ROYAL SOCIETY OF CHEMISTRY

Conservation of Mass

Practical video

Supporting resources

Registered charity number: 207890

Contents

Teacher notes

These resources support the practical video **Conservation of mass**, available here: rsc.li/373X3aW

The value of experiencing live practical work cannot be overstated. Numerous studies provide evidence of its value in terms of student engagement, understanding, results and the likelihood of continuing to study chemistry or work in a related field. This video can be used to complement live practical work, as well as helping learners to understand the methods, equipment and skills when they cannot access the lab.

How to use this video

The video and additional resources are designed to be used flexibly, but some suggestions follow.

Flipped learning

Learners view the video ahead of the live practical lesson to help it run more smoothly and keep objectives in focus. This may also help build confidence for some learners and improve their outcomes in the lesson. Use questions from the set provided as part of the preparation task.

Consolidation and revision

Learners view the video after the practical – this may be directly after the lesson or students can return to it as part of revision for examinations.

Revisiting a practical with a different focus

A practical experiment can support many learning outcomes. Focussing on just one or two of those in a lesson will help ensure that the aims are achieved. The video could be used to revisit the experiment with a different focus.

Home learning

Whether it is remote teaching, homework, or individual learner absence, the video provides an opportunity to engage with a practical experiment and the associated skills when learners are not in the lab.

Other tips

- **Provide your own commentary**

  Mute the voice over and provide your own commentary. This will allow you to better engage with learners and adapt to the needs and objectives of your lesson.
- **Use questions**

  A set of pause-and-think questions are provided in two formats, one for teacher-led questions and discussion and a student worksheet which can be used independently by learners. Select from these or create your own questions to help engage learners and target specific aims.

Notes on running the practical experiments

Two practical experiments are shown in this video:

- the reaction of magnesium with oxygen
- the reaction of calcium carbonate with hydrochloric acid

Technician notes including the equipment list and safety notes are available as a separate document here: rsc.li/373X3aW. If you are planning to carry out the practicals in the classroom, you will need to carry out your own risk assessment.

The reaction of magnesium with oxygen takes around 30–45 minutes, depending on the competence of the class. To fit both activities into one hour in the laboratory it is possible to run both experiments concurrently. Once the crucible is being heated over a roaring blue flame in the first experiment, learners can begin the calcium carbonate with hydrochloric acid reaction. You should be able to complete the reaction in the conical flask before the magnesium has fully reacted. Learners can measure change of mass and clear away their glassware while waiting for the crucible to cool.

TIP: ***It is a good idea for learners to practice lifting the lid on and off the crucible and the crucible off the pipe clay triangle before they start. This has the added bonus of checking that all the tongs are functioning correctly.***

Procedure for the reaction of magnesium with oxygen

1. Take a piece of magnesium about 10–15 cm long. Twist it into a loose coil.
2. Put the magnesium inside the crucible and place the crucible with the lid on a mass balance. Record the total mass of the magnesium, crucible and lid.
3. Set up the Bunsen burner on the heat resistant mat with the tripod. Place the pipe clay triangle over the tripod, ensuring that it is secure. Place the crucible containing the magnesium in the pipe clay triangle and put the lid on.
4. Light the Bunsen burner and begin to heat the crucible. It is best to start with a gentle blue flame, but you will need to use a roaring flame (with the air hole fully open) to get the reaction to go.

   If you are going to complete the reaction of magnesium with oxygen and the reaction of calcium carbonate with hydrochloric acid concurrently then you can begin the second procedure here. You must make sure you continue to monitor the crucible and Bunsen burner.
5. Once the crucible is hot, gently lift the lid with the tongs a little to allow some oxygen to get in. You may see the magnesium begin to flare up. If the lid is off for too long then the magnesium oxide product will begin to escape. Avoid this.
6. Keep heating and lifting the lid until you see no further reaction.
7. Turn off the Bunsen burner and allow the apparatus to cool.
8. Place the crucible with lid containing the product onto a mass balance. Record the total mass of the crucible, lid and product.

Procedure for the reaction of calcium carbonate with hydrochloric acid

1. Measure out 20 cm^3 of hydrochloric acid in a measuring cylinder.
2. Place the 20 cm^3 hydrochloric acid into a 250 cm^3 conical flask.
3. Place this onto a mass balance. While the conical flask is still on the mass balance, add 2–3 marble chips to the top-pan. Record the total mass of the flask, acid and marble chips.
4. Add the marble chips to the conical flask.
5. Gently swirl the flask.
6. Record the mass after 3 minutes (or before if there is no more fizzing).

