1. In your own words, explain what a hydrogen bond is.

A hydrogen bond is a bond between two molecules that have high polarity due specifically to having assymetrical shapes with hydrogen bonded to O, F, or N. The slight negative region of one molecule is attracted to the slight positive charge of the other molecule.

2. Draw the hydrogen bonding between three water molecules.

3. Describe why hydrogen bonding is responsible for the high boiling point of water.

The hydrogen bonds cause water to need more energy in order for molecules to be able to break free and fly away as a gas. This results in a higher boiling point.

4. Define each property and then describe how hydrogen bonding affects the property.

<table>
<thead>
<tr>
<th>Property</th>
<th>Definition</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Tension</td>
<td>Attractive forces at the surface of the liquid.</td>
<td>-Bugs can walk on water, capillary action.</td>
</tr>
<tr>
<td>Specific Heat Capacity</td>
<td>Energy required to heat 1 gram of a substance 1 °C.</td>
<td>-It is hard to heat up water, and it stores a lot of energy.</td>
</tr>
<tr>
<td>Heat of Vaporization</td>
<td>Energy required to vaporize 1 gram of a liquid.</td>
<td>-It is extremely hard to vaporize water so it cools when it evaporates and heats when it condenses.</td>
</tr>
<tr>
<td>Vapor Pressure</td>
<td>The pressure exerted on a liquid by it’s own vapor at equilibrium in a sealed container.</td>
<td></td>
</tr>
</tbody>
</table>

5. Explain how large bodies of water are able to keep air cool during high energy days.

The energy is going into the water causing it to evaporate instead of heating up the air.

6. What effect does a surfactant have on water?

A surfactant interrupts the hydrogen bonding at the surface of the water.

7. Explain why we maintain unusual warmth as clouds form during winter in Portland.

When the water vapor loses energy, becoming a liquid (cloud), we receive that energy in the form of heat. That is why we have warmer winters than other places at the same latitude.

8. Using the structure of liquid water versus solid water, explain why ice floats.

When ice forms, it locks into an expanded hexagonal grid held rigidly together by hydrogen bonds. This expansion causes the structure to be less dense than the liquid.
**15.2 – Aqueous Systems**

1. Distinguish between a solution and an aqueous solution. 
   *A solution is any substance dissolved into another substance. An aqueous solution is specifically a solute dissolved in water.*

2. Define the following:
   - **Solute:** *The substance being dissolved that you put into the solution.*
   - **Solvent:** *The substance that does the dissolving. The solvent is the foundation of the solution.*

3. Identify the solute and solvent in a dilute aqueous solution of potassium chloride. 
   *Potassium Chloride is the solute, water is the solvent.*

4. Describe and diagram the process of solvation.

5. What is the significance of the statement “likes dissolve likes”? What does “likes” refer to? 
   *Polar substances will dissolve in Polar substances, non-polar will dissolve in non-polar.*

6. Complete the following

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>A compound that conducts an electrical current when dissolved in water or melted</th>
<th>NaCl, CuSO₄, NaOH, Strong acids, strong bases.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonelectrolyte</td>
<td>A compound that does not conduct an electrical current when dissolved in water or melted</td>
<td>Sugar, alcohol</td>
</tr>
<tr>
<td>Strong Electrolyte</td>
<td>A compound that completely dissociates in water. All of the compound become ions.</td>
<td>Most salts, strong acids, Strong bases</td>
</tr>
<tr>
<td>Weak Electrolyte</td>
<td>A compound that only partially ionizes when dissolved in water. Only a fraction of the compound exists as ions.</td>
<td>Some salts, organic acids, weak acids and bases.</td>
</tr>
</tbody>
</table>

