

4.1 Amounts, equations and limiting reagents

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS limiting reagent • mole

Objective

Amounts, equations and limiting reagents. Supported SL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

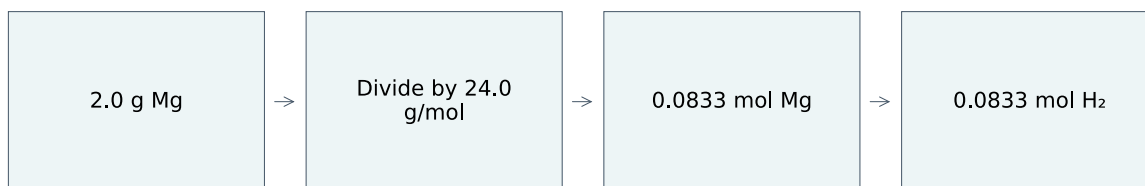
1 Key knowledge and worked examples

■ What would explain this observation?

- The smallest mass of reactant is not necessarily the **limiting reagent**. The balanced equation compares particle amounts, not grams directly.
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

■ Build the model

- The **mole** measures amount of substance. Use molar mass to convert mass into amount. Balanced equation coefficients give mole ratios; they do not give equal masses.
- mole: The SI unit of amount of substance; limiting reagent: The reactant that limits the possible product amount.



■ **Choose evidence that can test it**

- Calculate the amount available for each reactant and divide by its coefficient. The smaller ratio limits the reaction. Use that reactant to calculate the maximum product before comparing actual yield.
- Write the balanced equation first, include units in molar masses, then convert each given mass or solution volume into amount. Convert cubic centimetres to cubic decimetres before using concentration in moles per cubic decimetre.

■ **Work from known quantities**

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- Known: 2.0 g of Mg reacts with excess acid. Use amount = mass/molar mass. With molar mass Mg = 24.0 g per mole, amount Mg = $2.0/24.0 = 0.0833$ mol. In $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$, amount H₂ = amount Mg = 0.0833 mol.

Example:

Calculate amount in 5.0 g of a substance with molar mass 100 g per mole. Use the same sequence: known quantities → model → relation → substitution → unit and interpretation.

■ **Check the conclusion and its limits**

- Excess acid means acid does not limit the stated calculation. A coefficient of 2 before HCl does not double the hydrogen amount.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

Balanced equation coefficients always give reactant mass ratios. This claim is false: Excess acid means acid does not limit the stated calculation. A coefficient of 2 before HCl does not double the hydrogen amount.

Key:

Amounts, equations and limiting reagents: Calculate the amount available for each reactant and divide by its coefficient. The smaller ratio limits the reaction. Use that reactant to calculate the maximum product before comparing actual yield.

2 Practice

2.1 Which step comes first in a reacting-mass calculation? Choose one answer.

- **A** Compare masses without an equation
- **B** Use a balanced equation and convert mass to amount
- **C** Assume every mole ratio is 1:1

[1]

2.2 Calculate amount in 5.0 g of a substance with molar mass 100 g per mole. Show the relation, substitution and units.

[2]

2.3 Decide whether this claim is true and justify: Balanced equation coefficients always give reactant mass ratios.

[2]

2.4 The SI unit of amount of substance: write the technical term.

[1]

3 Exam-style questions

3.1 For $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$, 0.10 mol Mg meets 0.12 mol HCl. Identify the limiting reagent, hydrogen amount and leftover Mg. [4]

Solutions

2.1 B Calculate the amount available for each reactant and divide by its coefficient. The smaller ratio limits the reaction. Use that reactant to calculate the maximum product before comparing actual yield.

2.2 $n = m/M = (5.0 \text{ g}) / (100 \text{ g/mol}) = 0.050 \text{ mol}$.

2.3 False. Excess acid means acid does not limit the stated calculation. A coefficient of 2 before HCl does not double the hydrogen amount.

2.4 mole. mole means The SI unit of amount of substance.

3.1 HCl limits: $0.12/2 = 0.060 \text{ mol}$ reaction. H_2 0.060 mol ; Mg left 0.040 mol . Stoichiometric coefficients, not equal starting amounts, determine the limit.