STATION 1 – CALCULATIONS

ANSWER KEY

1. pH = $-\log(1.0 \times 10^{-8}) = 8.00$
2. pH = $-\log(5.91 \times 10^{-6}) = 5.228$
3. pH = $14 - 3.50 = 10.50$
4. pOH = $-\log(1.0 \times 10^{-10}) = 10.00$ pH = $14 - 10.00 = 4.00$
5. pOH = $-\log(4.28 \times 10^{-3}) = 2.369$ pH = $14 - 2.369 = 11.631$
6. $[OH^-] = 2(9.2 \times 10^{-7}) = 18.4 \times 10^{-7}$ pOH = $-\log(18.4 \times 10^{-7}) = 5.735$ pH = $14 - 5.735 = 8.26$
7. $[H^+] = 10^{-6.000} = 1.00 \times 10^{-6}$ M
8. $[H^+] = 10^{-4.882} = 1.31 \times 10^{-5}$ M
9. $[H^+] = \frac{1 \, x \, 10^{-14}}{6.1 \, x \, 10^{-5}} = 1.6 \times 10^{-10}$ M
10. pH = $14 - 10.22 = 3.78$ $[H^+] = 10^{-3.78} = 1.7 \times 10^{-4}$ M
11. pH = $-\log(1 \times 10^{-4}) = 4.0$ (mental math!)
12. pH = $-\log(1 \times 10^{-11}) = 11.0$ (mental math!)
13. pH = $-\log(7 \times 10^{-5})$ = between 4 and 5 (mental math!) calculator says: 4.2
14. pH = $-\log(3.11 \times 10^{-12})$ = between 11 and 12 (mental math!) calculator says: 11.507

STATION 2 – STRONG ACID VS. WEAK ACID

ANSWER KEY

1. Both acids ionize in water to produce H^+(aq) and A^-(aq) ions.
2. 100% of the strong acid molecules breaks into H^+(aq) and A^-(aq) ions. The strong acid completely ionizes. The strong acid ionization equation uses a single arrow, indicating 100% completion. Only a small percentage of the weak acid molecules breaks into H^+(aq) and A^-(aq) ions. The weak acid partially ionizes. The weak acid ionization equation uses a double arrow, indicating equilibrium is established.
3. Examine the two solutions below.
    a. HCl is a strong acid because all the molecules produce H^+(aq) and Cl^-(aq). $HC_2H_3O_2$ is a weak acid because only some of the molecules produce H^+(aq) and $C_2H_3O_2^-$(aq). The majority of the $HC_2H_3O_2$ molecules stay whole as $HC_2H_3O_2$ molecules (i.e. the molecules do not ionize)
    b. $HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$
    $HC_2H_3O_2(aq) \leftrightarrow H^+(aq) + C_2H_3O_2^-(aq)$
4. Both solutions are 3.0×10^{-5} M
    a. HCl is a strong acid. $HC_2H_3O_2$ is a weak acid. If two acids are at the same concentration, then the stronger acid will produce a higher concentration of H^+ because the stronger the acid, the greater the percent ionization. 100% of the HCl molecules ionize into H^+ and Cl^- ions. Only a small percentage of $HC_2H_3O_2$ ionize into H^+ and $C_2H_3O_2^-$ ions. Since both HCl and $HC_2H_3O_2$ have the same initial concentrations, but HCl ionizes to a greater extent, HCl will have the higher H^+ concentration.
    b. The higher the pH, the lower the H^+ concentration of a solution. Since $HC_2H_3O_2$ has a lower H^+ concentration than HCl, $HC_2H_3O_2$ would have the higher pH.

