This Worksheet is due within the first five minutes of lecture on the due date: __________________________

**LATE WORKSHEETS WILL NOT BE ACCEPTED.**

Solve the following problems, giving complete set-ups, including all units, and using correct significant figures. If work is not shown, **NO CREDIT** will be given for the correct answer.

**A.** Answer the following questions with respect to the equation: \( \text{2 ZnS + 3 O}_2 \rightarrow \text{2 ZnO + 2 SO}_2 \)

[Molar masses: Zn = 65.38, O = 16.00, ZnO = 81.39, SO\(_2\) = 64.06]

1. How many moles of oxygen are required to make 0.0116 moles of sulfur dioxide?

   \[
   0.0116 \text{ mole SO}_2 \left( \frac{2 \text{ mole O}_2}{5 \text{ mole SO}_2} \right) = 0.0046 \text{ mole O}_2
   \]

2. How many moles of oxygen must be used to produce 49.26 grams of zinc oxide?

   \[
   49.26 \text{ g ZnO} \left( \frac{1 \text{ mole ZnO}}{81.39 \text{ g ZnO}} \right) \left( \frac{3 \text{ mole O}_2}{2 \text{ mole ZnO}} \right) = 0.9079 \text{ mole O}_2
   \]

3. If 9.25 kg of sulfur dioxide are produced in the reaction, how many grams of zinc oxide are produced?

   \[
   9.25 \text{ kg SO}_2 \left( \frac{1 \text{ kg}}{100 \text{ g SO}_2} \right) \left( \frac{1 \text{ mole ZnO}}{81.39 \text{ g ZnO}} \right) \left( \frac{2 \text{ mole SO}_2}{1 \text{ mole ZnO}} \right) = 1.18 \times 10^4 \text{ g ZnO}
   \]

4. How many grams of oxygen are needed to react with \(8.75 \times 10^{22}\) formula units of zinc sulfide?

   \[
   8.75 \times 10^{22} \text{ f.u. ZnS} \left( \frac{1 \text{ mole ZnS}}{6.02 \times 10^{23} \text{ f.u. ZnS}} \right) \left( \frac{3 \text{ mole O}_2}{2 \text{ mole ZnS}} \right) \left( \frac{2 \text{ mol SO}_2}{1 \text{ mole O}_2} \right) = 6.98 \text{ g O}_2
   \]

**B.** Silver oxide and carbon dioxide react to produce silver carbonate. [Molar masses: silver oxide = 231.74, carbon dioxide = 44.01, silver carbonate = 275.75]

1. Write the balanced equation for the reaction.

   \[
   \text{Ag}_2\text{O} + \text{CO}_2 \rightarrow \text{Ag}_2\text{CO}_3
   \]

2. How many grams of silver carbonate are produced when 25.0 g silver oxide react completely with carbon dioxide?

   \[
   25.0 \text{ g Ag}_2\text{O} \left( \frac{1 \text{ mole Ag}_2\text{O}}{231.74 \text{ g Ag}_2\text{O}} \right) \left( \frac{1 \text{ mole Ag}_2\text{CO}_3}{1 \text{ mole Ag}_2\text{O}} \right) \left( \frac{275.75 \text{ g Ag}_2\text{CO}_3}{1 \text{ mole Ag}_2\text{CO}_3} \right) = 29.78 \text{ g Ag}_2\text{CO}_3
   \]
C. Phosphorus trichloride reacts with chlorine to produce phosphorus pentachloride. [Molar masses: phosphorus trichloride = 137.33, phosphorus pentachloride = 208.24]

1. Write the balanced equation for the reaction.

\[ \text{PCl}_3 + \text{Cl}_2 \rightarrow \text{PCl}_5 \]

2. How many grams of phosphorus pentachloride are produced from 3.0 mg of phosphorus trichloride?

\[
3.0 \text{ mg PCl}_3 \left( \frac{1 \text{ g PCl}_3}{10^3 \text{ mg}} \right) \left( \frac{1 \text{ mole PCl}_3}{183.53 \text{ g PCl}_3} \right) \left( \frac{1 \text{ mole PCl}_5}{1 \text{ mole PCl}_3} \right) \left( \frac{208.24 \text{ g PCl}_5}{1 \text{ mole PCl}_5} \right) = 0.0045 \text{ g PCl}_5
\]

