

Chapter 4

Solution: -> Any homogeneous mixture. All parts of the mixture have the identical composition.

Solvent – The substance in a solution that causes the solution to be made. Usually it is the most abundant substance in the mixture.

Solute – The substance that is dissolved. There can be more than one solute in a solution. In the most common solution, the solute is a solid or a liquid and the solvent is a liquid.

An **aqueous** solution is one in which the solvent is water. For now we will only deal with aqueous solutions.

Electrolyte – Substance that conducts electricity in aqueous solution.

Types:

1. Salts (ionic compound between a metal and non-metal or polyatomic anion)
2. Acids & bases

Electrolytes can be weak or strong. A strong electrolyte breaks down into its ions (dissociates) 100%, while a weak electrolyte dissociates only partially. This is usually indicated by a double arrow in the equation, indicating that the reaction is reversible, meaning that both the ions and non-ionic form are present in the solution. Learn the list of strong, weak and non-electrolytes in Table 4.1 on page 107.

The process of dissolving in water is called **hydration**. Water molecules surround and attract the ions.

A common reaction in solutions is a **precipitation** reaction, which results in one or more products being an insoluble substance (called a **precipitate**)



Subscript symbols: s = solid; l = liquid; g = gas; aq = aqueous

Solubility shows the maximum amount of solute that can dissolve.

Solubility varies with temperature. For a gas dissolved in a liquid, the solubility **always decreases** as temperature increases. For solids dissolved in liquids, there is no general rule about the variation of solubility with temperature, except that most often solubility **increases** as temperature increases.

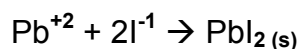
Some substances are soluble, some are slightly soluble and some are insoluble. An insoluble substance is actually very slightly soluble, which you will deal with in Chem 2.

The equations we have seen so far are **molecular equations**, because the full formula of all substances is listed.

Sometimes it is convenient to use a shortcut with equations involving electrolytes. If you write equation with all dissolved electrolytes listed as ions, it is called an **ionic equation**.

If an ion appears on both sides of the equation unchanged, then we call those ions **spectator ions**. We can rewrite the equation without these ions. This shortcut is called a **net ionic equation**.

In the previous equation, Na^+ and NO_3^{-1} are spectator ions. The net ionic equation becomes:



There are several ways to define acids and bases. We will discuss 2 of these.

The first was defined by the Swedish Chemist, Svante Arrhenius in the 19th century.

Definition of acid:

Produce excess H^+ ions in aqueous solutions

Definition of base:

Produce OH^- ions in aqueous solutions

This is limited to aqueous solutions only. In 1932, Danish chemist, Johannes Bronsted gave a more general definition:

acid - Proton donor – H atom contains 1 electron and a nucleus with only 1 proton, therefore an H^+ is simply a proton. Acids donate H^+ ions to bases.

base - Proton acceptor - acids donate H^+ ions to bases.

H_3O^+ or simply (H^+) is called the hydronium ion

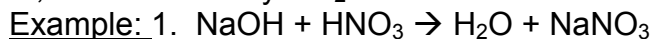
Acids and bases are electrolytes and therefore come in strong and weak forms:

strong acids - HCl , HBr , HI , HNO_3 , H_2SO_4 , HClO_4

strong bases - LiOH , NaOH , KOH , $\text{Ca}(\text{OH})_2$, $\text{Sr}(\text{OH})_2$, & $\text{Ba}(\text{OH})_2$

Polyprotic acids – Acids that contain >1 acidic H's (H₂SO₄, H₃PO₄, etc)

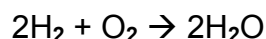
Neutralization Reaction: - Reaction between an acid and a base. Products always H₂O and a salt (in aqueous solutions). There might also be other products, most commonly CO₂.



Net ionic equation – Na⁺ and NO₃⁻¹ remain unchanged during the reaction. They are spectator ions. The net ionic equation displays only those species that change. In our example it would be: OH⁻¹ + H⁺ → H₂O
All strong acid + strong base reactions have this same net ionic equation.

At this point we will consider that there are 4 types of reactions (one way to classify reactions) (Different than in book)

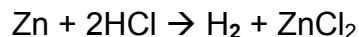
1. Combination (synthesis) - A + B → C
2 or more smaller substances combine to form one larger substance.



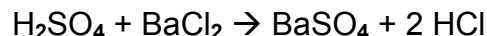
2. Decomposition - C → A + B
One larger substances breaks down into 2 or more smaller substances.



3. Substitution -> AB + C → AC + B
One element displaces another element.



4. Double Displacement (Metathesis) - AB + CD → AD + CB
Two elements exchange places.



Concentration: The actual amount of solute that is dissolved in a particular solution.

We will look at one of the most common forms here:

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{L of solution}}$$

Frequently chemists need to dilute a more concentrated solution to a more dilute solution. The formula to figure this out is:

$$C_1V_1 = C_2V_2$$

The technique of **titration** is used to analyze for amount of acid and/or base. A solution of accurately known concentration, called a **standard solution** is added gradually to another solution of unknown concentration, until the chemical reaction between the 2 solutions is complete.

Equivalence Point – When exactly equivalent amounts of acid and base have reacted. Equilibrium of $\text{H}^+ + \text{OH}^- \leftrightarrow \text{H}_2\text{O}$ lies very far to the right, therefore practically no H^+ or OH^- around and even the small amount around are equal, therefore no excess of either one (as long as both acid & base are strong. We will discuss other situations in Gen. Chem 2). But for sure all acid & base gone at equivalence point. The equivalence point (basically the same as the **endpoint**) is usually signaled by a change of color from a dye used as an indicator. The most common acid-base indicator is **phenolphthalein**.

The calculation for a titration can be approached in a number of ways, but at this time we will approach it as a stoichiometry problem. The difference between a standard stoichiometry problem and the one here is that molarity (moles/liter) is used as a conversion factor for the solutions to find moles or liters and we divide by liters to obtain molarity. Let's do example 4.10 on page 137.