Answer Key to Selected Questions

**ALE 19. Acid–Base, Redox Reactions + an Introduction to Chemical Equilibrium**

**Important!!**
Check your responses with those below. Do not copy these answers onto your ALE—doing so is plagiarism and will not result in any learning. Rather, determine where you went wrong, what concepts you need to apply/learn, redo those problems that you missed and then recheck your answers. Seek help from the members in your group and from the instructor as needed.

1. The net ionic equation for the aqueous neutralization reaction between acetic acid and sodium hydroxide is different from that for the reaction between hydrochloric acid and sodium hydroxide. Explain by writing the molecular and net ionic equation for each reaction.
   
   **Molecular Equations:**
   a. Acetic Acid + Sodium hydroxide:
      \[ \text{CH}_3\text{COOH}(aq) + \text{NaOH}(aq) \rightarrow \text{NaCH}_3\text{COO}(aq) + \text{H}_2\text{O}(l) \]
   b. Hydrochloric Acid + Sodium Hydroxide:
      \[ \text{HCl}(aq) + \text{NaOH}(aq) \rightarrow \text{NaCl}(aq) + \text{H}_2\text{O}(l) \]
   
   **Note:** the net Ionic Equations for the two reactions are *not* be the same! Don’t forget that acetic acid, CH₃COOH, is a weak acid and HCl is a strong acid.

2. Complete the following acid-base reactions with balanced molecular, total ionic and net ionic equations:
   a. Cesium hydroxide (aq) + nitric acid (aq):
      
      **Molecular Equation:** \[ \text{CsOH}(aq) + \text{HNO}_3(aq) \rightarrow \text{CsNO}_3(aq) + \text{H}_2\text{O}(l) \]
      
      **Total Ionic Equation:** ?????
      
      **Net Ionic Equation:** ?????
   
   b. Calcium hydroxide (aq) + acetic (aq):
      
      **Molecular Equation:** \[ \text{Ca(OH)}_2(aq) + 2\text{CH}_3\text{COOH}(aq) \rightarrow \text{Ca(CH}_3\text{COO)}_2(aq) + 2\text{H}_2\text{O}(l) \]
      
      **Total Ionic Equation:** ?????
      
      **Net Ionic Equation:** ?????

3. If 26.35 mL of a standard 0.1650 \( M \) KOH solution is required to neutralize 35.00 mL of H₂SO₄, what is the molarity of the sulfuric acid?
   
   **Balanced Molecular Equation:** \[ 2\text{KOH}(aq) + \text{H}_2\text{SO}_4(aq) \rightarrow 2\text{H}_2\text{O}(l) + \text{K}_2\text{SO}_4(aq) \]
   
   \( 0.06211 \ M \text{H}_2\text{SO}_4 \)

4. A sodium hydroxide solution was standardized by titrating 25.00mL of 0.1528 \( M \) standard hydrochloric acid. The initial buret reading of the sodium hydroxide was 2.24 mL, and the final reading upon reaching the endpoint was 39.21 mL. What is the molarity of the sodium hydroxide solution?
   
   **Balanced Molecular Equation:** \[ \text{NaOH}(aq) + \text{HCl}(aq) \rightarrow \text{NaCl}(aq) + \text{H}_2\text{O}(l). \]
   
   \( 0.1033 \ M \text{NaOH} \)

5. Explain why an oxidizing agent undergoes reduction in a redox reaction.
   
   *An oxidizing agent causes something else to be oxidized; i.e., to lose electrons. The oxidizing agent accepts these electrons and becomes reduced.*
6. Give the oxidation number of each element in the following compounds or ions.
   a.) KBr: \( K = +1 \) \( Br = -1 \)
   b.) BrF\(_3\): \( Br = +3 \) \( F = -1 \)
   c.) HBrO\(_3\): \( H = +1 \) \( Br = +5 \) \( O = -2 \)
   d.) CBr\(_4\): \( C = +4 \) \( Br = -1 \)