Integrated instructions

Printable integrated instructions are provided for learners. These are available as a separate download at rsc.li/373X3aW.

Integrated instructions use clear numbering, arrows and simple pictograms, like an eye to show where observations are required. These have been developed using cognitive load theory. Integrated instructions remove unnecessary information, and therefore reduce extraneous load on learners, increasing the capacity of their working memory to think about what they are doing and why. Read more about the use of integrated instructions here: rsc.li/2SdSqkQ.

Results tables

Printable results tables have been provided in two formats. The first set has space to record results from both the combustion of magnesium and the reaction of hydrochloric acid with marble chips. The second set has a third row to allow for the repeat of the hydrochloric acid and marble chip reaction in a closed system. Both versions of the table are available with and without headings.

Key terms

Learners will need to have a clear understanding of the following scientific terminology:

- conservation of mass
- reactant
- product
- state
- gas
- formula

An example Frayer model for the term 'conservation' is included in these resources. You can find more examples, and tips on how to use Frayer models in your teaching here: rsc.li/2WXtuAz.

Prior knowledge

Learners should be familiar with the particle model of matter from their 11–14 learning. They should be able to describe how the arrangement of particles changes as a substance moves between different states.

Learners should also be able to use the periodic table to identify symbols for elements and suggest formula for compounds. Learners should be confident writing word and symbol equations;

There are some questions included which ask learners to balance equations and add state symbols. Depending on where conservation of mass occurs in your scheme of work your learners may not have come across this yet. Adapt the questions to make them relevant to the stage and level that you are at.

Some of the challenge tasks require knowledge from other topics. It would be useful for learners to be able to recall the products of acid base reactions, in particular the general equation:

metal carbonate + acid → a salt + water + carbon dioxide

Common misconceptions

Learners sometimes get unconvincing results when heating magnesium in a crucible. It is worth evaluating what they have done as there are several reasons why their results may be disappointing:

- the magnesium oxide product may escape as they lift the lid
- not all the magnesium may have reacted (the product may still look a bit grey rather than white)
- they may have prodded the product with their splint so not all of it got weighed (more common than you might expect)
- not taring the balance correctly when measuring the mass
- having the magnesium coiled too tightly so that not all of it reacts

Some learners think that gases have no mass and that substances in their solid state have a greater mass than in their liquid form, confusing density with mass. Use carefully structured demonstrations to address these misunderstandings before introducing chemical changes that appear to violate the law of conservation of mass. Some examples of demonstrations can be found in the article 'How to teach conservation of mass' (see rsc.li/2XcHadN).

Diagnostic multiple-choice questions are a great way to explore learners' reasoning behind their answers. Best Evidence Science Teaching resources provide a great starting point to explore their ideas about conservation of mass. Students are given a question and multiple plausible explanations for an observation. They then choose and justify which explanation they agree with. You can also provide students with thought experiments and ask them to provide their own explanations (see the thinking questions resource). Read more about diagnostic questioning here: https://edu.rsc.org/ideas/how-to-use-multiple-choice-questions-for-formative-assessment/3007976.article. Best Evidence Science Teaching resources on the topic of Particles and structure can be found here: https://www.stem.org.uk/best/chemistry-earth-science/big-idea-particles-and-structure.

Intended outcomes

It is important that the purpose of each practical is clear from the outset, defining the intended learning outcomes helps to consolidate this. Outcomes can be categorised as hands on, what students are going to do with objects, and minds on, what students are going to do with ideas to show their understanding. We have offered some differentiated suggestions for this practical. You may wish to focus on just one or two, or make amendments based your students' own needs. (Read more at rsc.li/2JMvKa5.)

Consider how you can share outcomes and evaluation with learners, empowering them to direct their own learning.

