Forestville Central School • AP Chemistry Name ____________________________________

16 • Acids, Bases and salts

16.1 – 16.3 Lecture Practice Problems

16.1 – 16.2 Definitions, Characteristics and Properties of Acids and Bases

a) Arrhenius and Bronsted Lowery Theories

Bronsted – Lowery Problems

1. What is the conjugate base for each of the following acids?

(a) $HClO_4$ (b) H_2S (c) PH_4^+

2. What is the conjugate acid for each of the following bases?

(a) CN^- (b) SO_4^{2-} (c) H_2O

3. The hydrogen sulfite ion is amphoteric

(a) Write an equation for the reaction of HSO_3^- with water, in which it acts as an acid.

(b) Write an equation for the reaction of HSO_3^- with water, in which it acts as an base.

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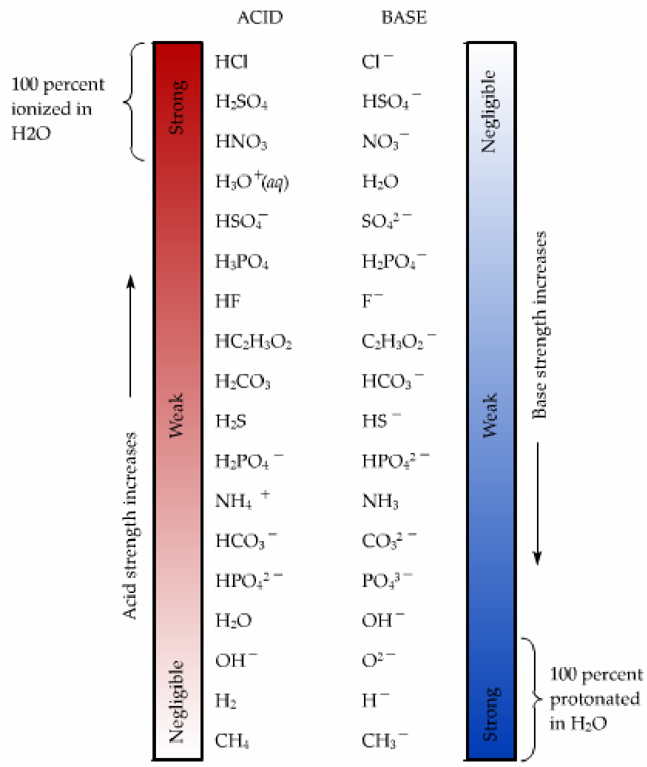
16.2 Acid-Base Conjugate Pairs

An **acid** is defined as a proton (H+) donor while a **base** is a proton acceptor. The substance that is produced after an acid has donated its proton is called the **conjugate base** while the substance formed when abase accepts a proton is called the **conjugate acid**. The conjugate acid can donate a proton to the conjugate base, to reform the original reactants in the reverse reaction.

$$\underset{\text{acid}}{HF} + \underset{\text{base}}{H_2O} \leftrightarrows \underset{\text{c. acid}}{H_3O^+} + \underset{\text{c. base}}{F^-}$$

Equilibrium lies to the left since H_3O^+ is a stronger acid than HF



- In the reaction above HF is the acid and H_2O is the base.
- The HF has given a proton to the H_2O, forming H_3O^+ and F^-.
- Since the product H_3O^+ can donate a proton back to F^- it is labeled the conjugate acid, while the F^- is the conjugate base.

Equilibrium: Strong acids almost completely ionize in solution. Weak acids do not. So, Equilibrium favors the donation of the proton from the stronger acid to the stronger base and shifts equilibrium when this occurs.

Label the following as being a strong acid, a weak acid, or a species with negligible acidity.

1. HNO_2 __________
2. H_2SO_4 __________
3. HPO_4^{2-} __________
4. CH_4 __________
5. $CH_3NH_3^+$ __________

Label the following as being a strong base, a weak base, or a species of negligible basicity

6. $C_2H_3O_2^-$ __________
7. HCO_3^- __________
8. O^{2-} __________
9. Cl^- __________
10. NH_3 __________

Direction: Identify the acid, the base, the conjugate acid, and the conjugate base in each of the equations. Also state if the equilibrium lies to the left or right and a reason to support your answer.

1. $HSO_4^- + CO_3^{2-} \rightleftharpoons SO_4^{2-} + HCO_3^-$ Equilibrium position __________

2. $PO_4^{3-} + H_2O \rightleftharpoons HPO_4^{2-} + OH^-$ Equilibrium position __________

3. $NH_4^+ + OH^- \rightleftharpoons NH_3 + H_2O$ Equilibrium position __________

4. $HCO_3^- + F^- \rightleftharpoons$ ______ + _______ Equilibrium position __________

5. $O^{2-} + H_2O \rightleftharpoons$ ______ + _______ Equilibrium position __________

6. $HC_2H_3O_2 + HS^- \rightleftharpoons$ ______ + _______ Equilibrium position __________

7. $NH_4^+ + CN^- \rightleftharpoons HCN + NH_3$ Equilibrium position __________

8. $HCHO_2 + PO_4^{3-} \rightleftharpoons CHO_2^- + HPO_4^{2-}$ Equilibrium position __________

16.3 Autoionization of Water and pH

Pure water has a very small tendency to ionize, acting both as an acid (donating a proton) and as a base (accepting a proton).

$$H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

At 25°C, the K_c for this process is 1.0×10^{-14}, which means that only about one molecule per billion undergoes this **autoionization**. The equilibrium expression for the autoionization of water is

$$K_c = [H_3O^+][OH^-]$$

(Recall that a liquid does not appear in the equilibrium expression.)

Because the autoionization of water is a very important equilibrium, its equilibrium constant is given a special subscript, *w*. For any aqueous solution at 25°C, the product of hydronium and hydroxide ion concentrations is equal to K_w. In neutral water, where the only source of either ion is the autoionization, the hydronium and hydroxide ion concentrations are equal.

$$K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$$

$$[H_3O^+] = [OH^-] = \sqrt{1 \times 10^{-14}} = 1.0 \times 10^{-7}$$

So the concentrations of both hydronium ion and hydroxide ion in neutral water is 1.0×10^{-7} *M*.

Autoionization of Water Practice Problems

1. Calculate the concentration of H^+ ions (aq) in

(a) a solution in which $[OH^-]$ is 0.010 M

(b) a solution in which $[OH^-]$ is 2.0×10^{-9} M

(c) What is the hydroxide ion concentration in an aqueous solution in which the hydronium ion concentration is 0.13 *M*?