7. Write equations to show how the following ionic compounds dissolve in water.

   **Example:**  \( \text{CaCl}_2(\text{s}) \rightarrow \text{Ca}^{2+}(\text{aq}) + 2 \text{Cl}^{-}(\text{aq}) \)

   a. KOH:  \( \text{KOH}(\text{s}) \rightarrow \text{K}^+(\text{aq}) + \text{OH}^-(\text{aq}) \)

   b. Na₃PO₄:  \( \text{Na}_3\text{PO}_4(\text{s}) \rightarrow 3\text{Na}^+(\text{aq}) + \text{PO}_4^{3-}(\text{aq}) \)
8. Which of the following compounds are soluble in water? Explain your answer in terms of polarity.
   a. CH₄  **Not soluble because it is non-polar (perfect symmetry with tetrahedral shape)**
   b. KCl  **Soluble because it is ionic and the ion charges like the polarity of water.**
   c. He  **Not soluble because the atom is non-polar**
   d. (NH₄)₂CO₃  **Soluble because it is ionic and the ion charges like the polarity of water.**
   e. NH₃  **Soluble because the molecule is polar (pyramidal shape with an unshared pair of electrons on the nitrogen) and likes the polarity of water.**

A2: Chapter 16.1-16.2 - Solutions (pp 471-486)
**Section 16.1 (pgs 471-479)**
1. Name three factors that influence the rate at which a solute dissolves in a solvent.
   - Temperature, surface area, disturbance(stirring), or pressure

2. Define saturated solution, solubility, and unsaturated solution.
   - **Saturated solution** = A solution in which the maximum amount of solute is dissolved in a given amount of solvent
   - **Solubility** = The maximum amount of solute that can dissolve in a given amount of solvent at a specific temperature.
   - **Unsaturated solution** = A solution in which less than the maximum amount of solute is dissolved in the solvent. The solution could dissolve more of the solute at that temperature.

3. Explain miscible and immiscible.
   - **Miscible** is when a liquid can dissolve into another liquid. **Immiscible** is when liquids don’t.

4. Describe two ways you could change:
   a. a saturated solution to an unsaturated solution
      1. Add solvent
      2. Heat the solution
   b. an unsaturated solution to a saturated solution
      1. Remove solvent by evaporation or boiling
      2. Cool the solution
      3. Add solute.

5. Read page 474-475: If a saturated solution of sodium ethanoate is cooled, what change might you observe?
   - *The sodium ethanoate will begin to crystallize as the solution can’t dissolve it all.*

6. Use the solid substances listed in **Table 16.1** on page 475 to make a general statement that relates a change in solubility of a solid to a change in temperature. Provide one example.
   - **Temperature rises, so does solubility. All of the lines curve up, meaning as temperature moves up to the right, the grams per volume also increase.**

7. What mass of AgNO₃ can be dissolved in 250 g of water at 20°C? How do you know?
   \[
   \frac{222.0 \text{ gAgNO}_3}{100 \text{ gH}_2\text{O}} = \frac{x \text{ gAgNO}_3}{250 \text{ gH}_2\text{O}}, \quad x\text{gAgNO}_3 = \left( \frac{(250 \text{ gH}_2\text{O})}{100 \text{ gH}_2\text{O}} \right) \times 222.0 \text{ gAgNO}_3 = 555 \text{ gAgNO}_3
   \]
Section 16.2 (pgs 480-486)

Molarity
8. A solution has a volume of 2.0 L and contains 36.0 g of glucose. If the molar mass of glucose is 180 g/mol, what is the molarity of the solution?

\[
M = \frac{\text{moles}}{\text{volume}} = \left( \frac{36 \text{ g } C_6H_{12}O_6}{2.0 \text{ L}} \right) \left( \frac{1 \text{ mol } C_6H_{12}O_6}{180 \text{ g } C_6H_{12}O_6} \right) = 0.10 \text{ M}
\]

9. A solution has a volume of 250 mL and contains 0.70 mol NaCl. What is its molarity?

\[
M = \left( \frac{n}{V} \right) = \frac{\text{moles}}{\text{volume}} = \left( \frac{0.7 \text{ mol}}{250 \text{ mL}} \right) \left( \frac{1000 \text{ mL}}{1 \text{ L}} \right) = 2.8 \text{ M}
\]

Making Dilutions
10. How many milliliters of a stock solution of 4.00 M KI would you need to prepare 250.0 mL of 0.760 M KI?

\[
M_1V_1 = M_2V_2 \text{ so, } V_1 = \frac{M_2V_2}{M_1} = \frac{(0.760 \text{ M})(250.0 \text{ mL})}{(4.00 \text{ M})} = 47.5 \text{ mL}
\]

