Grading:
1. ____/4
2. ____/4
3. ____/12
4. ____/8
5. ____/8
6. ____/5
7. ____/18
8. ____/8
9. ____/8
10. ____/8
TOTAL: ____/83

**To receive full credit for any problem, you must show your work, use significant figures in a sensible way, and include correct units.**

1. (4 points) What is the average speed of a water molecule at 100°C?

\[ u = \sqrt{\frac{3.83 \times 10^{-4} \cdot 373}{18.02}} = 719 \text{ m/s} \]

2. (4 points) The ideal gas law is most applicable at
   a) low pressures and low temperatures
   b) low pressures and high temperatures  [Circle this choice]
   c) high pressures and low temperatures
   d) high pressures and high temperatures
3. (12 points) Write balanced molecular, ionic, and net ionic equations for the reaction of aqueous solutions of potassium carbonate and nickel (II) nitrate.

\[ \text{K}_2\text{CO}_3 + \text{Ni}(\text{NO}_3)_2 \rightarrow 2\text{KNO}_3 + \text{NiCO}_3(s) \]
\[ 2\text{K}^+ + \text{CO}_3^{2-} + \text{Ni}^{2+} + 2\text{NO}_3^- \rightarrow 2\text{K}^+ + 2\text{NO}_3^- + \text{NiCO}_3(s) \]
\[ \text{CO}_3^{2-} + \text{Ni}^{2+} \rightarrow \text{NiCO}_3(s) \]

4. (8 points) If 36.21 mL of KMnO₄ solution titrates 50.0 mL of 0.0428 M H₃AsO₃ according to the following equation, what is the molarity of the KMnO₄ solution?

\[ 2\text{MnO}_4^- + 6\text{H}^+ + 5\text{H}_3\text{AsO}_3 \rightarrow 2\text{Mn}^{2+} + 5\text{H}_3\text{AsO}_4 + 3\text{H}_2\text{O} \]

\[
\frac{0.0500 \text{ L} \times 0.0428 \text{ M}}{0.0361} = 0.0214 \text{ mol H}_3\text{AsO}_3 \times \frac{2 \text{ MnO}_4^-}{5 \text{ H}_3\text{AsO}_3} = 0.00856 \text{ mol MnO}_4^-
\]

\[ M = \frac{\text{mol MnO}_4^-}{L} = \frac{0.00856}{0.0361} = 0.236 \text{ M} \]

5. (8 points) What mass of C₆H₅O₆ is required to react completely with 21.15 mL of a 0.0495 M Br₂ solution according to the following equation?

\[ \text{M = 6(12.0) + 8(35.5) + 6(16.0) = 176.12 g/mnl} \]
\[ \text{C}_6\text{H}_5\text{O}_6 + \text{Br}_2 \rightarrow \text{C}_6\text{H}_5\text{O}_6 + 2\text{HBr} \]

\[
\frac{0.0215 \text{ L} \times 0.0495 \text{ M}}{0.00105 \text{ mol Br}_2 = 0.00105 \text{ mol C}_6\text{H}_5\text{O}_6}
\]

\[
0.00105 \times \frac{176.12 \text{ g C}_6\text{H}_5\text{O}_6}{1 \text{ mol}} = 0.185 \text{ g would}
\]

6. (5 points) Circle the reaction(s) in which a precipitate would form if aqueous solutions of these substances were mixed.

a) NaNO₃ and NH₄Cl
b) Pb(ClO₄)₂ and K₃PO₄
c) Cu(NO₃)₂ and LiCl
d) HCl and NaOH
e) NaOH and FeCl₃
7. **(18 points)** Assign the oxidation number to each atom in each reaction. Then identify which type of atom is oxidized and which is reduced in each of the following reactions.

   a) \( 3 \text{Sn}^{2+} + 18 \text{Cl}^- + \text{BrO}_3^- + 6 \text{H}^+ \rightarrow 3 \text{SnCl}_6^{2-} + \text{Br}^- + 3 \text{H}_2\text{O} \)

   

   

   oxidized

   reduced

   

   b) \( 2 \text{Mn}^{2+}(\text{aq}) + 5 \text{HBrO}_3(\text{s}) \rightarrow 2 \text{MnO}_4(\text{aq}) + 5 \text{BiO}^+(\text{aq}) + \text{H}^+(\text{aq}) + 2 \text{H}_2\text{O(l)} \)

   

   

   oxidized

   reduced

   

   c) \( 3 \text{Se}(\text{s}) + 4 \text{NO}_3(\text{aq}) + 4 \text{H}^+ \rightarrow 3 \text{SeO}_2(\text{s}) + 4 \text{NO}(\text{g}) + 2 \text{H}_2\text{O} \)

   

   oxidized

   reduced

   

8. **(8 points)** A sample of a gaseous compound with a mass of 3.216 g has a volume of 2236 mL at 27.0°C and 0.967 atm. Calculate the molar mass of the compound.

   \[
   \rho = \frac{m}{V} = \frac{3.216 \text{g}}{2236 \text{mL}} = 1.438 \text{ g/L}
   \]

   \[
   M = \frac{dRT}{\rho} = \frac{(1.438)(0.0821)(300)}{0.967} = 56.63 \text{ g/mol}
   \]

9. **(8 points)** A sample of a gas at 30.0°C has a pressure of 1.23 atm and a volume of 24.7 L. If the volume of the gas is compressed to 8.39 L at the same temperature, what is the pressure at this new volume?

   

   

   \[
   \rho V_1 = nRT \quad \text{and} \quad \rho V_2 = nRT \quad \Rightarrow \rho V_1 = \rho_2 V_2
   \]

   \[
   (1.23)(24.7) = \rho_2 (8.39) \quad \Rightarrow \quad \rho_2 = 3.62 \text{ atm}
   \]

10. **(8 points)** Calculate the pressure of 32.0 g of CO\(_2\) gas in a volume of 1.1 L at -33°C.

   

   

   \[
   n = \frac{320 \text{g}}{44.015 \text{g/mol}} = 0.727 \text{ mol}
   \]

   \[
   \rho = \frac{nRT}{V} = \frac{(0.727)(0.0821)(245)}{1.1} = 13.02 \text{ atm}
   \]