S'more Chemical Equation Stoichiometry and Limiting Reactants Worksheet

1. Balance the following chemical equations:
   (a) $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$
   (b) $Fe_2O_3 + H_2 \rightarrow Fe + H_2O$
2. Calculate the moles of CO_2 produced when 10 moles of $C_6H_{12}O_6$ react completely with excess O_2.
3. If 8.5 grams of H_2 react with excess O_2, how many grams of H_2O will be formed? (Molar mass: H_2 = 2 g/mol, H_2O = 18 g/mol)
4. Identify the limiting reactant when 5 moles of Fe_2O_3 react with 15 moles of H_2. Write the balanced equation first.
5. Theoretical and Percent Yield:
   (a) If the theoretical yield of a reaction is 25 grams of product and the actual yield is 20 grams, calculate the percent yield.
   (b) Explain what factors might cause a reaction to have a percent yield less than 100
6. S'more Chemistry Context:
   (a) Using the analogy of making s'mores (2 crackers + 1 chocolate + 1 marshmallow = 1 s'more), calculate how many s'mores can be made from 10 crackers, 5 chocolates, and 8 marshmallows. Identify the limiting reactant.
   (b) If you have 3 s'mores leftover from a camping trip, calculate the percent yield if you expected to make 12 s'mores initially.
7. Challenge Problem:
   (a) A reaction requires 3 moles of A for every 2 moles of B. If you start with 12 moles of A and 10 moles of B, determine the limiting reactant and calculate the amount of product formed assuming a 1:1 molar ratio of product to B.
8. Real-Life Application:
   (a) Ammonia (NH_3) is produced using nitrogen gas (N_2) and hydrogen gas (H_2) in the Haber process: $N_2 + 3H_2 \rightarrow 2NH_3$. If you have 28 grams of N_2 and 12 grams of H_2, determine the limiting reactant and calculate the mass of NH_3 produced. (Molar masses: N_2 = 28 g/mol, H_2 = 2 g/mol, NH_3 = 17 g/mol)

Solutions

1. **Balancing Chemical Equations:**
   (a) $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
   (b) $Fe_2O_3 + 3H_2 \rightarrow 2Fe + 3H_2O$

2. **Moles of CO_2 Produced:**
   (a) From the equation, 1 mole of $C_6H_{12}O_6$ produces 6 moles of CO_2. Therefore, 10 moles of $C_6H_{12}O_6$ produce 60 moles of CO_2.

3. **Mass of H_2O Produced:**
   (a) Moles of $H_2 = \frac{8.5}{2} = 4.25$ moles. From the equation, 1 mole of H_2 forms 1 mole of H_2O. Therefore, 4.25 moles of H_2O are formed. Mass of $H_2O = 4.25 \times 18 = 76.5$ grams.

4. **Limiting Reactant:**
   (a) $Fe_2O_3 + 3H_2 \rightarrow 2Fe + 3H_2O$. From the stoichiometry, 5 moles of Fe_2O_3 require 15 moles of H_2. Both are used completely; no limiting reactant.

5. **Theoretical and Percent Yield:**
   (a) Percent Yield $= \frac{Actual Yield}{Theoretical Yield} \times 100 = \frac{20}{25} \times 100 = 80\%$.
   (b) Factors include incomplete reactions, side reactions, or loss of product during handling.

6. **S'more Chemistry Context:**
   (a) For 10 crackers, 5 chocolates, and 8 marshmallows: 10 crackers need 5 chocolates and 5 marshmallows. Since only 5 chocolates are available, chocolate is the limiting reactant. Maximum s'mores = 5.
   (b) Percent Yield $= \frac{Actual Yield}{Expected Yield} \times 100 = \frac{3}{12} \times 100 = 25\%$.

7. **Challenge Problem:**
   (a) For 3A + 2B $\rightarrow$ Product: Starting with 12 moles of A and 10 moles of B: $\frac{12}{3} = 4$ reactions for A, and $\frac{10}{2} = 5$ reactions for B. A is the limiting reactant. Product = 4 moles.

8. **Real-Life Application:**
   (a) $N_2 + 3H_2 \rightarrow 2NH_3$: Moles of $N_2 = \frac{28}{28} = 1$ mole, Moles of $H_2 = \frac{12}{2} = 6$ moles. From the stoichiometry, 1 mole of N_2 reacts with 3 moles of H_2. N_2 is the limiting reactant. NH_3 formed $= 2 \times 1 = 2$ moles. Mass $= 2 \times 17 = 34$ grams.