Name: _____ **Date:** _____

Stoichiometry Showdown: Senior Chemists vs. The Law of Mass Action

Challenge students to move beyond basic mole conversions into the realm of non-ideal gas behavior, partial yields, and multi-step industrial synthesis analysis.

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1. In the industrial synthesis of adipic acid ($H_2C_6H_8O_4$), a precursor to Nylon-6,6, a process yields 85.0% of the theoretical mass. If 500.0g of cyclohexane is oxidized, but 25.0g of unreacted starting material is recovered, what is the effective mole-to-mole relationship used to calculate actual yield?

A. The ratio between the initial mass of cyclohexane and the theoretical moles of adipic acid.
B. The ratio between the reacted moles of cyclohexane and the product of theoretical yield and 0.85.
C. The stoichiometry of the balanced equation regardless of the unreacted mass.
D. The density of adipic acid divided by the Avogadro constant.

2. In a titration involving a polyprotic acid like H_3PO_4 with NaOH, the stoichiometric point for the second equivalence requires exactly double the moles of base compared to the first, assuming complete dissociation of the second proton.

A. True
B. False

3. A 10.0L vessel contains a mixture of Ne and Ar. If the total pressure is 2.0 atm and the mole fraction of Ne is 0.75, the partial pressure of Ar is _____.

A. 0.25 atm
B. 0.50 atm
C. 1.50 atm
D. 1.00 atm

4. Consider the combustion of a complex hydrocarbon fuel. If the analysis of the exhaust gas shows 12 moles of CO_2 and 14 moles of H_2O, which empirical formula represents the original analyte?

A. C_3H_7
B. C_6H_7
C. CH_2
D. $C_{12}H_{28}$

5. The limiting reactant in a chemical process is always the substance present in the smallest mass at the start of the reaction.

A. True
B. False

6. In the decomposition of potassium chlorate ($2KClO_3 \rightarrow 2KCl + 3O_2$), if 2.0 moles of $KClO_3$ decompose fully, the volume of O_2 produced at STP is approximately _____.

A. 22.4 L

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B. 44.8 L
C. 67.2 L
D. 33.6 L

7. During the synthesis of aspirin, a student uses a 2:1 molar excess of acetic anhydride relative to salicylic acid. If the reaction has a 70% yield, what factor primarily determines the mass of the final product?

A. The volume of acetic anhydride.
B. The chemical potential of the catalyst.
C. The amount of salicylic acid used.
D. The atmospheric pressure in the lab.

8. An unknown gas has a density of 1.25 g/L at STP. The molar mass of this gas is most likely _____.

A. 14 g/mol
B. 28 g/mol
C. 44 g/mol
D. 16 g/mol

9. A solution contains 0.1M Ag^+ and 0.1M Pb^{2+}. As Cl^- is added, which stoichiometric calculation is required to determine which salt precipitates first?

A. Comparing the Solubility Product Constants (Ksp) with the ion product (Q).
B. Calculating the total mass of the solvent.
C. Subtracting the molar mass of Ag from Pb.
D. Measuring the pH of the neutral solution.

10. In a closed system reacting N_2 and H_2 to form NH_3 (Haber process), the total number of moles of gas remains constant throughout the reaction.

A. True
B. False