Question and Answer on Mole Calculations:

Solving this set of questions as an example:

9g of Mg added to 300 cm cube 0.1 mol dm/m^3 HCl at room temperature.

a) Write the balanced equation with state symbols.

b) Decide the limiting and excess reagent.

c) Calculate the no. of moles of leftover substance.

d) Calculate volume of H2 produced at room temperature.

e) Calculate mass of one H2 molecule.

f) Calculate mass of MgCl2 produced.

g) Calculate % yield for 2.3 MgCl2(s) obtained.

h) Calculate atom economy for MgCl2.

i) Calculate mass of H2 produced.

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

Given: 9.00 g Mg added to **300 cm^3** (i.e. 0.300 dm^3 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 NA = 6.022×10^{23}

Atomic/molecular masses used (g·mol^{-1}): Mg = **24.305**, H = **1.008**, Cl = **35.453** → HCl = 36.461, $MgCl_2$ = 24.305 + 2×35.453 = **95.211**, H_2 = **2.016**.

a) Balanced equation (with state symbols)

Mg (s)+2HCl (aq)→MgCl2 (aq)+H2 (g)

b) Limiting and excess reagent

1. Moles of Mg:

Moles of Mg = 9.0024.3 = 0.370 mol

2. Moles of HCl:

Mole of HCl = cV = 0.100×0.300 = 0.0300 mol

Reaction requires 2 mol HCl per 1 mol Mg → required HCl for all Mg = 2 × 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 H_2 produced at room temperature

Moles H_2 produced = moles Mg consumed (1:1) = **0.01500 mol**.

Volume:

Volume of H_2 = 0.01500 × 24.0 = 0.360 L = 360 cm^3

e) Mass of one H_2 molecule

Rounded molar mass H_2 = **2.0 g·mol^{-1}**.

Mass per molecule:

Mass of one H2 = 2.0 g ÷ 6.022×10^{23}= 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 $MgCl_2$ produced (theoretical)

Moles $MgCl_2$ formed = moles Mg consumed = **0.01500 mol**.

Rounded molar mass $MgCl_2$ = 24.3 + 2(35.5) = 95.3 g/mol

Mass:

Mass of $MgCl_2$ = 0.01500 × 95.3 = 1.4295 g

Rounded (3 s.f.):

Mass of MgCl2,theoretical ≈ 1.43 g

g) % yield if 2.3 g $MgCl_2(s)$ obtained

% yield = actualtheoretical × 100 = 2.301.4295 × 100 ≈ 160.9%

Rounded:

% yield ≈ 161%

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

h) Atom economy for $MgCl_2$

Atom economy =Mr(desired) ÷ ∑Mr(reactants) × 100%

Mr(MgCl2)=95.3

Reactants: Mg (24.3) + 2 × HCl (2×36.5 = 73.0) → total = 24.3 + 73.0 = 97.324.3 + 73.0 = 97.324.3 + 73.0 = 97.3

Atom economy=97.3 ÷ 95.3 × 100% = 97.9%

i) Mass of H_2 produced

Moles H_2 = 0.01500 mol. Molar mass H_2 (rounded) = 2.0 $g\cdot mol^{-1}$.

Mass of H_2 = 0.01500 × 2.0 =0.0300 g

Mass of H_2 = 0.01500 × 2.0 = 0.0300 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 ≈ 8.64 g).
- Volume of H_2=0.360 L
- Mass of one H_2 molecule ≈ 3.32×10^{-24} g
- Theoretical $MgCl_2$ = **1.43 g**; actual 2.30 g → **161% yield** (experimental error)
- Atom economy ≈ **97.9%**
- Mass H_2 produced ≈ **0.0300 g**