# CHM 130

# Electrolytes: Acids, Bases and Salts

## Introduction

Acids can be described as substances that produce hydrogen ions (H+) when dissolved in water. This definition was first proposed by the Swedish chemist Svante Arrhenius for solutions that conduct electricity and share common properties such as sour taste and the ability to change the color of the plant dye called litmus from blue to pink. A typical reaction used to describe an acid is when hydrochloric acid is dissolved in water to form hydronium ion (H3O+) and chloride ion (Cl-).

 HCl(g) + H2O(l) → H3O+(aq) + Cl-(aq)

Bases are substances that produce hydroxide ions (OH-) when dissolved in water. These substances also conduct electricity and share common properties such as bitter taste, slippery to the touch, and the ability to change the color of litmus from pink to blue. A typical reaction used to describe a base is the when sodium hydroxide (NaOH) is dissolved in water to form hydroxide ions (OH-) and sodium ion (Na+).

 NaOH(s) → Na+(aq) + OH-(aq)

Salts consist of a positively charged ion (excluding H+) and a negatively charged ion (excluding OH-). Salts are made up of a metal cation (or ammonium ion, NH4+) and a nonmetal anion (or an oxyanion). Salts are formed in three ways:

1. reaction of acids and bases in a neutralization reaction,
2. replacing of a hydrogen atom in an acid with a metal (single replacement reactions),
3. the reaction of two other salts in a double replacement reaction.

Neutralization reaction: HCl(aq) + NaOH(s) → NaCl(aq) + H2O(l)

Single replacement reaction: 2 Na(s) + 2 HCl(aq) → 2 NaCl(aq) + H2(g)

Double replacement reaction: 2 NaCl(aq) + Pb(NO3)2(aq) → 2 NaNO3(aq) + PbCl2(s)

Pure water will not conduct an electric current. However, when acids, bases, and salts interact with water the resulting aqueous solutions will conduct electricity. Therefore, acids, bases, and salts are called **electrolytes**. Other substances such as sugar and alcohol dissolve in water but are nonconductors and are called **nonelectrolytes**.

When an aqueous solution conducts electricity it is because it contain ions which are free to move in the solution. The electrical current through the solution is the movement of these ions to the positive and negative electrodes of the conductivity apparatus. The ions are the result of the dissociation of ionic substances such as the base NaOH and the salt NaCl:

NaOH(s) → Na+(aq) + OH-(aq) NaCl(s) → Na+(aq) + Cl-(aq)

or the ionization of compounds which react with water to form hydronium ions (H3O+).

HCl(g) + H2O(l) → H3O+(aq) + Cl-(aq)

Electrolytes are classified as strong or weak depending on the extent to which they exist as ions in solution. **Strong** electrolytes are essentially **100% ionized**; that is they completely dissociate in solution and exist only as ions. Weak electrolytes are considerably less ionized; only a small amount of the dissolved substance exists as ions, the remainder being in the un-ionized or molecular form. Most salts are strong electrolytes.

There are seven **strong acids** (HCl, HNO3, H2SO4, HBr, HI, HClO4, HClO3) and ten **strong bases** (Group 1 hydroxides: LiOH, NaOH, KOH, RbOH, CsOH, FrOH and lower Group 2 hydroxides: Ca(OH)2, Sr(OH)2, Ba(OH)2, and Ra(OH)2) which all dissociate 100% in aqueous solutions and are all strong electrolytes. All other acids and bases are considered weak electrolytes.

# \*\* Don’t Forget to Wear Your Safety Goggles \*\*

1. All of the following tests are performed in well plates using the conductivity apparatus. The electrodes should be thoroughly rinsed with distilled water between testing of different solutions.
2. Each test is performed by filling a well about half full of the solution to be tested and lowering the electrodes from the conductivity apparatus into the solution. If the solution contains a large number of ions (a strong electrolyte solutions), the conductivity light should blink or at least light strongly. If the solution contains relatively few ions (a weak electrolyte solution), the conductivity light will be very dim – you may have to shield the light with your hand to see the light, so watch carefully. If the conductivity light does not light at all, the solution contains virtually no ions and is a non-electrolyte solution.
3. Test the conductivity of deionized water.
4. Test the conductivity of tap water.
5. Add a small amount of sugar to a well that is half full of deionized water. Dissolve the sugar and test the solution for conductivity.
6. Add a small amount of solid NaCl to a well and test the conductivity of the solid.
7. Add a small amount of deionized water to the NaCl well. Dissolve the salt and test the solution for conductivity.
8. Test the conductivity of glacial acetic acid.
9. Strong and weak acids and bases. Test the following: 1 molar solutions for conductivity: (a) acetic acid, (b) hydrochloric acid, (c) ammonium hydroxide, and (d) sodium hydroxide.
10. Test the following 0.10 M salt solutions for conductivity: (a) sodium nitrate, (b) ammonium acetate, (c) copper (II) sulfate, and (d) ammonium chloride.
11. Place any excess solutions in the waste container located in the hood and rinse the well plate with deonized water.