	Hands on	Minds on
Effective at a lower level	**Students correctly:** • Light a Bunsen burner safely and use the appropriate flame • Follow instructions • Use a top pan balance • Handle equipment while hot	**Students can** • Record results in a table • Write a word equation for each reaction • Identify where the perceived change in mass has come from • Calculate change in mass
Effective at a higher level	**Students correctly:** • Lift the lid without losing any product • Judge when the reaction has completed • Suggest improvements to increase accuracy	**Students can:** • Record to an appropriate number of decimal places • Write a balanced symbol equation for each reaction • Explain why there is a perceived change in mass • Use change in mass calculations to work out the mass of the reactants

How to use the additional resources

Using the pause-and-think questions

Pause-and-think questions are supplied in two formats: a teacher version for 'live' questioning and a student version which can be used during independent study. The time stamps allow you to pause the video when presenting to a class, or learners to use for active revision.

The questions could also be used to support delivery of the experiment as a demonstration or class practical. Responses will help you to assess understanding and address misconceptions.

Teacher version

The questions are presented in a table and you can choose to use as many or as few questions as appropriate for your class and the learning objectives.

Some questions have two timestamps to allow you to adapt the questions for different classes or scenarios. Pause the videos at the earlier timestamp to ask a question before the answer is given, useful for revision or to challenge learners. Pause at the later timestamp to ask a question reflectively and assess whether learners have understood what they have just heard or seen. This would be useful when introducing a topic, in a flipped learning scenario or when additional support and encouragement is needed.

Think about how you will ask for responses. Variation may help to increase engagement – students could write and hold up short answers; more complex questions could be discussed in groups.

Not all answers to questions are included in the video. Some of the questions will draw on prior learning or extend learners' thinking beyond the video content.

Student version

The same questions are offered as a printable worksheet for learners. Use in situations where there is not a teacher present to guide discussion during the video, for example homework, revision or a remote learning environment.

Using the structure strips

Writing about chemistry encourages students to reflect on their understanding, formulate new ideas and make links between ideas in new ways. Students also need to practice for longer-answer questions in examinations. Structure strips provide scaffolded prompts and help overcome 'fear of the blank page'. The student sticks the strip into the margin of their exercise book or onto an A4 sheet of paper and writes alongside it. Use this long-answer question to consolidate learning after the practical and/or for revision. (Read more at rsc.li/2P0JDlW.)

Long-answer question:

A student has a conical flask containing 200 cm^3 of hydrogen peroxide.

They added the catalyst manganese oxide which speeds up the decomposition of hydrogen peroxide to water and oxygen. At the end of the reaction they observed that the mass of water produced was less than the mass of hydrogen peroxide they started with.

The student is concerned that the law conservation of mass does not work.

Explain how conservation of mass can still be applied even when there is an observed change in mass.

Using the follow-up worksheet

The follow up worksheet for this video develops mathematical skills and brings together other aspects of quantitative chemistry. There are two differentiated versions.

The support sheet is presented in a table format which helps to break down the stages of each calculation into smaller steps and appears less daunting for learners than a long list of questions. Guidance on how to structure the calculations are given in faded text to further support learners.

The challenge sheet is laid out linearly and includes an additional task which approaches calculations with molar values.

The questions in this follow up activity concentrate on the reaction of magnesium and oxygen. Learners could be further challenged to write their own questions and mark scheme based on the reaction of calcium carbonate with hydrochloric acid.

Additional resources

Frayer model: conservation

1. **What does the word conservation mean to you?**

   Where have you come across this word before?

2. **Definition of the word conservation.**

   Can you think of any words which are similar to conservation?

   Conserve = jam

Conservation

3. **Draw a simple diagram(s) to describe the word ‘conservation’ AND ‘conservation o**f mass’.

4. **Which of the following are correct uses of the words conservation and conserve?**

   We need to conserve the rainforests as they provide habitats for thousands of species.

   York Minster is currently being conserved because the old bricks are being replaced.

   In a chemical reaction mass is not lost or gained – it remains the same and is conserved.

   I had a conservation with my friends at lunch about the football at the weekend.

Available in landscape format as editable slide at rsc.li/373X3aW.

