

# [The empirical formula of magnesium oxide essay sample](https://assignbuster.com/the-empirical-formula-of-magnesium-oxide-essay-sample/)

Experimental Design

Focus Question

What is the empirical formula for magnesium oxide?

Hypothesis

The combustion of magnesium will generate data which can be used to calculate the empirical formula of magnesium oxide.

Theory

The following combination reaction was used in this experiment:

Magnesium + Oxygen ï¿½ Magnesium Oxide

The Law of Conservation of Mass can be used to determine the amount of oxygen which has reacted with a given amount of magnesium in order to produce a measured amount of magnesium oxide. These masses can then be converted into moles in order to determine the simplest molar ratio and thus the empirical formula for magnesium oxide.

Variables

Variables identified

Type of variable

Treatment

Amount of magnesium used

Independent variable

Different groups will use different masses. Masses will be small enough to ensure that the reaction can occur without requiring the lid to be lifted too often.

Mass of magnesium oxide

Dependent Variable

The mass of this product will be measured after it has been observed that no further reaction will occur.

Container used

Controlled Variable

A crucible with a lid will be used in order to allow the combustion in a closed environment, preventing the loss of magnesium oxide powder.

Surface area of magnesium

Controlled Variable

Magnesium ribbon will be used in all cases.

Concentration of oxygen in the container

Controlled Variable

The experiments will all be performed on the same day, in the same laboratory, i. e., the atmospheric conditions and oxygen concentration will be the same.

Temperature of flame

Controlled Variable

A blue flame will be used in all cases, using the same burner with the air hole completely open.

Apparatus and Materials

\* Crucible and lid (1)

\* Mg ribbon (1)

\* Tripod stand (1)

\* Bunsen Burner (1)

\* Crucible tongs (1)

\* Clay triangle (1)

\* 0. 001g Electronic scale (1)

Safety Aspects

Safety Concern

Risk

Precaution

MSDS reference

Burning magnesium

Eye damage

Do not look at the burning Mg for prolonged periods of time.

Burning magnesium

Inhalation

Ensure that the room is well ventilated.

Hot apparatus

Skin damage

Use tongs to handle the crucible lid – do not attempt to weigh crucible until it is cool.

Protocol Diagram

Diagram 1 – apparatus as set up for Empirical Formula Experiment

Procedure

1. Zero the scales, weigh the crucible and lid and record the mass.

2. Loosely coil the magnesium ribbon and place into the crucible while on the scales. Replace the lid and record the mass.

3. Set up the Bunsen burner (as shown in the diagram above) by placing the clay triangle on the tripod.

4. Place the magnesium into the crucible and position it on the tripod stand using the clay triangle.

5. Close the hole on the Bunsen burner and light the burner.

6. Open the hole so that the Bunsen burner is on the blue flame and place the tripod (with the crucible in it) over the Bunsen burner.

7. Periodically lift the lid (using the tongs) to check if the reaction is complete.

8. When the reaction is finished turn off the Bunsen burner and allows the crucible to cool.

9. Once cooled, zero the scales and use the tongs to carefully place the crucible and lid on the scales. Record the mass.

10. Repeat steps 1 – 9 (OR collect results from other groups).

Experimental Report

Data Collection and Processing

Photograph of Lab Setup

Photo 1: Laboratory Setup

1. Crucible was used because magnesium could melt plastics when its temperature is high.

2. In order to prevent the crucible from falling through the tripod, a clay triangle was employed.

3. Bunsen burner was placed underneath the crucible so that the magnesium could be heated efficiently.

Qualitative Observation

Photo 2: Reaction taking place

At the beginning of the reaction, there were not any changes. Meanwhile, the lid was lifted twice. A few minutes later, the magnesium started glowing brilliantly (see the photo above). It glowed for a while until it stopped naturally. White powder was seen in the crucible.

Raw Data Table

\*Ms. Crook’s class’ data was used because the data obtained in Table 1 did not have enough dots to draw a graph.

Data Processing

Overview

In order to calculate the empirical formula of magnesium oxide, the net masses of magnesium, magnesium oxide and oxygen were first to be determined. To reach molar ratios, the number of moles of magnesium and oxygen were reached and simplified into the lowest whole number ratios. The empirical formula of magnesium oxide was then decided. During data processing, the percentage uncertainties associated with masses were found so that the percentage uncertainties of the number of moles were concluded. They were later converted into absolute uncertainties. A scatter graph was drawn to show the compositions of magnesium and oxygen within magnesium oxide. The percentage yield of magnesium oxide was also found.

