $[OH^-]$ calculations

$pH + pOH = 14$

$pH = -\log[H^+]$

$[H^+] = 10^{-pH}$

$pOH = -\log[OH^-]$

$[OH^-] = 10^{-pOH}$

1. What volume of a 0.1234 M solution of sodium hydroxide is required to completely react with 3.457 g of sulfuric acid? $2NaOH + H_2SO_4 \rightarrow 2H_2O + Na_2SO_4$

$$3.457\,g\,H_2SO_4 \times \frac{1\,mole\,H_2SO_4}{98.08\,g\,H_2SO_4} \times \frac{2\,mole\,NaOH}{1\,mole\,H_2SO_4} \times \frac{L}{0.1234\,mole\,NaOH} = \boxed{0.5713\,L}$$

2. If 25.0 mL of hydrochloric acid solution were used to titrate 2.077 g of calcium hydroxide, what is the molarity of the hydrochloric acid solution?

$$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$$

$$2.077\,g\,Ca(OH)_2 \times \frac{1\,mole\,Ca(OH)_2}{74.096\,g\,Ca(OH)_2} \times \frac{2\,mole\,HCl}{1\,mole\,Ca(OH)_2} \times \frac{1}{0.0250\,L} = \boxed{2.24\,M\,HCl}$$

$HC_2H_3O_2 + NaOH \rightarrow H_2O + NaC_2H_3O_2$

3. A 25.00 mL sample of acetic acid was titrated with 20.00 mL of a 0.4157 M sodium hydroxide solution. What is the concentration of acetic acid?

$$0.02000\,L \times \frac{0.4157\,mole\,NaOH}{L} \times \frac{1\,mole\,HC_2H_3O_2}{1\,mole\,NaOH} \times \frac{1}{0.02500\,L} = \boxed{0.3326\,M}$$

4. Fill in the table

$[H_3O^+]$	$[OH^-]$	pH	pOH
1.23×10^{-5} M	8.13×10^{-10} M	4.910	9.090
1.20×10^{-8} M	8.23×10^{-7} M	7.915	6.085
5.9×10^{-6} M	1.7×10^{-9} M	5.23	8.77
2.8×10^{-6} M	3.5×10^{-9} M	5.55	8.45

5. Determine which of the following is the most basic and which is the most acidic
   a. pH = 3 — pH = 3 → most acidic
   b. pOH = 3 — pH = 11
   c. $[H^+] = 1 \times 10^{-12}$ — pH = 12
   d. $[OH^-] = 1 \times 10^{-2}$ — pOH = 2 → pH = 12 → Most basic

6. What is the pH of a solution prepared by adding 0.023 g of calcium hydroxide in enough water to make 2.23 L of solution?

$$0.023\,g\,Ca(OH)_2 \times \frac{1\,mole\,Ca(OH)_2}{74.096\,g\,Ca(OH)_2} \times \frac{2\,mole\,OH^-}{1\,mole\,Ca(OH)_2} \times \frac{1}{2.23\,L} = 2.78 \times 10^{-4}\,M\,OH^-$$

$pOH = -\log(2.78 \times 10^{-4}) = 3.555$ $\boxed{pH = 10.44}$

7. What is the pH of a solution prepared by adding 0.045 g of hydrochloric acid in enough water to make 2.23 L of solution?

$$0.045\,g\,HCl \times \frac{1\,mole\,HCl}{36.46\,g\,HCl} \times \frac{1\,mole\,H^+}{1\,mole\,HCl} \times \frac{1}{2.23\,L} = 5.53 \times 10^{-4}$$ $\boxed{pH = 3.26}$

8. What volume of hydrogen, measured at STP, is released when a 1.44 g chip of calcium is added to 125 mL of a 1.25 M solution of hydrochloric acid? $Ca + 2HCl \rightarrow CaCl_2 + H_2$

$1.44\,g\,Ca \times \frac{1\,mole\,Ca}{40.08\,g\,Ca} = \boxed{0.0359\,mole\,Ca}$ → L.R.

$0.125\,L \times \frac{1.25\,mole\,HCl}{L} = 0.156\,mole\,HCl$

$0.0359\,mole\,Ca \times \frac{1\,mole\,H_2}{1\,mole\,Ca} = 0.0359\,mole\,H_2$

$PV = nRT$

$V = \frac{0.0359\,mole\,H_2 \times 62.37\,L \cdot torr \times 273}{mole \cdot K \times 760\,torr}$