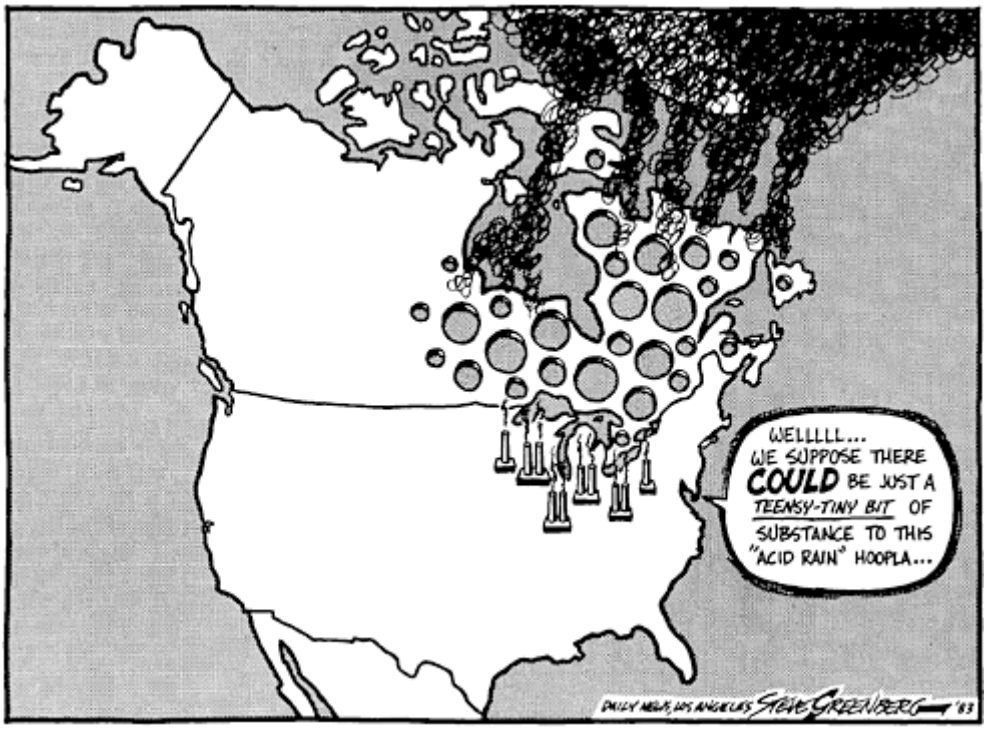
SALTUS GRAMMAR SCHOOL

S9 Science



Topic 9G – Environmental Chemistry

Name: .....

Class: ..... **Date:**.....

Summary

This unit looks at the effects of pollution – both natural and that caused by humans – with the emphasis on the causes and effects of acid rain. It goes on to look at ways of monitoring pollution and why this needs to be done, and concludes by looking at the evidence for global warming and some of its consequences.

Topic	Objectives
Natural Pollution	• Explain why rainwater is naturally acidic • Describe how a volcanic eruption can affect climate • Describe the effect of volcanic pollution on food chains
Acid Rain	• Explain what causes acid rain • Describe some of the effects of acid rain • Explain how acid rain can be reduced, and why we should do this
Monitoring Pollution	• Explain why air pollution needs to be monitored • Describe different ways in which air pollution can be monitored
Global Warming	• Describe the effects of carbon dioxide in the atmosphere • Explain what climate change means • Describe how climate predictions are made

This unit consists of about 10 lessons and a test, which is about 3 weeks work. Extension material is available. Additional notes and annotations are encouraged. This booklet and further resources can be found on BlackBoard. The syllabus is mainly based on the Exploring Science scheme, which is based on the UK National Curriculum. Material has been sourced from Exploring Science, Spotlight Science and CGP Books.

- Level ladder – for you to check off how you are doing
- Summary sheets – basic notes for revision
- Quick Quiz – revision aid, please use notes and text book to assist you!