D. Answer the following questions with respect to the equation: \[ \text{Al}_4\text{C}_3 + 12 \text{ H}_2\text{O} \rightarrow 4 \text{ Al(OH)}_3 + 3 \text{ CH}_4 \]

[Molar masses: \( \text{Al}_4\text{C}_3 = 143.96 \), \( \text{H}_2\text{O} = 18.02 \), \( \text{Al(OH)}_3 = 78.00 \), \( \text{CH}_4 = 16.04 \)]

1. How many grams of \( \text{Al}_4\text{C}_3 \) are needed to react with 1.045 moles of water?

\[
1.045 \text{ mole H}_2\text{O} \left( \frac{1 \text{ mole Al}_4\text{C}_3}{12 \text{ mole H}_2\text{O}} \right) \left( \frac{143.96 \text{ g Al}_4\text{C}_3}{1 \text{ mole Al}_4\text{C}_3} \right) = 12.54 \text{ g Al}_4\text{C}_3
\]

2. How many grams of \( \text{Al}_4\text{C}_3 \) react to produce 6.21 \times 10^{11} \text{ f.u. } \text{Al(OH)}_3 \text{ units of aluminum hydroxide?}

\[
6.21 \times 10^{11} \text{ f.u. Al(OH)}_3 \left( \frac{1 \text{ mole Al(OH)}_3}{6.02 \times 10^{23} \text{ f.u. Al(OH)}_3} \right) \left( \frac{1 \text{ mole Al}_4\text{C}_3}{4 \text{ mole Al(OH)}_3} \right) \left( \frac{143.96 \text{ g Al}_4\text{C}_3}{1 \text{ mole Al}_4\text{C}_3} \right) = 3.71 \times 10^{11} \text{ g Al}_4\text{C}_3
\]

3. How many grams of \( \text{CH}_4 \) are produced when 18.66 g of aluminum hydroxide are formed?

\[
18.66 \text{ g Al(OH)}_3 \left( \frac{1 \text{ mole Al(OH)}_3}{18.66 \text{ g Al(OH)}_3} \right) \left( \frac{3 \text{ mole CH}_4}{1 \text{ mole Al(OH)}_3} \right) \left( \frac{16.04 \text{ g CH}_4}{1 \text{ mole CH}_4} \right) = 2.878 \text{ g CH}_4
\]

E. Answer the following questions with respect to the equation: \[ \text{CH}_4 + 3 \text{ CO}_2 + 4 \text{ NH}_3 \rightarrow 4 \text{ HCN} + 6 \text{ H}_2\text{O} \]

[Molar masses: \( \text{CO}_2 = 44.01 \), \( \text{NH}_3 = 17.03 \), \( \text{H}_2\text{O} = 18.02 \), \( \text{CH}_4 = 16.04 \), \( \text{HCN} = 27.03 \)]

When 275 grams of ammonia were added to carbon dioxide and methane, \( \text{CH}_4 \), there were still 42 grams of ammonia remaining, unreacted, when the reaction was over.

1. How many grams of ammonia reacted?

\[
275 \text{ g NH}_3 - 42 \text{ g NH}_3 = 233 \text{ g NH}_3
\]

2. How many moles of water were produced?

\[
233 \text{ g NH}_3 \left( \frac{1 \text{ mole NH}_3}{17.03 \text{ g NH}_3} \right) \left( \frac{6 \text{ mole H}_2\text{O}}{4 \text{ mole NH}_3} \right) = 20.5 \text{ mole H}_2\text{O}
\]

3. How many grams of methane reacted with the ammonia?

\[
233 \text{ g NH}_3 \left( \frac{1 \text{ mole NH}_3}{17.03 \text{ g NH}_3} \right) \left( \frac{1 \text{ mole CH}_4}{4 \text{ mole NH}_3} \right) \left( \frac{16.04 \text{ g CH}_4}{1 \text{ mole CH}_4} \right) = 59.4 \text{ g CH}_4
\]
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Solve the following problems, giving **complete set-ups, including all units**, and using correct significant figures. If work is not shown, **NO CREDIT** will be given for the correct answer.

