**Ch 17 Acids and Bases Name:**

*17.1 Heartburn*  Read this section.

*17.2 The Nature of Acids and Bases*

Know the general properties of an acid and be familiar with the common acids in *Table 17.1*.

The structures of HCl, H2SO4, and HNO3 should be familiar from the bonding chapters. These acids are often referred

to as mineral or inorganic acids. While \_\_\_\_\_\_\_\_\_\_\_\_\_ acid (found in vinegar) and \_\_\_\_\_\_\_\_\_\_\_\_ acid found in

oranges are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ic acids. Since many are found in living things they were referred to as organic acids.

They contain one or more –COOH groups.

Draw this carboxylic acid group:

Know the general properties of bases and be familiar with the common bases in *Table 17.2*. What are organic bases also called? Give some examples.

Bases feel slippery because they react with \_\_\_\_\_\_\_s on your skin to make \_\_\_\_\_\_\_\_\_\_\_\_. *CC17.1 \_\_\_\_*

*17.3 Definitions of Acids and Bases*

Remember the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ definition from chapter 5. It is important to note that acids do not just “dissociate”

in water since the \_\_\_\_ ions are highly reactive they bond to \_\_\_\_\_\_\_\_\_\_\_\_ to form \_\_\_\_\_\_\_\_ (hydronium ion) so we

say that acids *ionize* in solution. *(H+and H3O+ can be used \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ly.)*

Bases like \_\_\_\_\_\_\_ are \_\_\_\_\_\_\_\_\_\_ compounds which \_\_\_\_\_\_\_\_\_\_\_\_ate in water. Under this definition, acids and

base \_\_\_\_\_\_\_\_\_ize each other to make \_\_\_\_\_\_\_\_\_\_\_\_: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ *(eqn)*

According to the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_-Lowery definition of an acid is a proton \_\_\_\_\_\_\_\_\_\_\_\_\_ and a base is a proton

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. (All \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_acids are also B-L acids.) Note how HCl donates a proton to water to

form \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Explain why ammonia is a B-L base.

Water can act both as a B-L \_\_\_\_\_\_\_ and as a B-L \_\_\_\_\_\_\_\_ which makes it an \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ic substance.

Note in *Figure 17.3* you have 2 sets of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ acid-base pairs. How do you determine the CA of a base?

*Practice 17.1*

a) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ b) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*CC17.2 \_\_\_ (Why is it NOT a conjugate a-b pair?)*

*17.4 Acid Strength and the Acid Ionization Constant (K*a*)*

What is the difference between a strong acid and a weak acid and how is this represented in the ionization equation?

*You should memorize the strong acids in Table 17.3.*

Look at *Figures 17.4 &17.5*. Both HCl and HF are completely soluble in water. How do the particulate diagrams show that HCl is a strong acid while HF is a weak acid?

What determines whether an acid will be strong or weak *(Figure 17.6)*?

*In general, the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the acid, the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the conjugate \_\_\_\_\_\_\_\_\_\_ and vice versa.*

*Note the examples of weak acids in Table 17.4. Organic acids are often weak acids.*

Write the 2 forms of the *K*a expression for HA (any generic weak acid):

What is the weakest and strongest acid listed in *Table 17.5*? *CC17.3 \_\_\_ CC17.4 \_\_\_\_ (K*a is \_\_\_\_\_\_\_er)

*17.5 Autoionization of Water and pH*

Write the 2 forms of the autoionization equations for water and the equilibrium constant expression *K*w.

At \_\_\_\_oC, *K*w = \_\_\_\_\_\_\_\_\_\_\_\_ therefore the [H+] = [ ] = \_\_\_\_\_\_\_\_\_\_\_\_\_\_.

In an acidic solution [ ] > [ ] and a basic solution [ ] > [ ] but the product of the concentrations for acidic or basic solutions at 25oC will always be 1.0 x 10-14.