11. Suppose you need 250 mL of 0.20 M NaCl, but the only supply of sodium chloride you have is 1.0 M NaCl. How do you prepare the required solution? Assume that you have the appropriate volume-measuring devices on hand.

\[
M_1V_1 = M_2V_2 \text{ so, } V_1 = \frac{M_2V_2}{M_1} = \frac{(0.20 \text{ M})(250.0 \text{ mL})}{(1.00 \text{ M})} = 50 \text{ mL}
\]

Percent solutions
12. If 10 mL of pure acetone is diluted with water to a total solution volume of 200 mL, what is the percent by volume of acetone in the solution?

\[
\% (v/v) = \frac{V_{\text{solute}}}{V_{\text{solution}}} = \frac{10 \text{ mL}}{200 \text{ mL}} = .05 = 5\% (v/v)
\]

13. A bottle of hydrogen peroxide antiseptic is labeled 3.0% (v/v). How many mL H\textsubscript{2}O\textsubscript{2} are in a 400.0 mL solution?

\[
\% (v/v) = \frac{V_{\text{solute}}}{V_{\text{solution}}} = \frac{xml}{400 \text{ mL}} = 3.0 \text{ mL} , \quad xml = \frac{(3.0 \text{ mL})(400 \text{ mL})}{(100 \text{ mL})} = 12 \text{ mL}
\]

14. Calculate the grams of solute required to make 250 mL of 0.10% MgSO\textsubscript{4} (m/v).

\[
\% (m/v) = \frac{\text{Mass solute}}{V_{\text{solution}}} = \frac{xml}{250 \text{ mL}} = \frac{0.10 g}{100 \text{ mL}} , \quad xml = \frac{(0.10 g)(250 \text{ mL})}{(100 \text{ mL})} = 0.25 g
\]
Problems

15. You have the following stock solution available; 4.0M KNO₃. Calculate the volume you must dilute to make 50.0 mL of 0.20 M KNO₃

\[ M_1V_1 = M_2V_2 \text{ so, } V_1 = \frac{M_2V_2}{M_1} = \frac{(0.20M)(50.0 \text{ mL})}{(4.0M)} = 2.5 \text{ mL} \]

16. Calculate the moles and grams of solute in each solution
   a. 1.0 L of 0.50 M NaCl
      \[ M = \frac{\text{moles}}{\text{volume}}, \text{ moles} = (M)(V) = \left(\frac{0.50 \text{ mol NaCl}}{1 \text{ L}}\right)(1.0 \text{ L}) = 0.50 \text{ mol NaCl} \left(\frac{58.44 \text{ gNaCl}}{1 \text{ mol NaCl}}\right) = 29 \text{ gNaCl} \]
   b. 5.0 x 10² mL of 2.0M KNO₃
      \[ M = \frac{\text{moles}}{\text{volume}}, \text{ moles} = (M)(V) = \left(\frac{2.0 \text{ mol}}{1 \text{ L}}\right)(5.0 \times 10² \text{ mL}) \left(\frac{1 \text{ L}}{1000 \text{ mL}}\right) = 1.0 \text{ mol KNO₃} \left(\frac{101.11 \text{ gKNO₃}}{1 \text{ mol KNO₃}}\right) = 101 \text{ gKNO₃} \]

17. Calculate the grams of solute required to make the following solutions
   a. 2.5 L of normal saline solution (0.90% NaCl (m/v))
      \[ 2.5L \left(\frac{1000\text{ mL}}{1 \text{ L}}\right) = 2500\text{ mL} \]
      \[ \% \left(\frac{\text{m}}{\text{v}}\right) = \frac{\text{Mass solute}}{\text{Volume Solution}}, \quad \frac{xg}{2500\text{ mL}} = \frac{0.90g}{100\text{ mL}}, \quad x\text{ mL} = \frac{(0.90g)(2500\text{ mL})}{(100\text{ mL})} = 22.5g \]
   b. 50.0 mL of 4.0% MgCl₂
      \[ \% \left(\frac{\text{m}}{\text{v}}\right) = \frac{\text{Mass solute}}{\text{Volume Solution}}, \quad \frac{xg}{50\text{ mL}} = \frac{4.0g}{100\text{ mL}}, \quad x\text{ mL} = \frac{(4.0g)(50\text{ mL})}{(100\text{ mL})} = 2.0g \]

