4.1 Amounts, equations and limiting reagents

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS limiting reagent • mole

Objective

Amounts, equations and limiting reagents. Original classroom practice for IB HL; not an official IB paper.

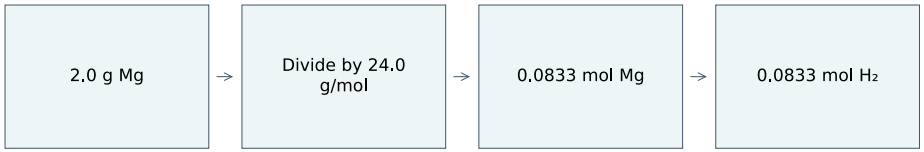
1 Key knowledge and worked examples

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.

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.

In the lab: 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

- 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 Mg + 2HCl → MgCl2 + H2, amount H2 = amount Mg = 0.0833 mol.

Your turn: Calculate amount in 5.0 g of a substance with molar mass 100 g per mole.

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.

Not true: Balanced equation coefficients always give reactant mass ratios. Coefficients give ratios of amounts in moles, not masses. Because each substance has a different molar mass, a 2:1 mole ratio is generally not a 2:1 mass ratio.

Key:

- The mole measures amount of substance.
- Calculate the amount available for each reactant and divide by its coefficient.
- Watch for: excess acid means acid does not limit the stated calculation.

Write from an amount of 0.30 mol

- A sample has mass 12.0 g and molar mass 40 g per mole.
- Find the amount. A mole ratio from an equation is not a mass ratio.

2 Practice

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

- **A** Compare masses without an equation
- **B** Assume every mole ratio is 1:1
- **C** Use a balanced equation and convert mass to amount [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: Coefficients give ratios of amounts in moles, not masses. [2]

2.4 The SI unit of amount of substance: write the technical term. [1]

3 Exam-style questions

3.1 For $Mg + 2HCl \rightarrow MgCl_2 + H_2$, 0.10 mol Mg meets 0.12 mol HCl. Identify the limiting reagent, hydrogen amount and leftover Mg. [4]

Solutions

2.1 C A reacting-mass calculation starts from the balanced equation, because only the equation gives the mole ratio, and masses must be converted to amounts before the ratio applies. Comparing masses directly or assuming 1:1 skips the chemistry.

2.2 n=m/M=(5.0 g)/(100 g/mol)=0.050 mol.

2.3 True. True. Coefficients give ratios of amounts in moles, not masses. Because each substance has a different molar mass, a 2:1 mole ratio is generally not a 2:1 mass ratio.

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

3.1 HCl limits:0.12/2=0.060 mol reaction. $H_2$0.060 mol;Mg left0.040 mol. Stoichiometric coefficients, not equal starting amounts, determine the limit.