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Excerpt
More Information

1 Planet Earth

This chapter contains investigations on:

- **1.1** Estimating the percentage of oxygen in the air
- **1.2** The effects of acid rain on metal
- **1.3** The effect of carbon dioxide on the atmosphere

Practical investigation 1.1 Estimating the percentage of oxygen in the air

Planning the investigation

This is a simple investigation that stretches over two lessons, which ideally need to be at least a week apart. The set-up and recording data sections should take no more than 20 minutes in each of the two lessons. A simple explanation of rusting will help students to understand where the oxygen is going in the tube. Students should understand that the volume of gas lost (the oxygen used in rusting) is replaced by an equal volume of water being drawn up the tube. As this is a short practical, it fits in well with the teacher demonstration of air being passed over heated copper (Activity 1.1 in the coursebook). By the end of this investigation, students should be able to state the composition of clean, dry air.

This investigation will focus on the following skills:

- AO3.1 Demonstrate knowledge of how to safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)
- AO3.3 Make and record observations, measurements and estimates
- AO3.4 Interpret and evaluate experimental observations and data.

Setting up for the investigation

Each group will require: iron wool, boiling tube, rubber bung, beaker (250 cm^3), measuring cylinder (25 cm^3), glass rod, permanent marker pen. See Figure 1.1. Students can complete the work alone or in pairs.

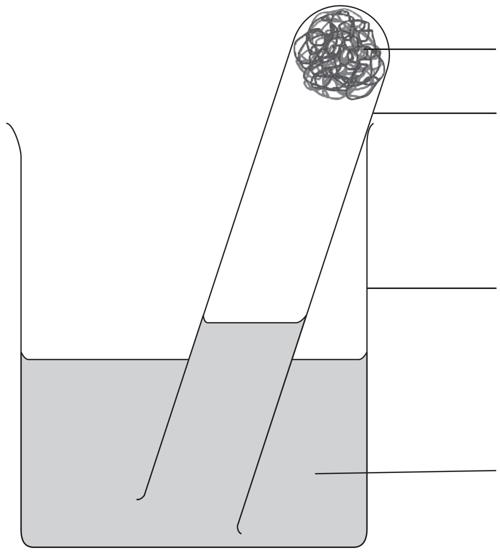

Figure 1.1

Safety considerations

There are no significant safety issues with this experiment other than glassware.

What could go wrong and how to avoid it / Common errors when conducting this investigation

Some students may struggle to invert the boiling tube or to remove the bung in the beaker once it is submerged in the water. A teacher demonstration may be useful. Likewise, ensure that the iron wool is packed in tightly at the end of the boiling tube and cannot fall down into the beaker.

Ensure that students do remove the bung from the end of the boiling tube. If the experiment is conducted in a warm environment, it is possible for the water in the beaker to evaporate, so the beakers may need to be topped up every few days to prevent them from drying out. If students do not add enough water to the boiling tube, the level of water inside may be below the water level in the beaker so they will not be able to draw a line with the marker. Tell students that, if this is the case, they will need to refill the boiling tube with more water from the beaker than before and try again.

How to support struggling students

The quantitative nature of the investigation can be simplified by getting the students to measure the distance between the bottom of the boiling tube and the lines that they make. They can then complete the data-handling section using these measurements rather than having to measure the volume.

How to stretch more able students

More able students can be tasked with collecting the data from the whole class and then calculating a class average. They can also assess whether any groups have anomalous data, giving reasons for their suggestions.

Opportunities for analysis/further discussion

In this investigation, iron is present in excess; how would there being less iron affect the results? A demonstration of air being passed over heated copper can be used to generate data with which to compare the students' results.

Scientific explanation

As the iron reacts with oxygen in the air it rusts and therefore removes the oxygen from inside the boiling tube. This results in a reduction in gas volume and therefore water from the beaker is drawn up the tube. The difference between the start and finish volumes represents the volume of oxygen in the air. The students should be able to estimate the percentage of oxygen in the air to be approximately 21 per cent.

Answers to workbook questions

1 Rusting, iron, iron oxide, oxygen, volume, water, difference

2 The iron wool will change colour from grey to red/brown.

3 Rusting is a slow reaction and so, if the tube is not left for a week, the reaction may not have ended. This would mean that there would still be oxygen in the tube.

4 A gas syringe would give more precise results.

5 Errors marking the lines, errors while measuring volume, reaction not yet complete.

6 Students might suggest a variety of methods, but the general idea should involve a substance that absorbs carbon dioxide (soda lime, sodium hydroxide, potassium hydroxide, etc.) and some closed container with a method of measuring the volume taken up. Very able students will recognise the need to use larger volumes as the percentage of carbon dioxide in the air is very small.

