

Stoichiometry: Limiting Reactant & Yield

Key steps

Stoichiometry steps: (1) balanced equation → (2) grams ÷ molar mass = moles → (3) multiply by the mole ratio (coefficients) → (4) moles × molar mass = grams

Limiting reactant: work out how much product each reactant could make; the one that makes *less* is limiting.

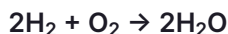
Percent yield = actual yield ÷ theoretical yield × 100 · Give answers to 3 significant figures.

Molar masses (g/mol): H 1.01, C 12.01, N 14.01, O 16.00, Na 22.99, Mg 24.31, Al 26.98, S 32.07, Cl 35.45, K 39.10, Ca 40.08, Fe 55.85, Cu 63.55

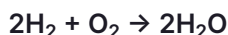
A Mole ratios

4 marks

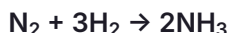
1. How many moles of O₂ are needed to react with 4.0 mol of H₂?



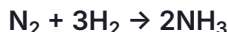
2. How many moles of H₂O form from 3.0 mol of O₂?



3. How many moles of NH₃ form from 2.5 mol of N₂?



4. How many moles of H₂ are needed to make 8.0 mol of NH₃?

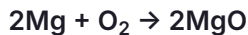


B Mass-to-mass stoichiometry

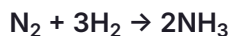
8 marks

2 marks each. Show grams → moles → mole ratio → grams.

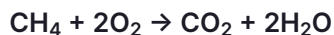
5. What mass of MgO forms from 12.0 g of Mg?



6. What mass of NH_3 forms from 14.0 g of N_2 ?



7. What mass of CO_2 forms from 8.00 g of CH_4 ?



8. What mass of O_2 forms when 24.5 g of KClO_3 decomposes?

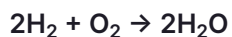


C Limiting reactant

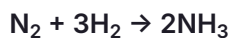
7 marks

Q9 and Q11 are worth 2 marks each; Q10 is worth 3.

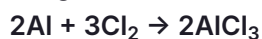
9. 4.00 g of H_2 reacts with 16.0 g of O_2 . Which is the limiting reactant, and what mass of H_2O forms?



10. 28.0 g of N_2 reacts with 9.00 g of H_2 . Which is the limiting reactant, and what mass of NH_3 forms? How many grams of H_2 are left over?



11. 10.0 g of Al reacts with 35.0 g of Cl_2 . Which is the limiting reactant, and what mass of AlCl_3 forms?



D Percent yield

4 marks

12. The theoretical yield of a reaction is 18.0 g, and 15.3 g is collected. What is the percent yield?

13. In question 5, the theoretical yield of MgO is 19.9 g. A student collects 17.5 g. What is the percent yield?

14. Heating 50.0 g of CaCO_3 produces 25.2 g of CaO ($\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$). Find the percent yield.

E Spot the mistake

2 marks

15. For $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$, a student says 4.0 g of H_2 reacts with 2.0 g of O_2 "because the ratio is 2 : 1." Explain the error and correct it.

16. A student decides the reactant with the smaller mass must be the limiting reactant. Explain the error and correct it.

F Challenge

2 marks

17. A student reports a percent yield of 108%. Give two likely reasons.

18. Propane burns: $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$. What mass of CO_2 forms from 44.0 g of propane?

Stoichiometry: Limiting Reactant & Yield

Name: _____

Date: _____ Score: ____ / 27

ANSWER KEY

Key steps

Stoichiometry steps: (1) balanced equation → (2) grams ÷ molar mass = moles → (3) multiply by the mole ratio (coefficients) → (4) moles × molar mass = grams

Limiting reactant: work out how much product each reactant could make; the one that makes *less* is limiting.

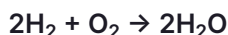
Percent yield = actual yield ÷ theoretical yield × 100 · Give answers to 3 significant figures.

Molar masses (g/mol): H 1.01, C 12.01, N 14.01, O 16.00, Na 22.99, Mg 24.31, Al 26.98, S 32.07, Cl 35.45, K 39.10, Ca 40.08, Fe 55.85, Cu 63.55

A Mole ratios

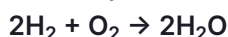
4 marks

1. How many moles of O₂ are needed to react with 4.0 mol of H₂?



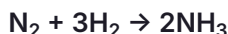
$$4.0 \times 1/2 = 2.0 \text{ mol}$$

2. How many moles of H₂O form from 3.0 mol of O₂?



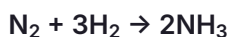
$$3.0 \times 2/1 = 6.0 \text{ mol}$$

3. How many moles of NH₃ form from 2.5 mol of N₂?



$$2.5 \times 2/1 = 5.0 \text{ mol}$$

4. How many moles of H₂ are needed to make 8.0 mol of NH₃?



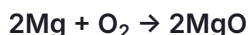
$$8.0 \times 3/2 = 12 \text{ mol}$$

B Mass-to-mass stoichiometry

8 marks

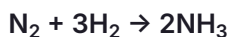
2 marks each. Show grams → moles → mole ratio → grams.

