Honors Chemistry Worksheet – Limiting Reactants and Percent Yield

NEATLY show all work, equations, units, labels and significant figures in solving the following problems. Use dimensional analysis format wherever possible.

1. Calcium hydroxide, used to neutralize acid spills, reacts with hydrochloric acid forming a soluble salt and water.

(a) If you have spilled 6.31 mol of HCl and put 2.84 mol of Ca(OH)2 on it, which substance is the limiting reactant?

(b) How many moles of the excess reactant remain?

(c) What mass of water forms?

2. Aluminum oxidizes to form the metallic oxide.

(a) Powdered Al (0.048 mol) is placed into a container containing 0.030 mol O2. What is limiting reactant?

(b)How many moles of the excess reactant remain?

(c) What mass of metallic oxide forms?

3. Heating zinc sulfide in the presence of oxygen yields zinc oxide and sulfur dioxide.

(a) If 1.72 mol of ZnS is heated in the presence of 3.04 mol of O2, which is the limiting reactant?

(b) How many moles of the excess reactant remain?

4. Chlorine can replace bromine in bromide compounds forming a chloride compound and elemental bromine. If chlorine is bubbled through a solution of potassium bromide, it will replace the bromide ion.

(a) When 0.855 g of Cl2 and 3.205 g of KBr are mixed in solution, which is the limiting reactant?

(b) How many grams of each product are formed?

5. A process by which zirconium metal can be produced from the mineral zirconium (IV) orthosilicate, ZrSiO4, starts by reacting it with chlorine gas to form zirconium (IV) chloride.

ZrSiO4 + Cl2 🡪 ZrCl4 + SiO2  + O2

(a) What mass of ZrCl4 can be produced if 862.0 g of ZrSiO4 and 950.0 g of Cl2 are available?

6. In the reaction BaCO3  + HNO3 🡪 Ba(NO3)2  + CO2 + H2O, what mass of Ba(NO3)2 can be formed by combining 55.00g BaCO3 and 26.41 g HNO3?

7. Huge quantities of sulfur dioxide are produced from zinc sulfide by reacting it with oxygen.

(a) If the typical yield is 86.78%, how much SO2 should be expected if 4,897.0 g of ZnS are used?

8. Aspirin, C9H8O4, is synthesized by the reaction of salicylic acid, C7H6O3, with acetic anhydride, C4H6O3.

C7H6O3 + C4H6O3 🡪 C9H8O4 + H2O

(a) When 20.0 g of C7H6O3and 20.0g of C4H6O3 react, which is the limiting reagent?

(b) What mass in grams of aspirin are formed?

9. Dichlorine monoxide, Cl2O is sometimes used as a powerful chlorinating agent in research. It can be produced by passing chlorine gas over heated mercury(II) oxide forming the oxide and the chloride of mercury(II).

(a) What is the percent yield, if the quantity of the reactants is sufficient to produce 0.86 g of Cl2O but only 0.71 g is obtained?

10. In the commercial production of the element arsenic, arsenic(III) oxide is heated with carbon, which reduces the oxide to the metalloid and produces carbon dioxide.

(a) If 8.87g of As2O3 is used in the reaction and 5.33 g of As is produced, what is the percent yield?

(b) If 67.0 g of carbon is used up in a different reaction and 425.0 g of As is produced, calculate the percent yield of this reaction.

11. Assume that the following hypothetical reaction takes place.

2 A + 7 B 🡪 4 C + 3 D

Calculate the percent yield in each of the following cases:

(a) The reaction of 0.0251 mol of A produces 0.0349 mol of C.

(b) The reaction of 1.19 mol of A produces 1.41 mol of D.

(c) The reaction of 189 mol of B produces 39 mol of D.

(d) The reaction of 3500. mol of B produces 1700. mol of C.

Honors Chemistry Worksheet – Limiting Reactants and Percent Yield **ANSWER KEY**

NEATLY show all work, equations, units, labels and significant figures in solving the following problems. Use dimensional analysis format wherever possible.

1. Calcium hydroxide, used to neutralize acid spills, reacts with hydrochloric acid forming a soluble salt and water.

**Ca(OH)2 + 2 HCl(aq) --------------------> CaCl2(aq) + 2 H2O(l)**

(a) If you have spilled 6.31 mol of HCl and put 2.84 mol of Ca(OH)2 on it, which substance is the limiting reactant?

**6.31 mol HCl x 1 mol Ca(OH)2 = 3.16 mol Ca(OH)2**

**2 mol HCl**

**3.16 mol of Ca(OH)2 would be needed to neutralize all of the hydrochloric acid, however; only 2.84 mol of calcium hydroxide is available. Therefore, calcium hydroxide (Ca(OH)2) is the limiting reactant.**

(b) How many moles of the excess reactant remain?

