Name:_____ **Name:**_____

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Worksheet 11 Acids & Bases: Defined, Conjugates, Strength, Kw, pH, and pOH

Objectives

Definitions

Arrhenius: An acid produces hydrogen ions in water. A base produces hydroxide ions in water.

Bronsted – Lowry: An acid is a proton door. A base is a proton acceptor.

Lewis: An acid is an electron pair acceptor. A base is an electron pair donor.

Conjugates

The conjugate base of an acid has a proton removed from the acid.

$$\mathrm{CH_3COOH}(aq) \rightleftharpoons \mathrm{CH_3COO^-}(aq) + \mathrm{H^+}(aq)$$

Acid **Conjugate Base**

The conjugate acid of a base has a proton added to the base.

$$\mathrm{CH_3NH_2}(aq) + \mathrm{H^+}(aq) \rightleftharpoons \mathrm{CH_3NH_3^+}(aq)$$

Base **Conjugate Acid**

Strength

The strength of an acid depends on two (related) factors. How easy it is to break the bond to the acidic proton and how stable the conjugate base is. The longer a bond is the easier it is to break and the stronger the acid. The more polar a bond is the easier it is to break and the stronger the acid. The more stable the conjugate base is the easier it is to form and the stronger the acid. The more delocalized the charge is on the conjugate base the more stable it is and the stronger the acid. The more electronegative an element is the more stable is is with a negative charge and the stronger it's conjugate acid.

K_w

$[H^+][OH^-] = 1.00 \times 10^{-14}$ at 25 °C (Different at different temperatures!)

In a neutral solution at 25 °C $[H^+] = [OH^-] = 1.00 \times 10^{-7}$ *M* in pure water (different with acidic or basic solutes added or at a different temperature).

pH & pOH

$$\mathrm{pH} = -\log\left[\mathrm{H^+}\right] \qquad \mathrm{pOH} = -\log\left[\mathrm{OH^-}\right]$$

$$\left[\mathrm{H^+}\right] = 10^{-\mathrm{pH}} \qquad \left[\mathrm{OH^-}\right] = 10^{-\mathrm{pOH}} \qquad \mathrm{pH} + \mathrm{pOH} = 14.00\,(\text{at } 25\ ^\circ\mathrm{C})$$

1.) Label the acid and the base in each of the following reactions. Label the the conjugate base (C.B.) and the conjugate acid (C.A.) in the first three equations.

$$\mathrm{HCl}(aq) + \mathrm{KOH}(aq) \rightarrow \mathrm{KCl}(aq) + \mathrm{H_2O}(l)$$

$$\mathrm{CH_3COOH}(aq) + \mathrm{H_2O}(l) \rightleftharpoons \mathrm{CH_3COO^-}aq + \mathrm{H_3O^+}(aq)$$

$$\mathrm{H_2O}(l) + \mathrm{KF}(aq) \rightleftharpoons \mathrm{KOH}(aq) + \mathrm{HF}(aq)$$

$$\mathrm{BF_3}(aq) + \mathrm{NaF}(aq) \rightarrow \mathrm{NaBF_4}(aq)$$

$$\mathrm{CH_3CH_2CH_2CH_2CH_2CH_2Cl} + \mathrm{AlCl_3} \rightarrow \mathrm{CH_3CH_2CH_2CH_2CH_2CH_2^+} + \mathrm{AlCl_4^-}$$

2.) Label the stronger acid of each pair. Explain why it is the stronger acid.

$\mathrm{HNO_3}$ or $\mathrm{HClO_4}$

$\mathrm{CH_2ClCOOH}$ or $\mathrm{CH_3COOH}$

$\mathrm{HNO_2}$ or HCN

HF or HCl

$\mathrm{HSbF_6}$ or HI

3.) At 100 °C the ion–product constant for water, K_w, is 5.13×10^{-13}. What is the pH of pure water when it boils at 100 °C?

pH = _____

4.) What is the pH of a solution that is made by dissolving 5.199 g of NaOH (a strong electrolyte) in enough water to make 475 mL of solution?

pH = _____

5.) What is the $[OH^-]$ in a solution that has a pH of 4.922?

$[OH^-]$ = _____ *M*

6.) What is the pOH of a solution that is made by adding 729 mL of D.I. water to 25.0 mL of 15.8 *M* nitric acid?

pOH = _____

7.) Consider the following reaction:

$$CH_3COO^- + HF \rightleftharpoons CH_3COOH + F^-$$

Given that K_a for HF is 6.6×10^{-4} and the K_a for CH_3COOH is 1.8×10^{-5} (both at 25°C), is *K* for this reaction at 25°C less than, greater than, or equal to 1? Explain.