Pause-and-think questions

Teacher version

Timestamp(s)		Question	Answer/discussion points
00:00	00:30	What do you think is meant by the term ‘conservation of mass’? Write a definition in your own words or share your ideas with the class.	See the separate Frayer model as an example of how to explore learners’ ideas about ‘conservation’ before showing the video.
00:53		Write down or improve your definition. Try to include the words ‘reactants’ and ‘products’.	Mass (or matter) cannot be created or destroyed during a chemical reaction. Products and reactants will have the same mass.
01:12		How can you explain the conservation of mass when a liquid turns into a gas? Does steam have mass? What about oxygen gas?	Conservation of mass still applies even when there is a change in state. Gasses still contain the same number of atoms.
01:29		**Reaction of magnesium and oxygen**	
01:39	01:54	What is the name of the white powder formed when magnesium reacts with oxygen?	Magnesium oxide
02:06	02:11	Why does the crucible need a loose fitting lid?	To ensure that oxygen can get in and the reaction can complete.
02:13	02:20	Why is the magnesium in a loose curl?	It needs to be curled to fit in the base of the crucible but only loosely so that oxygen can still get to the surface of the metal.
02:32	02:43	Record the mass of magnesium and the crucible in the results table.	48.29 g Draw or use one of the printable results tables provided.
03:30	03:47	Why do we need to carefully lift the lid?	To allow oxygen into the crucible. To check that the reaction has completed. Carefully, to ensure that no product escapes.
04:05	04:11	Why is it important that we don’t lose any of the white powder?	Loss of the powder will reduce the final mass that we are trying to measure.
04:23		Record the final mass of the crucible in the results table.	48.36 g
		Is the final mass more than or less than the starting mass?	The mass has increased.
04:31		**Reaction of calcium carbonate with hydrochloric acid**	
04:52		When filling the measuring cylinder you must bend down to observe it at eye-level. Why?	A parallax error will occur if you read the measuring cylinder from above or below the level it is filled to. The measuring cylinder must be stood on a flat surface.
05:08		Record the mass of the marble chips and flask of acid in your results table.	80.60 g
05:14	05:23	What are the products of a reaction between hydrochloric acid and calcium carbonate? Can you write a word and balanced symbol equation?	Calcium chloride (salt), water and carbon dioxide

05:20 05:23	What do the bubbles forming tell us? Can you name the product? How could you test to see if you are right?	A gas is being released. The gas is carbon dioxide. Test by bubbling the product through limewater using a bung and delivery tube.
05:27	What is meant by ‘the reaction completes’?	One of the reactants is completely used up so the reaction ends.
05:36	There are some marble chips still visible in the beaker. What does this tell us about the reactants?	The calcium carbonate is in ‘excess’. The hydrochloric acid has all reacted.
05:39	How might the reaction have been different if we had used larger marble chips?	Larger chips of the same mass would have a smaller surface area to volume ratio. This would give a slower rate of reaction. The final mass should still be the same but it would take longer for the reaction to complete.
	Alternative: How might the reaction have been different if we had used powdered CaCO3? Less chips? More chips?	These would affect the rate of reaction but not the final change in mass.
05:44	Record the final mass in the results table.	80.13 g
	Is the final mass more than or less than the starting mass?	The mass has decreased.
05:48	**Calculating the change in mass**	
06:00	Complete the results table by calculating the change in mass (pause with equation on screen).	48.36 – 48.29 = +0.07 80.13 – 80.60 = -0.49
06:06 06:15	What does a positive/negative change in mass mean?	A positive change in mass means that we have observed an increase in mass. A negative change in mass means that we have observed a decrease in mass.
07:00	Add state symbols to the symbol equation.	$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$
07:18	Add state symbols to the symbol equation.	$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$
08:11	Why does the sealed bag have the same mass before and after the reaction?	Because the closed system prevents the carbon dioxide from being lost to the surroundings. The mass of the gas is still included in the total mass of the sealed bag.
08:11	What would happen if the bag was opened?	The carbon dioxide gas would escape to the surroundings and the mass would decrease.
08:30	Please see the separate resource for a structure strip and suggested response to the following long-answer question:	
	A student has a conical flask containing 200 cm^3 of hydrogen peroxide. *They added the catalyst manganese oxide which speeds up the decomposition of hydrogen peroxide to water and oxygen. At the end of the reaction they observed that the mass of water produced was less than the mass of hydrogen peroxide they started with.* *The student is concerned that the law of conservation of mass does not work.* *Explain how conservation of mass can still be applied even when there is an observed change in mass.*	

Pause-and-think questions

Student version

Pause the video at the time stated to test or revise your knowledge of these practical experiments.

Time	Question
00:30	What does the word ‘conservation’ mean?
00:30	What do you think is meant by the term ‘conservation of mass’? Write a definition in your own words.
00:53	Improve your definition. Try to include the words ‘reactants’ and ‘products’.
01:39	What is the name of the white powder formed when magnesium reacts with oxygen?
02:11	Why does the crucible need a loose fitting lid?
02:20	Why is the magnesium in a loose curl?
03:47	Why do we need to carefully lift the lid?
04:11	Why is it important that we don’t lose any of the white powder?
04:23	Is the final mass more than or less than the starting mass?
04:52	When filling the measuring cylinder you must stand with it at eye-level. Why?