Produced: November 2014

A – Natural Pollution

text ref: 80 - 81

Objectives:

- Explain why rainwater is naturally acidic
- Describe how a volcanic eruption can affect climate
  Describe the effect of volcanic pollution on food chains

Notes:

LAB – Acids and Alkalis

Can we find out if common solutions are acidic or alkaline?

Complete the following sentences, using words from the box.

colour	pH	indicator	alkaline

The _____ scale is used to measure how acidic or _____ a solution is. To test a solution we use an _____ that changes _____ as the pH changes.

Colour in the indicator chart below to show the colours of universal indicator at different pH values.

In this experiment you will investigate the pH of different solutions.

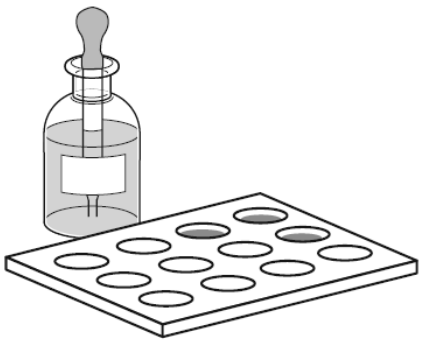
1	2	3	4	5	6	7	8	9	10	11	12	13	14

more acidic ← neutral → more alkaline

Apparatus

- some common solutions
- pipette
- universal indicator liquid and dropping pipette
- dimple tile
- eye protection

Wear eye protection. ⚠



Method

A Add a drop of a solution to a dimple in the tile.

B Add a drop of universal indicator to the dimple.

C Use a fresh dimple for each solution.

Recording your results

Solution	Colour of indicator	pH	Type of solution

I CAN...

- recall the meanings of acid, alkali and pH
- describe the pH of some common solutions.

RESEARCH – The Laki Eruption

The Laki volcano system in Iceland started to erupt in June 1783. As well as sulphur dioxide, the volcanoes gave off a lot of hydrogen fluoride and hydrogen chloride. Both these gases dissolve in water to form acids. Toxic fluoride compounds killed over half of the farm animals in Iceland and around a quarter of the human population died. The rest of Europe was also affected, as winds blew the sulphur dioxide across the rest of the continent.

Research

Find out more about the Laki eruption, using library resources or the internet. Here are some of the things you could find out about.

- Where is Iceland?
- How does sulphur dioxide kill people directly?
- How fast did the cloud of poisonous gas spread across Europe?
- Why did so many people die in Iceland? (*Hint:* It was not just because of poisonous gases.)
- What caused deaths in Europe? (*Hint:* It was not just the poisonous gas.)

Reporting your research

You can report your findings in one of the following ways:

- an encyclopaedia article
- a leaflet to be given to tourists visiting the Laki volcanoes or a display board to be used in a visitor centre
- a series of newspaper reports by an Icelandic reporter in 1783
- a series of newspaper reports by a reporter in the UK in 1783 (remember that it would have taken weeks for news to get from Iceland to the UK)
- an article for a modern scientific magazine, outlining what happened in 1783 and in the years following, and contrasting this with how scientists and governments might act today to reduce the number of deaths caused by the eruption.

Natural or Human?