1. What mass, in grams, of iron (III) sulfide can be produced from the reaction of 1.75 L of a 0.300 M iron (III) acetate solution with an excess of sodium sulfide? (Molar masses: Fe(C₂H₃O₂)₃ = 232.98  Na₂S = 78.05  NaC₂H₃O₂ = 83.03  Fe₂S₃ = 207.89)
   \[
   2 \text{Fe(C}_2\text{H}_3\text{O}_2\text{)}_3(\text{aq}) + 3 \text{Na}_2\text{S(aq)} \rightarrow 6 \text{NaC}_2\text{H}_3\text{O}_2(\text{aq}) + \text{Fe}_2\text{S}_3(\text{s})
   \]
   \[
   1.75 \text{ L soln} \left( \frac{0.300 \text{ mole Fe(C}_2\text{H}_3\text{O}_2\text{)}_3}{\text{L soln}} \right) \left( \frac{1 \text{ mole Fe}_2\text{S}_3}{2 \text{ mole Fe(C}_2\text{H}_3\text{O}_2\text{)}_3} \right) \left( \frac{207.89 \text{ g Fe}_2\text{S}_3}{1 \text{ mole Fe}_2\text{S}_3} \right) = 54.16 \text{ g Fe}_2\text{S}_3
   \]

2. What volume, in mL, of 0.250 M silver nitrate solution is needed to react with 45.0 mL of 0.187 M potassium phosphate solution? (Molar masses: AgNO₃ = 169.87  K₃PO₄ = 212.27  Ag₃PO₄ = 418.58  KNO₃ = 101.10)
   \[
   3 \text{AgNO}_3(\text{aq}) + \text{K}_3\text{PO}_4(\text{aq}) \rightarrow \text{Ag}_3\text{PO}_4(\text{s}) + 3 \text{KNO}_3(\text{aq})
   \]
   \[
   0.0450 \text{ L soln} \left( \frac{1.187 \text{ mole } K_3PO_4}{\text{1 L soln}} \right) \left( \frac{1 \text{ mole AgNO}_3}{2.50 \text{ mole } K_3PO_4} \right) \left( \frac{1 \text{ L soln}}{10^{-3} \text{ L}} \right) = 101 \text{ mL soln}
   \]

3. 76.91 mL of a 0.556 M oxalic acid solution are required to react with 28.43 mL of a sodium hydroxide solution. What is the molar concentration of the sodium hydroxide solution? (Molar masses: H₂C₂O₄ = 90.04  NaOH = 40.00  H₂O = 18.02  Na₂C₂O₄ = 134.00)
   \[
   \text{H}_2\text{C}_2\text{O}_4(\text{aq}) + 2 \text{NaOH(aq)} \rightarrow 2 \text{H}_2\text{O(l)} + \text{Na}_2\text{C}_2\text{O}_4(\text{aq})
   \]
   \[
   \frac{0.07691 \text{ L soln} A \left( 0.556 \text{ mole H}_2\text{C}_2\text{O}_4 \right)}{0.02843 \text{ L soln B} \left( 1 \text{ mole H}_2\text{C}_2\text{O}_4 \right)} = 3.01 \text{ M NaOH}
   \]

4. 42.99 grams of Zn are added to a phosphoric acid solution containing 16.20 grams of H₃PO₄ and they react according to the equation: \[3 \text{Zn(s)} + 2 \text{H}_3\text{PO}_4(\text{aq}) \rightarrow \text{Zn}_3(\text{PO}_4)_2(\text{s}) + 3 \text{H}_2(\text{g})\] (Molar masses: Zn = 65.39  H₃PO₄ = 98.00  Zn(PO₄)₂ = 386.11  H₂ = 2.02)
   a. What is the limiting reactant? \[4a. \text{H}_3\text{PO}_4\]
   b. What is the excess reactant? \[4b. \text{Zn}\]
   \[
   42.99 \text{ g Zn} \left( \frac{1 \text{ mole Zn}}{65.39 \text{ g Zn}} \right) = 0.6594 \text{ mole Zn}
   \]
   \[
   16.20 \text{ g H}_3\text{PO}_4 \left( \frac{1 \text{ mole H}_3\text{PO}_4}{98.00 \text{ g H}_3\text{PO}_4} \right) = 0.1653 \text{ mole H}_3\text{PO}_4
   \]
   \[
   0.1653 \text{ mole H}_3\text{PO}_4 \left( \frac{3 \text{ mole Zn}}{2 \text{ mole H}_3\text{PO}_4} \right) = 0.2480 \text{ mole Zn}
   \]
5. What mass, in grams, of lead (II) chromate can be produced from 12.00 mL of 10.00 M potassium chromate solution with 120.00 mL of 2.000 M lead(II) nitrate solution? (Molar masses: K₂CrO₄ = 194.19 Pb(NO₃)₂ = 331.21 KNO₃ = 101.10 PbCrO₄ = 323.19)