05:14 What are the products of a reaction between hydrochloric acid and calcium carbonate?

____

Can you write a word and balanced symbol equation for this reaction?

_______________ + _______________ → _______________ + _________ + ____________

_________ + _________ → __________ + __________+ __________

05:20 What do the bubbles forming tell us?

____

Can you name the product?

____

05:27 What is meant by 'the reaction completes'?

____

____

____

05:36 There are some marble chips still visible in the beaker. What does this tell us about the reactants?

____

____

05:39 How might the reaction have been different if we had used larger marble chips?

____

____

05:44 Is the final mass more or less than the starting mass?

____

06:00 Complete the results table:

reaction	**total mass before (g)**	**total mass after (g)**	**change in mass (g)**
magnesium and oxygen	48.29	48.36	
calcium carbonate and hydrochloric acid	80.60	80.13	

change in mass (g) = total mass after (g) – total mass before (g)

06:06 What does a positive or negative change in mass mean?

____

____

____

07:00 Add state symbols to the symbol equation:

$2Mg$ ☐ + O_2 ☐ → $2MgO$ ☐

07:18 Add state symbols to the symbol equation:

$CaCO_3$ ☐ + $2HCl$ ☐ → $CaCl_2$ ☐ + CO_2 ☐ + H_2O ☐

08:11 Why does the sealed bag have the same mass before and after the reaction?

____

____

____

What would happen to the mass if the bag was now opened?

____

08:30 Now try writing a longer answer to this question using the structure strips:

A student has a conical flask containing 200 cm^3 of hydrogen peroxide.

They added the catalyst manganese oxide which speeds up the decomposition of hydrogen peroxide to water and oxygen. At the end of the reaction they observed that the mass of water produced was less than the mass of hydrogen peroxide they started with.

The student is concerned that the law of conservation of mass does not work.

Explain how conservation of mass can still be applied even when there is an observed change in mass.

Conservation of mass Structure strip	**Conservation of mass Structure strip**	**Conservation of mass Structure strip**	**Conservation of mass Structure strip**	**Conservation of mass Structure strip**
Define what is meant by ‘conservation of mass’.	Define what is meant by ‘conservation of mass’.	Define what is meant by ‘conservation of mass’.	Define what is meant by ‘conservation of mass’.	Define what is meant by ‘conservation of mass’.
Describe an open and closed system.	Describe an open and closed system.	Describe an open and closed system.	Describe an open and closed system.	Describe an open and closed system.
State the products of the decomposition of hydrogen peroxide.	State the products of the decomposition of hydrogen peroxide.	State the products of the decomposition of hydrogen peroxide.	State the products of the decomposition of hydrogen peroxide.	State the products of the decomposition of hydrogen peroxide.
Compare the states of matter of the reactants and products.	Compare the states of matter of the reactants and products.	Compare the states of matter of the reactants and products.	Compare the states of matter of the reactants and products.	Compare the states of matter of the reactants and products.
Explain why an observed change in mass has occurred.	Explain why an observed change in mass has occurred.	Explain why an observed change in mass has occurred.	Explain why an observed change in mass has occurred.	Explain why an observed change in mass has occurred.
Suggest an improvement to the method or equipment which would allow the law of conservation of mass to be observed.	Suggest an improvement to the method or equipment which would allow the law of conservation of mass to be observed.	Suggest an improvement to the method or equipment which would allow the law of conservation of mass to be observed.	Suggest an improvement to the method or equipment which would allow the law of conservation of mass to be observed.	Suggest an improvement to the method or equipment which would allow the law of conservation of mass to be observed.