18. What is the concentration (in % (m/v)) of the following solutions?
   a. 20.0 g KCL in 0.60 L of solution
      \[ 0.60L \left(\frac{1000\text{ mL}}{1 \text{ L}}\right) = 600\text{ mL} \], \[ \% \left(\frac{\text{m}}{\text{v}}\right) = \frac{\text{Mass solute}}{\text{Volume Solution}}, \quad \frac{xg}{600\text{ mL}} = \frac{20.0g}{600\text{ mL}}, \quad x\text{ mL} = \frac{(20.0g)(600\text{ mL})}{(600\text{ mL})} = 0.033 = 3.3\% \left(\frac{\text{m}}{\text{v}}\right) \]
   b. 32 g NaNO₃ in 2.0 L solution
      \[ 2.0L \left(\frac{1000\text{ mL}}{1 \text{ L}}\right) = 2000\text{ mL} \], \[ \% \left(\frac{\text{m}}{\text{v}}\right) = \frac{\text{Mass solute}}{\text{Volume Solution}}, \quad \frac{xg}{2000\text{ mL}} = \frac{32g}{2000\text{ mL}}, \quad x\text{ mL} = \frac{(32g)(2000\text{ mL})}{(2000\text{ mL})} = 0.016 = 1.6\% \left(\frac{\text{m}}{\text{v}}\right) \]

19. Hydrogen peroxide is often sold commercially as a 3.0% (m/v) aqueous solution.
   a. If you buy a 250 mL bottle of 3.0% H₂O₂, how many grams of hydrogen peroxide have you purchased?
      \[ \% \left(\frac{\text{m}}{\text{v}}\right) = \frac{\text{Mass solute}}{\text{Volume Solution}}, \quad \frac{xg}{250\text{ mL}} = \frac{3.0g}{100\text{ mL}}, \quad x\text{ mL} = \frac{(3.0g)(250\text{ mL})}{(100\text{ mL})} = 7.5g \]
   b. What is the molarity of this solution?
      \[ M = \frac{\text{moles}}{\text{volume}} = \left(\frac{3.0gH₂O₂}{100\text{ mL}}\right) \left(\frac{1\text{ mol H₂O₂}}{34.02 \text{ g H₂O₂}}\right) \left(\frac{1000\text{ mL}}{1 \text{ L}}\right) = 0.88 M \]
A3: Solutions, Concentration & Molarity

16.2: Concentration Problems (show work)

1. Find the molarity of a solution made from 106.0 grams of chloric acid (HClO₃) dissolved in 1700 mL of water.

\[ M = \frac{\text{moles}}{\text{volume}} = \left( \frac{106.0 \text{ g HClO}_3}{1700 \text{ mL}} \right) \left( \frac{1 \text{ mol HClO}_3}{84.46 \text{ g HClO}_3} \right) \left( \frac{1000 \text{ mL}}{1 \text{ L}} \right) = 0.74 \text{ M} \]

2. How many grams are needed to prepare 500 mL of a 2.5 M calcium fluoride solution?

\[ M = \frac{\text{moles}}{\text{volume}}, \text{moles} = (M)(V) = \left( \frac{2.5 \text{ mol}}{1 \text{ L}} \right) (500 \text{ mL}) \left( \frac{1 \text{ L}}{1000 \text{ mL}} \right) \left( \frac{101.11 \text{ g CaF}_2}{1 \text{ mol CaF}_2} \right) = 98 \text{ g CaF}_2 \]

3. What is the concentration of a solution in % (m/v) made by dissolving 2.3 g NaCl in enough water to have 125 mL of solution?

\[ \% \left( \frac{\text{m}}{\text{v}} \right) = \frac{\text{mass solute}}{\text{volume solution}} = \left( \frac{2.3 \text{ g NaCl}}{125 \text{ mL}} \right) = 0.018 = 1.8\% \text{ m/v} \]

4. How many grams ethyl alcohol are contained in 1 fluid ounce (= 30.0 mL) bourbon if the concentration of ethyl alcohol is 35.6% (m/v)?

