Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Q & D ON SOME OF THE ACID/BASE THEORIES

There are at least three theories covering Acid/Base behavior. The most conservative of the three was the first theory propounded, and thus the oldest. It is the Arrhenius (Uh-ren-ē-us) Theory. It is the theory most closely linked with "wet" chemistry. These pages will focus on Arrhenius Theory, but also introduce the (unnamed) Bronsted-Lowry Theory of Acids and Bases.

Water (H2O) is a molecule (made with covalent bonds). Largely, it tends to stay together, and molecules of water do NOT separate readily into charged species, (ions). However, a few molecules of water will break down producing a very small number of ions which exist surrounded by the remaining water molecules.

H2O + H2O ⮀ H+1(aq) + OH-1(aq)

1 x 10-7 1 x 10-7 (note: 1 x 10-7 = 0.0000001)

This is a relatively small value !!

* In all likelihood, H+1(aq) does not exist, alone in water. (It’s just an easy way to denote an acid species, in water).
* What is much more likely is that a lost H+ bonds to a H2O molecule and produces H3O+ (***hydronium ion***). Per the reading, the species H+ and H3O+ are used interchangeably to identify an acid in water. (Everyday Chemistry Laboratory Manual)
* The OH-(aq) ion is called ***hydroxide ion***. Hydroxide ion represents a base.
* Thus, if you notice the above equation, when water molecules break down into ions, they do so, so that there is an equal number (or an equal concentration) of acid and base ions in pure water, at room temperature!
* The concentration of H+(aq) can be measured! This leads us to the idea of **pH** (pondus hydrogenii … from the Danish scientist, Soren Sorensen)
* This pH value is obtained by taking the negative log of the hydrogen ion concentration … or stated more mathematically,

**pH = - log [H+]**

* Now, Nature (and scientists) can mess around with the relationship between the H+ and OH- in water. By messing around with the “normal” balanced concentrations of the two ions in pure water, the pH of an aqueous solution can be changed.
* Some compounds, when added to water, can INCREASE the concentration H+(aq) and, in doing so, decrease the concentration of OH-(aq). Not surprisingly, other compounds when added to water can increase the concentration of OH- ions and decrease the concentration of H+ ions.

☯Acids, in general are any species that can donate a H+.Arrhenius (Uh-ren-e-us) Acids are substances which

when added to water, cause the concentration of H+1 to increase, by donating H+ specifically to water molecules. As these acids add H+ to water, the OH- concentration decreases.

examples of acids: HCl, H2S, HF, HNO3, HCH3OO (or CH3COOH3)

Remember the original equation: H2O + H2O ⮀ H+1(aq) + OH-1(aq)

This can be simplified as: H2O ⮀ H+1(aq) + OH-1(aq) where the collisions between

water molecules are assumed.

If to a sample of pure water, HCl is added, the HCl can ADD TO the H+ in pure water.

This added H+ drives the concentration of OH- down, through an idea we describe as

shifting the equilibrium. Cutting to the chase, at the end of everything, the concentration

of H+ will have been increased, and the OH- concentration reduced to a smaller value.

H2O + HCl ⮀ H+1(aq) + Cl-1 + **OH-1**(aq)

(really H3O+)

☯A base is any species which ***accepts*** a H+. Arrhenius Bases are substances which when added to water, cause

the (OH)-1 [hydroxide ion] to increase (& causes the amount of H+1 to decrease) … Or more sophisticatedly stated, a

base can readily accept a H+ to produce water. An acid is often seen as a proton donor while a base is a

proton acceptor.

examples of bases: LiOH, NaOH, KOH, Ca(OH)2 NH3 (which exists as NH4OH in water)

H2O + NaOH ⮀ **H+1(aq)** + Na+1 + OH-1(aq)

other common (non-Arrhenius) bases: CaCO3(s) Na2CO3 and NaHCO3

calcium carbonate sodium carbonate sodium hydrogen carbonate

calcite, limestone, washing soda baking soda

marble sodium bicarb

* Not all acids dissociate to the same extent. Some dissociate into H+ completely…. (For every molecule of acid, one ion of H+ is produced.) These are called strong acids.
* Most acids dissociate poorly. Only a fraction of the available molecules dissociates into H+ ions. These acids are called weak acids.
* What is good for the goose is good for the gander … There are strong and weak bases. Strong bases yield 100% of possible OH- ion, and weak bases yield a fraction of the available OH-.
* Never assume however, that a weak acid or weak base is “safe” … Strong and weak only refer to the level or extent that they dissociate into H+ and OH-. They can be darn right dangerous. Many poisons are essentially weak bases, for instance.
* The leftover bits of an acid dissociating in water and the leftover portions into water are reactive too!
* In fact, an acid once dissociated produces an ion which can act as a base … And, a base when dissociated in water, will produce an ion, which can act as an acid. The acid and the negative ion left over after its dissociation are ***conjugates*** of each other.
* The base and the positive ion left over after its dissociation are conjugates of each other.

☯pH Scale relates the concentration of H+1 in an aqueous solution to a readily understandable integer

neutral

1\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_7\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_14

more acidic <----------- **a**cidic solution **b**asic solution ---------> more basic

pH = - log [H+1(aq)] e.g. assume a H+1(aq) concentration of 0.000001 or 1 x 10-6

assume a H+1(aq) concentration of 0.1 or 1x 10-1

* pH can be measured, using pH paper or with a meter. pH paper is impregnated with weak acids and bases which when reacted with a particular concentration of H+ or OH- ,change color.
* The pH meter was invented by Arnold Beckman in the late 1930s.

☯Acid / Base Neutralization: Acids react with bases to produce water and some sort of salt.

For instance: HCl(aq) + NaOH(aq) → H2O + NaCl

but there are some 50,000 salts! NaCl just happens to be an edible, neutral (in pH) salt …

HCN + LiOH → H2O + LiCN (which is a deadly poison)

* When a solution is neutralized, the pH is 7 …. as the H+ and OH- are equal in concentration. However,

the presence of some conjugates can be a challenge! Read On.

☯Buffer Solution: A buffer solution is (often) a mixture of a weak acid and the salt containing the acid’s

conjugate base. Because part of the solution is made with an acid, and a salt made from the conjugate base

of that acid, the solution will be able to resist changes in pH. **Hence, in general a buffer is a solution with**

**both a little acid and a little base, and the solution can resist a change in pH.**

* That is, were you to add a few extra drops of acid, the conjugate base in the solution, could neutralize it

and keep the pH from changing.

* Were you to add a few extra drops of base, the acid you used to make the buffer solution, can react with

the excess base and help keep the solution, at its pH.

* Your blood is essentially a buffer solution.
* **In tonight’s laboratory, your team will make a buffer mixture (a buffer solution). There will be a little acid, and a salt containing that acid’s conjugate base.**

☯A few facts:

* + Human blood is approximately a pH of 7.3
  + The pH of the ocean is approximately 7.5 to 8.4
  + Rain (pre-industrial revolution) had a pH of approximately 5.5
  + Antacids, like TUMS and Rolaids are weak bases.
  + Calcium carbonate = limestone, chalk, seashell, the crunchy parts of insect exoskeletons, TUMS
  + Strong hydroxide bases (e.g. NaOH) **react with fats to produce soap** and glycerol (a.k.a. glycerin)
  + Acids will react with active metals (iron, zinc, magnesium) with H2(g) gas as a product
  + Acids will react with bases to produce water and a salt (a category of ionic compound)
  + Acids can "burn" / damage proteins
  + Acids (well, most) do NOT react with noble metals such as platinum, gold, silver, palladium