Chemistry 211 Name: _____
Fall 2023 Please Print
Test 2

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

1. How many significant figures are in the answer to the following problem: $\frac{2.511 - 2.311}{2736}$?

   A) 1 B) 2 C) 3 D) 4 E) 5

2. What is the concentration of a sodium chloride (NaCl) solution after 40 mL of water is added to 60 mL of a solution that is initially 2.00 *M*?

   A) 0.67 *M* B) 0.80 *M* C) 1.20 *M* D) 1.33 *M* E) 2.00 *M*

3. Which of the following ionic compounds has the lowest water solubility?

   A) $CaSO_4$ B) $CoCO_3$ C) KCl D) $(NH_4)_2S$ E) $Ni(NO_3)_2$

4. Which of the following is a precipitation reaction?

   A) $Cu(OH)_{2\,(aq)} + 2\ HNO_{3\,(aq)} \rightarrow Cu(NO_3)_{2\,(aq)} + 2\ H_2O_{(\ell)}$
   B) $H_2SO_{4\,(aq)} + 2\ NH_{3\,(aq)} \rightarrow (NH_4)_2SO_{4\,(aq)}$
   C) $FeCl_{3\,(s)} + 3\ AgNO_{3\,(g)} \rightarrow 3\ AgCl_{(s)} + 3\ Fe(NO)_{3\,(aq)}$
   D) $2\ SrS_{(s)} + 2\ HCl_{(aq)} \rightarrow SrCl_{2\,(aq)} + H_2S_{(g)}$
   E) None is a precipitation reaction.

5. What is the oxidation number of the phosphorus atom in $Mg_3(PO_4)_2$?

   A) -1 B) +1 C) +3 D) +5 E) +7

6. Which of the following is a formation reaction?

   A) $2\ Al_{(s)} + 3\ O_{(g)} \rightarrow Al_2O_{3\,(s)}$
   B) $2\ Al_{(s)} + {}^3/_2\ O_{2\,(g)} \rightarrow Al_2O_{3\,(s)}$
   C) $4\ Al_{(g)} + 3\ O_{2\,(g)} \rightarrow 2\ Al_2O_{3\,(s)}$
   D) $2\ Al_{(g)} + {}^3/_2\ O_{2\,(g)} \rightarrow Al_2O_{3\,(s)}$
   E) None of the above.

7. Which of the following processes is endothermic?

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

8. What is ΔH for the net reaction below?

   $H_{2\,(g)} + F_{2(g)} \longrightarrow 2\ HF_{(g)}$ ΔH = -537 kJ
   $C_{(s)} + 2\ F_{2\,(g)} \longrightarrow CF_{4\,(g)}$ ΔH = -680 kJ
   $2\ C_{(s)} + 2\ H_{2\,(g)} \longrightarrow C_2H_{4\,(g)}$ ΔH = 52.3 kJ
   $C_2H_{4\,(g)} + 6\ F_{2\,(g)} \rightarrow 2\ CF_{4\,(g)} + 4\ HF_{(g)}$ ΔH = ?

   A) -2,486 kJ B) -1,702 kJ C) -1,165 kJ D) 234 kJ E) 1,165 kJ

9. Which of the following is a statement of the first law of thermodynamics?

A) Energy can be freely exchanged between the system and the surroundings only in an open container.
B) The enthalpy of a reaction is independent of the number of steps taken.
C) Energy can be neither created nor destroyed.
D) It is possible to measure the exact energy of a substance only at absolute zero (0 K).
E) The heat of reaction of any spontaneous process must be negative.

Discussion Questions: (Show your work to receive credit.)

1. A solution of $CaCl_2$ in water forms a mixture that is 22.0% calcium chloride by mass. If the total mass of the solution is 166.1 g, what masses of $CaCl_2$ and water were used? What is the $CaCl_2$ molar concentration? Assume the solution density is 1.00 g/mL. (10 points)

$$\text{mass}_{CaCl2} = (166.1\ g_{soln})\left(\frac{0.220\ g_{CaCl2}}{1\ g_{soln}}\right) = 36.5\ g_{CaCl2}$$

$$\text{mass}_{H2O} = 166.1\ g_{soln} - 36.5\ g_{CaCl2} = 129.6\ g_{H2O}$$

$$[CaCl_2] = (36.5\ g_{CaCl2})\left(\frac{1\ mol_{CaCl2}}{110.98_{CaCl2}}\right)\left(\frac{1}{166.1\ g}\right)\left(\frac{1.00\ g_{soln}}{mL_{soln}}\right)\left(\frac{1000\ mL_{soln}}{L_{soln}}\right) = 1.98\ M$$

2. Propane burns according to the reaction: $C_3H_{8\,(g)} + 5\ O_{2\,(g)} \rightarrow 3\ CO_{2\,(g)} + 4\ H_2O_{(\ell)}$

If 10.0 g of propane is reacted with 5.00 g of oxygen, which of the reactants is limiting?