\[ \text{K}_2\text{CrO}_4(\text{aq}) + \text{Pb(NO}_3\text{)_2(}\text{aq}) \rightarrow 2 \text{KNO}_3(\text{aq}) + \text{PbCrO}_4(\text{s}) \]

\[ 0.1200 \text{L soln (10.0 mole K}_2\text{CrO}_4/\text{L}) = 0.120 \text{ mole K}_2\text{CrO}_4 \]
\[ 0.120 \text{ mole K}_2\text{CrO}_4/(1 \text{ mole K}_2\text{CrO}_4) = 120 \text{ mole K}_2\text{CrO}_4 \]

6. 52.3 g of silver nitrite is reacted with 61.8 g grams of potassium carbonate which produces silver carbonate and potassium nitrite. (Molar masses: AgNO₂ = 152.87 K₂CO₃ = 138.21 Ag₂CO₃ = 275.75 KNO₂ = 85.10)

\[ 2 \text{AgNO}_2(\text{s}) + \text{K}_2\text{CO}_3(\text{aq}) \rightarrow \text{Ag}_2\text{CO}_3(\text{s}) + 2 \text{KNO}_2(\text{aq}) \]

a. What mass, in grams, of silver carbonate is produced?

\[ 52.3 \text{ g } \text{AgNO}_2/(152.87 \text{ g AgNO}_2) = 0.342 \text{ mole AgNO}_2 \]
\[ 0.342 \text{ mole AgNO}_2/(1 \text{ mole K}_2\text{CO}_3) = 0.342 \text{ mole K}_2\text{CO}_3 \]
\[ 0.342 \text{ mole AgNO}_2/(2 \text{ mole AgNO}_2) = 0.171 \text{ mole K}_2\text{CO}_3 \]

b. How many grams of silver nitrite and potassium carbonate will remain at the end of the reaction?

\[ 0.447 \text{ mole K}_2\text{CO}_3 - 0.171 \text{ mole K}_2\text{CO}_3 = 0.276 \text{ mole K}_2\text{CO}_3 \]
\[ 0.276 \text{ mole K}_2\text{CO}_3/(138.21 \text{ g K}_2\text{CO}_3) = 39.1 \text{ g K}_2\text{CO}_3 \]

7. Bismuth reacts with oxygen as follows: 4 Bi(s) + 5 O₂(g) → 2 Bi₂O₅(s) When 75.0 g of Bi and an excess of oxygen are reacted, 75.0 g of Bi₂O₅ 0.5 is produced. What is the percent yield for the reaction? (Molar masses: Bi = 208.98 O₂ = 32.00 Bi₂O₅ = 497.96)

Theor. yield: 75.0 g Bi/(208.98 g Bi) = 375.9 g Bi₂O₅

\[ \frac{375.9 \text{ g Bi}_2\text{O}_5}{89.4 \text{ g Bi}_2\text{O}_5} \times 100 = 85.9\% \]

8. The percent yield for the following reaction is 35.6%. 2 NO(g) + O₂(g) → 2 NO₂(g)

a. What will be the actual yield of NO₂ when 81.5 g of NO is reacted with excess O₂?

\[ 81.5 \text{ g NO}/(30.01 \text{ g NO}) = 2.71 \text{ mole NO} \]
\[ 2.71 \text{ mole NO}/(1 \text{ mole NO}_2) = 2.71 \text{ mole NO}_2 \]

b. How many grams of NO must be used in order to give an actual yield of 9.11 x 10⁻¹⁴ mg NO₂?

\[ 9.11 \times 10^{-14} \text{ g NO}_2/(2.56 \times 10^{12} \text{ g NO}_2) = 3.55 \times 10^{-12} \text{ g NO}_2 \]
\[ 2.56 \times 10^{12} \text{ g NO}_2/(1 \text{ mole NO}_2) = 2.56 \times 10^{12} \text{ g NO}_2 \]

Worksheet 13C