SCIENCE FOUNDATIONS

Limiting and excess reagents

Difficulty level: Advanced

Science Foundations

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Overview of the concept

This is how a baker knows the cake batter runs out of eggs before flour, so the number of cakes depends on the eggs and the leftover flour just sits there. A factory ordering chemicals works out which ingredient runs out first, because that is what sets how much product it can make. A cook doubling a recipe finds out fast which ingredient they are short on. Knowing limiting and excess reagents tells you what really caps the amount you can make, and what will be left over when you stop.



Rule

Limiting and excess reagents: the limiting reagent is the reactant that runs out first, and it sets how much product can form.

Find it by working out how much product each reactant could make and taking the smaller amount. The other reactant is in excess and some of it is left over.

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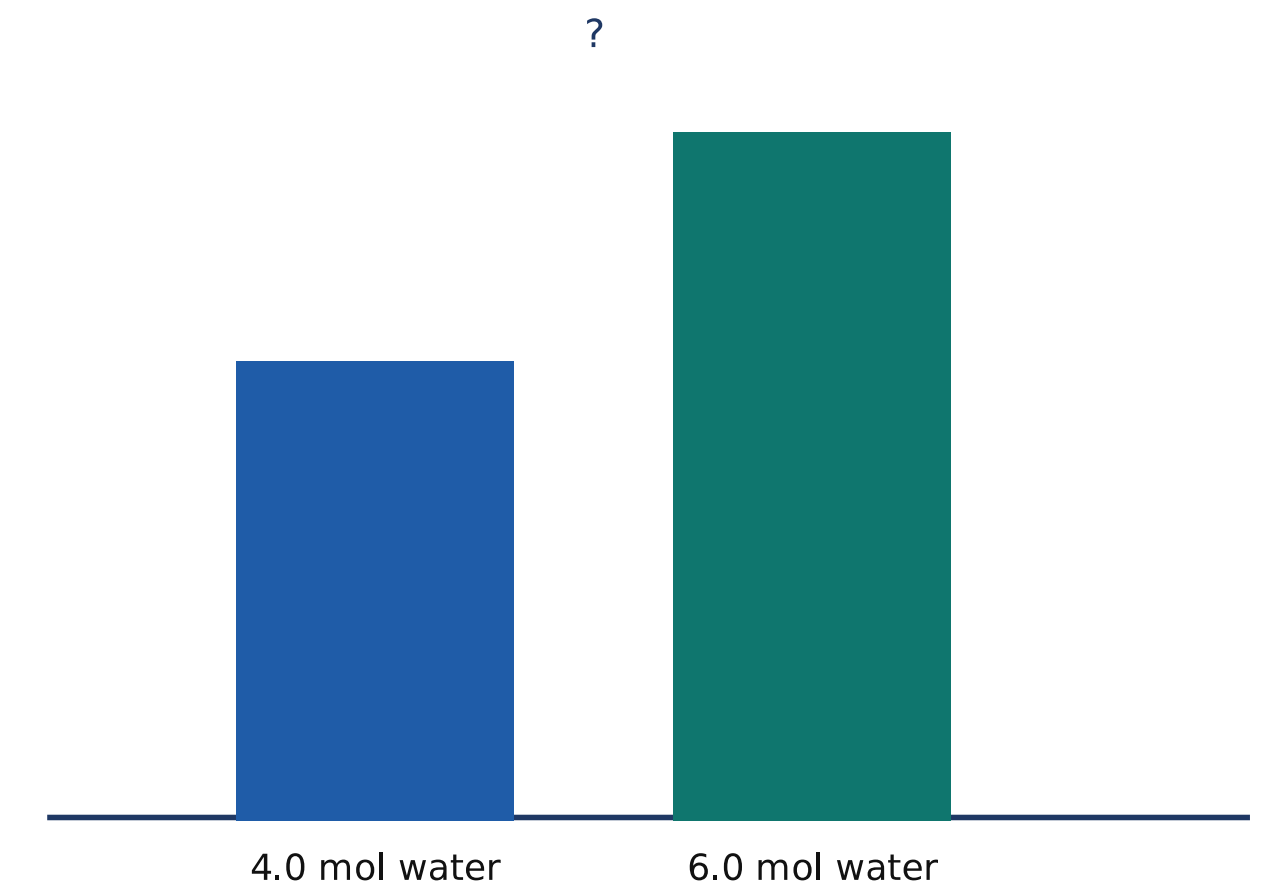
Worked examples

EXAMPLE 1

Q Find the limiting reagent: 4.0 moles H_2 and 3.0 moles O_2 in $2H_2 + O_2 \rightarrow 2H_2O$.



