Practice Homework 23: Theoretical Yield and Percent Yield Calculations

Definitions/Helpful Info
• Again, this assignment is not due.

<table>
<thead>
<tr>
<th>STEP 1</th>
<th>STEP 2</th>
<th>STEP 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM</td>
<td>mol ratios</td>
<td>MM</td>
</tr>
<tr>
<td>mass (mass)</td>
<td>moles (initial)</td>
<td>moles (final)</td>
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• STEPS for calculation Theoretical Yield
  ▪ STEP 1: Convert mass of initial value to moles
  ▪ STEP 2: Use mole ratios (the coefficients) to convert moles of initial substance to moles of final substance
  ▪ STEP 3: Convert moles of final substance to mass of final substance.

• Percent Yield Equation (memorized)
  ▪ %-yield = \( \frac{\text{experimental yield}}{\text{theoretical yield}} \times 100 \)

  YOU CAN ALSO USE
  ▪ %-yield = \( \frac{\text{actual yield}}{\text{theoretical yield}} \times 100 \)

Instructions
• Determine the theoretical yield and the experimental yield, given the information in each question.
• You must show your work, including units, through each step of the calculations.
• You will need your own paper for this set of problems.

Questions

<table>
<thead>
<tr>
<th>70.90 g/mol</th>
<th>26.98 g/mol</th>
<th>133.33 g/mol</th>
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<tbody>
<tr>
<td>1) 2 ( \text{Cl}_2(\text{g}) ) + 3 ( \text{Al}(\text{s}) ) → 2 ( \text{AlCl}_3(\text{s}) )</td>
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1a) Calculate the theoretical yield of aluminum chloride (in grams) that can be produced from 10.00 grams of aluminum metal.

1b) A student performed this experiment and obtained 25.23 grams of aluminum chloride. Determine the percent yield of aluminum chloride.
2) \[2 \text{Cl}_2\text{O}_7(s) + 3 \text{H}_2\text{O}(l) \rightarrow 2 \text{HClO}_4(aq)\]

2a) An initial mass of 4.00 grams of dichlorine heptoxide was used to synthesize a sample of perchloric acid. Calculate the theoretical yield, given this information.

2b) If 4.17 grams of perchloric acid was generated, calculate the percent yield for this experiment.

3a) Calculate the mass of carbon dioxide (in grams) that can be produced from 20.00 grams of butane liquid.

3b) Calculate the percent yield if a student uses 20.00 grams of butane, but obtains 55.22 grams of carbon dioxide.

4a) What is the mass (in grams) of fluorine gas that can be produced from 75.00 grams of iodine pentafluoride.

4b) Calculate the percent yield if a student uses 75.00 grams of iodine pentafluoride, but obtains 24.22 grams of fluorine gas.

5a) Calculate the theoretical yield of vanadium(III) oxide, assuming you begin with 200.00 grams vanadium metal.

5b) When this experiment is performed by a researcher, an experimental yield of 183.2 grams is produced. Calculate the percent yield for this experiment.

6a) If a mass of 16.00 grams of calcium phosphide is initially present in the experiment, calculate the mass of phosphine gas (PH₃) that should be generated.

6b) If a mass of 6.12 grams of phosphine gas is actually generated, calculate the percent yield in this experiment.

6c) Extra Credit: The experimenter is puzzled by his calculation in 6b. Then he looks at his product, and it seems to be wet. What could the possible explanation to the “weird answer” to Question 6b? Hint: Look at the reactants.
7) \[ 6 \text{KI}(aq) + 6 \text{H}_2\text{O}(l) + 2 \text{KMnO}_4(aq) \rightarrow 3 \text{I}_2(s) + \text{MnO}_2(s) + 8 \text{KOH}(aq) \]

7a) Calculate the mass of manganese(IV) oxide that can be synthesized from 15.00 grams of potassium iodide.

7b) Calculate the percent yield of this experiment if a mass of 1.982 grams of manganese(IV) oxide is produced.

8) \[ 2 \text{NI}_3(s) \rightarrow 1 \text{N}_2(g) + 3 \text{I}_2(s) \]

8a) Calculate the theoretical yield of iodine, assuming an initial mass of 80.00 g of nitrogen triiodide.

8b) Calculate the percent yield, if a mass of 70.00 grams of iodine is obtained in an experiment.

Question 9

277.13 g/mol \hspace{1cm} 28.02 g/mol \hspace{1cm} 18.02 g/mol \hspace{1cm} 28.01 g/mol \hspace{1cm} 12.01 g/mol

Reaction 9a) \[ 2 \text{C}_7\text{H}_5\text{N}_3\text{O}_6(s) \rightarrow 3 \text{N}_2(g) + 5 \text{H}_2\text{O}(g) + 7 \text{CO}(g) + 7 \text{C}(s) \]

277.13 g/mol \hspace{1cm} 28.02 g/mol \hspace{1cm} 2.02 g/mol \hspace{1cm} 28.01 g/mol \hspace{1cm} 12.01 g/mol

Reaction 9b) \[ 2 \text{C}_7\text{H}_5\text{N}_3\text{O}_6(s) \rightarrow 3 \text{N}_2(g) + \text{H}_2(g) + 12 \text{CO}(g) + 2 \text{C}(s) \]

The compound \( \text{C}_7\text{H}_5\text{N}_3\text{O}_6 \) is trinitrotoluene (TNT). TNT can explosively decompose from either of the reactions above. Under controlled conditions, 5.00 grams actually yielded 2.97 grams of carbon monoxide gas.

Question 9a: Calculate the theoretical yield of carbon monoxide gas by through both reactions.

Question 9b: Determine whether the reaction occurred by Reaction 9a or Reaction 9b.

Question 9c: Determine the theoretical yield of this reaction.

Answer Key will be up by tomorrow afternoon.
Answers

1a) 32.95 g AlCl₃
1b) 76.58%-yield AlCl₃

2a) 4.30 g HClO₄
2b) 94.9%-yield HClO₄

3a) 60.58 g CO₂
3b) 91.96%-yield CO₂

4a) 32.11 g F₂
4b) 75.43%-yield F₂

5a) 294.23 g V₂O₃
5b) 62.265%-yield V₂O₃

6a) 5.972 g PH₃
6b) 103%-yield PH₃
6c) The extra mass is probably due to unreacted water still in the product.

7a) 77.16 g MnO₂
7b) 90.72%-yield MnO₂

8a) 2.620 g I₂
8b) 75.66%-yield I₂

9a) Reaction 9a produces 2.16 g CO. Reaction 9b produces 3.70 g CO

9b) As 2.97 g CO was produced experimentally, the reaction most likely proceeded through Reaction 9b.

9c) As the reaction proceeded through Reaction 9b, the percent yield of CO would be 85.5%