\[ \% \left( \frac{\text{m}}{\text{v}} \right) = \frac{\text{mass solute}}{\text{volume solution}} = \frac{x \text{ g}}{30 \text{ mL}} = 0.356, \quad xg = 10.7 \text{ g} \]

5. If I make a solution by adding water to 35 mL of methanol (CH₃OH) until the final volume of the solution is 275 mL, what is the percent by volume of methanol in this solution (v/v%)?

\[ \% \left( \frac{\text{v}}{\text{v}} \right) = \frac{V \text{ solute}}{V \text{ volume solution}} = \frac{35 \text{ mL}}{275 \text{ mL}} = 0.13 = 13\% \text{ v/v} \]

Dilution Problems (show work)

6. How many mL of a 5.0 M stock solution are needed to prepare 200 mL of a 0.5 M solution?

\[ M_1V_1 = M_2V_2 \quad \text{so,} \quad V_1 = \frac{M_2V_2}{M_1} = \frac{(0.5 \text{ M})(200 \text{ mL})}{(5.0 \text{ M})} = 20 \text{ mL} \]

7. Describe how one would make 500 mL of a 5.5 M NaCl solution from a stock solution of 12M:

\[ M_1V_1 = M_2V_2 \quad \text{so,} \quad V_1 = \frac{M_2V_2}{M_1} = \frac{(5.5 \text{ M})(500 \text{ mL})}{(12 \text{ M})} = 230 \text{ mL} \]
8. How many liters of stock 12 molar hydrochloric acid would you need to make 300 ml of 1.0 molar hydrochloric acid? After showing work, diagram and describe the process in words.

\[ M_1V_1 = M_2V_2 \text{ so, } V_1 = \frac{M_2V_2}{M_1} = \frac{(10.\text{ M})(300\text{ mL})}{(12\text{ M})} = 25\text{ mL} \]

I would pour 25 mL of 12 molar stock solution into a 300mL volumetric flask. Then I would dilute with water until it was exactly 300 mL. This would be a less concentrated solution of 1.0 molar.

A4: Ch 19 Reading Guide Acid and Bases

19.1: Acid Base Theories

1. List each of the properties of an acid and a base.

<table>
<thead>
<tr>
<th>Acid</th>
<th>Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sour Taste</td>
<td>Slippery</td>
</tr>
<tr>
<td>Corrodes Metal</td>
<td>Caustic</td>
</tr>
<tr>
<td>React with bases to neutralize</td>
<td>Taste Bitter</td>
</tr>
<tr>
<td></td>
<td>React with acids to neutralize</td>
</tr>
</tbody>
</table>

2. Give the Bronsted-Lawry definition of an acid with an example.

Hydrogen-ion donor (proton donor)

i.e. HNO₃

3. Give the Bronsted-Lawry definition of a base with an example.

Hydrogen-ion acceptor (proton acceptor)

i.e. NH₃

4. Define a conjugate acid and a conjugate base. What is a conjugate pair? Give examples.

Conjugate acid: Particle formed when a base gains a hydrogen ion,

\[ \text{NH}_3 \rightarrow \text{NH}_4^+ \]

Conjugate base: Particle formed when an acid donates (loses) a hydrogen ion,

\[ \text{HCl} \rightarrow \text{Cl}^- \]

5. What does amphoteric mean? Provide an example.

Amphoteric is a substance that can act as an acid or base. A good example is HSO₄⁻¹.

6. Using the table (19.3) on page 591, tell whether you expect each substance listed to behave as an acid or a base, and give its conjugate partner.

<table>
<thead>
<tr>
<th>Acid or Base</th>
<th>Conjugate Pair</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. HCl</td>
<td>Acid Cl⁻</td>
</tr>
<tr>
<td>2. OH⁻</td>
<td>Base H₂O</td>
</tr>
<tr>
<td>3. H₂SO₄</td>
<td>Acid HSO₄⁻⁻</td>
</tr>
<tr>
<td>4. NH₄⁺</td>
<td>Acid NH₃</td>
</tr>
<tr>
<td>5. Cl⁻</td>
<td>Base HCl</td>
</tr>
</tbody>
</table>

7. Using the table (19.3) on page 651, which substance is found as both an acid and a base? What is its conjugate pair as an acid, and what is its conjugate pair as a base?

