CHM 111 Test 3 Name: _____
Spring 2026 (Please print)

Multiple Choice: (4 points each. Put answers in left margin as capital letters.)

1. How much water would increase in temperature by 14.1 ºC if 72.7 J of heat were added to it. The specific heat of water is 4.184 J/g•ºC.

   A) 0.0464 g B) 0.811 g C) 1.23 g D) 429 g E) None of these

2. The correct number of protons, neutrons, and electrons in $S^-$ (S-31) is:

   A) 15p, 16n, 14e C) 16p, 15n, 15e E) 16p, 15n, 17e
   B) 15p, 16n, 16e D) 16p, 15n, 16e

3. What is the charge on nickel in $VPO_4$?

   A) 0 B) +2 C) +3 D) +4 E) +6

4. Which of the following is molecular oxygen?

   A) O B) $O_2$ C) $O_3$ D) $O_4$ E) $O_5$

5. Calculate the molar mass (g/mol) for the compound, titanium(IV) sulfate, $Ti(SO_4)_2$.

   A) 95.93 B) 143.92 C) 191.79 D) 239.99 E) 287.53

6. What percentage of aluminum chloride is aluminum?

   A) 13.4% B) 19.9% C) 26.7% D) 34.6% E) 49.9%

7. Which of the following is true for the reaction: $AgCl_{(s)} + 126\ kJ \rightarrow Ag^+_{(aq)} + Cl^-_{(aq)}$

   A) the reaction is exothermic, and the heat of the reaction is positive
   B) the reaction is exothermic, and the heat of the reaction is negative
   C) the reaction is endothermic, and the heat of the reaction is positive
   D) the reaction is endothermic, and the heat of the reaction is negative
   E) none are true

8. Which of the following processes is most likely to be endothermic?

   A) Water freezing C) A light bulb emitting light E) A block resting on a table
   B) Coal burning D) The reaction of sodium and water

9. For the reaction: $MnO_{2\ (s)} + 4\ HCl_{(aq)} \rightarrow MnCl_{2\ (aq)} + Cl_2 + 2\ H_2O_{(\ell)}$, how many moles of $MnO_2$ are consumed when 15.2 moles of $H_2O$ are produced?

   A) 7.6 mol B) 15.2 mol C) 22.8 mol D) 30.4 mol E) none of these

10. How many moles of $MnO_2$ are needed to completely react with 24.8 grams of HCl?

A) 0.170 mol  B) 0.340 mol  C) 0.680 mol  D) 1.32 mol  E) 2.72 mol

Discussion Questions:

1. Define: (4 points each)

   combustion reaction – a reaction that produces a flame

   empirical formula – a chemical formula that gives the smallest whole-number ratio of each type of atom present in a compound

   theoretical yield – in a reaction, the amount of reactant or product the amount calculated from the stoichiometry

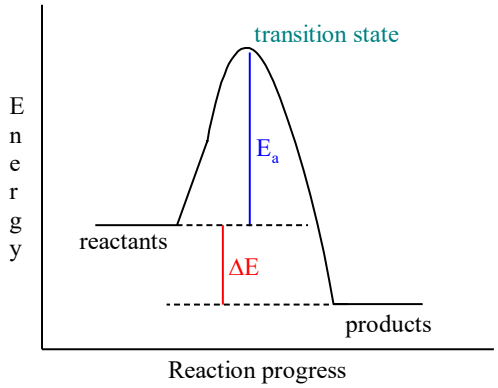
Fill-in-the-blanks (4 points each)

1. $SiF_4$ silicon tetrafluoride, $N_2O_4$ dinitrogen tetroxide

2. $Cu_2O$ copper(I) oxide, $Mg(NO_3)$ magnesium nitrate

3. Avogadro's number = $6.022 \times 10^{23}$

4.




For questions 4-5, provide reaction types, but do not use the same type twice.

5. $CH_{4\,(g)} + 3\ O_{2\,(g)} \rightarrow CO_{2\,(g)} + 2\ H_2O_{(\ell)}$ combustion

6. $PbCO_{3\,(s)} \rightarrow PbO_{(s)} + CO_{2\,(g)}$ decomposition

7. Balance: $C_3H_{8\,(g)} + 5\ O_{2\,(g)} \rightarrow 3\ CO_{2\,(g)} + 4\ H_2O_{(\ell)}$

8. When solutions of magnesium bromide and lithium carbonate are mixed, solid magnesium carbonate forms and lithium bromide remains in solution. Write the balanced equation.