What is the maximum mass of carbon dioxide that can be produced? What is the percent yield if 50.0 g of CO_2 is made? (15 points)

$$\text{mol}_{C3H8} = (10.00\ g_{C3H8})\left(\frac{1\ \text{mol}_{C3H8}}{44.10\ g_{C4H10}}\right) = 0.2268\ \text{mol}_{C3H8}$$

$$\text{mol}_{O2} = (15.00\ g_{O2})\left(\frac{1\ \text{mol}_{O2}}{32.00\ g_{O2}}\right) = 0.4688\ \text{mol}_{O2}$$

$$\text{mol}_{O2}(\text{needed}) = (0.2268\ \text{mol}_{C4H10})\left(\frac{5\ \text{mol}_{O2}}{1\ \text{mol}_{C3H8}}\right) = 1.13\ \text{mol}_{O2}$$

but we have only 0.4688 mol_{O2} which is not enough to completely react all of the C_3H_8 so O_2 is the limiting reagent.

$$\text{mol}_{O2} = (15.00\ g_{O2})\left(\frac{1\ \text{mol}_{O2}}{32.00\ g_{O2}}\right)\left(\frac{3\ \text{mol}_{CO2}}{5\ \text{mol}_{O2}}\right)\left(\frac{44.01\ g_{CO2}}{1\ \text{mol}_{CO2}}\right) = 12.4\ g_{CO2}\ \text{will be produced.}$$

$$\%\ \text{yield} = \frac{10.0\ g_{CO2}}{12.4\ g_{CO2}} \times 100\% = 80.6\%$$

3. Complete the following: (10 points)

$2\ ClO_{2\ (g)} + 2\ O_{3\ (g)} \rightarrow \_\_\_\ Cl_2O_{6\ (g)} + 2\ O_{2\ (g)}$

Solid nickel(II) hydroxide reacts with aqueous hydrobromic acid to produce aqueous nickel(II) bromide and water.

$Ni(OH)_{2\ (s)} + 2\ HBr_{(aq)} \rightarrow NiBr_{2\ (aq)} + 2\ H_2O_{(\ell)}$

4. What are standard conditions in thermochemistry? (4 points) 25 ºC and 1 atm pressure

5. A researcher studying the nutritional value of a new candy places a 6.40 g sample of the candy inside a bomb calorimeter and combusts it in excess oxygen. The observed temperature increase is 2.11 ºC. If the heat capacity of the calorimeter is 42.90 kJ•K^{-1}, how many kilojoules are there per gram of candy? (5 points)

ΔT = 2.11 ºC = 2.11 K.

$$\text{Energy}_{\text{sample}} = \left(\frac{42.90\ \text{kJ}}{\text{K}}\right)(2.11\ \text{K}) = 90.5\ \text{kJ}$$

$$\text{Energy}_{\text{g candy}} = \frac{90.5\ \text{kJ}}{6.40\ \text{g}} = 14.1\ \text{kJ/g}$$

6. Is the following process exothermic, endothermic, or neither? Explain. (10 points)

a) $CO_{2\ (s)} \rightarrow CO_{2\ (g)}$ Endothermic, because energy must be put in to disrupt the attractions that hold the solid together.

b) $2\ I_{(g)} \rightarrow I_{2(g)}$ Exothermic, because energy is released from the attractions involved in creating the I-I bond

7. From the following data: (10 points)

$2\ KClO_{3\ (s)} \longrightarrow 2\ KCl_{(s)} + 3\ O_{2\ (g)}$ $\Delta H^o_{rxn} = -89.4$ kJ

a) Is the reaction endothermic or exothermic?
b) How much energy would be absorbed or released if 10.75 g of potassium chloride formed?
c) If an unknown quantity of potassium chlorate is burned with a heat change of -325 kJ, what mass of potassium chlorate burned?

a) exothermic

b) $\Delta H = (10.75\ g_{KCl})\left(\frac{1\ mol_{KCl}}{74.55\ g_{KCl}}\right)\left(\frac{-89.4\ kJ}{2\ mol_{KCl}}\right) = -6.44\ kJ$

c) $mass_{KClO3} = (325\ kJ)\left(\frac{2\ mol_{KClO3}}{-89.4\ kJ}\right)\left(\frac{122.5\ g_{KClO3}}{1\ mol_{KClO3}}\right) = 891\ g_{KClO3}$