Water (H₂O): OH⁻ and H₃O⁺
8. Identify each of the following reactants as either an acid or a base. Also label the two products as conjugate acid-base pairs.
   1. \( \text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{OH}^- + \text{NH}_4^+ \)
   2. \( \text{HCl} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^- \)
   3. \( \text{CH}_3\text{COOH} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{CH}_3\text{COO}^- \)

9. Predict, Apply & Synthesize:
   a. Write the equation for the ionization of hydrocyanic acid (HCN) with water. Label the acid, base, conjugate acid, and conjugate base.
      \( \text{HCN} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{CN}^- \)
   b. Write the equation for the ionization of nitric acid (HNO₃) with water. Label the acid, base, conjugate acid, and conjugate base.
      \( \text{HNO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{NO}_3^- \)
   c. Write the equation for the ionization of CO₃²⁻ with water. Label the acid, base, conjugate acid, and conjugate base.
      \( \text{CO}_3^{2-} + \text{H}_2\text{O} \rightarrow \text{HCO}_3^- + \text{OH}^- \)

19.2: Hydrogen Ions and Acidity
10. Draw the equation for water self ionization and explain what it means.
    \[ \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{OH}^- \], \text{In this ionization equation, water splits into hydrogen ions and hydroxide ions.} \]

11. What happens when \([\text{H}^+]\) increases? What happens when \([\text{H}^+]\) decreases?
    \[ \text{When } [\text{H}^+] \text{ increases } [\text{OH}^-] \text{ decreases and the acidity increases.} \]
    \[ \text{When } [\text{H}^+] \text{ decreases } [\text{OH}^-] \text{ increases and the acidity decreases.} \]

12. What is the equation for the ion product for water? How does this relate to question #14?
    \[ K_w = [\text{H}^+][\text{OH}^-] = 1.00 \times 10^{-14} \]

13. Explain what an acidic solution is using an example.
    \[ \text{An acidic solution is when the } [\text{H}^+] \text{ is greater than } 1.0 \times 10^{-7}\text{M and the } [\text{OH}^-] \text{ is less than } 1.0 \times 10^{-7}\text{M.} \]
14. Explain what a basic solution is using an example.

An basic solution is when the \([H^+]\) is less than \(1.0 \times 10^{-7} M\) and the \([OH^-]\) is greater than \(1.0 \times 10^{-7} M\).

15. Classify each solution as acidic or basic, or neutral.
   a. \([H^+] = 6.0 \times 10^{-10} M\) Basic
   b. \([OH^-] = 3.0 \times 10^{-3} M\) Basic
   c. \([H^+] = 2.0 \times 10^{-7} M\) Acidic
   d. \([OH^-] = 1.0 \times 10^{-7} M\) Neutral

16. If the hydroxide-ion concentration of an aqueous solution is \(1 \times 10^{-3} M\), what is the \([H^+]\) in the solution?

   \([H^+]\) = \(\frac{1.0 \times 10^{-14}}{1 \times 10^{-3}} M = 1 \times 10^{-11} M\)
   Basic

17. What is pH, and what is the equation for calculating it?

   \(pH = -\log[H^+]\)

18. Find the pH of each solution
   a. \([H^+] = 0.045 M\) \(pH = -\log[0.045] = 1.3\)
   b. \([H^+] = 8.7 \times 10^{-6} M\) 5.1
   c. \([H^+] = 0.0015 M\) 2.8

19. Calculate \([H^+]\) for each solution.
   a. \(pH = 5.00\) \([H^+] = 10^{-5.00} = 1.00 \times 10^{-5} M\)
   b. \(pH = 12.83\) \(1.5 \times 10^{-13} M\)

Calculate the pH of each solution.
   a. \([OH^-] = 4.3 \times 10^{-5} M\) \(pH = 9.6\)
   b. \([OH^-] = 5.0 \times 10^{-5} M\) \(pH = 5.7\)

A5: Calculating pH Worksheet (Goals 10 – 11)

1. You add a substance to pure water and the pH rises from 7 to 9. What has happened to the concentration of \(H_3O^+\) ions?

