R = 0.0821 L•atm/mol•K
Multiple Choice: (4 points each. Put answers in left margin as capital letters.)

1. Which of the following sets of measurements is most precise for 5.00 g reference weight?
   A) 4.92 g, 5.00 g, 5.02 g
   B) 4.97 g, 4.98 g, 4.99 g
   C) 4.93 g, 5.01 g, 5.07 g
   D) 5.03 g, 5.03 g, 5.04 g
   E) 4.90 g, 4.95 g, 5.00 g

2. Which of the following is least likely to represent a real compound?
   A) Al(C_2H_3O_2)_3 (Al(CH_3CO_2)_3)
   B) Gal_3
   C) K_2SO_4
   D) MgPO_4
   E) SrCO_3

3. Which of the following would be soluble in water?
   A) Al_2S_3
   B) CaSO_4
   C) NiCO_3
   D) Fe(OH)_3
   E) Fe_3(PO_4)_2

4. Which of the following solutions conducts electricity the best?
   A) 0.30 M CaCl_2
   B) 0.30 M CaSO_4
   C) 0.20 M Na_2SO_4
   D) 0.20 M Na_3PO_4
   E) 0.15 M (NH_4)_3PO_4

5. What is the oxidation number of the chromium atoms in Na_2Cr_2O_7?
   A) 0
   B) +2
   C) +4
   D) +6
   E) +8

6. Gases behave most ideally at:
   A) high temperature and high pressure
   B) high temperature and low pressure
   C) low temperature and high pressure
   D) low temperature and low pressure

7. Which of the following gases would have the slowest root-mean-square velocity?
   A) CH_4
   B) CO_2
   C) H_2
   D) NH_3
   E) SF_6

8. A gas mixture contains 1.00 moles of hydrogen, 2.00 moles of helium, and 3.00 moles of nitrogen. If the total pressure of the container is 5.00 atm, what is partial pressure of nitrogen?
   A) 0.833 atm
   B) 1.67 atm
   C) 2.00 atm
   D) 2.50 atm
   E) 5.00 atm
Discussion Questions: (Show your work to receive credit.)

1. Define the following: (12 points)
   - **stoichiometry** – the quantity relationship between reacting chemical species
   - **non-electrolyte** – an aqueous solution that does not conduct electricity
   - **miscible** – mixable in any ratio

2. Zinc hydroxide is used as an absorbent in surgical dressings and to attach dyes to cloth (mordant). It may be prepared by the following reaction:
   \[ \text{ZnCl}_2(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Zn(OH)}_2(\text{s}) + 2\text{NaCl}(\text{aq}) \]
   - What is the limiting reagent when 125 mL of a 0.15 M ZnCl$_2$ is mixed with 125 mL of a 0.15 M NaOH solution? What mass of zinc hydroxide is produced? (10 points)
     - \[ \text{mol}_{\text{ZnCl}_2} = \left( \frac{0.15 \text{ mol}_{\text{ZnCl}_2}}{\text{L}} \right) (0.125 \text{ L}) = 0.188 \text{ mol}_{\text{ZnCl}_2} \]
     - \[ \text{mol}_{\text{NaOH}} = \left( \frac{0.15 \text{ mol}_{\text{NaOH}}}{\text{L}} \right) (0.125 \text{ L}) = 0.188 \text{ mol}_{\text{NaOH}} \]
     - \[ \text{mol}_{\text{NaOH}}(\text{needed}) = (0.188 \text{ mol}_{\text{ZnCl}_2}) \left( \frac{2 \text{ mol}_{\text{NaOH}}}{1 \text{ mol}_{\text{ZnCl}_2}} \right) = 0.376 \text{ mol}_{\text{NaOH}} \]
     - To use up all of the ZnCl$_2$, one needs 0.376 mol$_{\text{NaOH}}$, but there is only 0.188 mol present, so NaOH is the limiting reagent.
     - \[ \text{mass}_{\text{Zn(OH)}_2} = \left( \frac{0.15 \text{ mol}_{\text{NaOH}}}{\text{L}} \right) (0.125 \text{ L}) \left( \frac{1 \text{ mol}_{\text{Zn(OH)}_2}}{2 \text{ mol}_{\text{NaOH}}} \right) \left( \frac{99.4 \text{ g}_{\text{Zn(OH)}_2}}{1 \text{ mol}_{\text{Zn(OH)}_2}} \right) = 0.932 \text{ g}_{\text{Zn(OH)}_2} \]