SOLUTION

From H_2: 4.0 moles H_2 make 4.0 moles H_2O (1 to 1).

From O_2: 3.0 × 2 = 6.0 moles H_2O (1 to 2)

Compare: less product comes from H_2, so H_2 limits.

The result is hydrogen is limiting; 4.0 moles of water form.

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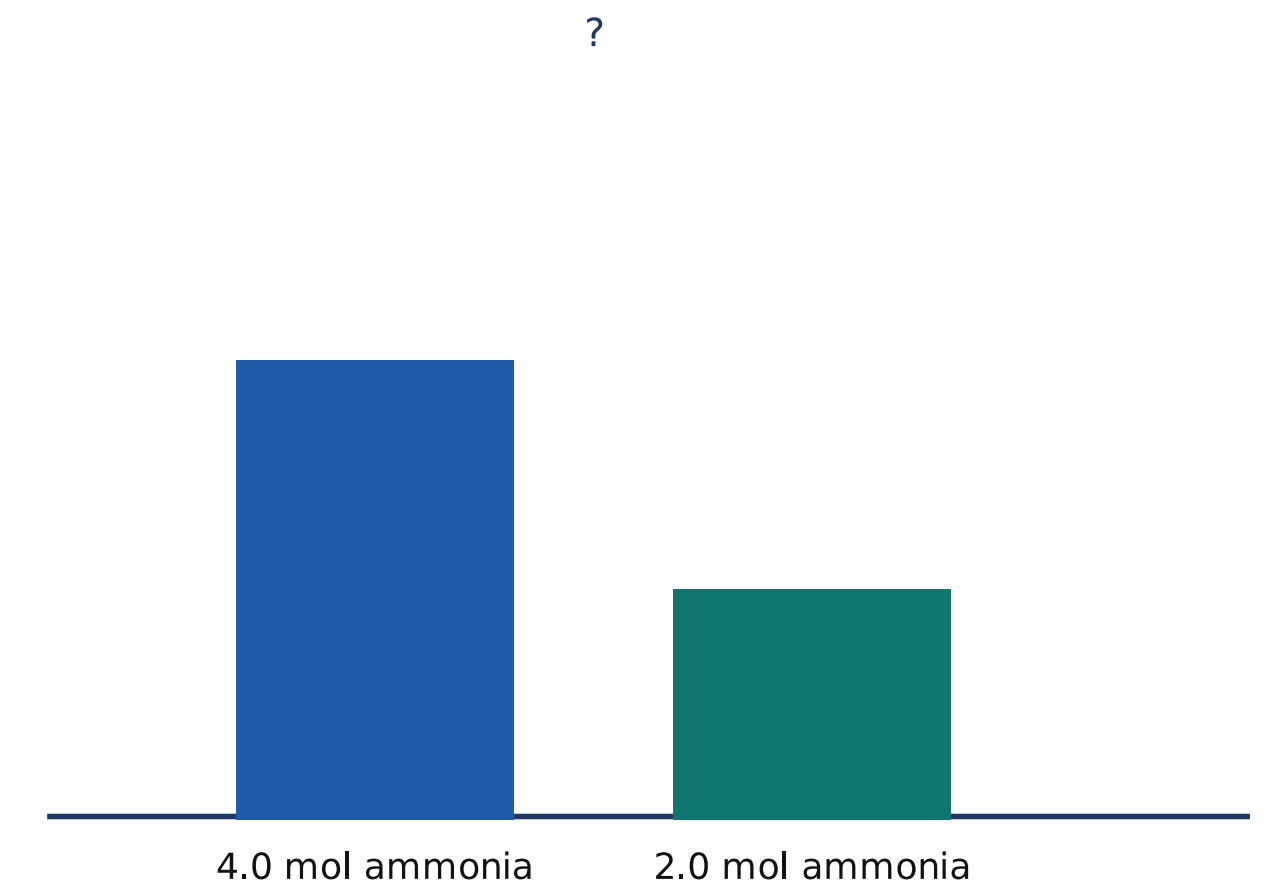
EXAMPLE 2

Q Find the limiting reagent: 2.0 moles N_2 and 3.0 moles H_2 in $N_2 + 3H_2 \rightarrow 2NH_3$.



