CHM 111 Test 3 Name: _____
Spring 2025 (Please print)

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

1. 1.30 kJ of heat is required to raise the temperature of 444 g of lead from 15 ºC to its final temperature. Taking the specific heat capacity of lead to be 130 J/(kg•ºC), the final temperature is:

   A) 22.5 ºC C) 37.5 ºC E) None of these
   B) 30 ºC D) 45 ºC

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

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

3. What is the charge on nickel in $NiSO_4$?

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

4. Which of the following must be an empirical formula?

   A) C_3H_8 B) $C_4H_2(OH)_2$ C) C_4H_8 D) C_6H_6 E) N_2O_4

5. Calculate the molar mass (g/mol) for the compound, aluminum chloride, $AlCl_3$.

   A) 62.435 B) 106.36 C) 116.49 D) 124.87 **E) 133.34**

6. What percentage of aluminum chloride is aluminum?

   A) 20.2% B) 45.7% C) 69.5% D) 70.4% E) 78.1%

7. Which of the following is true for the reaction: $2\ H_{2(g)} + O_{2\ (g)} \rightarrow 2\ H_2O_{(g)} + 286$ kJ

   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) ice melting
   B) natural gas burning
   C) iron rusting
   D) the reaction produces a solid
   E) all of the above indicate a reaction is likely endothermic.

9. For the reaction: $4\ HCN + 5\ O_2 \rightarrow 2\ N_2 + 4\ CO_2 + 2\ H_2O$, how many moles of O_2 are consumed when 18.7 moles of H_2O are produced?

   A) 4.00 mol B) 7.48 mol C) 18.7 mol D) 37.4 mol **E) 46.8 mol**

10. How many moles of N_2 are needed to completely react with 24.8 grams of O_2?

    A) 0.0775 mol B) 0.155 mol **C) 0.310 mol** D) 0.620 mol E) 1.24 mol

Discussion Questions:

1. Define: (4 points each)

   mole – the number of atoms of carbon-12 in 12.0 g of carbon-12

   combustion – any reaction that produces a flame

   limiting reactant – a reagent that is completely consumed in a chemical reaction

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

1. BBr_3 – boron tribromide, CH_4 – methane

2. chromium(III) oxide - Cr_2O_3, $Ca(OCl)_2$ – calcium hypochlorite

3. Avogadro's number = 6.022×10^{23}

4. A reaction's actual yield might be lower than its theoretical yield because _____.
   a) Not waiting until the reaction completes, or
   b) Many reactions yield secondary products, or
   c) Impure reactants.

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

5. $3\ Ba(NO_3)_{2\ (aq)} + 2\ Al_2(SO_4)_{3\ (aq)} \rightarrow 3\ BaSO_{4\ (s)} + 2\ Al(NO_3)_{3\ (aq)}$ double displacement

6. $4\ As_{(s)} + 3\ O_{2\ (g)} \rightarrow As_4O_{6\ (s)}$ single displacement (or oxidation-reduction)

7. Balance: $2\ Ca_3(PO_4)_2 + 6\ SiO_2 \rightarrow P_4O_{10} + 6\ CaSiO_3$

8. Aqueous silver(I) nitrate reacts with aqueous hydrochloric acid to produce solid silver(I) chloride and sodium nitrate. Write the balanced equation.

   $AgNO_{3\ (aq)} + HCl_{(aq)} \rightarrow AgCl + NaNO_{3\ (aq)}$

Show your work problems

1. Naturally occurring copper consists of ^{63}Cu (62.9296 amu) and ^{65}Cu (64.9278 amu), with an average mass of 63.546 amu. What is the percent composition of Cu in terms of these two isotopes? (4 points)

   63.546 amu = (%^{63}Cu)(62.9296 amu) + (%^{65}Cu)(64.9278 amu)
   Let %^{63}Cu = x. then %^{65}Cu = 1-x
   63.546 amu = x(62.9296 amu) + (1-x)(64.9278 amu)
   1.3818 amu = 1.9982x amu
   x = 0.6915
   %^{63}Cu = 0.6915 * 100% = 69.15%
   %^{65}Cu = 100% - 69.15% = 30.85%

2. Glucose is composed of 40.0% carbon, 6.7% hydrogen, and 53.3% oxygen by mass. What is its empirical formula? If its molar mass is approximately 180 g/mol, what is its molecular formula? (You may **NOT** work backwards from the molar mass.) (6 points)

   Assume 100 g of compound:

   $\text{mol}_C = (40.0\ g_C)\left(\frac{1\ \text{mol}_O}{12.01\ g_O}\right) = 3.31\ \text{mol}_C$ $\qquad \left(\frac{3.31\ \text{mol}_C}{3.31\ \text{mol}_C}\right) = 1$

   $\text{mol}_H = (6.7\ g_H)\left(\frac{1\ \text{mol}_H}{1.008\ g_H}\right) = 6.6\ \text{mol}_O$ $\qquad \left(\frac{6.6\ \text{mol}_H}{3.31\ \text{mol}_C}\right) = 2.00\ \text{mol}_H\ \text{per mol}_S$

   $\text{mol}_O = (53.3\ g_O)\left(\frac{1\ \text{mol}_O}{16.00\ g_O}\right) = 3.31\ \text{mol}_H$ $\qquad \left(\frac{3.31\ \text{mol}_O}{3.31\ \text{mol}_C}\right) = 2.00\ \text{mol}_O\ \text{per mol}_C$

   $\Rightarrow$ empirical formula = CH_2O

   The empirical weight of CH_2O is 30.0 g/eu.
   $\frac{180\ \text{g/mol}}{30.0\ \text{g/eu}} = 6.0\ \text{eu/mol} \Rightarrow$ molecular formula = $C_6H_{12}O_6$

3. For the reaction: (4 points)

   $Cu_{(s)} + 2\ AgNO_{3\ (aq)} \rightarrow 2\ Ag_{(s)} + Cu(NO_3)_{2\ (aq)}$

   A sample of 3.75 g of copper metal and 2.43 g $AgNO_3$ are reacted.

   a) What is the limiting reagent? Be sure to include your rationale.
   b) What is the theoretical yield of silver metal?

   $\text{mol}_{Cu} = 3.75\ g_{Cu}\left(\frac{1\ \text{mol}_{Cu}}{63.54 g_{Cu}}\right) = 0.0590\ \text{mol}_{Cu}$

   $\text{mol}_{AgNO3} = 2.43\ g_{AgNO3}\left(\frac{1\ \text{mol}_{AgNO3}}{169.9\ g_{AgNO3}}\right) = 0.0143\ \text{mol}_{AgNO3}$

   Now calculate how much silver(I) nitrate is needed to completely react with the copper $(0.0590\ \text{mol}_{Cu})\left(\frac{2\ \text{mol}_{AgNO3}}{1\ \text{mol}_{Cu}}\right) = 0.118\ \text{mol}_{AgNO3}$, but you only have 0.0143 mol of $AgNO_3$, so it is the limiting reagent.

   $\text{mass}_{Ag} = (2.43\ g_{AgNO3})\left(\frac{1\ \text{mol}_{AgNO3}}{169.9\ g_{AgNO3}}\right)\left(\frac{2\ \text{mol}_{Ag}}{2\ \text{mol}_{AgNO3}}\right)\left(\frac{107.87\ g_{Ag}}{\text{mol}_{Ag}}\right) = 1.54\ g_{Ag}$

4. What is most of the activation energy used for in a chemical reaction?
   Breaking reactant bonds.