3. Write out the balanced molecular equation between aqueous nitric acid and aqueous ammonia. What is the net ionic equation? (8 points)
   - \[ \text{HNO}_3(\text{aq}) + \text{NH}_3(\text{aq}) \rightarrow \text{NH}_4\text{NO}_3(\text{aq}) \]
   - \[ \text{H}^+(\text{aq}) + \text{NH}_3(\text{aq}) \rightarrow \text{NH}_4^+(\text{aq}) \]

4. A solution of SnCl$_2$ is needed to have [Cl$^-$] = 0.244 M. What mass of SnCl$_2$ must be dissolved in 125 mL of water to achieve this concentration of chloride ion? (5 points)
   - \[ \text{mass}_{\text{SnCl}_2} = \left( \frac{0.244 \text{ mol}_{\text{Cl}^-}}{\text{L}} \right) (0.125 \text{ L}) \left( \frac{1 \text{ mol}_{\text{SnCl}_2}}{2 \text{ mol}_{\text{Cl}^-}} \right) \left( \frac{187.61 \text{ g}_{\text{SnCl}_2}}{1 \text{ mol}_{\text{SnCl}_2}} \right) = 2.86 \text{ g}_{\text{SnCl}_2} \]

5. Why would two liquids that do not mix to a significant extent be miscible as vapors/gases? (4 points)
   - In a liquid, the molecules are in constant, close physical contact, while in the gas phase they are widely separated. In the latter cases the interactions between molecules are unimportant, while in the former they are very important.
6. For the reaction: \(2 \text{ FeCl}_2 (aq) + \text{ AuCl}_3 (aq) \rightarrow 2 \text{ FeCl}_3 (aq) + \text{ AuCl}_2 (aq)\), (8 points)
   i) identify the reducing agent, and
   ii) indicate the beginning and ending charges on that species.
   i) \(\text{FeCl}_2\)
   ii) \(\text{Fe}^{2+}\) and \(\text{Fe}^{3+}\)

7. Calculate the molar mass of a vapor that has a density of 7.135 g/L at 12 ºC and 0.9776 atm (5 points)

\[
\text{MW} = \frac{\left(\frac{0.0821 \text{ L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}\right) \cdot 285 \text{ K} \cdot \left(\frac{7.135 \text{ g}}{\text{L}}\right)}{0.9776 \text{ atm}} = 171 \text{ g/mol}
\]

8. Explain Charles’ law \((V \propto T)\) in terms of the kinetic molecular theory. (6 points)

   When molecules are heated, they accelerate. This causes them to strike container walls more forcefully resulting in an increase in pressure. They also strike the walls more often, also increasing pressure. Since pressure remains constant, the walls must move outward to reduce the collision rate and the volume drops.

9. What are the five assumptions of the kinetic molecular theory of gases? (10 points)
   a) Gases consist of large numbers of molecules of widely spaced molecules. Because of this, the total volume of the molecules is negligible when compared to the total volume of the container. (i.e. we can ignore the volume of the molecules)
   b) The gas molecules are in continuous, random, straight-line motion.
   c) The average kinetic energy is proportional to absolute temperature.
   d) Energy can be transferred between molecules during collisions, but the average kinetic energy is constant at constant temperature. (i.e. The collisions are elastic.)
   e) Attractive and repulsive forces between molecules are not important.