



Determining the volume of one mole of hydrogen gas

Learning objectives

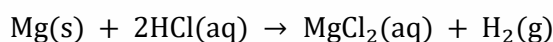
- 1 Measure the volume of hydrogen gas produced in a metal–acid reaction.
- 2 Analyse the results to determine the volume of one mole of a gas.
- 3 Evaluate the accuracy of the result obtained.

Introduction

One mole of any gas occupies the same volume when measured under the same conditions of temperature and pressure. At room temperature and pressure (RTP) this volume is 24.0 dm³ or 24,000 cm³.

In chemistry, room temperature and pressure are 20°C and 1 atmosphere.

Magnesium reacts with hydrochloric acid to produce a salt – magnesium chloride – and hydrogen gas.



In this experiment, you will measure the volume of hydrogen gas produced by the reaction of a known mass of magnesium with excess hydrochloric acid. You will then use the results to determine the volume of one mole of hydrogen gas at RTP.

Equipment

- Safety glasses
 - Burette
 - Burette stand
 - Beaker, 250 cm³
 - Funnel
 - Balance (minimum 2 d.p.)
 - Emery paper
 - Hydrochloric acid, 2.0 mol/dm³
 - Magnesium ribbon, 3.5 cm
- DANGER: flammable





Method

1. Clean a piece of magnesium ribbon by gently rubbing it with emery paper and measure its mass accurately. It should have a mass between 0.02 and 0.04 g. If not, adjust the amount used.
2. Measure 25 cm³ of 2.0 mol/dm³ hydrochloric acid into the burette. Slightly tilt the burette and carefully add 25 cm³ of water on top of the acid by running the water down the inside of the burette. Try not to disturb the acid layer.
3. Push the magnesium into the end of the burette so it will stay in position with its own tension.
4. Add 50 cm³ of water to a 250 cm³ beaker.
5. Quickly invert the burette into the water – your teacher will show you how to do this. If this is done quickly and carefully, very little liquid is lost. Clamp the burette vertically.
6. It is important that the liquid level in the burette starts on the graduated scale. If it is not on the scale, momentarily open the tap. This allows the level to drop.
7. Take the burette reading (*Remember*: the burette is upside down).
8. Observe the magnesium reacting as the acid diffuses downwards. Wait until all the magnesium has reacted.
9. Record the new volume in the burette (*Remember*: the burette is upside down).

Results

A	Mass of magnesium ribbon used (g)	
B	Initial burette reading (cm ³)	
C	Final burette reading (cm ³)	
D	Volume of hydrogen produced (cm ³)	



Analysis

Follow the guidance to calculate the volume of one mole of hydrogen based on your results.

1. Complete the results table by calculating the volume of hydrogen gas produced. This is the difference between the two burette readings (**B** – **C** = **D**).
2. Calculate the amount in mol of Mg reacted. Use the equation:

$$\text{mol} = \frac{\text{mass in g}}{\text{RAM}}$$

Relative atomic mass (RAM) = 24.

3. From the balanced equation 1 mol of Mg produces 1 mol of H₂ gas.
Use this fact to write down the amount in mol of H₂ gas produced based on the amount in mol of Mg you reacted.

4. Calculate the volume of 1 mol of H₂ gas by dividing the volume measured by the amount in mol of H₂ produced.

$$\text{volume of 1 mol of H}_2 \text{ in cm}^3 = \frac{\text{volume measured in cm}^3}{\text{amount of H}_2 \text{ produced in mol}}$$

Volume of one mole of hydrogen gas = _____ cm³



Evaluation

1. Calculate the percentage difference between your value and the true value for the volume of one mole of gas at RTP. Use the equation:

$$\% \text{ difference} = \frac{\text{difference between the experimental value and the true value}}{\text{true value}} \times 100$$

Percentage difference = _____%

2. How close to the true value was the experimental value? Suggest two reasons for the difference.

3. How could you improve the experiment to obtain a more accurate value?



Further questions

Answer the following questions about the method used in this experiment.

4. Why was 25 cm³ of water added on top of the 2 mol/dm³ hydrochloric acid in the burette?

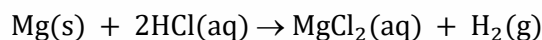
5. A student missed the instruction to take care not to disturb the acid layer in step 2 and mixed the acid and water prior to inverting the burette. Describe what impact this would have on the experiment.

6. Explain why it was important to use between 0.02 g and 0.04 g of magnesium ribbon.



Practice calculations

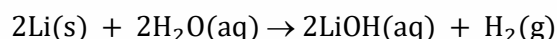
1. Magnesium reacts with acid to make a salt and hydrogen gas:



- (a) When 0.5 mol of magnesium is reacted with an excess of hydrochloric acid, how many moles of hydrogen are produced?

- (b) Calculate the amount in mol of hydrogen produced from the reaction of 6 g of magnesium with an excess of hydrochloric acid.

2. Lithium reacts with water to produce lithium hydroxide and hydrogen gas:



- (a) When 0.5 mol of lithium is reacted with an excess of water, how many moles of hydrogen are produced?

- (b) Calculate the amount in mol of hydrogen produced from the reaction of 14 g of lithium with an excess of hydrochloric acid.

3. If 0.05 mol of gas has a volume of 1200 cm³ at RTP, show by calculation that the volume of 1 mol of gas is 24,000 cm³.