Structure strip: suggested answer content

Conservation of mass Structure strip	
Define what is meant by 'conservation of mass'.	The law of conservation of mass states that mass is always conserved during a chemical reaction. Mass cannot be created or destroyed during a reaction. This means that the total mass of the reactants before a reaction will be the same as the total mass of the products after the reaction. The total number of atoms remains the same but they are rearranged to make new products.
Describe an open and closed system.	An open system is one in which energy and matter can pass easily to and from the surroundings. A closed system does not allow any mass or energy to escape. In a closed system you will be able to easily observe the conservation of mass. Reactions in an open system may appear to violate the law of conservation of mass.
State the products of the decomposition of hydrogen peroxide.	Hydrogen peroxide slowly decomposes to form the products water and oxygen. Manganese oxide acts as a catalyst in this reaction. This means that it speeds up the decomposition of hydrogen peroxide while undergoing no change itself and so its mass remains constant.
Compare the states of matter of the reactants and products.	Hydrogen peroxide is a liquid at room temperature. The decomposition reaction is exothermic, but does not give off enough heat to vaporise the water therefore the products of the reaction are liquid water and oxygen gas. This can be shown by using state symbols in the word equation: Hydrogen peroxide (aq)* → water (l) + oxygen (g) *The state symbol for hydrogen peroxide is aq because we do not use 100% hydrogen peroxide by volume. However, do not reduce marks if a learner uses the symbol (l) in their answer.
Explain why an observed change in mass has occurred.	In an open system there will be an observed change in mass during this reaction. The total mass of the water and manganese oxide at the end of the reaction will be less than the total mass of the hydrogen peroxide and manganese oxide before the reaction. Since the manganese oxide is unchanged the loss of mass has to have occurred during the decomposition. Since the oxygen is in a gaseous state and the reaction occurred in an open system we can account for the loss in mass because the oxygen has dissipated into the surroundings. Therefore the loss in mass is equal to the mass of oxygen produced.
Suggest an improvement to the method or equipment which would allow the law of conservation of mass to be observed.	In order to be able to observe the law of conservation of mass you need to prevent the oxygen from escaping into the surroundings. There are a number of methods you could use to collect the oxygen gas. You could attach a balloon to the neck of the flask or complete the reaction inside a sealed bag. Alternatively, you could connect the conical flask to a gas syringe using a rubber bung and delivery tube. This way you could measure the volume of gas collected and use that to calculate the mass.

Follow-up worksheet: calculations (support)

<table>
<tr><td colspan="6">1. Write a balanced symbol equation for the following reaction:</td></tr>
<tr><td colspan="6">magnesium + oxygen → magnesium oxide
___Mg + ___O_2 → ___MgO</td></tr>
<tr><td>2. What is the atomic mass of Mg?</td><td></td><td>3. What is the relative formula mass of O_2?</td><td>16 x 2 =</td><td>4. What is the relative formula mass of MgO?</td><td>24 + 16 =</td></tr>
<tr><td colspan="3">5. What is the mass of magnesium that would react with 1 g of oxygen?</td><td colspan="3">(2 x RAM of Mg) / RFM of O_2
(2 x _____) ÷ ______ = _________
___________ g</td></tr>
<tr><td colspan="3">6. What is the mass of magnesium oxide that would be produced from 1 g of oxygen?</td><td colspan="3">(2 x RFM of MgO) / RFM of O_2
(2 x _____) ÷ ______ = _______
___________ g</td></tr>
<tr><td colspan="6">A magnesium strip was heated in a crucible over a Bunsen flame. The total mass of the crucible and magnesium before was 48.29 g. The total mass of the crucible and magnesium oxide after was 48.36 g.</td></tr>
<tr><td colspan="6">Change in mass (g) = total mass after (g) – total mass before (g)</td></tr>
<tr><td colspan="2">7. What is the change in mass?</td><td>_____ - ______=
________ g</td><td colspan="2">8. What is the mass of oxygen that combined with magnesium in this reaction?</td><td>_________ g</td></tr>
<tr><td colspan="6">9. What is the mass of a magnesium strip that would have completely reacted to produce that change in mass?</td></tr>
<tr><td colspan="6">Mass of Mg that would react with 1 g of O_2 (Q5) x mass of O_2 (Q8)
_______ x _______ = ______
=_________ g</td></tr>
<tr><td colspan="6">10. What is the mass of magnesium oxide that would be produced from 0.07 g of oxygen?</td></tr>
<tr><td colspan="3">Mass of MgO that would be produced from 1 g of O_2 (Q6) x mass of O_2 (Q8)
_______ x _______ = ________
=_______ g</td><td colspan="3">Or alternatively, mass of Mg strip calculated in Q9 + mass of oxygen (Q8)
_______ + _______ = ________
=_______ g</td></tr>
<tr><td colspan="6">The actual mass of the magnesium strip that was added to the crucible was 0.13 g.</td></tr>
<tr><td>11. What should the theoretical change in mass have been?</td><td>(RFM of O_2 / 2 x RAM of Mg) x actual mass of Mg =
(____÷____) x
_____ = ______
= ________ g</td><td>12. What should the theoretical yield of magnesium oxide have been?</td><td>(RFM of MgO / RAM of Mg) x actual mass of Mg =
(____÷____) x
_____ = ______
=________ g</td><td>13. Was the actual change in mass smaller or larger than the theoretical change in mass?</td><td></td></tr>
<tr><td colspan="6">14. How can you account for the difference between the actual and the theoretical change?</td></tr>
<tr><td colspan="6"></td></tr>
</table>

