

Question and Answer on Mole Calculations:

Solving this set of questions as an example:

9g of Mg added to 300 cm³ 0.1 mol dm⁻³ HCl at room temperature.

- Write the balanced equation with state symbols.
- Decide the limiting and excess reagent.
- Calculate the no. of moles of leftover substance.
- Calculate volume of H₂ produced at room temperature.
- Calculate mass of one H₂ molecule.
- Calculate mass of MgCl₂ produced.
- Calculate % yield for 2.3 MgCl₂(s) obtained.
- Calculate atom economy for MgCl₂.
- Calculate mass of H₂ produced.

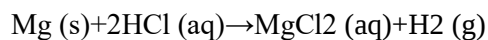
Let's solve this step by step using the data given.

Given: 9.00 g Mg added to **300 cm³** (i.e. 0.300 dm³ or 0.300 L) of **0.100 mol·dm⁻³ HCl** at room temperature (use 24.0 L·mol⁻¹ as molar gas volume at RTP).

Use Avogadro's number $N_A = 6.022 \times 10^{23}$

Atomic/molecular masses used (g·mol⁻¹): Mg = **24.305**, H = **1.008**, Cl = **35.453** → HCl = 36.461, MgCl₂ = 24.305 + 2×35.453 = **95.211**, H₂ = **2.016**.

a) Balanced equation (with state symbols)



b) Limiting and excess reagent

1. Moles of Mg:

$$\text{Moles of Mg} = \frac{9.00}{24.3} = 0.370 \text{ mol}$$

2. Moles of HCl:

$$\text{Mole of HCl} = cV = 0.100 \times 0.300 = 0.0300 \text{ mol}$$

Reaction requires 2 mol HCl per 1 mol Mg → required HCl for all Mg = $2 \times 0.370 = 0.741$, but only 0.0300 mol HCl is available.

→ HCl is limiting; Mg is in excess.

c) Number of moles of leftover substance

Moles HCl available = 0.0300 mol → this will be entirely consumed.

Moles Mg consumed = mole of HCl/2 = 0.0300/2 = 0.01500 mol

Moles Mg leftover = initial – consumed = 0.370294–0.01500=0.35529 mol

nMg (leftover)=0.355 mol

(If you prefer 3 s.f.: 0.355 mol.)

Mass of Mg leftover (optional) = 0.35537 × 24.3 = 8.64 g (≈ **8.64 g**).

d) Volume of H₂ produced at room temperature

Moles H₂ produced = moles Mg consumed (1:1) = **0.01500 mol**.

Volume:

Volume of H₂ = 0.01500 × 24.0 = 0.360 L = 360 cm³

e) Mass of one H₂ molecule

Rounded molar mass H₂ = **2.0 g·mol⁻¹**.

Mass per molecule:

Mass of one H₂ = 2.0 g ÷ 6.022×10²³= 3.321×10⁻²⁴ g

In kg:

3.321×10⁻²⁷ kg

Mass of one H₂ ≈ 3.32×10⁻²⁴ g (=3.32×10⁻²⁷ kg)

f) Mass of MgCl₂ produced (theoretical)

Moles MgCl₂ formed = moles Mg consumed = **0.01500 mol**.

Rounded molar mass MgCl₂ = 24.3 + 2(35.5) = 95.3 g/mol

Mass:

Mass of MgCl₂ = 0.01500 × 95.3 = 1.4295 g

Rounded (3 s.f.):

Mass of MgCl₂,theoretical ≈ 1.43 g

g) % yield if 2.3 g MgCl₂(s) obtained

$$\% \text{ yield} = \frac{\text{actual}}{\text{theoretical}} \times 100 = \frac{2.301}{1.4295} \times 100 \approx 160.9\%$$

Rounded:

$$\% \text{ yield} \approx 161\%$$

(>100% indicates experimental error or impurity — unchanged conclusion.)

h) Atom economy for MgCl₂

$$\text{Atom economy} = \frac{\text{Mr}(\text{desired})}{\sum \text{Mr}(\text{reactants})} \times 100\%$$

$$\text{Mr}(\text{MgCl}_2) = 95.3$$

$$\text{Reactants: Mg (24.3) + 2} \times \text{HCl (2} \times 36.5 = 73.0) \rightarrow \text{total} = 24.3 + 73.0 = 97.3$$

$$\text{Atom economy} = \frac{97.3}{95.3} \times 100\% = 97.9\%$$

i) Mass of H₂ produced

$$\text{Moles H}_2 = 0.01500 \text{ mol. Molar mass H}_2 \text{ (rounded)} = 2.0 \text{ g} \cdot \text{mol}^{-1}.$$

$$\text{Mass of H}_2 = 0.01500 \times 2.0 = 0.0300 \text{ g}$$

$$\text{Mass of H}_2 = 0.01500 \times 2.0 = 0.0300 \text{ g}$$

Quick results (rounded molar masses)

- Mole of Mg = 0.370 mol
- Mole of HCl = 0.0300 mol
- Limiting reagent: **HCl**; Mg in excess (0.355 mol left $\approx$ 8.64 g).
- Volume of H₂ = 0.360 L
- Mass of one H₂ molecule $\approx 3.32 \times 10^{-24}$ g
- Theoretical MgCl₂ = **1.43 g**; actual 2.30 g $\rightarrow$ **161% yield** (experimental error)
- Atom economy $\approx$ **97.9%**
- Mass H₂ produced $\approx$ **0.0300 g**