# Determination of the relative atomic mass of magnesium

## Aim

To calculate the relative atomic mass of magnesium metal. In this activity you will react magnesium metal with a known concentration of sulfuric acid and measure the volume of hydrogen gas produced. This will be used to calculate the relative atomic mass of the metal.

Time required for activity: 1 hour

## Introduction

Magnesium is a reactive Group 2 metal that readily reacts with sulfuric acid, hydrogen is produced in this reaction.

magnesium + sulfuric acid → magnesium sulfate + hydrogen

You will use a known concentration of sulfuric acid. By collecting and accurately measuring the volume of gas and the mass of magnesium used, the relative atomic mass of magnesium can be calculated. You will use the relationships between moles and gas volume, and moles and mass you have studied.

## Specification Content Links

Chemistry A H432: 2.1.3(a); 2.1.3(b); 2.1.3(c); 2.1.3(e); 2.1.3(f); 2.1.3(g); 2.1.3(i)

Chemistry B H433: EL(b)(i); EL(b)(ii); DF(a)

## Health and Safety

The 1.00moldm–3 sulfuric acid causes skin and serious eye irritation so make sure you wear eye protection at all times. See the following [CLEAPSS student safety sheet](https://science.cleapss.org.uk/resource/sss022-sulfuric-vi-acid.pdf).

The hydrogen gas produced in the reaction is flammable so make sure that there are no naked flames in the laboratory.

## Equipment

* eye protection
* access to a balance reading to at least two decimal places
* conical flask
* stopper and delivery tube
* measuring cylinder (250 cm3)
* trough
* stands, bosses and clamps
* measuring cylinder (50 cm3)
* 1.00 mol dm–3 aqueous sulfuric(VI) acid, H2SO4(aq)
* magnesium ribbon

magnesium

H2SO4(aq)

250 cm3 measuring cylinder

**Fig. 1** Equipment set up for measurement of gas volume.

| Procedure | Understanding |
| --- | --- |
| 1. Set up the apparatus as shown in Fig. 1.

Clamp the conical flask and 250 cm3 measuring cylinder in place. | Read through the procedure thoroughly before you begin. Why is it important to consider the capacity of the measuring cylinder used to collect the gas? Explain how you would choose the appropriate size.  |
| 1. Using a measuring cylinder, add 50.0cm3 of 1.00moldm–3 aqueous sulfuric acid (an excess) to the conical flask.
 | The acid must be in excess, why is this? How could you check that an excess is being used?  |
| 1. Weigh accurately between 0.12g and 0.16g of magnesium. Record the exact mass of magnesium using an appropriate format.
 | Why do you need to know the exact mass of magnesium used for the reaction? What is the error on the balance being used? How can you calculate the error in this measurement?  |
| 1. Remove the stopper, add the magnesium to the flask and quickly replace the stopper.
 | Why is it important to replace the stopper quickly? How could this impact the calculation of the relative atomic mass?  |
| 1. Collect the gas and record the final volume of hydrogen.
 | How will you know when the reaction is complete?Why is it important to allow the reaction to reach completion?  |

## Analysis

1. Using the equation below, deduce the amount, in moles, of magnesium that was reacted:

Mg(s) + H2SO4(aq) → MgSO4(aq) + H2(g)

1. Using the moles of magnesium reacted, calculate the relative atomic mass of magnesium.

### Practical skills, apparatus and techniques assessed

| a | Reference | Description of skill/technique |
| --- | --- | --- |
|  | 1.2.1 (b) | Identified hazards and was able to minimise risks.Safely and correctly completed activity. |
|  | 1.2.1 (c) | Followed written instructions without guidance. |
|  | 1.2.1 (d) | Measure gas volume measurements in cm3. Keep contemporaneous record of measurements.  |
|  | 1.2.1 (e) | Recorded results in appropriate table.Recorded subsequent calculations using raw data. |
|  | 1.2.1 (f) | Results presented in scientific way, including headings and units in tables. Recorded results using appropriate units. |
|  | 1.2.1 (j) | Demonstrated competency in recording gas volumes using a measuring cylinder.  |
|  | 1.2.2 (a) | Used appropriate apparatus to record volume. |
|  | 1.2.2 (k) | Safely and carefully handled the sulfuric acid.  |

## Extension Questions and Further Investigations

1. When you add the magnesium, you are introducing two errors: one results in a smaller volume of gas and the other a larger volume of gas.
2. What are these errors and what effects do they have on the calculated relative atomic mass of magnesium? Calculate the percentage uncertainties in the measurements that you have made. Identify the most significant uncertainty and how this could be reduced.
3. Plan a modification to this experiment so that the magnesium and acid can be mixed with no/minimal error in the measured volume of gas.
4. You have assumed room temperature and pressure.
5. Plan and, if you have time, repeat the experiment measuring the actual temperature and pressure. Repeat the analysis, making use of the ideal gas equation.
6. An alternative method for determining the relative atomic mass of magnesium involves purification of the magnesium sulfate synthesised. Discuss what hazards would be involved in this purification.

An alternative method for determining the relative atomic mass of magnesium involves reacting magnesium oxide with sulfuric acid, evaporating the resulting solution to obtain magnesium sulfate and using the mass of the product to calculate the value for Ar­. This alternative method could be carried out as an extension activity. You could then compare the results from both methods and the potential sources of error. Links are provided for information on the alternative method at the end of this document.

## Scientific and Practical Understanding

Relative atomic mass is calculated using the following equation:

$$relative atomic mass = \frac{mass (g)}{moles}$$

In this activity you measured the volume of hydrogen gas produced when reaction of magnesium metal reacted with sulfuric acid. So, before the relative atomic mass of the metal can be calculated the number of moles that have reacted must be deduced by looking at the stoichiometry in the balanced equation for the reaction. The number of moles of hydrogen can be found from the molar gas volume as follows:



The number of moles of magnesium that reacted can then be deduced and the relative atomic mass calculated from the equation above.

To determine the volume of the displaced water accurately, it is important to use an appropriately sized measuring cylinder. The larger the capacity of the measuring device, generally the lower the resolution of the measuring scale so you should choose a cylinder that is the next largest available compared to the expected total volume of gas to be produced.

When measuring mass, an electronic mass balance can be used to determine the mass of an object. Often a laboratory mass balance will have a resolution of 0.1g (or even 0.01g). When recording mass readings, trailing zeros after the decimal point should be recorded, as these indicate the instrument resolution.

## Notes and References

You can use a gas syringe, rather than a measuring cylinder, to collect the gas evolved in the reaction. If the common 100 cm3 gas syringe is used, the mass of magnesium used will need to be halved. A balance that reads to three decimal places would then be recommended to reduce the uncertainty in mass measurements given by a two decimal place balance.

Alternative method for determination of the relative atomic mass of magnesium:

[Preparing salts by neutralisation of oxides and carbonates](https://edu.rsc.org/experiments/preparing-salts-by-neutralisation-of-oxides-and-carbonates/1762.article)

[Formula Determination - Teacher Guidance](https://ocr.org.uk/Images/170201-determination-of-the-formula-of-hydrated-magnesium-sulfate-activity-teacher-instructions.pdf)

If this alternative method is carried out insteadof the method described in the main method provided here, students must be given an alternative activity in which to demonstrate the technique of measuring volume of gas.

Health and safety should always be considered before undertaking any practical work. A full risk assessment of any activity should always be undertaken. It is advisable to check the [CLEAPSS website](http://www.cleapss.org.uk/) in advance of undertaking the practical tasks.

We recommend that this practical is trialled in advance of giving it to students. Keep trial results as part of centre records for assessing the Practical Endorsement.