Follow-up worksheet: calculations (challenge)

Part one: reacting masses approach

1. Write a balanced symbol equation for the following reaction:

   magnesium + oxygen → magnesium oxide

   ____

2. What is the atomic mass of Mg? ______________________________

3. What is the relative formula mass of O_2? ______________________________

4. What is the relative formula mass of MgO? ______________________________

5. What is the mass of magnesium that would react with 1 g of oxygen?

   ____

   ____

   ____

6. What is the mass of magnesium oxide that would be produced from 1 g of oxygen?

   ____

   ____

   ____

A magnesium strip was heated in a crucible over a Bunsen flame. The total mass of the crucible and magnesium before was 48.29 g. The total mass of the crucible and magnesium oxide after was 48.36 g.

7. What is the change in mass? ______________________________

8. What is the mass of oxygen that combined with magnesium in this reaction? ______________

9. What is the mass of a magnesium strip that would have completely reacted to produce that change in mass?

   ____

   ____

   ____

10. What is the mass of magnesium oxide that would be produced from 0.07 g of oxygen?

    ____

    ____

    ____

The actual mass of the magnesium strip that was added to the crucible was 0.13 g.

11. What should the theoretical change in mass have been?

    ____

    ____

    ____

12. What should the theoretical yield of magnesium oxide have been?

    ____

    ____

    ____

13. Was the actual change in mass smaller or larger than the theoretical change in mass that you calculated?

14. How might you account for the difference between the actual and the theoretical change?

Part two: mole calculations

Remember: number of moles = mass (g) / relative formula mass

15. In part one you worked out the mass of oxygen that combined with magnesium by calculating the change in mass (Q7 and Q8).

    How many moles of oxygen is this equal to?

16. What is the mass of 0.4 moles of magnesium oxide?

17. What is the mass of magnesium required to produce 0.4 moles of MgO?

18. The actual mass of the magnesium strip used in part 1 was given as 0.13 g. If the length of this strip was 8 cm, what length of magnesium strip would you need to make 0.4 moles of MgO?