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Practical investigation 1.2 The effects of acid rain on metal

Planning the investigation

This is a simple investigation gathering qualitative data on the effect of acid rain on various metals. The set-up will take approximately 25 minutes but will need to be left and returned to at least a week later. The observation stage of the investigation should take no more than 5 minutes for each occasion. Ideally, the investigation should be left for longer than a week to allow corrosion to take place on all of the reactive metals. Students will need to understand that the sulfur dioxide in solution will produce sulfuric acid, which will evaporate and create an acid atmosphere inside the plastic box. It might be worth explaining the reactions of metals with acids in a simple form. By the end of this investigation, students should be able to state how sulfur dioxide from the combustion of fossil fuels, which contain sulfur compounds, leads to acid rain.

This investigation will focus on the following skills:

- AO3.1 Demonstrate knowledge of how to safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)
- AO3.3 Make and record observations, measurements and estimates
- AO3.4 Interpret and evaluate experimental observations and data
- AO3.5 Evaluate methods and suggest possible improvements.

Setting up for the investigation

Each group will require: zinc foil, tin foil, iron sheet, magnesium ribbon, copper foil, polystyrene foam sheet (approx. 1 cm thick), clear plastic box with tight-fitting lid, beaker (100 cm^3), scissors, measuring cylinder (50 cm^3), marker pen, sandpaper.

A well-sealed bottle of the sulfur dioxide solution should be placed in the fume cupboard and kept there. To make the solution: dissolve 9.5 g sodium metabisulfite in 100 cm^3 of water. Add 100 cm^3 of 0.5 mol/dm^3 sulfuric(VI) acid then make up to 250 cm^3. This needs to be made in a fume cupboard less than 24 hours before use.

Students can work in pairs or fours.

Safety considerations

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Eye protection must be worn throughout. The bottle of sulfur dioxide must be labelled TOXIC – sulfur dioxide will be given off. It is important that students do not remove the sulfur dioxide solution from the fume cupboard. Once the experiment is underway the plastic boxes must remain sealed. It is worth reminding students about this before the observation part of the investigation. Students with asthma or other breathing problems should not take part in the pouring of acid in the fume cupboard.

What could go wrong and how to avoid it / Common errors when conducting this investigation

The pieces of metal will fall over if they are not secured into the foam; ask students to test that these will not fall by tilting the plastic box. It may be necessary to control access to the fume cupboard and send the students in one group at a time. This will prevent overcrowding and allow a safer working environment. Close teacher supervision of the pouring of acid stage may be needed depending on the maturity of the class involved. Many of the metal strips will look similar and so, if possible, get the strips cut into different shapes so that it is possible to identify which metal each is made of. Students may struggle to identify the level of corrosion. It is important that clear plastic food container boxes are used to enable clear observation. The corrosion will take some time depending on the ambient temperature in the laboratory/classroom so very little may be observed after a week. Patience is required.

How to support struggling students

The experiment can be organised so that the group does not have to use all of the metals available. It is possible to set up the investigation in advance and allow it to run for a few weeks. This can then lead to students comparing the metals strips' appearance to the ones prepared by you. This will in effect speed up the whole process by removing the need for students to set up the experiment themselves and can work well with groups that might lack patience or the maturity to use the sulfur dioxide solution. With groups that cannot be trusted not to open the plastic box, it is possible for you to photograph the results and then invite comparison between the before and after appearance.

How to stretch more able students

Ask students to label using chemical symbols rather than names of metals. If possible, use a wider range of metals or ask them to predict what will happen to different metals based on the reactivity series. If time allows, students could complete the investigation they design at the end of the evaluation section looking at how to protect metals from acid rain. Students can write word or symbol equations for the reactions taking place on the metals that have corroded.

Opportunities for analysis/further discussion

The concept of protection can be investigated alongside ways of reducing the concentration of acid in the air.

Scientific explanation

The sulfuric acid solution creates an acid atmosphere inside the plastic box. The acid then reacts with the more reactive metals to form corrosion. The more reactive the metals are, the more they will corrode.

Answers to workbook questions

1. Dependent on student results, but magnesium and aluminium should show greatest corrosion.
2. Dependent on student results, but magnesium is most likely.
3. It is the most reactive, highest in the reactivity series.
4. Dependent on student results, but copper is least likely to corrode.
5. It is the least reactive, lowest in the reactivity series.
6. Painting, grease, covered in plastic, sacrificial protection, kept in dry environment
7. To remove grease or dirt that would reduce the effect of the acid / to remove oxidation layer that would protect the metal / to make sure the acid can come into contact with the surface of the metal
8. Painted, covered in grease, used only indoors
9. The concentration of acid rain in the atmosphere is much lower than inside the plastic box.
10. Repeated the experiment but used water instead of sulfur dioxide solution

Practical investigation 1.3 The effect of carbon dioxide on the atmosphere

Planning the investigation

This is a simple practical that will build on students' ability to take measurements using a thermometer. Students will need to understand that antacid tablets (that contain a carbonate) produce carbon dioxide when mixed with water. This can be demonstrated by bubbling the gas produced through some limewater. The set-up should take approximately 10 minutes, but it is important that students work quickly because the experiment needs to run for at least 45 minutes. By the end of this investigation, students should be able to state that carbon dioxide is a greenhouse gas and explain how it may contribute to climate change.