   The concentration of \(H_3O^+\) ions decreases as you go from a pH of 7 to 9 because the 7 represents \([H_3O^+]\) of \(10^{-7}\) and the 9 represents \(10^{-9}\). \(10^{-9}\) is 100 times smaller than \(10^{-7}\).

   Is the substance added an acid or a base?

   The substance added must have been a base because it received the \(H_3O^+\) ions, therefore causing a reduction in the concentration of the \(H_3O^+\) ions. Bases are \(H_3O^+\) ion receivers.

2. A friend claims that a 1.0 M HCl solution contains no \(OH^-\) ions. Do you agree? Explain your answer.

   This cannot be true since \([OH^-][H_3O^+] = 10^{-14}\). Therefore, if \(OH^-\) were zero, the answer could not equal \(10^{-14}\).

3. What is the pH of a solution of 0.0056 M KOH solution?

   \([H^+] = 1.0 \times 10^{-14}/0.0056M = 1.8 \times 10^{-12} M\).

   Therefore, the \(pH = -\log [1.8 \times 10^{-12}] = 11.7\)
4. Use the following equations to complete the table.

\[
\text{pH} = -\log [H_3O^+] \\
K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14} \\
[H^+] = 10^{-\text{pH}}
\]

<table>
<thead>
<tr>
<th>SUBSTANCE</th>
<th>pH</th>
<th>([H_3O^+])</th>
<th>([OH^-])</th>
<th>Acid or Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>apple juice</td>
<td>3.50</td>
<td>3.16 \times 10^4 M</td>
<td>3.16 \times 10^{11} M</td>
<td>Acid</td>
</tr>
<tr>
<td>drain cleaner</td>
<td>13.00</td>
<td>1.00 \times 10^{13} M</td>
<td>1.00 \times 10^{-1} M</td>
<td>Base</td>
</tr>
<tr>
<td>window cleaner</td>
<td>11</td>
<td>1.0 \times 10^{11} M</td>
<td>1.0 \times 10^{-3} M</td>
<td>Base</td>
</tr>
<tr>
<td>strawberries</td>
<td>3.5</td>
<td>3.2 \times 10^4 M</td>
<td>3.1 \times 10^{11} M</td>
<td>Acid</td>
</tr>
<tr>
<td>sea water</td>
<td>7.9</td>
<td>1.4 \times 10^8 M</td>
<td>7.4 \times 10^{-7} M</td>
<td>Base</td>
</tr>
<tr>
<td>lemon juice</td>
<td>2.3</td>
<td>5.0 \times 10^3 M</td>
<td>2.0 \times 10^{-12} M</td>
<td>Acid</td>
</tr>
</tbody>
</table>

5. Solution A has a pH of 3.0 and solution B has a pH of 5.0. Which solution has a larger concentration of \(H_3O^+\) ions?

Solution A is more acidic and so it has more \(H_3O^+\) ions.

How many times larger?

100x larger because \(10^{-5}(100) = 10^{-3}\)

Which solution has the larger concentration of \(OH^-\) ions?

Solution B is less acidic and more basic so it has more \(OH^-\) ions.

How many times larger?

100 times more

6. Solution A has a pH of 8.0 and solution B has a pH of 11.0. Which solution has a larger concentration of \(OH^-\) ions?

Solution B is more basic and so it has more \(OH^-\) ions.

How many times larger?

1000x larger because \(10^{11}(1000) = 10^8\)

Which solution has the larger concentration of \(H_3O^+\) ions?

Solution A is more acidic and so it has more \(H_3O^+\) ions.

How many times larger?

1000x larger

7. Determine the pH of a 2.50 \(\times\) 10\(^{-6}\) M HNO\(_3\) solution.

Since this acid completely dissociates, the pH = \(-\log[2.5\times10^{-6}] = 5.6\)

8. Determine the pH of a 0.00005 M NaOH solution.

The \([H^+] = 1.0 \times 10^{-14}/0.00005M = 2 \times 10^{-10} M.
Therefore, the pH = -Log [2 \times 10^{-10}] = 9.70

9. What is the \([H_3O^+]\) of a solution having a 4.6 \(\times\) 10\(^{-5}\) M of \(OH^-\) ions?

\([H_3O^+] = 1.0 \times 10^{-14}/4.6 \times 10^{-5} M = 2.2 \times 10^{-10} M\)