7. Identify the oxidizing agent and the reducing agent in each of the following:
   a.) \( 8 \text{H}^+(aq) + \text{Cr}_2\text{O}_7^{2-}(aq) + 3 \text{SO}_3^{2-}(aq) \rightarrow 2 \text{Cr}^{3+}(aq) + 3 \text{SO}_4^{2-}(aq) + 4 \text{H}_2\text{O}(l) \)
       Oxidizing agent: \( \text{Cr}_2\text{O}_7^{2-} \) Reducing agent: \( \text{SO}_3^{2-} \)
   b.) \( \text{NO}_3^{-}(aq) + 4 \text{Zn}(s) + 7 \text{OH}^{1-}(aq) + 6 \text{H}_2\text{O}(l) \rightarrow 4 \text{Zn}^{2+}(aq) + \text{NH}_3(aq) \)
       Oxidizing agent: \( \text{NO}_3^{-} \) Reducing agent: \( \text{Zn} \)

8. A person’s blood alcohol (ethanol: \( \text{C}_2\text{H}_5\text{OH} \)) level can be determined by titrating a sample of blood plasma (blood minus the red blood cells and the white blood cells) with a potassium dichromate solution. The balanced net ionic equation is:
   \( 16 \text{H}^+(aq) + 2 \text{Cr}_2\text{O}_7^{2-}(aq) + \text{C}_2\text{H}_5\text{OH}(aq) \rightarrow 4 \text{Cr}^{3+}(aq) + 2 \text{CO}_2(g) + 11 \text{H}_2\text{O}(l) \)
   If 35.46 mL of 0.05961 \( M \) \( \text{Cr}_2\text{O}_7^{2-} \) is required to titrate 28.00 g of blood plasma, what is the mass percent of alcohol in the blood?
   \[ \text{mass} \% \text{C}_2\text{H}_5\text{OH} = 0.1739\% \text{C}_2\text{H}_5\text{OH} \]

9. What is the name of the kind of reaction that leads to each of the following?
   a.) An increase in the number of substances: decomposition
   b.) A decrease in the number of substances: combination
   c.) No change in the number of substances: displacement

12. In a combination reaction, 2.22 g magnesium metal is heated with 3.75 g of nitrogen gas.
    a.) Write the balanced chemical equation for the reaction: \( 3\text{Mg}(s) + \text{N}_2(g) \stackrel{\Delta}{\longrightarrow} \text{Mg}_3\text{N}_2(s) \)
    b.) Which reactant is in excess? \( \text{Mg} \) is the limiting reactant; \( \text{N}_2 \) is present in excess.
    c.) How many moles of product are formed? 0.0304 mol \( \text{Mg}_3\text{N}_2 \)
    d.) After reaction, how many grams of each reactant and product are present? 3.07 g \( \text{Mg}_3\text{N}_2 \) produced; There will be no Mg remaining 2.90g \( \text{N}_2 \) present in excess

13. Why is the equilibrium state called “dynamic”?
    The equilibrium state is dynamic, because the forward and reverse processes continue even after apparent change has ceased.
14. Describe what happens at the molecular level when acetic acid (a weak acid) dissolves in water.

Acetic acid molecules are constantly and randomly colliding with each other and with water molecules. Occasionally, an $H^+$ is transferred from an acetic acid molecule to a water molecule as a result of one of these collisions. At first, this process occurs at a larger rate than the reverse transfer of an $H^+$ from a $H_3O^+$ to a $CH_3COO^-$. As the concentration of $H^+$ and $CH_3COO^-$ build up, the rate of transfer of $H^+$ between them equals the rate of transfer of $H^+$ between $CH_3COOH$ and $H_2O$ and equilibrium is reached when about 2% of the $CH_3COOH$ molecules have ionized.

The following equation is a summary of the above:

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

15. **Problem 4.121**: Sodium peroxide, $Na_2O_2$, is often used in self-contained breathing devices, such as those used in fire emergencies, because it reacts with exhaled $CO_2$ to form $Na_2CO_3$ and $O_2$. How many liters of exhaled air can react with 80.0 g of $Na_2O_2$ if each liter of exhaled air contains 0.0702 g of $CO_2$?

**Balanced Equation**: $2 Na_2O_2(s) + 2 CO_2(g) \rightarrow 2 Na_2CO_3(s) + O_2(g)$

$$643 \text{ L air}$$