This investigation will focus on the following skills:

- AO3.1 Demonstrate knowledge of how to safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)
- AO3.3 Make and record observations, measurements and estimates
- AO3.5 Evaluate methods and suggest possible improvements.

Setting up for the investigation

Each group will need: two large clear plastic drinks bottles (at least 1.5 dm^3), two thermometers, two rubber bungs with holes for thermometers (or modelling clay), lamp, meter rule, measuring cylinder (1000 cm^3 or 500 cm^3), two antacid tablets, marker pen.

Students can work in pairs or threes.

Safety considerations

When it is left on for a long period of time, the lamp will become quite hot. If possible, the practical should be set up in an area away from where students will be working for the remainder of the lesson, for example on a windowsill. If possible, it is better to have the thermometers already inside the rubber bungs or modelling clay, as students may break them while trying to insert them.

What could go wrong and how to avoid it / Common errors when conducting this investigation

It is very important that the seal on the bottles is airtight: if the carbon dioxide escapes, the experiment will not provide good data. This is more of a problem when using modelling clay. Having the plastic bottle pre-labelled also avoids confusion.
Students can become distracted when adding the seltzer tablets and forget to add the bung. Some students may become excited by the effervescence of the antacid tablets and so will add more than the method calls for. It is also possible for students to forget to take the initial reading of the temperature.

How to support struggling students

A digital thermometer/data logger can be used to give readings that are easier for less able students to record. The teacher can demonstrate the practical with students helping at specific points. If the students might struggle using lamps, it is possible to place the bottles on a sunny windowsill or area in direct sunlight.

How to stretch more able students

It is possible to extend the practical to investigate how the mass of the antacid tablet affects the temperature change. The tablets can be crushed and weighed in masses of 1 g, 2 g and 3 g. Students can then design their own results table and plot a line graph for temperature changes.

Opportunities for analysis/further discussion

What is the relationship between carbon dioxide concentration and the temperature increase? Is there a point where increasing the carbon dioxide concentration has no further effect? A discussion around the limitations of the experimental model could take place. More able students may note that what is actually being measured here is that carbon dioxide has a high capacity to hold heat. In the case of the greenhouse effect, it is the reflected infrared radiation that is trapped by carbon dioxide.

Scientific explanation

When the antacid tablets are mixed with water, carbon dioxide gas is released. The carbon dioxide gas in the bottle absorbs infrared radiation from the lamp and so the bottle warms up more than the bottle with normal air.

Answers to workbook questions

1. Dependent on students' own results.
2. Carbon dioxide increases the temperature change.
3. Volume of bottle, volume of gas, time in lamp light, same light intensity, same distance from lamp, same volume of water in bottles
4. Pass gas through limewater. Colour change from clear to cloudy white.
5. If the bottle is closer to the lamp, the light intensity will be higher and this will affect the temperature change. Light intensity will no longer be a controlled variable.
6. The bottle placed closer would show a higher increase in temperature.
7. Crush and weigh the tablets then repeat the experiment for different masses of tablet. Alternatively, investigate half a tablet or one, two and three tablets to see if changing the mass of antacid affects the temperature change.

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Answers to exam-style questions

1 **a** Mark the tube every day until the volume of air inside remains constant. [1]

b Boiling tube/test-tube [1] / Beaker [1]

c 1 mark for each volume read correctly, 1 mark for each decrease in volume calculated.

Repeat	Gas syringe reading / cm^3	Decrease in volume / cm^3
1	69	31
2	71	29
3	76	24
4	64	36

d 30 [1] cm^3 [1]

e 0 [1] cm^3 [1]

Total [15]

2 **a** Silver is expensive. [1] / Silver is a soft metal. [1]

b Aluminium [1]

c Very corroded / more corrosion than aluminium / completely corroded / magnesium dissolves completely [1]

d Universal Indicator / pH meter / data logger with pH attachment [1]

e All points correctly plotted [3] –1 for each mistake.
Best-fit line or dot to dot [1]
Axis labels [1]

f Day 5 [1]

g Day 10 [1] Acidity decreased / lake became less acidic [1]

Total [13]

3 Control the type of metal (i.e. use only one). [1]
Then treat each strip with a different type of protection (the independent variable). [1]
Place in a container with acid rain. [1]
Observe after 1 or 2 weeks. [1]
Appropriate safety consideration (goggles / fume cupboard / not opening the container) [1]

Total [5]