*CC17.5 \_\_\_\_*

*Practice 17.2 a) \_\_\_\_\_\_\_\_\_\_\_\_\_\_ b) \_\_\_\_\_\_\_\_\_\_\_\_\_ c) \_\_\_\_\_\_\_\_\_\_\_\_\_\_*

How is pH defined? *(pH comes from “power” or “potential” of hydronium)* What values correspond to acidic, basic, and neutral?

*Note how significant figures of pH (by decimal places) are determined from the concentration of the H+. Normally we deal with solution concentrations which are between 1 and 10-14M. Negative pH values and those above 14 are no longer logarithmic.* How many times more acidic is a pH 1.2 solution than a pH 4.2 solution?

*Practice 17.3 (note how the [H+] is found for the basic solution) Practice 17.4 (use your 2nd function key for inv log or use 10−pH)*

How is pOH defined? *(note in Figure 17.8 the scale values are reversed)*

By taking the log of both sides of the *K*a expression you get: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ =14.00

p*K*a = \_\_\_\_\_\_\_\_\_\_\_ (This is useful so you do not have to deal with the exponential notation of the *K*a values. It is

also a way to compare strength of the weak acid – the \_\_\_\_\_\_\_\_\_\_\_\_ the *K*a the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the acid.)

Read *Chemistry and Medicine: Ulcers*

*17.6 Finding the [H3O+] and pH of Strong and Weak Acid Solutions*

Why except in extremely dilute acids does the autoionization of water not affect [H+]?

The [H+] in a strong \_\_\_\_\_\_\_\_ solution is \_\_\_\_\_\_\_\_\_\_ to the concentration of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ acid.

This is not true for weak acids because they only \_\_\_\_\_\_\_\_\_\_\_\_ly ionize in solution thus an \_\_\_\_ chart must be used.

*Review both Example 17.5 & 17.6 in both cases “x” can be assumed to be \_\_\_\_\_\_\_\_\_\_ since the % ionization is less than \_\_\_%. Complete Practice 17.6*

*Example 17.7 shows how the “x is small” approximation does not work and the quadratic must be used.*

*Practice 17.8*

*CC17.7 \_\_\_\_(Explain) CC17.8 \_\_\_\_(Explain)*

% ionization is formally defined at the top of pg750 *Practice 17.9*

The table at the top of pg751 shows that [H+]eq of a weak acid \_\_\_\_\_\_\_\_\_\_\_\_\_\_ with increasing [HA]int of the acid but

% ionization \_\_\_\_\_\_\_\_\_\_\_\_\_. This can be explained by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ principle since the system will shift to

the side with more particles. It can better be explained by a *Q* vs *K* argument as shown in the equilibrium unit.

*CC17.9 greatest % ionization \_\_\_\_ (Why?) lowest pH \_\_\_\_ (Why?)*

*Mixtures of Acids* This section is not tested by AP. Important things to know: If you have a mixture of a strong acid and a weak acid the strong acid will dominate since it will completely ionize and the large amount of H+ ions will suppress the ionization of the weak acid. When you have a mixture of weak acids the acid with the larger *K*a will dominate.

*CC17.10 \_\_\_\_ Explain your answer.*

*17.7 Base Solutions*

A \_\_\_\_\_\_\_\_\_\_ base completely \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in solution. 1.0M NaOH (main ingredient in \_\_\_\_\_\_\_\_\_\_ for

example produces a solution with [Na+]and [OH−] = \_\_\_\_\_. Most strong bases are group \_\_\_ or \_\_\_ metal

hydroxides. *(Remember Group 1A compounds are highly soluble in water. Group 2A metal hydroxides are only slightly soluble in water, but what does dissolve COMPLETELY dissociates.)*

Unlike strong bases that contain \_\_\_\_and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in water, weak bases produce OH− by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

a proton (B-L base). Write the general eqn:

The classic example of a weak base is NH3 (\_\_\_\_\_\_\_\_\_\_\_\_\_\_). Just as weak acids have *K*a values bases have *K*b values. Write the *K*b expression for NH3:

In *Table 17.8­* besides NH3 all but 2 of the bases are \_\_\_\_\_\_\_\_\_\_s. Which 2 are not?