STATION 3 – WATER

ANSWER KEY

1. Water is a polar molecule. The partial negative charge of the oxygen atom attracts H^+ ions. Thus, water can take/accept H^+ ions (i.e. protons), making water capable of acting as a base.
2. The electronegativity difference between hydrogen and oxygen makes the O−H bond in methanoic acid polar. This creates a partial positive charge on the H bonded to the oxygen, making it easier for this H to be attracted to and taken by a base. The H bonded to the carbon lacks this partial positive charge and is more difficult to take.
3. H_3O^+. When an acid ionizes it will donate H^+. When H^+ bonds with water, H_3O^+ (hydronium) ion is produced. H_3O^+ and H^+ are often used interchangeably.
4. Nitrogen has two lone electrons. These electrons attract positive H^+ ions. Since nitrogen can attract H^+ many bases contain nitrogen.
5. OH^-. When a base ionizes it will take H^+ from water. Think of water as HOH…after losing the H^+, OH^- is left behind.
6. Acid or base? Write the ionization/hydrolysis equation.
    a. Acid; $CH_3CH_2COOH(aq) + H_2O(l) \leftrightarrow H_3O^+(aq) + CH_3CH_2COO^-(aq)$
    b. Base; $C_2H_5NH_2(aq) + H_2O(l) \leftrightarrow C_2H_5NH_3^+(aq) + OH^-(aq)$
    c. Base; $CH_3NH_2(aq) + H_2O(l) \leftrightarrow CH_3NH_3^+(aq) + OH^-(aq)$
    d. Base; $NO_2^-(aq) + H_2O(l) \leftrightarrow HNO_2(aq) + OH^-(aq)$
    e. Acid; $NH_4^+(aq) + H_2O(l) \leftrightarrow H_3O^+(aq) + NH_3(aq)$

STATION 4 – THE MEANING OF NEUTRAL

ANSWER KEY

1. 0°C: $K_w = x^2$ — $0.11 \times 10^{-14} = x^2$ — $x = 3.3 \times 10^{-8}$ M = $[H^+]$
   10°C: — $0.31 \times 10^{-14} = x^2$ — $x = 5.6 \times 10^{-8}$ M = $[H^+]$
   100°C: — $7.50 \times 10^{-14} = x^2$ — $x = 2.74 \times 10^{-7}$ M = $[H^+]$

2. 0°C: pH = $-\log[H^+]$ — pH = $-\log(3.3 \times 10^{-8}) = 7.48$
   10°C: — pH = $-\log(5.6 \times 10^{-8}) = 7.25$
   100°C: — pH = $-\log(2.74 \times 10^{-7}) = 6.562$

3. Neutral. Both H_3O^+ and OH^- have a concentration of 2.74×10^{-7} M at 100°C. Since $[H_3O^+] = [OH^-]$ at 100°C, water is neutral.

4. K_w increases as temperature increases, indicating that the forward reaction becomes more favored as temperature increases. Thus, the ionization of water is endothermic.

STATION 5 – CONJUGATE ACID-BASE PAIRS

ANSWER KEY

1. Pair #1: HNO_3 (acid), NO_3^- (conjugate base) Pair #2: H_2O (base), H_3O^+ (conjugate acid)

2. Pair #1: CN^- (base), HCN (conjugate acid) Pair #2: $HC_2H_3O_2$ (acid), $C_2H_3O_2^-$ (conj. Base)

3. Pair #1: NH_4^+ (acid), NH_3 (conjugate base) Pair #2: F^- (base), HF (conjugate acid)

4. Pair #1: PO_4^{3-} (base), HPO_4^{2-} (conjugate acid) Pair #2: H_2O (acid), OH^- (conjugate base)

5. $C_3H_5O_3^-$ $Kb = \frac{1 \: x \: 10^{-14}}{1.38 \: x \: 10^{-4}} = 7.25 \text{ x } 10^{-11}$

6. CN^- $Kb = 1.6 \text{ x } 10^{-5}$

7. HCO_3^- $Kb = 2.3 \text{ x } 10^{-8}$

8. $C_5H_5NH^+$ $Ka = \frac{1 \: x \: 10^{-14}}{1.7 \: x \: 10^{-9}} = 5.9 \text{ x } 10^{-6}$

9. $CH_3NH_3^+$ $Ka = 2.28 \text{ x } 10^{-11}$

10. $(C_2H_5)_3NH^+$ $Ka = 2.5 \text{ x } 10^{-11}$