

Acid-Base Titrations & Redox Reactions (Chapter 4 Pt 2)

I. Big Idea

Previously, we've talked about precipitation reactions and how they're useful to us in lab. Today we're going to discuss two more types of reactions: **acid-base reactions & redox reactions**. Before we get there, let's define some terms.

The general reaction between an acid and a base is:



Arrhenius definition of "Acid" -

Makes H^+ in solution

Arrhenius definition of "Base" -

Makes OH^- in solution

II. Acid-Base Titrations

- Determine the concentration of NaOH if 10.0 mL of the solution took 11.5 mL of 2.0 M HCl to reach the equivalence point in a titration.

Balanced eq: $\text{HCl (aq)} + \text{NaOH (aq)} \rightarrow \text{H}_2\text{O (l)} + \text{NaCl (aq)}$

$$(11.5 \times 10^{-3}) \text{ L of HCl} \times \frac{2.0 \text{ mol HCl}}{1 \text{ L of HCl}} \times \frac{1 \text{ mol NaOH}}{1 \text{ mol HCl}} \\ = 0.023 \text{ mol NaOH}$$

$$\frac{0.023 \text{ mol NaOH}}{10.0 \times 10^{-3} \text{ L}} = 2.3 \text{ M NaOH}$$

- How many milliliters of 0.610 M NaOH solution are needed to neutralize 20.0 mL of a 0.245 M H_2SO_4 solution?

Balanced eq: $\text{H}_2\text{SO}_4 + 2\text{NaOH} = 2\text{H}_2\text{O} + \text{Na}_2\text{SO}_4$

$$(20.0 \times 10^{-3}) \text{ L of H}_2\text{SO}_4 \times \frac{0.245 \text{ mol H}_2\text{SO}_4}{1 \text{ L of H}_2\text{SO}_4} \times \frac{2 \text{ mol NaOH}}{1 \text{ mol H}_2\text{SO}_4} \times \frac{1 \text{ L NaOH}}{0.610 \text{ mol NaOH}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \\ = 16.1 \text{ mL NaOH}$$

- You are titrating a solution of sodium hydroxide of unknown concentration with a solution of phosphoric acid that has a concentration of 0.300 M. Starting with 29.0 mL of the sodium hydroxide solution, you use 16.8 mL of the acid to titrate the base to completion. Calculate the concentration of the sodium hydroxide solution.

Balanced eq: $3\text{NaOH} + \text{H}_3\text{PO}_4 \rightarrow \text{Na}_3\text{PO}_4 + 3\text{H}_2\text{O}$

$$(16.8 \times 10^{-3}) \text{ L of H}_3\text{PO}_4 \times \frac{0.300 \text{ mol H}_3\text{PO}_4}{1 \text{ L of H}_3\text{PO}_4} \times \frac{3 \text{ mol NaOH}}{1 \text{ mol H}_3\text{PO}_4} = 0.01512 \text{ mol NaOH}$$

$$\frac{0.01512 \text{ mol NaOH}}{29.0 \times 10^{-3} \text{ L}} = 0.52 \text{ M NaOH}$$

What is a titration? - the slow addition of one solution of a known concentration (called a titrant) to a known volume of another solution of unknown concentration until the reaction reaches neutralization.

4. A 0.350-g sample of an acid, HX, requires 25.4 mL of a 0.140 M NaOH solution for complete reaction. Calculate the molar mass of the acid.
 (A) 42.3 g/mol (B) 68.4 g/mol (C) 98.4 g/mol (D) 121.3 g/mol
 (E) none of these

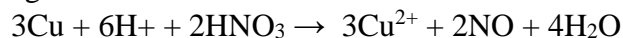
Balanced eq: $\text{HX (aq)} + \text{NaOH (aq)} \rightarrow \text{H}_2\text{O (l)} + \text{NaX (aq)}$

$$(25.4 \times 10^{-3}) \text{ L of NaOH} \times \frac{0.140 \text{ mol NaOH}}{1 \text{ L of H}_2\text{SO}_4} \times \frac{1 \text{ mol HX}}{1 \text{ mol NaOH}} = 0.003556 \text{ mol HX}$$

$$\frac{0.350 \text{ g HX}}{0.003556 \text{ mol HX}} = 98.4 \text{ g/mol HX}$$

III. Redox Reactions

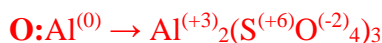
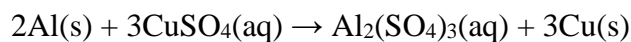
5. Which of the following reactions does not involve oxidation-reduction?
 (A) $\text{MnO}_2 + 4\text{HI} \rightarrow \text{I}_2 + 2\text{H}_2\text{O} + \text{MnI}_2$
 (B) $\text{LiOH} + \text{HCl} \rightarrow \text{H}_2\text{O} + \text{LiCl}$
 (C) $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$
 (D) $\text{Mg} + 2\text{HI} \rightarrow \text{MgI}_2 + \text{H}_2$
 (E) All the above are oxidation-reduction reactions
6. In the following reaction, which species is the reducing agent?



- a. Cu^{2+} b. HNO_3 c. Cu d. NO e. H^+

The reducing agent is the species that gets oxidized. Cu loses electrons to become Cu^{2+} .

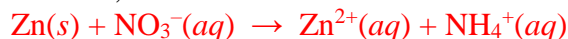
7. Identify the oxidation numbers of all of the elements in the following equation as well as indicate which element was oxidized and which was reduced.



Al was oxidized, Cu was reduced.

IV. Balancing Redox Reactions in Acidic or Basic Solution

8. Balance the following equation in acidic solution. When the following reaction is balanced in acidic solution, what is the coefficient of water?



Add them together to get:

Reduction – gains electrons

Oxidation – loses electrons

Oxidation Agent – the species that is itself reduced

Reducing Agent – the species that is itself oxidized



Coefficient of water = 3 on the right.

First, we write the skeleton equation then separate it into half-reactions. We start with balancing all the atoms except hydrogen and oxygen (zinc and nitrogen look good here). Then we add water to balance the oxygens and hydrogen ions to balance the hydrogens. We then balance the charge on each half reaction by adding electrons to either side. We then scale the reaction so that the oxidation half reaction loses the same number of electrons that the reduction reaction will gain. Add the reactions together and simplify to get above.

9. Balance the following reaction occurs in aqueous acid solution. What is the coefficient of NO_3^- ?
 $\text{NO}_3^- + \text{I}^- \rightarrow \text{IO}_3^- + \text{NO}_2$



Add them together to get:



First, we write the skeleton equation then separate it into half-reactions. We start with balancing all the atoms except hydrogen and oxygen (nitrogen and iodine looks good here). Then we add water to balance the oxygens and hydrogen ions to balance the hydrogens. We then balance the charge on each half reaction by adding electrons to either side. We then scale the reaction so that the oxidation half reaction loses the same number of electrons that the reduction reaction will gain. Add the reactions together and simplify to get above.

10. Balance the following equation in basic solution and determine the coefficient of OH^- and its location (right side or left side) in the equation. Also identify the oxidizing and reducing agents in the reaction.



Add them together to get:



First, we write the skeleton equation then separate it into half-reactions. We start with balancing all the atoms except hydrogen and oxygen (cesium and phosphorus looks good here). Then we add water to balance the oxygens and hydroxides to balance the hydrogens. (Alternatively, you could add hydrogen ions and balance it in acidic medium, then switch it later). We then balance the charge on each half reaction by adding electrons to either side. We then scale the reaction so that the oxidation half reaction loses the same number of electrons that the reduction reaction will gain. Add the reactions together and simplify to get above.