#### Name \_ ***Answer Key*** \_\_ Section # \_\_\_\_\_\_\_\_\_\_\_Lab Partner \_\_\_\_\_\_\_\_\_\_\_\_\_

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Electrolytes: Acids, Bases & Salts Report Sheet

# Part A – Conductivity of Solutions *(if students did not get these results they had some contamination)*

|  |  |  |  |
| --- | --- | --- | --- |
| Molecule | Nonelectrolyte | Strong Electrolyte | Weak Electrolyte |
| Deionized water | ***✓*** |  |  |
| Tap water |  | ***✓*** |  |
| Sugar solution | ***✓*** |  |  |
| NaCl solid | ***✓*** |  |  |
| NaCl solution |  | ***✓*** |  |
| Glacial HC2H3O2  | ***✓*** |  |  |
| 1.0 M HC2H3O2  |  |  | ***✓*** |
| 1.0 M HCl  |  | ***✓*** |  |
| 1.0 M NH4OH |  |  | ***✓*** |
| 1.0 M NaOH |  | ***✓*** |  |
| 0.1 M NaNO3 |  | ***✓*** |  |
| 0.1 M NH4C2H3O2 |  | ***✓*** |  |
| 0.1 M CuSO4 |  | ***✓*** |  |
| 0.1 M NH4Cl |  | ***✓*** |  |

Part B – Complete the following questions.

1. Classify each of the following compounds as an acid (A), a base (B), a salt (S), or none (N) and

Strong electrolyte (SE), weak electrolyte (WE) or nonelectrolyte (NE).

(a) H2SO4(aq) \_\_ ***A*** \_\_,\_\_ ***SE*** \_\_ (b) NH4C2H3O2 (aq) \_\_ ***S*** \_\_,\_\_ ***SE*** \_\_

(c) HI(aq) \_\_ ***A*** \_\_,\_\_ ***SE*** \_\_ (d) Ca(OH)2(aq) \_\_ ***B*** \_\_,\_\_ ***SE*** \_\_

(e) Li2CO3(aq) \_\_ ***S*** \_\_,\_\_ ***SE*** \_\_ (f) Cu(NO3)2(aq) \_\_ ***S*** \_\_,\_\_ ***SE*** \_\_

(g) LiOH(aq) \_\_ ***B*** \_\_,\_\_ ***SE*** \_\_ (h) C6H12O6(aq) glucose \_\_ ***N*** \_\_,\_\_ ***NE*** \_\_

(i) KNO3(aq) \_\_ ***S*** \_\_,\_\_ ***SE*** \_\_ (j) Deionizied water \_\_ ***N*** \_\_,\_\_ ***NE*** \_\_

(k) Tap Water \_\_ ***N*** \_\_,\_\_ ***SE*** \_\_ (l) HC2H3O2 (aq) \_\_ ***A*** \_\_,\_\_ ***WE*** \_\_

(m) NH4Cl(aq) \_\_ ***S*** \_\_,\_\_ ***SE*** \_\_ (n) NH4OH (aq) \_\_ ***B*** \_\_,\_\_ ***WE*** \_\_

1. Complete and balance the following reactions, classify each compound in thereactants and the products formed (acid, base, salt, or water). Assume all combinations have a chemical reaction to form new substances as products.

(a) \_***1***\_\_K2SO4 (aq)+ \_\_***1***\_BaCl2 (aq) → \_***1*** ***BaSO4*** \_(s) + \_ ***2 KCl (aq)*** \_

classify: \_\_\_***S***\_\_\_ \_\_\_***S***\_\_\_ \_\_\_\_***S***\_\_\_\_ \_\_\_***S***\_\_\_\_

 (b) \_***1***\_\_LiOH (aq)+ \_***1***\_\_HI (aq) → \_ ***1 Li I (aq)*** \_ + \_***1*** ***H2O (l)*** \_

classify: \_\_\_***B***\_\_\_\_ \_\_\_***A***\_\_\_ \_\_\_\_***S***\_\_\_\_\_ \_\_\_***W***\_\_\_\_

 (c) \_\_***2***\_\_H3PO4 (aq)+ \_\_***3***\_\_Ba(OH)2 (aq) → \_ ***1 Ba3(PO4)2*** \_(s) + \_  ***6 H2O (l)*** \_

classify: \_\_\_***A***\_\_\_\_ \_\_\_***B***\_\_\_ \_\_\_\_\_***S***\_\_\_\_ \_\_\_***\_W***\_\_\_

(d) \_\_***1***\_\_CuF2 (aq)+ \_\_***1***\_\_Li2CO3 (aq) → \_ ***1 CuCO3***\_(s) + \_ ***2 LiF (aq)*** \_

classify: \_\_\_***S***\_\_\_\_ \_\_\_***S***\_\_\_ \_\_\_\_***S***\_\_\_\_\_ \_\_\_***S***\_\_\_\_