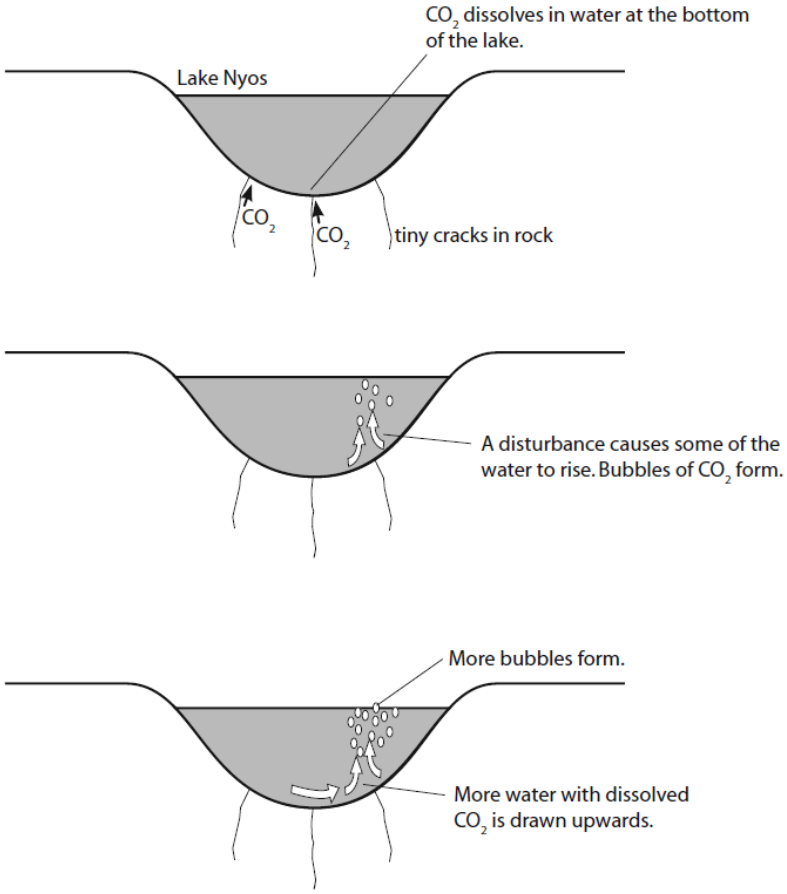
Some forms of pollution occur naturally but many forms are caused by human actions. The list below shows some different kinds of pollution. Tick the 'human' or 'natural' circle next to each one and explain your answer.

	Human	Natural
1 Pollen from wild flowers makes your eyes water.	◯	◯
2 Gases from a volcano dissolve in rainwater and the acidic rain kills plants.	◯	◯
3 Fires are being used to clear forest. The smoke makes it hard to breathe.	◯	◯
4 You walk past a field where cows are grazing. Pollen from the grass makes you sneeze.	◯	◯
5 Lightning starts a forest fire and the smoke makes it difficult for planes to land at a nearby airport.	◯	◯
6 A stream flowing out of an old mine has harmful chemicals in it.	◯	◯
7 There is a south wind and everything gets covered with a thin layer of sand blown over from the Sahara desert.	◯	◯

	Human	Natural
8 Rain washes fertiliser into a stream which affects the fish.	◯	◯
9 Buildings in a city turn black from soot in the air.	◯	◯
10 Dust and droplets of sulphuric acid from a volcano spread around the world in the air. This makes the weather cooler.	◯	◯

Natural or Human? (LAPTOP)

Lake Nyos is a small, deep lake in Cameroon, which is near the equator in Africa. It is only 1.5 km long and just under 1 km wide, and is 1000 m high on the slopes of an inactive volcano. In August 1986 a suffocating gas flooded into three villages near the lake. Around 4000 people managed to run away but 1700 people and thousands of animals died.

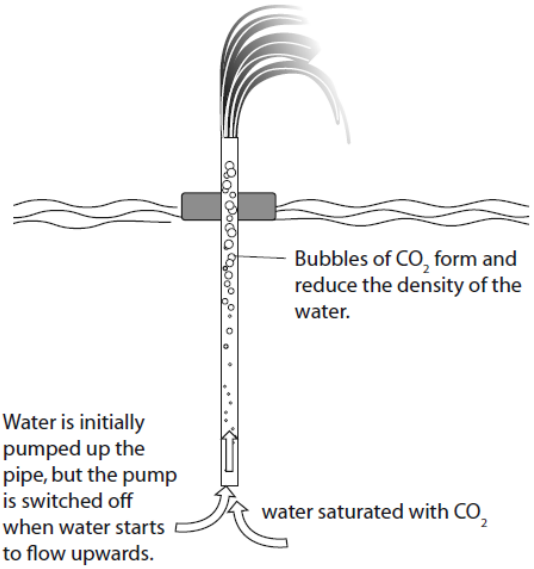


The gas was carbon dioxide, released from a magma chamber beneath the lake. Geologists investigating the disaster think this is what happened:

- Like most lakes, Lake Nyos has warm, less dense water at the surface, and colder, denser water at the bottom. The water pressure at the bottom of the lake is higher than at the top.
- Carbon dioxide (CO_2) gradually seeped through rocks from magma under the ground nearby, and dissolved in the water at the bottom of the lake. This continued for many years and the water at the bottom became saturated with CO_2.
- A sudden disturbance, such as a landslide, disturbed the layers of water and some of the dense water with dissolved CO_2 rose to the surface.
- As the water rose the pressure got less and some of the CO_2 came out of solution – just like opening a bottle of fizzy drink after you have shaken it. The bubbles of CO_2 made the water rise even faster and eventually a fountain of water formed, releasing a cloud of gas.
- CO_2 is denser than air so the cloud flowed down the hillside to the villages.

Engineers are trying to make sure that Lake Nyos does not have another gas release by 'degassing' the lake as shown on the right.

Most lakes contain some dissolved CO_2 but the layers of water in them 'turn over' regularly every year so the CO_2 does not build up to dangerous levels. This turnover happens in spring and autumn and is caused by temperature changes.



1 a How does the pressure in the lake vary with depth?

b Explain why.

2 a How does the amount of gas in a saturated solution change with pressure?

b Explain how you worked out your answer.

3 Explain how a bottle of fizzy drink is a model that can help you to think about the gas release at Lake Nyos.

4 Shallow lakes do not build up enough dissolved CO_2 in the water at the bottom to lead to a gas release. Suggest why this is so.

5 People and animals died over a wide area near the lake but the only plants that died were on the edges of the lake. Explain in as much detail as you can:

a how the gas killed humans and other animals

b why plants were hardly affected.

6 Use information from the diagram to help you to write a paragraph to explain how the degassing pipe works.

7 a Write a paragraph to explain why most lakes turn over in the autumn. Thinking about the following points will help you to work out your explanation.

- How is the water in the lake warmed in the summer?
- How does the density of water depend on temperature?
- In which part of the lake will the warmest water be? Why?
- What will happen to the temperature of the surface waters in autumn?
- What effect will this have on the density of this water?

b Suggest why Lake Nyos does not regularly turn over. (*Hint:* think about the climate in Cameroon.)

I CAN... • extract information from a text • explain the use of a model to help me to think about gas releases • use ideas about temperature and density to explain degassing and lake turnovers.

B – Acid Rain

text ref: 82 - 83

Objectives:

- Explain what causes acid rain
- Describe some of the effects of acid rain
- Explain how acid rain can be reduced, and why we should do this

Notes:

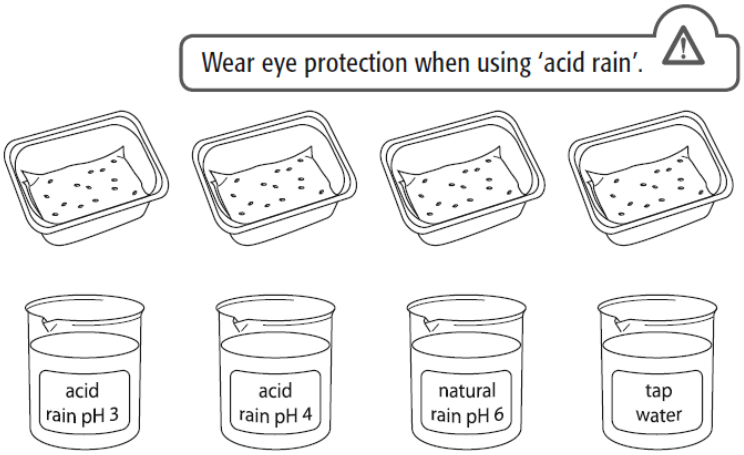
LAB: Acid Rain and Germination

Does acid rain affect the germination of seeds?