Follow-up worksheet: calculations (support / challenge part one) ANSWERS

<table>
<tr><td colspan="6">1. Write a balanced symbol equation for the following reaction:</td></tr>
<tr><td colspan="6">magnesium + oxygen → magnesium oxide
2Mg + ___O_2 → **2**MgO</td></tr>
<tr><td>2. What is the atomic mass of Mg?</td><td>**24**</td><td>3. What is the relative formula mass of O_2?</td><td>**16 x 2 = 32**</td><td>4. What is the relative formula mass of MgO?</td><td>**24 + 16 = 40**</td></tr>
<tr><td colspan="3">5. What is the mass of magnesium that would react with 1 g of oxygen?
(RAM of Mg / RFM of O_2)</td><td colspan="3">**(2 x RAM of Mg) / RFM of O_2**
(2x24)/32 = 0.6857
= 1.50 g</td></tr>
<tr><td colspan="3">6. What is the mass of magnesium oxide that would be produced from 1 g of oxygen?</td><td colspan="3">**(2 x RFM of MgO) / RFM of O_2**
(2 x 40)/32 = 2.5
= 2.50 g</td></tr>
<tr><td colspan="6">A magnesium strip was heated in a crucible over a Bunsen flame. The total mass of the crucible and magnesium before was 48.29 g. The total mass of the crucible and magnesium oxide after was 48.36 g.</td></tr>
<tr><td colspan="6">**Change in mass (g) = total mass after (g) – total mass before (g)**</td></tr>
<tr><td colspan="2">7. What is the change in mass?</td><td>**48.36 - 48.29 = 0.07 g**</td><td colspan="2">8. What is the mass of oxygen that combined with magnesium in this reaction?</td><td>**0.07 g**</td></tr>
<tr><td colspan="6">9. What is the mass of a magnesium strip that would have completely reacted to produce that change in mass?</td></tr>
<tr><td colspan="6">**Mass of Mg that would react with 1 g of O_2 (Q5) x mass of O_2 (Q8)**
1.5 x 0.07 = 0.105
= 0.11 g</td></tr>
<tr><td colspan="6">10. What is the mass of magnesium oxide that would be produced from 0.07 g of oxygen?</td></tr>
<tr><td colspan="3">**Mass of MgO that would be produced from 1 g of O_2 (Q6) x mass of O_2 (Q8)**
2.50 x 0.07 = 0.175
= 0.18 g</td><td colspan="3">**Or alternatively,**
answer to mass of Mg strip calculated in Q9 + mass of oxygen (Q8)
0.11 + 0.07 = 0.18 g</td></tr>
<tr><td colspan="6">The actual mass of the magnesium strip that was added to the crucible was 0.13 g.</td></tr>
<tr><td>11. What should the theoretical change in mass have been?*</td><td>**RFM of O_2 / RAM of Mg =**
32/48 = 0.67
0.67 x 0.13 = 0.0871
= 0.09 g*</td><td>12. What should the theoretical yield of magnesium oxide have been?</td><td>**RFM of MgO / RAM of Mg =**
80/48 = 1.67
1.67 x 0.13 = 0.2171
= 0.22 g</td><td>13. Was the actual change in mass smaller or larger than the theoretical change in mass?</td><td>**0.07<0.09 smaller**</td></tr>
<tr><td colspan="6">14. How can you account for the difference between the actual and the theoretical change?</td></tr>
<tr><td colspan="6">• **Some of the product may have been lost to the surroundings when the crucible lid was lifted to let in the oxygen**
• **The reaction may not have gone to completion (some of the magnesium may not have fully reacted).**</td></tr>
</table>

*Note: learners using the challenge sheet may take a different approach to arrive at this answer

Part two: mole calculations

Remember: number of moles = mass (g) / relative formula mass

15. In part one you worked out the mass of oxygen that combined with magnesium by calculating the change in mass (Q7 and Q8).

    How many moles of oxygen is this equal to?

    Number of moles = mass (g) / relative formula mass

    = 0.07 / 32

    = 0.0021875

    = 0.0022 mol

16. What is the mass of 0.4 moles of magnesium oxide?

    mass = number of moles x relative formula mass

    = 0.4 x 40

    = 16.0 g

17. What is the mass of magnesium required to produce 0.4 moles of MgO?

    Method 1

    From the equation 2 moles of Mg produces 2 moles of MgO

    Therefore 0.4 moles of Mg produces 0.4 moles of MgO

    Mass of Mg = moles x RFM = 0.4 x 24 = 9.6 g

    Method 2

    To produce 1 g:

    Amount of magnesium = RAM of magnesium / RFM of magnesium oxide

    = 24 / 40 = 0.6 g

    To produce 16.0 g:

    0.6 x 16.0 = 9.6 g

18. The actual mass of the magnesium strip used in part 1 was given as 0.13 g. If the length of this strip was 8 cm, what length of magnesium strip would you need to make 0.4 moles of MgO?

    8 cm = 0.13 g

    0.08 m = 0.13 g

    Metres per gram: 0.08 / 0.13 = 0.62 m/g

    0.62 x 9.6 = 5.95 m

reaction	total mass before (g)	total mass after (g)	change in mass (g)
magnesium and oxygen			
calcium carbonate and hydrochloric acid			

change in mass (g) = total mass after (g) – total mass before (g)

reaction	total mass before (g)	total mass after (g)	change in mass (g)
magnesium and oxygen			
calcium carbonate and hydrochloric acid			

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reaction	total mass before (g)	total mass after (g)	change in mass (g)
magnesium and oxygen			
calcium carbonate and hydrochloric acid			
calcium carbonate and hydrochloric acid in a sealed bag			

change in mass (g) = total mass after (g) – total mass before (g)

reaction	total mass before (g)	total mass after (g)	change in mass (g)
magnesium and oxygen			
calcium carbonate and hydrochloric acid			
calcium carbonate and hydrochloric acid in a sealed bag			

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