   $MgBr_{2\,(aq)} + Li_2CO_{3\,(aq)} \rightarrow MgCO_{3\,(s)} + 2\ LiBr_{(aq)}$

Show your work problems

1. Milk of magnesia is one of the oldest antacids. The material is a slurry of a magnesium compound in water. The compound is 41.7% magnesium, 54.9% oxygen, and 3.5% hydrogen. The mineral weighs about 60 g per mole. What are its empirical and molecular formulas? (You may **NOT** work backwards from the molar mass.) (6 points)

   Assume 100 g of compound:

   $\text{mol}_{Mg} = (41.7\ \text{g}_{Mg})\left(\frac{1\ \text{mol}_{Mg}}{24.305\ \text{g}_{Mg}}\right) 1.72\ \text{mol}_{Mg}$ $\qquad \frac{1.72\ \text{mol}_{Mg}}{1.72\ \text{mol}_{Mg}} = 1$

   $\text{mol}_{O} = (54.9\ \text{g}_{O})\left(\frac{1\ \text{mol}_{O}}{15.9994\ \text{g}_{O}}\right) = 3.43\ \text{mol}_{O}$ $\qquad \frac{3.43\ \text{mol}_{O}}{1.72\ \text{mol}_{Mg}} = 1.99\ \text{mol}_{O}\ \text{per mol}_{Mg}$

   $\text{mol}_{H} = (3.5\ \text{g}_{H})\left(\frac{1\ \text{mol}_{H}}{1.00794\ \text{g}_{H}}\right) = 3.47\ \text{mol}_{H}$ $\qquad \frac{3.47\ \text{mol}_{H}}{1.72\ \text{mol}_{Mg}} = 2.02\ \text{H per mol}_{Mg}$

   $\Rightarrow$ empirical formula = $MgO_2H_2$

   $$\text{empirical weight} = \left(\frac{24.0\ \text{g}_{Mg}}{\text{mol}_{Mg}}\right)\left(\frac{1\ \text{mol}_{Mg}}{\text{eu}}\right) + \left(\frac{16.0\ \text{g}_{O}}{\text{mol}_{O}}\right)\left(\frac{2\ \text{mol}_{O}}{\text{eu}}\right) + \left(\frac{1.0\ \text{g}_{H}}{\text{mol}_{H}}\right)\left(\frac{2\ \text{mol}_{H}}{\text{eu}}\right) = 58$$

   g/eu

   $$\text{empirical units} = \left(\frac{60\ \text{g}}{\text{molecule}}\right)\left(\frac{\text{eu}}{58\ \text{g}}\right) = 1.03\ \text{eu/molecule} \approx 1\ \text{eu/molecule}$$

   Thus, the molecular formula is $MgO_2H_2$.

2. When silver(I) nitrate is mixed with calcium chloride according to the reaction:

   $2\ AgNO_{3\ (aq)} + CaCl_{2\ (aq)} \longrightarrow 2\ AgCl_{(s)} + Ca(NO_3)_{2\ (aq)}$

   silver(I) chloride forms. What is the maximum mass of silver(I) chloride that can be produced by combining 3.00 g of each reactant? What is the precent yield if 1.50 g AgCl is produced? (8 points)

   Determine the limiting reagent by first calculating the number of moles of each substance present.

   $\text{mol}_{AgNO3} = (3.00\ \text{g})\left(\frac{1\ \text{mol}_{AgNO3}}{169.9\ \text{g}_{AgNO3}}\right) = 0.0176\ \text{mol}_{AgNO3}$

   $\text{mol}_{CaCl2} = (3.00\text{g})\left(\frac{1\ \text{mol}_{CaCl2}}{111.0\ \text{g}_{CaCl2}}\right) = 0.0270\ \text{mol}_{CaCl2}$

   Now determine how much calcium chloride is required to use up all of the silver(I) nitrate.

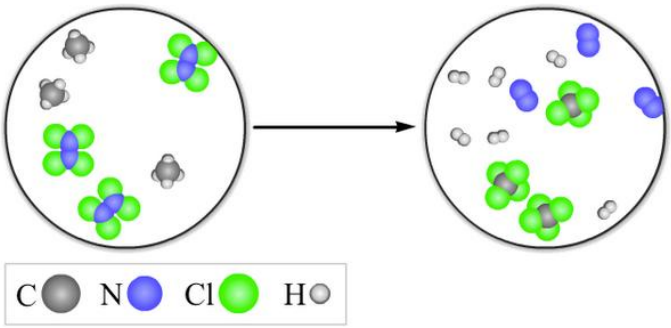
   $\text{mol}_{CaCl2}(\text{required}) = (0.0176\ \text{mol}_{AgNO3})\left(\frac{1\ \text{mol}_{CaCl2}}{2\ \text{mol}_{AgNO3}}\right) = 0.00883\ \text{mol}_{CaCl2}$

   But you have 0.0270 $\text{mol}_{Al}$, which is more than enough $CaCl_2$ so all of the $AgNO_3$ is consumed. Thus, silver(I) nitrate is the limiting reagent.

   $\text{mass}_{AgNO3} = (3.00\ \text{g})\left(\frac{1\ \text{mol}_{AgNO3}}{169.9\ \text{g}_{AgNO3}}\right)\left(\frac{2\ \text{mol}_{AgCl}}{2\ \text{mol}_{AgNO3}}\right)\left(\frac{143.3\ \text{g}_{AgNO3}}{1\ \text{mol}_{AgCl}}\right) = 2.53\ \text{g}$

   $\text{percent yield} = \frac{1.50\ \text{g}}{2.53\ \text{g}} \times 100\% = 59.3\%$

3. Write the balanced equation for




$3\ CH_{4\,(g)} + 3\ N_2Cl_{4\,(g)} \rightarrow 6\ H_{2\,(g)} + 3\ N_{2\,(g)} + 3CCl_{4\,(g)}$