Acid rain could affect the life cycles of plants by affecting how they grow or by affecting the germination of seeds. You can investigate seed germination using cress seeds.

Apparatus

- margarine or yoghurt pots
- paper towel
- plastic bags
- cress seeds
- 'acid rain' samples
- eye protection



Planning

1 What is the variable that you are going to change in your investigation?

2 Describe how you will carry out your investigation. Remember to include these in your plan:

- what you will need to keep the same to make your test fair
- how many seeds you will use in each pot – explain why you will use this number
- what observations you will make, and when you will make them
- what you will do to make sure you stay safe during your investigation.

3 Show your plan to your teacher before you start.

Recording your results

4 How will you record your results?

5 When you have recorded all your results, you could present them as a bar chart. Explain why it is helpful to present results in this way.

Considering your results/conclusions

6 Write a conclusion for your investigation that explains what you have found out.

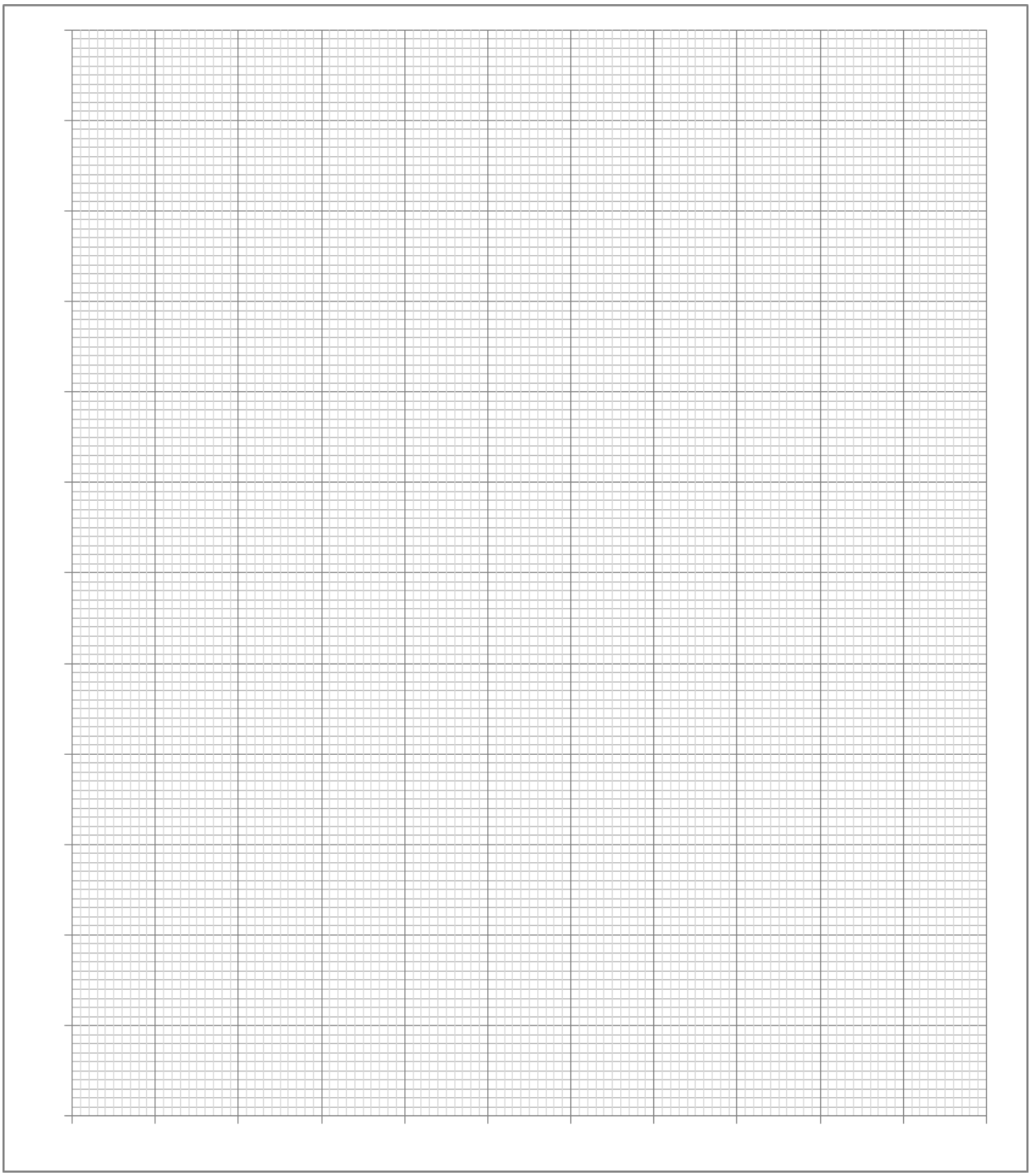
7 How is your investigation a model for what could happen to plants growing in areas with acid rain? Does your conclusion apply to all plants?