5. What mass of MgO forms from 12.0 g of Mg?



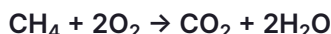
$$12.0 \text{ g} \div 24.31 = 0.494 \text{ mol Mg}; \times 2/2 = 0.494 \text{ mol MgO}; \times 40.31 = 19.9 \text{ g MgO}$$

6. What mass of NH₃ forms from 14.0 g of N₂?



$$14.0 \text{ g} \div 28.02 = 0.500 \text{ mol N}_2; \times 2/1 = 0.999 \text{ mol NH}_3; \times 17.04 = 17.0 \text{ g NH}_3$$

7. What mass of CO₂ forms from 8.00 g of CH₄?



$$8.00 \text{ g} \div 16.05 = 0.498 \text{ mol CH}_4; \times 1/1 = 0.498 \text{ mol CO}_2; \times 44.01 = 21.9 \text{ g CO}_2$$

8. What mass of O₂ forms when 24.5 g of KClO₃ decomposes?



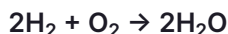
$$24.5 \text{ g} \div 122.55 = 0.200 \text{ mol KClO}_3; \times 3/2 = 0.300 \text{ mol O}_2; \times 32.00 = 9.60 \text{ g O}_2$$

C Limiting reactant

7 marks

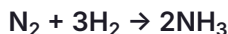
Q9 and Q11 are worth 2 marks each; Q10 is worth 3.

9. 4.00 g of H_2 reacts with 16.0 g of O_2 . Which is the limiting reactant, and what mass of H_2O forms?



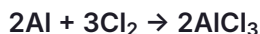
H_2 : 1.98 mol $\rightarrow$ 1.98 mol H_2O ; O_2 : 0.500 mol $\rightarrow$ 1.00 mol H_2O . Limiting: O_2 ; mass of H_2O = 18.0 g

10. 28.0 g of N_2 reacts with 9.00 g of H_2 . Which is the limiting reactant, and what mass of NH_3 forms? How many grams of H_2 are left over?



N_2 : 0.999 mol $\rightarrow$ 2.00 mol NH_3 ; H_2 : 4.46 mol $\rightarrow$ 2.97 mol NH_3 . Limiting: N_2 ; mass of NH_3 = 34.1 g; H_2 left over = 2.94 g

11. 10.0 g of Al reacts with 35.0 g of Cl_2 . Which is the limiting reactant, and what mass of AlCl_3 forms?



Al: 0.371 mol $\rightarrow$ 0.371 mol AlCl_3 ; Cl_2 : 0.494 mol $\rightarrow$ 0.329 mol AlCl_3 . Limiting: Cl_2 ; mass of AlCl_3 = 43.9 g

D Percent yield

4 marks

12. The theoretical yield of a reaction is 18.0 g, and 15.3 g is collected. What is the percent yield?

$$15.3 \div 18.0 \times 100 = 85.0\%$$

13. In question 5, the theoretical yield of MgO is 19.9 g. A student collects 17.5 g. What is the percent yield?

$$17.5 \div 19.9 \times 100 = 87.9\%$$

14. Heating 50.0 g of CaCO_3 produces 25.2 g of CaO ($\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$). Find the percent yield.

$$\text{theoretical} = 50.0 \div 100.09 \times 56.08 = 28.0 \text{ g}; 25.2 \div 28.0 \times 100 = 90.0\%$$

E Spot the mistake

2 marks

15. For $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$, a student says 4.0 g of H_2 reacts with 2.0 g of O_2 "because the ratio is 2 : 1." Explain the error and correct it.

Coefficients are mole ratios, not mass ratios. 4.0 g H_2 = 1.98 mol, which needs 0.990 mol O_2 = 31.7 g O_2 .

16. A student decides the reactant with the smaller mass must be the limiting reactant. Explain the error and correct it.

Compare moles using the mole ratio, not grams. In question 9, H_2 has the smaller mass (4.00 g vs 16.0 g), but O_2 is limiting.

F Challenge

2 marks

17. A student reports a percent yield of 108%. Give two likely reasons.

The product was still wet (water adds mass) or contained impurities or unreacted solid; a weighing error is also possible.

18. Propane burns: $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$. What mass of CO_2 forms from 44.0 g of propane?

$$44.0 \text{ g} \div 44.11 = 0.998 \text{ mol } \text{C}_3\text{H}_8; \times 3/1 = 2.99 \text{ mol } \text{CO}_2; \times 44.01 = 132 \text{ g } \text{CO}_2$$