Sample Calculation

Mass of magnesium, magnesium oxide, oxygen

The known: m(Crucible+lid)= 32. 144g, m(Crucible+lid+Mg)= 32. 230g, m(Crucible+lid+MgO)= 32. 287g

m(Mg)= m(Crucible+lid+Mg)- m(Crucible+lid)= 32. 230-32. 144= 0. 086g

m(MgO)= m(Crucible+lid+MgO)- m(Crucible+lid)= 32. 287-32. 144= 0. 143g

m(O)= m(MgO)- M(Mg)= 0. 143-0. 086= 0. 057g

Absolute uncertainties of the mass of magnesium, magnesium oxide and oxygen

Due to subtraction was employed, to calculate the net mass of magnesium and magnesium oxide, the absolute uncertainties were added. E. g., the absolute uncertainty of magnesium = ï¿½ (0. 001 + 0. 001) = ï¿½ 0. 002g

The mass of oxygen was reached by subtracting the mass of magnesium from the mass of magnesium oxide; thus, the absolute uncertainties of the mass of oxygen were the addition of the uncertainties of the mass of magnesium and magnesium oxide, i. e., the absolute uncertainty of oxygen = ï¿½ (0. 002 + 0. 002) = ï¿½ 0. 004g

No. of moles of magnesium, oxygen

The formula was employed, MM (Mg) = 24. 31g/mol, MM (O) = 16. 00g/mol, the masses has already been calculated above. Thus, substitute the values into the formula:

n(Mg)= 0. 086/24. 31= 3. 5\*10^-3mol

n(O)= 0. 057/16. 00= 3. 6\*10^-3mol

The results gained were rounded up to 3 decimals so that they are consistent with the absolute uncertainties.

Percentage uncertainties associated with masses and number of moles

Due to division was employed; the absolute uncertainties of the mass of each element have to be converted into percentage uncertainties so that they could be added together.

% uncertainty (Mg)= absolute uncertainty/measurement\*100%

= 0. 002/0. 086\*100%

= 2. 3%= 2%

The uncertainty was rounded up to 1 significant figure because uncertainties cannot be more precise than its measurement.

There was no percentage uncertainties involved in molar mass. Consequently, the percentage uncertainty of the mass becomes the percentage uncertainty of the number of moles.

Conversion of the uncertainties

In the end, the absolute uncertainties of the number of moles were accessed.

Absolute uncertainty (Mg)= ï¿½ actual measurement\*percentage uncertainty (Mg)

=  3. 5\*10^-3mol\*2% = ï¿½ 7\*10^-5

Simplest molar ratios

r= n(Mg): n(O)

=(3. 5\*10^-3/3. 5\*10^-3):(3. 6\*10^-3/3. 5\*10^-3)

= 1: 1. 0

= 1: 1

The empirical formula of magnesium

1 1

MgO

Percentage yield of magnesium oxide

To find out how much magnesium has reacted with oxygen to produce the magnesium oxide, the percentage yield was determined.

Percentage yield = actual mass of the product/ theoretical mass of the product \* 100%

Theoretical mass = number of moles of the product \* molar mass

According to the balanced equation: 2Mg + O2  2MgO, it can be deduced that 1 mole of magnesium with excess oxygen will produce 1 mole of magnesium oxide.

Therefore, if n (Mg) = 0. 006 mol, actual m (Mg) = 0. 221g,

n (MgO) = n (Mg) = 0. 006 mol

Theoretical mass (MgO) = 0. oo6\*(24. 31+16. 00) = 0. 247g

Percentage yield = 0. 221/ 0. 247 \* 100% = 89%

Only 89% of the magnesium reacted with the oxygen.

Presentation

\*The percentage uncertainties of the number of moles were the percentage uncertainties of the mass of each element (explained in Sample Calculation Section). The final value was the greatest percentage errors in Table 2.

\*The values of some of the absolute uncertainties are 0. 000. This does not mean that there were no uncertainties; it was only because the uncertainties were so small that when they were rounded up to 3 decimal places, they became 0. 000.

\*Trial 4 seemed to be anomalous. Thus, when calculating the average, the results from Trial 4 were excluded. It is noticed that Ave. of n (Mg) is 0. 006 and Ave. of n (O) is 0. 004; their ratio seems to be 3: 2. However, all the calculations were done by Excel and rounded up to 3 decimals. As a result, the Ave. ratio calculated is 1: 1.

\*Extrapolation was involved drawing the graph (magnesium: 0. 000 mol, oxygen: 0. 000 mol) since it is believed when there is no magnesium present, no oxygen will be reacting to form magnesium oxide.

This graph shows the relationship of the composition of magnesium and oxygen within the compound, magnesium oxide. It can be seen that the amount of magnesium is proportional to the amount of oxygen. The gradient of the line of best fit is 0. 6005. The positive gradient indicates that an increase in the amount of magnesium will result in a proportional increase in the amount of oxygen. There are outlier points in the graph. The most obvious one could have affected the value of the gradient. In addition, the correlation coefficient (R2) is 0. 5751, which is away from 1, indicating not all the points lie on the linear line.

This graph presents the same information as the graph shown above except that it excludes the most obvious outlier point (0. 006, 0. 001). As a result, the gradient increased (became 0. 694) and the R2 value got closer to 1.