SOLUTION

From N_2: 2.0 × 2 = 4.0 moles NH_3 (1 to 2)

From H_2: 3.0 × 2 ÷ 3 = 2.0 moles NH_3 (3 to 2)

Compare: less product comes from H_2, so H_2 limits.

The result is hydrogen is limiting; 2.0 moles of ammonia form.

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Practice questions

1 In $2H_2 + O_2 \rightarrow 2H_2O$, 8.0 mol H_2 and 3.0 mol O_2 are mixed. Which reactant is limiting, and how many moles of water form?

- **A** Hydrogen limits, 8.0 mol of water form
- **B** Oxygen limits, 6.0 mol of water form
- **C** Hydrogen limits, 6.0 mol of water form
- **D** Oxygen limits, 8.0 mol of water form

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2 In $2H_2 + O_2 \rightarrow 2H_2O$, 6.0 mol H_2 and 2.0 mol O_2 are mixed. How much H_2 is left over when the reaction stops?

- **A** 0 mol of H_2 left over
- **B** 2.0 mol of H_2 left over
- **C** 4.0 mol of H_2 left over
- **D** 6.0 mol of H_2 left over

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3

In $N_2 + 3H_2 \rightarrow 2NH_3$, 5.0 mol N_2 and 9.0 mol H_2 are mixed. Which reactant is limiting, and how many moles of ammonia form?

A Nitrogen limits, 10.0 mol of ammonia form

B Hydrogen limits, 10.0 mol of ammonia form

C Hydrogen limits, 6.0 mol of ammonia form

D Nitrogen limits, 6.0 mol of ammonia form

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4 In $N_2 + 3H_2 \rightarrow 2NH_3$, 1.0 mol N_2 and 6.0 mol H_2 are mixed. Which reactant is in excess?

- **A** Nitrogen
- **B** Hydrogen
- **C** Neither
- **D** Both

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5 What is a limiting reagent?

- **A** The reactant that runs out first
- **B** The reactant left over after the reaction stops
- **C** The product that forms fastest
- **D** The reactant with the largest amount

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What is an excess reagent?

A The reactant that runs out first

B The product that forms last

C The reactant left over after the reaction stops

D The reactant with the smallest amount

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In $2H_2 + O_2 \rightarrow 2H_2O$, how many moles of H_2 are needed to react completely with 4.0 mol O_2?

A 2.0 mol of H_2

B 4.0 mol of H_2

C 8.0 mol of H_2

D 16.0 mol of H_2

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8 **If only one reactant amount is given, is there a limiting reagent to find? Explain.**

- **A** Yes, the other reactant always limits
- **B** No, the given reactant limits by default
- **C** No, the reaction cannot start
- **D** Yes, the given reactant is always in excess

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9 **In $N_2 + 3H_2 \rightarrow 2NH_3$, 2.0 mol N_2 and 6.0 mol H_2 are mixed. Which reactant is limiting?**

- **A** Nitrogen
- **B** Hydrogen
- **C** Neither, both run out together
- **D** Cannot tell

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What happens to the excess reagent when the reaction stops?

A It all reacts eventually

B Some of it remains unreacted

C It turns into the limiting reagent

D It evaporates away

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ANSWER KEY

1. Oxygen limits, 6.0 mol of water form

2. 2.0 mol of H_2 left over

3. Hydrogen limits, 6.0 mol of ammonia form

4. Hydrogen

5. The reactant that runs out first

6. The reactant left over after the reaction stops

7. 8.0 mol of H_2

8. No, the given reactant limits by default

9. Neither, both run out together

10. Some of it remains unreacted

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