

### Titration Practice Problems

Chemists perform titrations to determine the concentration of an unknown acid or base solution. In the Virtual Lab that we did in class, the mole ratio was always 1:1. However, in the real world, that is not always so. Therefore, it is important to account for the different mole ratios, when performing titration calculations.

The formula for titration calculations is  $M_A C_B V_A = M_B C_A V_B$ . Where M represents the molarity, C represents the mole coefficient from the balanced chemical equation, and V represents the volume used. As expected, A stands for acid, and B stands for base.

#### Sample Problem:

A student titrates 20.00 ml of 0.25 M  $H_2SO_4$  solution to neutralize an unknown concentration of NaOH. The equivalence point is reached when 25.00 ml of base are added. What is the concentration of the base?

$$M_A C_B V_A = M_B C_A V_B$$

Note that since we are solving for the concentration of the base, we are trying to solve for  $M_B$ . Therefore, the equation above can be rearranged as shown below:

$$\frac{M_A C_B V_A}{C_A V_B} = \frac{M_B C_A \cancel{V_B}}{C_A \cancel{V_B}}$$

$$\frac{M_A C_B V_A}{C_A V_B} = M_B$$

Now write the balanced chemical equation to determine the mole coefficients. The equation shows that there are two moles of base for every one mole of acid.



Now substitute the values into the appropriate places in the titration equation to determine the concentration of the base.

$$\frac{M_A C_B V_A}{C_A V_B} = \frac{(0.25 M) (2) (20.00 ml)}{(1) (25.00)} = M_B = 0.40 M NaOH$$

**Practice Problems:**

1. The concentration of NaOH is 0.50 M, if 30.0 ml is needed to titrate 35.0 mL of HCl acid, what is the concentration of the acid?
2. A 15.00 mL sample of acetic acid is titrated with 23.12 mL of 0.9940M Sodium Hydroxide. What is the concentration of the acetic acid?
3. A student titrates 28.3 ml of 0.1 M  $\text{H}_3\text{PO}_4$  solution to neutralize an unknown concentration of NaOH. The equivalence point is reached when 35.00 ml of base are added. What is the concentration of the base?
4. What volume of a 0.87 M solution of sulfuric acid would be needed to titrate 12.00 mL of a 0.225 M solution of strontium hydroxide?

**Bonus Question:**

A truck containing 2000 L of a 6.0M HCl has been in an accident and is in danger of spilling its cargo. What volume of 12.0 M calcium hydroxide should be sent to the scene in order to neutralize all of the acid in case the tank bursts?