The \_\_\_\_\_ pair on the \_\_\_\_\_\_\_\_\_\_\_\_\_\_atom in NH3 and the amines act as a \_\_\_\_\_\_\_\_\_\_\_\_\_\_ acceptor. *Figure 17.11*

*Practice 17.11 (use pOH to find pH)*

*Practice 17.12*

Read *Chemistry and Medicine: What’s in My Antacid?*

*17.8 The Acid-Base Properties of Ions and Salts*

Look at the equation for the reaction of a bicarbonate ion with water. Based on B-L, why is the ion a base?

The bicarbonate ion can come from NaHCO3 (\_\_\_\_\_\_\_\_\_ soda). Does it make sense that this compound is basic?

Anions can be thought of as the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ base of an \_\_\_\_\_\_\_\_. The anion of weak acid is a \_\_\_\_\_\_

base (the weaker the acid the stronger the conjugate base). The anion of a \_\_\_\_\_\_\_\_\_\_\_ acid is pH \_\_\_\_\_\_\_\_\_\_\_\_.

Write the reaction of the fluoride ion with water:

This is called a HYDROLYSIS reaction. Fluoride ions have a strong attraction for H+ ions so it forms \_\_\_\_

(hydrofluoric acid) and produces \_\_\_\_\_\_ions in the solution. *(Remember weak acids only partially ionize.)*

Review *Figure 17.12* and notice the weakest acids are ions that “want” their H+ back (like the strongest bases).

*Practice 17.13 a) \_\_\_\_\_\_\_\_\_\_\_ (HCHO2 is formic acid) b) \_\_\_\_\_\_\_\_\_\_\_\_ (HClO4 is perchloric acid)*

*Write a hydrolysis for the anion that acts as a weak base – show how OH− is produced:*

*Note: K*a x *K*b = *K*w *Taking the equations for reactions of HA and A−with water and adding them together results in the reaction for the autoionization of water, therefore K*w *is the product of the 2 K values. This equation is useful to obtain K*b *values for conjugate bases of weak acids. See the example for the acetate ion. Also: pK*a + p*K*b = 14

*Practice 17.14*

*CC17.11 \_\_\_\_*

Cations (typically group 1A metals) that are \_\_\_\_\_\_\_\_\_\_\_ions of \_\_\_\_\_\_\_\_\_\_ bases are pH neutral (they do NOT

hydrolyze). Cations of \_\_\_\_\_\_\_\_ bases act as weak \_\_\_\_\_\_\_\_\_s (they \_\_\_\_\_\_\_\_\_a proton “H+” to water during

hydrolysis to produce H3O+ in solution). Small, \_\_\_\_\_\_\_\_\_ charged \_\_\_\_\_\_\_\_\_\_ cations such as \_\_\_ and \_\_\_ form

weakly \_\_\_\_\_\_\_\_ solution. The hydration/hydrolysis reaction for Al3+ is shown at the bottom of pg762 and top of 763.

This can be simplified for our purposes as: **Al3+  + H2O ⇋ Al(OH)2+  + H+** Al3+ can attract a total of 3 OH− ions from water, but it is easier to show this in a series of steps since each step would have an associated *K*a value.

*Practice 17.15 (Write hydrolysis reactions for the 2 weak acid cations to show how H+ forms in solution.)*

a) \_\_\_\_\_\_\_\_\_ b) \_\_\_\_\_\_\_\_\_ c) \_\_\_\_\_\_\_\_\_

Since salts contain both a \_\_\_\_\_\_\_\_\_ and an \_\_\_\_\_\_\_\_\_. What determines the pH of the salt solution?

1) Salts with a cation from a \_\_\_\_\_\_\_\_\_\_ base and an anion from a strong \_\_\_\_\_\_\_ form \_\_\_\_\_\_\_\_\_ solutions.

Neither ion will HYDROLYZE in water.

2) Salts with neutral cations and anions that are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ bases of \_\_\_\_\_\_\_ acids form \_\_\_\_\_\_\_ solutions.

