Name: ______________________________

Unit 6

Advanced Topics in Solutions, Acids, & Bases

- Distinguish between the terms solute, solvent, solution and concentration (g dm^{-3} and mol dm^{-3}).
- Solve problems involving concentration, amount of solute and volume of solution.
- Define acids and bases according to the Brønsted–Lowry and Lewis theories.
- Deduce whether or not a species could act as a Brønsted–Lowry and/or a Lewis acid or base.
- Deduce the formula of the conjugate acid (or base) of any Brønsted–Lowry base (or acid).
- Outline the characteristic properties of acids and bases in aqueous solution.
- Distinguish between strong and weak acids and bases in terms of the extent of dissociation, reaction with water and electrical conductivity.
- State whether a given acid or base is strong or weak.
- Distinguish between strong and weak acids and bases, and determine the relative strengths of acids and bases, using experimental data.
- Distinguish between aqueous solutions that are acidic, neutral or alkaline using the pH scale.
- Identify which of two or more aqueous solutions is more acidic or alkaline using pH values.
- State that each change of one pH unit represents a 10-fold change in the hydrogen ion concentration $[H^+]$.
- Deduce changes in $[H^+]$ when the pH of a solution changes by more than one pH unit.

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Dilutions Worksheet

1. If I have 340 mL of a 0.5 M NaBr solution, what will be the concentration if I add 560 mL more water to it?

2. If I dilute 250 mL of 0.10 M lithium acetate solution to a volume of 750 mL, what will the concentration of this solution be?

3. If I leave 750 mL of a 0.50 M sodium chloride solution uncovered on a windowsill and 150 mL of the solvent evaporates, what will the new concentration of the sodium chloride solution be?

4. To what volume would I need to add water to the evaporated solution in problem 3 to get a solution with a concentration of 0.25 M?

Name: ___________________________________

Alternate Acid-Base Theories

There are three models to explain the nature of acids and bases:

1. *The Arrhenius Theory*
2. *The Brønsted-Lowry Model*
3. *The Lewis Model*

Each of these models is successively more general than the one that precedes it. The more general models include the earlier models.

Arrhenius

According to Arrhenius an acid is a substance that yields hydrogen ions (H^+) as the only positive ions in solution. The properties of acids are caused by excess hydrogen ions. A base on the other hand, is a substance that yields hydroxide ions (OH^-) as the only negative ions in aqueous solution. The properties of bases are caused by excess hydroxide ions.

Brønsted-Lowry

Brønsted-Lowry broadens the definition of acids and bases. According to Brønsted-Lowry, an acid is any species that can donate a proton to another. For example, when ammonia dissolves in water, water donates a proton to form the ammonium ion, so water is a Brønsted-Lowry acid ($NH_3 + H_2O \rightleftarrows NH_4^+ + OH^-$). According to Brønsted-Lowry, a base is any species (molecule or ion) that can combine with or accept a proton. In the reaction between water and hydrochloric acid, water acts as a Brønsted-Lowry base by accepting a proton ($HCl + H_2O \rightleftarrows H_3O^+ + Cl^-$). In the reaction $NH_3 + H_2O \rightleftarrows NH_4^+ + OH^-$ between ammonia and water, NH_4^+ and NH_3 are conjugate acid/base pairs. NH_4^+ behaves like a Brønsted-Lowry acid, donating a proton to become NH_3. NH_3 behaves like a Brønsted-Lowry base, accepting a proton to become NH_4^+. Conjugate acid-base pairs always differ by one hydrogen atom.

Lewis

The Lewis model expands the definition of acid and base even further. A Lewis acid is an electron pair acceptor. It has an empty atomic orbital that it can use to accept an electron pair from a molecule with a lone pair. It may be deficient in a pair of electrons. Boron trifluoride (BF_3) is a typical Lewis acid. It is electron deficient. Ammonia (NH_3) is a typical Lewis base. It has a lone pair of electrons. Boron trifluoride and ammonia will combine by forming a coordinate covalent bond.

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Acid and Base Anhydrides

Acids or bases minus water

H_2CO_3	H_2SO_3	$2HNO_3$
$-H_2O$	$-H_2O$	$-H_2O$
CO_2	SO_2	N_2O_5

Acid anhydrides form oxyacids when mixed with water. Notice the acid anhydrides are nonmetallic oxides. Acid anhydrides are the source of acid rain.

