

Name: _____ Date: _____

Answer Key: Stoichiometry Siege: Crush Quantitative Analysis for 11th Grade

Calculate theoretical yields and identify limiting reagents to optimize industrial chemical synthesis during this high-stakes reaction simulation.

1. A metallurgical engineer reacts 150.0 g of iron(III) oxide (Molar Mass = 159.7 g/mol) with excess carbon monoxide. If the process yields 88.5 g of liquid iron, what is the percent yield of the reaction? ($\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$)

Answer: B) 84.4%

The theoretical yield is $(150\text{g} / 159.7\text{g/mol}) * 2 * 55.85\text{g/mol} = 104.9\text{g}$. The percent yield is $(88.5\text{g} / 104.9\text{g}) * 100 = 84.4\%$.

2. In the combustion of octane ($2\text{C}_8\text{H}_{18} + 25\text{O}_2 \rightarrow 16\text{CO}_2 + 18\text{H}_2\text{O}$), the ratio of moles of oxygen consumed to moles of water produced is _____.

Answer: A) 25:18

The stoichiometric coefficients from the balanced equation directly provide the mole ratio: 25 moles of O_2 are required for every 18 moles of H_2O produced.

3. True or False: In a reaction where 2 moles of A react with 3 moles of B, if you start with equal masses of A and B, the substance with the higher molar mass is always the limiting reactant.

Answer: B) False

Limiting reactants depend on both the molar mass and the stoichiometric coefficient; a higher molar mass resulting in fewer moles does not guarantee it is limiting if the stoichiometry requires even less of it.

4. A chemist reacts 0.40 moles of Aluminum with 0.40 moles of Chlorine gas to form Aluminum Chloride ($2\text{Al} + 3\text{Cl}_2 \rightarrow 2\text{AlCl}_3$). Identify the limiting reactant and the moles of product formed.

Answer: B) Cl_2 is limiting; 0.27 moles AlCl_3 formed

Chlorine is limiting because $0.40\text{ moles } \text{Cl}_2 * (2 \text{ AlCl}_3 / 3 \text{ Cl}_2) = 0.267\text{ moles } \text{AlCl}_3$, whereas 0.40 moles Al would produce 0.40 moles AlCl_3 .

5. To synthesize 10.0 grams of Silver Chloride via the reaction $\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3$, the minimum mass of Sodium Chloride (58.44 g/mol) required is _____ grams.

Name: _____ Date: _____

Answer: A) 4.08

$10.0\text{g AgCl} / 143.32\text{g/mol} = 0.0698$ moles. Since the ratio is 1:1, 0.0698 moles * $58.44\text{g/mol NaCl} = 4.08\text{g}$.

6. In the decomposition of Potassium Chlorate ($2\text{KClO}_3 \rightarrow 2\text{KCl} + 3\text{O}_2$), what volume of O_2 gas is produced at STP from 122.5 g of KClO_3 (Molar Mass = 122.5 g/mol)?

Answer: C) 33.6 L

122.5g is 1 mole of KClO_3 . According to the 2:3 ratio, 1 mole KClO_3 produces 1.5 moles O_2 . 1.5 moles * $22.4\text{ L/mol} = 33.6\text{ L}$.

7. True or False: The empirical formula of a compound can be determined using only the percent composition by mass and the molar masses of the constituent elements.

Answer: A) True

The empirical formula represents the simplest whole-number ratio, which is derived by converting mass percentages to moles and finding their relative ratios.

8. If a gaseous hydrocarbon is 85.6% carbon and 14.4% hydrogen by mass, and has a molar mass of 42.1 g/mol, its molecular formula is _____.

Answer: C) C_3H_6

Empirical formula is CH_2 (14.03 g/mol). Molar mass $42.1 / 14.03 = 3$. Therefore, the molecular formula is $(\text{CH}_2)_3$ or C_3H_6 .

9. Analyze the reaction: $4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$. If 2.0 moles of NH_3 and 2.0 moles of O_2 react, how many moles of the excess reactant remain?

Answer: A) 0.4 moles NH_3

O_2 is limiting ($2.0/5 < 2.0/4$). 2.0 moles O_2 requires $(4/5)*2.0 = 1.6$ moles NH_3 . Remaining $\text{NH}_3 = 2.0 - 1.6 = 0.4$ moles.

10. True or False: In a balanced chemical equation, the total number of moles of reactants must always equal the total number of moles of products.

Answer: B) False

While mass must be conserved, the number of moles can change depending on the stoichiometry (e.g., $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ turns 3 moles of gas into 2 moles).