Ex: NaF (Na+ is neutral and F- acts as a base since it will take \_\_\_+ from water.

3) Salts with neutral anions and cations which are conjugate \_\_\_\_\_\_\_s of weak \_\_\_\_\_\_\_s form \_\_\_\_\_\_\_\_\_\_ solutions.

Ex: FeNO3 (Fe3+ removes OH− form water leaving \_\_\_+) NH4Br (NH4+ donates H+ to water to form \_\_\_\_\_\_+)

4) Salts with acidic cations and basic anions form solutions with a pH that depends on *K*a and *K*b.

*Practice 17.16 a) \_\_\_\_\_\_\_\_\_\_\_ b) \_\_\_\_\_\_\_\_\_\_\_ c) \_\_\_\_\_\_\_\_\_\_\_ d) \_\_\_\_\_\_\_\_\_\_\_*

*17.9 Polyprotic Acids CC17.12 \_\_\_\_*

These acids contain 2 or more \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ protons. For sulfurous acid which ionization step occurs more completely? How do you know?

Note *Table 17.10* shows successive *K*a values for several polyprotic acids. Based on *K*a1, which is the weakest?

*Note how in Example and Practice 17.17 you can base pH of weak polyprotic acids on K*a1. *In Example 17.18 notice you must you must consider the contribution of the 2nd step since the solution is dilute. (NOT required by AP.)*

Calculate what the pH of the 0.0100M H2SO4 solution would be if both H+ ions completely ionized.

pH = −log[H+] = *Notice this value is lower than the answer in Example 15.18*

*Example & Practice 17.19 are not required by AP. But qualitatively you should be able to discuss the ranking of amounts of ions in solutions based on K values. See Figure 17.13*

*17.10 Acid Strength and Molecular Structure*

*Figure 17.14*  Summarizes the combined effect of bond polarity and bond strength on the strength of binary acids. As

the H−Y bond becomes more \_\_\_\_\_\_\_ (negative charge towards the anion) and the H−Y bond becomes \_\_\_\_\_\_\_er

(Coulomb’s law down the group) the hydrides become \_\_\_\_\_\_\_\_ acidic.

In an \_\_\_\_\_acid, the more electronegative the “Y” the more it \_\_\_\_\_\_\_\_\_ens and \_\_\_\_\_\_\_\_\_\_\_\_\_s the H−O bond and

the more \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the oxyacid. *(top table pg771)* Additional \_\_\_\_\_\_\_\_\_\_\_\_ atoms draw \_\_\_\_\_\_\_\_\_\_\_\_

density away from “Y” which further weakens/polarizes the bond increasing \_\_\_\_\_\_\_\_\_\_\_\_y. *(bottom table pg771)*

*The chlorate series is a classic example. Notice chloric acid is a fairly STRONG acid.*

*CC 17.13 \_\_\_\_ (Explain)*

*17.11 Lewis Acids and Bases (This definition is not required by AP but it helps to understand acid-base behavior.)*

How are the Lewis definitions similar to the B-L definitions?

The Lewis acid-base reaction of BF3 and NH3 has appeared on AP exams as a bonding question. Compounds with “N” often act as Lewis bases due to the presence of the \_\_\_\_\_\_\_\_ pair. Why can compounds with Al and B act as Lewis acids?

Notice the reaction between water and carbon dioxide on pg773. This explains why carbonation is not simply the CO2 dissolving in water.

The reaction of Al3+ with water also more clearly shows how the aluminum ion becomes hydrated.

*17.12 Acid Rain* Read this section to learn how rain is naturally acidic and how it becomes more acidic due to pollution.

*Exercises* (pgs 779-783) #33, 34(b,d), 35(a,b,d), 37, 39, 41, 43, 44, 45, 47(a,b), 49c, 53, 55, 56, 57(a,b,c), 59a, 61, 65, 69, 81(a,c), 87, 89, 95, 97, 99, 101(a-d), 105, 117, 119, 125, 129