Limiting, Excess, Yield, and Purity Synthesis

Student Worksheet | `g10_u01_w04`

I can: identify a limiting reactant, calculate theoretical and percent yield, and separate a purity claim from a yield claim using mass-data models.
Frozen values: H 1.008, C 12.011, N 14.007, O 15.999, Mg 24.305, Al 26.982, Cl 35.450, Ca 40.078, Fe 55.845. Values are from `audits/atomic_masses_v2024.1.json`. Every context is a paper/digital data card; no chemical procedure, gas collection, or heating is requested. Carry guard digits until the final reported result.

1. Balance $N_2 + H_2 \rightarrow NH_3$. State the mole ratio that tests whether H_2 or N_2 limits.

2. A data card assigns 6.00 g H_2 and 28.0 g N_2 to item 1. Determine the limiting reactant by comparing available moles with required moles.

3. From item 2, calculate the theoretical mass of NH_3. Show a guard-digit chain before reporting with appropriate significant figures.

4. From item 2, calculate mass of excess N_2 remaining.

5. Balance $Fe_2O_3 + CO \rightarrow Fe + CO_2$. State the reactant ratio used to find the limiting reactant.

6. A record gives 16.0 g Fe_2O_3 and 8.00 g CO. Identify the limiting reactant and calculate theoretical mass of Fe.

7. Calculate the excess mass of Fe_2O_3 from item 6.

8. A product card reports 10.2 g Fe from item 6. Calculate percent yield. What does this percentage compare?

9. Balance $Al + O_2 \rightarrow Al_2O_3$.

10. A card lists 9.00 g Al and 12.0 g O_2. Identify the limiting reactant and calculate theoretical mass of Al_2O_3.

11. Calculate excess O_2 mass from item 10.

12. A 12.00 g mineral card is 85.0% $CaCO_3$ by a stated composition model. With $CaCO_3 \rightarrow CO_2$ as a stated 1 : 1 mole model, calculate theoretical CO_2 mass.

13. The card in item 12 lists 4.05 g CO_2 as its assigned collected mass. Calculate percent yield relative to the model's pure-$CaCO_3$ amount.

14. A 5.00 g metal card is 80.0% Mg and produces 6.00 g MgO in a stated model. Use $2Mg + O_2 \rightarrow 2MgO$ to calculate theoretical MgO and percent yield.

15. A 20.00 g ore is 75.0% Fe_2O_3 by a supplied composition card; CO is excess in the model. Predict theoretical Fe mass.

16. The item 15 product card assigns 9.44 g Fe. Calculate percent yield and explain why it is not the same as the ore purity.

17. A 10.00 g mixture is 75.0% Al. It is modeled with 20.00 g Cl_2 by $2Al + 3Cl_2 \rightarrow 2AlCl_3$. Convert both active reactant masses to moles and identify the limiting reactant.

18. From item 17, calculate theoretical $AlCl_3$ mass and excess Al mass.

19. A product card for item 17 assigns 23.5 g $AlCl_3$. Calculate percent yield. If the card instead listed a yield above 100%, give two model or measurement checks before claiming a new chemistry result.

20. A final card: 8.00 g mineral is 60.0% $CaCO_3$ and gives 2.00 g CO_2 under the same stated 1 : 1 model. Calculate theoretical CO_2 and percent yield, then state one condition required before interpreting the result as a material-performance claim.