Conclusion and Evaluation

Conclusion and Justification

According to the processed data, the hypothesis that the combustion of magnesium will generate data which can be used to calculate the empirical formula of magnesium oxide is supported because the molar ratios of magnesium and oxygen were managed. As it is shown in Table 3. 1, the average ratio of magnesium and oxygen is 1: 1, suggesting the empirical formula of magnesium oxide is MgO. However, it has to be noted that some of the results gained were controversial to each other, i. e., in one particular case, the calculated empirical formula of magnesium oxide is Mg4O. From Table 3 and Table 3. 1, the possible empirical formulas for magnesium oxygen were: MgO, Mg2O or Mg4O.

Theoretically, the empirical formula for magnesium oxide should be MgO because MgO is an ionic compound. When magnesium atoms and oxygen atoms react with each other, magnesium atoms lose 2 electrons to become Mg2+ (magnesium ions have a valence of 2+ charge) and oxygen ions gain 2 electrons to become O2- (oxygen ions have a valence of 2- charge). The outer shells of both ions will then be full so that they become stable like the noble gases. That is to say, the molar ratio of magnesium and oxygen should be 1: 1. Thus, the gradient of the scatter graph ought to be 1; though in the first graph the gradient is 0. 6.

After the elimination of the anomalous, the gradient became 0. 7 which is closer to 1. 0. It can be deduced that the off-true-value gradient was caused by some outlier points. From both Table 3. 1 and Graph 1, it can be seen that the absolute uncertainties of the mass and the number of moles of oxygen were extremely large, indicating the unreliability of the experiment results. Comparing to Graph 1, the correlation coefficient in Graph 2 improved after the outlier point was excluded, i. e., it became 0. 9, demonstrating that most of the dots lie on the linear line whose gradient is 0. 7. In addition, the percentage yield in Table 4. 1 shows the completion of the reaction. None of the results were close to 100%, suggesting magnesium did not react completely. Thus, the empirical formulas obtained were not accurate enough to determine the true formula.

In conclusion, the empirical formula of magnesium oxide can be calculated by the known; yet the accuracy may be affected by circumstances, such as the completion of the reaction. Nevertheless, the theoretical empirical formula of magnesium oxide is MgO.

Limitations of Experimental Design

Generally, the experiment went well since both qualitative and quantitative data had been produced. The empirical formula of magnesium oxide was deduced. Nonetheless, improvement can be made to achieve better results.

There were anomalies present (see Table 3 and Table 3. 1): one of the molar ratios calculated was 4: 1; some others were 2: 1. They were considered outlier points because they are off the true value which is 1: 1. The possible reasons could be: 1) the reactions were not fully completed; 2) the readings of the masses were incorrect since it took a while for the electronic balance to reach the real mass. Thus, if the experimenter did not wait till the readings stopped changing; the recorded data would be smaller than they were supposed to be. These could cause random errors. Another random error could be that when the crucible lid was lifted, the produced powdered magnesium oxide might have escaped the crucible. The mass would then be heavier than it was weighed. As shown on the graph, R2 (the correlation coefficient) equals to 0. 5751, indicating that the data was not very reliable since the value was away from 1. In addition, the data points did not spread out, i. e., they were gathering at 0. 004 to 0. 006 moles. Consequently, the gradient was influenced. The error bars were obviously significant, suggesting the recorded results were not precise.

Systematic errors could be caused by the precision of the equipment, e. g. the electronic balance. However, they can be avoided (see the next section).

Suggestions for Improvement

Limitation identified

Type of resultant error

(i. e., random or systematic)

Suggested method of improvement

Effects after the improvement

Completion of the reactions

Random error

Keep heating the crucible until the magnesium becomes white powder and stop glowing.

This allows magnesium to react with oxygen completely; random errors will be reduced.

Readings of masses

Random error

Wait until the readings stop changing; weigh at least 3 times to get an average.

Random errors reduced: the masses of the objects will be accurate.

Lid-lifting causing loss of mass of the products

Random error

Lift the lid every 3 minutes instead of irregular time intervals to ensure the reaction taking place thoroughly.

This prevents the reactants in the crucibles from escaping. Random errors reduced; thus, a more accurate empirical formula of magnesium oxide will be gained.

Experimenter’s lack of experience

Random error

Practice the procedures to perform the experiment, i. e., increase trials (3 trials) so that the experimenter will be familiar with the method.

Random errors reduced: fewer mistakes would be made during experimenting, such as weighing the masses; therefore, more accurate results, like the masses of the reagents can be obtained to draw better graphs.

Precision of the balance

Systematic error

The balance should be calibrated regularly.

The actual masses of the apparatus and reagents will be measured. No systematic errors will be involved.

Weighing the actual experimenting equipment and substances

Human error causing random error

\*In the experiment, it was required to weigh the mass of the crucible, its lid and magnesium oxide. It was observed that some of the products (white powder) left on the lid. If a different lid rather than the experimenting lid was taken to be weighed, then the results would be inaccurate because the lids have different masses.

Make sure there is only one set of each apparatus so that two pieces of the same apparatus will not be mistaken.

The actual magnesium oxide produced will be measured. No human errors will be involved; reduction of random error.