Evaluation

8 Are you sure of your conclusion? What could you do to gather more evidence?

9 How could you improve your investigation if you did it again? Explain your recommendations.

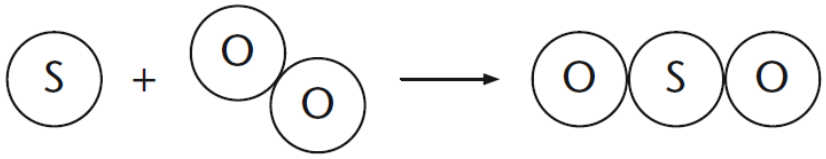
I CAN... • plan and carry out a safe and fair investigation • present my results clearly • draw a conclusion • evaluate my evidence and my working methods.



Acid Rain Equations

Chemists use word and symbol equations to summarise what happens in reactions. The main gases that cause rain to be acidic are sulphur dioxide, nitrogen dioxide and carbon dioxide. The gases from human sources that are the major contributors to acid rain are sulphur dioxide and nitrogen oxides.

We can show the reaction that forms sulphur dioxide in different ways:



sulphur	+	oxygen	→	sulphur dioxide
S	+	O_2	→	SO_2

The little 2 in O_2 shows that there are two oxygen atoms joined together to form a molecule. The 'di' part of dioxide also shows that there are two oxygen atoms in a molecule of sulphur dioxide.

1 Represent the reaction of carbon and oxygen using:

a a particle drawing

b a word equation

c a symbol equation.

Symbols and formulae

carbon – C

carbon dioxide – CO_2

Sulphur dioxide dissolves in water to form sulphuric acid. Acids can be neutralised by reacting them with alkalis. Calcium hydroxide is an alkali. It is made by adding calcium oxide to water. Names of other common alkalis are sodium hydroxide and potassium hydroxide. This is the word equation for the neutralisation reaction between calcium hydroxide and sulphuric acid:

sulphuric acid + calcium hydroxide → calcium sulphate + water

2 Make a table to show which of these elements are metals and which are non-metals:

calcium carbon nitrogen potassium sodium sulphur

3 Copy this sentence, choosing words from the brackets:

Non-metal oxides form (acids/alkalis) when they dissolve in water and metal oxides form (acids/alkalis).

4 Write word equations for the following reactions:

a sulphuric acid and sodium hydroxide

b nitric acid and calcium hydroxide

c nitric acid and sodium hydroxide.

I CAN...

