

Appendix 2

5. What is the volume of 1 mole of hydrogen gas? – Student Sheet

One mole of any gas occupies the same volume when measured under the same conditions of temperature and pressure. In this experiment you will calculate the volume of 1 mole of hydrogen at room temperature and pressure.

Intended lesson outcomes

By the end of this practical you should be able to:

- further develop skills in manipulating apparatus and accurate measurement;
- use the mole concept;
- calculate the molar volume at room temperature and pressure.

Background information




Magnesium reacts with acid to give a salt and water.

Question

- 1 Write the word and balanced equation for the reaction of magnesium with dilute hydrochloric acid.

If the mass of magnesium is measured, then the moles of magnesium can be calculated. Once this amount is known, you can use the equation you have written in Question 1 to calculate the moles of hydrogen that are produced. If the volume of this amount of hydrogen is measured, then you can calculate the volume of 1 mole, also known as the **molar volume**.

Safety

	You must wear eye protection throughout this experiment.
	Hydrochloric acid is corrosive . (Although the solution is very dilute, you should mop up any spillages and rinse any solution off your skin or clothing with water).
	Magnesium ribbon is highly flammable

Procedure

1. Clean a piece of magnesium ribbon about 3.5 cm long then weigh it accurately. This should weigh between 0.02 g and 0.04 g; if not, adjust the length of magnesium until it does.
2. Place about 30 cm³ 1M hydrochloric acid in the burette and top this up to 50 cm³ with water.
3. Push the magnesium into the top of the burette, above the liquid level, so that it is held by its own tension (see Fig. 5.1).
4. Add 50 cm³ of water to a crystallising dish.
5. Quickly invert the burette into the water. Provided you do this quickly and carefully, you will lose very little of the liquid in the burette. The liquid level should be on the graduated scale. If it is not, open the tap for a moment to allow the level to drop. Record the burette reading.

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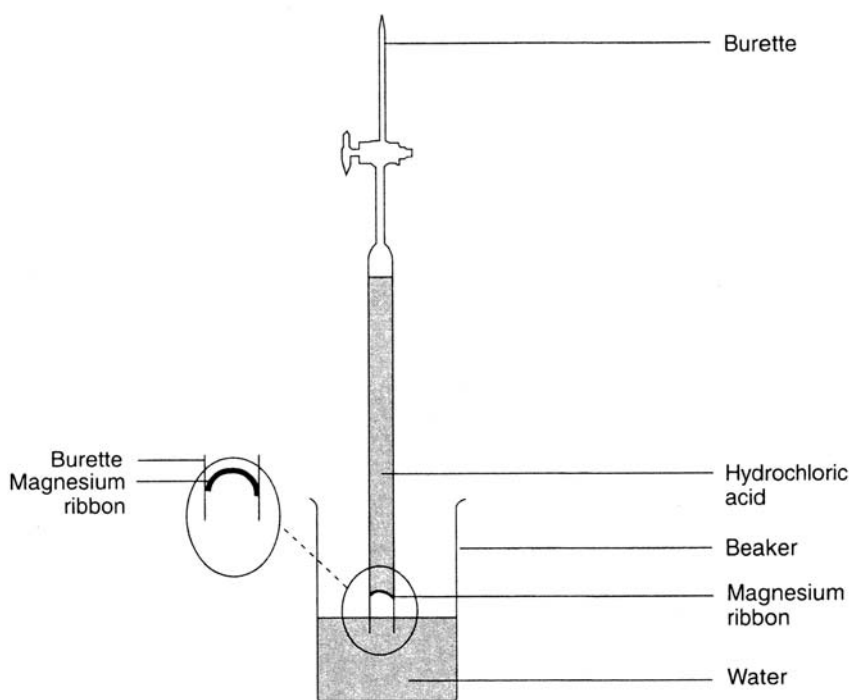


Figure 5.1

6. Clamp the burette and record the volume. Remember that the scale is now upside down.
7. Soon the acid will diffuse down to the magnesium and it will begin to react. When the magnesium has all reacted, note the new volume and calculate the volume of hydrogen produced.
8. Record the temperature of the laboratory.

Questions

- 2 (a) How many moles of magnesium did you use?
 (b) How many moles of hydrogen are produced? To calculate this you will need to refer to the equation you wrote in Question 1.
 (c) What is the volume of 1 mole of hydrogen gas at the temperature and pressure of the laboratory?
- 3 The general gas equation is $pV = nRT$, where p is the pressure, T is the temperature and R is the ideal gas constant. This can be used to calculate the volume of gas as standard temperature and pressure (s.t.p.). Since n , R and p stay the same, the equation for calculating this is

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Calculate the molar volume at s.t.p.

Appendix 2

5. What is the volume of 1 mole of hydrogen gas? – Teachers' Notes

In this practical students react magnesium quantitatively with hydrochloric acid. They collect the hydrogen gas and calculate the molar volume.

Learning outcomes

These are printed on the Student Sheet.

A suggested approach

Begin by explaining to students that the molar volume of any gas is always the same at the same temperature and pressure. In this experiment they are going to calculate this volume under room conditions. Inverting the burette safely and with little loss of liquid is not difficult but you will need to demonstrate the procedure before they start. Bring the lip of the crystallising dish up to the top of the burette and rest it there. Now swing the tap end round and upright. If the liquid level is not on the scale, open the tap momentarily to allow the liquid level to drop down to the scale. The actual practical should take approximately 30 minutes. There will then be time for students to do the calculations. Question 3 uses the general equation. If this has not been covered in theory, you may wish to give a very brief explanation, while saving a more rigorous explanation until later. The main point is that the volume of a gas varies in direct proportion to the temperature.

Technical information

Requirements per student/group:

Crystallising dish

50.0 cm³ burette

Clamp stand

1 mol dm⁻³ hydrochloric acid

0.02 g – 0.04 g standard magnesium ribbon (this is about 3.5 cm)

Thermometer

Safety

The main points are included on the Student Sheet but it is the teacher's responsibility to ensure that a full risk assessment is carried out prior to the practical session. MSDS sheets should be consulted so that the correct action can be taken in event of a spillage and/or accident.

Answers to questions on the Student Sheet

- 1 magnesium + hydrochloric acid → magnesium chloride + hydrogen
 $\text{Mg(s)} + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2\text{(aq)} + \text{H}_2\text{(g)}$
- 2 (a) Moles of Mg used = mass of Mg/ $A_r(\text{Mg})$
 It should be between 8.33×10^{-4} mol and 1.67×10^{-3} mol.
 (b) This depends on the moles of Mg used. It will be the same value as calculated in (a).
 (c) This will depend on the temperature and pressure of the room but students can expect an answer of approximately 24 dm³.
- 3 The volume at s.t.p. (0°C) will be approximately 22.4 dm³.