Environmental Source	Nonmetallic Oxide	Acid Formed
Car exhaust	Carbon dioxide Nitrogen oxides	Carbonic acid Nitric acid
Coal	Sulfur dioxide Carbon dioxide	Sulfurous acid Carbonic acid
Smelters	Sulfur dioxide Sulfur trioxide	Sulfurous acid Sulfuric acid
Volcanoes	Sulfur dioxide	Sulfurous acid
Lightning	Nitrogen oxides	Nitric acid

$2NaOH$	$Ca(OH)_2$	$2Al(OH)_3$
$-H_2O$	$-H_2O$	$-3H_2O$
Na_2O	CaO	Al_2O_3

Base anhydrides are metallic oxides. They can be found by subtraction of water, too.Base anhydrides such as lime (CaO) are use to neutralize acid soil.

Answer the questions below based on the reading above and your knowledge of chemistry.

1. State whether each of the following anhydrides is an acid or a base. Write the formula of the acid or base that forms:
   a) Li_2O ____________________
   b) P_2O_5 ____________________
   c) N_2O_5 ____________________
   d) BaO ____________________
   e) Cl_2O_7 ____________________
   f) Fe_2O_3 ____________________

2. State whether each of the following is an acid or base. Write the formula for the acid or base anhydrides that form.
   a) H_2SO_3 ____________________
   b) $HClO$ ____________________
   c) $Mg(OH)_2$ ____________________
   d) $HBrO_3$ ____________________
   e) $Zn(OH)_2$ ____________________
   f) KOH ____________________

3. What effect do carbon dioxide and nitrogen oxides in car exhaust have on the air?
   ____

Name: ___________________________________

Dissociation and Molarity

Study This:	Compound:	$Li_2(SO_4)$
	This formula:	Shows 2 Li^{1+} ions bonded to 1 $(SO_4)^{2-}$ ion
	When dissolved:	Produces a total of 3 ions per formula
	Diss. Eqtn:	$Li_2(SO_4) \xrightarrow{H_2O} 2\ Li^{1+}(aq) + 1\ (SO_4)^{2-}(aq)$
	Molar Mass:	(2x6.9 g) + (1x32.1 g) + (4x16.0 g) = 119.9 g / 1 mole
	Molarity:	If 119.9 grams of $Li_2(SO_4)$ are dissolved to make 1000 mL of solution… M = 1 mole/1.000 L = 1.0 Molar $Li_2(SO_4)$
	Molarity of Ions:	If the solution is 1.0 M in $Li_2(SO_4)$, then it is 2.0 M in Li^{1+} ions and 1.0 M in $(SO_4)^{2-}$ ions, or total, 3.0 M in ions. If the solution is 2.0 M in $Li_2(SO_4)$, then it is 4.0 M in Li^{1+} ions and 2.0 M in $(SO_4)^{2-}$ ions, or total, 6.0 M in ions.

See if you get it:

1.) How many ions of each type, and total, will each of these produce when dissociated?

A) $Na_2(CO_3)$
Na^{1+} ions ____
$(CO_3)^{2-}$ ions ____
Total # ions ____

B) $Mg(OH)_2$
Mg^{2+} ions ____
$(OH)^{1-}$ ions ____
Total # ions ____

C) $H_3(PO_4)$
H^{1+} ions ____
$(PO_4)^{3-}$ ions ____
Total # ions ____

2.) What is the Molarity of Na^{1+} ions in a solution that is 2.0 M Na_3P? ________

3.) What is the TOTAL Molarity of ions in a solution that is 3.0 M Li_2S? ________

4.) Which solution would be the best conductor? Why?

2.0 M Na_3P OR 3.0 M Li_2S

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Dissociation, Molarity, and Titration

In laboratory situation, chemists often need to neutralize acids or bases that do not have one H^+ or one OH^- per molecule. Before applying the titration equation, remember to adjust the molarity in order to account for the different number of hydrogen or hydroxide ions found in the compounds.

1. How many mL of 2.0 M $Mg(OH)_2$ are required to exactly neutralize 100. mL of a 3.0 M solution of HBr?

2. How many mL of 2.0 M HBr are needed to exactly neutralize 30. mL of 4.0 M $Mg(OH)_2$?

3. If 50.0 milliliters of 3.0 M H_3PO_4 completely neutralize 150.0 milliliters of $Mg(OH)_2$, what was the molarity of the $Mg(OH)_2$ solution?