**2.84 mol Ca(OH)2 x 2 mol HCl = 5.68 mol HCl**

**1 mol Ca(OH)2**

**Moles of excess HCl = Moles HCl available - Moles of HCl consumed’**

**= 6.31 mol HCl - 5.68 mol HCl**

**= 0.63 mol HCl**

(c) What mass of water forms?

**2.84 mol Ca(OH)2 x 2 mol H2O x 18.02 g H2O =102 g H2O**

**1 mol Ca(OH)2 1 mol H2O**

2. Aluminum oxidizes to form the metallic oxide.

**4 Al(s) + 3 O2(g) --------------> 2 Al2O3(s)**

(a) Powdered Al (0.048 mol) is placed into a container containing 0.030 mol O2. What is limiting reactant?

**0.048 mol Al x 3 mol O2 = 0.036 mol O2**

**4 mol Al**

**0.036 mol O2 required but only 0.030 mol O2 available; therefore oxygen is limiting reactant**

(b) How many moles of the excess reactant remain?

**0.030 mol O2 x 4 mol Al = 0.040 mol Al**

**3 mol O2**

**Moles excess Al = Moles Al available - Moles Al consumed**

**= 0.048 mol Al - 0.040 mol Al**

**= 0.008 mol Al**

(c) What mass of metallic oxide forms?

**0.030 mol O2 x 2 mol Al2O3 x 101.96 g Al2O3 = 2.0 g Al2O3**

**3 mol O2 1 mol Al2O3**

3. Heating zinc sulfide in the presence of oxygen yields zinc oxide and sulfur dioxide.

**2 ZnS(s) + 3 O2(g) -------------------> 2 ZnO(s) + 2 SO2(g)**

(a) If 1.72 mol of ZnS is heated in the presence of 3.04 mol of O2, which is the limiting reactant?

**1.72 mol ZnS x 3 mol O2  = 2.58 mol O2**

**2 mol ZnS**

**Since 2.58 mol O2 are required to react all of the ZnS and 3.04 moles of O2 are available, ZnS is the limiting reagent.**

(b) How many moles of the excess reactant remain?

**Moles of excess O2 = Moles O2 available - Moles of O2 consumed**

**= 3.04 mol O2 - 2.58 mol O2**

**= 0.46 mol O2**

4. Chlorine can replace bromine in bromide compounds forming a chloride compound and elemental bromine. If chlorine is bubbled through a solution of potassium bromide, it will replace the bromide ion.

**Cl2(g) + 2 KBr(aq) -------------------> 2 KCl(aq) + Br2(l)\**

(a) When 0.855 g of Cl2 and 3.205 g of KBr are mixed in solution, which is the limiting reactant?

**0.855 g Cl2 x 1 mol Cl2 x 1 mol Cl2 = 0.006 03 mol KBr**

**70.90 g Cl2 2 mol KBr**

**3.205 g KBr x 1 mol KBr = 0.026 93 mol KBr**

**119.00 g KBr**

**If all of the chlorine is consumed it would require 0.006 03 mol KBr to react. There are 0.026 93 mol KBr available which is more than needed. Therefore, Cl2 is the limiting reactant and KBr is in excess.**

(b) How many grams of each product are formed?

5. A process by which zirconium metal can be produced from the mineral zirconium (IV) orthosilicate, ZrSiO4, starts by reacting it with chlorine gas to form zirconium (IV) chloride.

ZrSiO4 + Cl2 🡪 ZrCl4 + SiO2  + O2

(a) What mass of ZrCl4 can be produced if 862.0 g of ZrSiO4 and 950.0 g of Cl2 are available?

6. In the reaction BaCO3  + HNO3 🡪 Ba(NO3)2  + CO2 + H2O, what mass of Ba(NO3)2 can be formed by combining 55.00g BaCO3 and 26.41 g HNO3?

7. Huge quantities of sulfur dioxide are produced from zinc sulfide by reacting it with oxygen.

**2 ZnS(s) + 3 O2(g) -------------> 2 ZnO(s) + 2 SO2(g)**

(a) If the typical yield is 86.78%, how much SO2 should be expected if 4,897.0 g of ZnS are used?

**4,897.0 g ZnS x 1 mol ZnS x 2 mol SO2 x 64.07 g SO2 x 86.78 g SO2**

**97.64 g ZnS 2 mol ZnS 1 mol SO2 100.00 g SO2**

**= 2,789 g SO2**

8. Aspirin, C9H8O4, is synthesized by the reaction of salicylic acid, C7H6O3, with acetic anhydride, C4H6O3.

C7H6O3 + C4H6O3 🡪 C9H8O4 + H2O

**2 C7H6O3 + C4H6O3 🡪 2 C9H8O4 + H2O**

(a) When 20.0 g of C7H6O3and 20.0g of C4H6O3 react, which is the limiting reagent?

**20.0 g C7H6O3 x 1 mol C7H6O3 x 1 mol C4H6O3 = 0.072 4 mol C4H6O3**

**138.13 g C7H6O3 2 mol C7H6O3**

**20.0 g C4H6O3 x 1 mol C4H6O3 = 0.196 mol C4H6O3**

**102.10 g C4H6O3**

**0.072 4 mol C4H6O3 are needed for complete reaction of the C7H6O3 and the amount of C4H6O3 available is 0.196 mol, therefore C7H6O3 limits the reaction.**

(b) What mass in grams of aspirin are formed?

**20.0 g C7H6O3 x 1 mol C7H6O3 x 2 mol C9H8O4 x 180.17 g C9H­8O4 =**

**138.13 g C7H6O3 2 mol C7H6O3 1 mol C9H8O4**

**= 26.1 g C9H8O4**

9. Dichlorine monoxide, Cl2O is sometimes used as a powerful chlorinating agent in research. It can be produced by passing chlorine gas over heated mercury(II) oxide forming the oxide and the chloride of mercury(II).

**2 Cl2(g) + HgO(s) ---------------> HgCl2(s) + Cl2O(g)**

(a) What is the percent yield, if the quantity of the reactants is sufficient to produce 0.86 g of Cl2O but only 0.71 g is obtained?

**% yield = mass of actual product x 100**

**mass theoretical product**

**= 0.71 g Cl2O x 100 = 83 % yield**

**0.86 g Cl2O**

10. In the commercial production of the element arsenic, arsenic(III) oxide is heated with carbon, which reduces the oxide to the metalloid and produces carbon dioxide.

**2 As2O3(g) + 3 C(s) ------------------> 4 As(s) + 3 CO2(g)**

(a) If 8.87g of As2O3 is used in the reaction and 5.33 g of As is produced, what is the percent yield?

**8.87 g As2O3 x 1 mol As2O3 x 4 mol As x 74.92 g As = 6.72 g As**

**197.84 g As2O3 2 mol As2O3 1 mol As**

**% yield = mass of actual product x 100**

**mass theoretical product**

**= 5.33 g As x 100 = 79.3 % yield**

**6.72 g As**

(b) If 67.0 g of carbon is used up in a different reaction and 425.0 g of As is produced, calculate the percent yield of this reaction.

**67.0 g C x 1 mol C x 4 mol As x 74.92 g As = 557 g As**

**12.01 g C 3 mol C 1 mol As**

**% yield = mass of actual product x 100**

**mass theoretical product**

**= 425.0 g As x 100 = 76.3 % yield**

**557 g As**

11. Assume that the following hypothetical reaction takes place.

2 A + 7 B 🡪 4 C + 3 D

Calculate the percent yield in each of the following cases:

(a) The reaction of 0.0251 mol of A produces 0.0349 mol of C.

**0.025 1 mol A x 4 mol C = 0.050 2 mol C**

**2 mol A**

**% yield = moles of actual product x 100**

**moles theoretical product**

**= 0.034 9 mol C x 100 = 69.5 % yield**

**0.050 2 mol C**

(b) The reaction of 1.19 mol of A produces 1.41 mol of D.

**1.19 mol A x 3 mol D = 1.78 mol D**

**2 mol A**

**% yield = moles of actual product x 100**

**moles theoretical product**

**= 1.41 mol D x 100 = 79.2 % yield**

**1.78 mol D**

(c) The reaction of 189 mol of B produces 39 mol of D.

**189 mol B x 3 mol D = 81.0 mol D**

**7 mol B**

**% yield = moles of actual product x 100**

**moles theoretical product**

**= 39 mol D x 100 = 48 % yield**

**81.0 mol D**

(d) The reaction of 3500. mol of B produces 1700. mol of C.

**3,500. mol B x 4 mol C = 2,000. mol C**

**7 mol B**

**% yield = moles of actual product x 100**

**moles theoretical product**

**= 1,700. mol C x 100 = 85.00 % yield**

**2,000. mol C**

ANSWER TO 1.127 of Brady and Senese

C7H8 + 2 KMnO4 -----------------> KC7H5O2 + 2 MnO2 + KOH + H2O

11.5 g KC7H5O2 x 100.0 g KC7H5O2 x 1 mol KC7H5O2 x 1 mol C7H8 x 92.15 g C7H8

71 g KC7H5O2 160.22 g KC7H5O2 1 mol KC7H5O2 1 mol C7H8

= 9.3 g C7H8