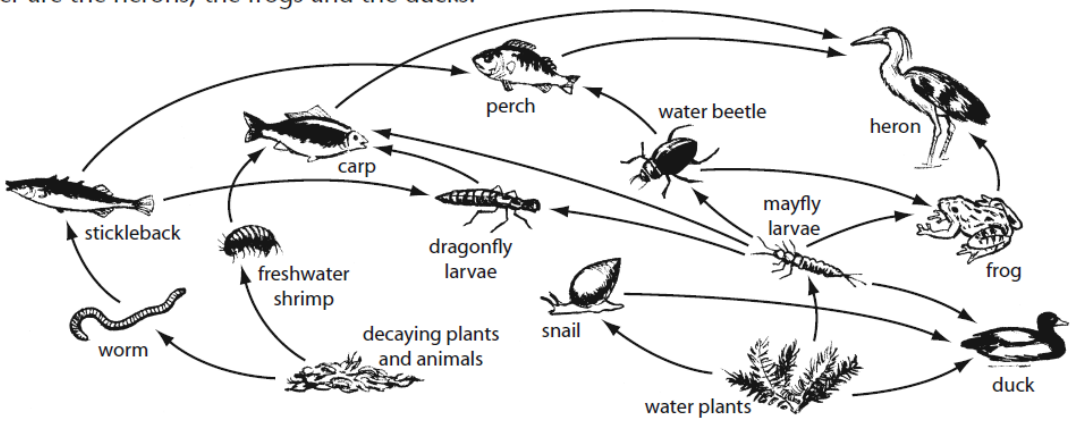
- write word equations for some reactions
- identify patterns in chemical reactions.

Acid Rain Flow Chart

Acidic Gases

Pollution and Food Webs

The diagram shows a food web for a lake. The only organisms that do not live completely in the water are the herons, the frogs and the ducks.



The lake becomes more acidic because of acid rain. This harms most of the organisms that live in the water, including the microbes that make dead organisms decay. It does not directly harm the herons, frogs and ducks.

1 a Which gases in the air cause acid rain?

b Describe two ways in which the amounts of these gases in the air can be reduced.

2 a Why doesn't the acid lake affect the ducks directly?

b After a year the population of ducks living on the lake has gone down. Explain why this has happened.

3 The lake is not acidic enough to harm the perch directly. Why will the numbers of perch go down?

4 Give two reasons why the population of snails in the lake would get smaller.

5 After a year there are more dead organisms on the lake bed that have not decayed. Give two reasons for this.

I CAN...
- recall the causes of acid rain and how acid rain can be reduced
- describe some of the effects of acid rain on food webs.

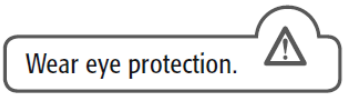
LAB: Oxides

What can we find out about oxides?

You are going to test some solutions of oxides of different elements and then make some predictions.

Apparatus

- bottles of oxide solutions
- universal indicator solution or papers
- teat pipettes
- test tubes
- test tube rack
- eye protection



Method

A Add 1 cm^3 of each solution to a separate test tube.

B Add a few drops of universal indicator solution (or a piece of universal indicator paper) to each test tube.

C Record the colours of the indicator in a table.

Solution	Indicator colour	pH	Type of Solution

Conclusion:

EXTENSION: The Ozone Layer

There are small amounts of a gas called ozone in the Earth's upper atmosphere. Scientists call this the 'ozone layer'. Ozone is a dangerous gas at ground level but in the upper atmosphere it helps to absorb harmful ultraviolet rays from the Sun.

This ozone is now being destroyed by air pollution. The main culprits are chemicals called chlorofluorocarbons or CFCs. These compounds used to be used as solvents, in aerosols and in refrigerators. They were useful because they are generally very unreactive. However, when CFCs escape into the atmosphere they can react with ozone and destroy it. CFCs in the atmosphere are eventually destroyed by natural chemical reactions but this can take hundreds of years.

The problem was first discovered in 1985. Scientists described the effect as 'a hole' in the ozone layer. It is not really a hole, just an area in the upper atmosphere where there is a reduced concentration of ozone. This reduction in ozone concentration has been linked with several problems. For example, the number of cases of skin cancer and eye cataracts has increased in recent years. These increases have been linked to an increase in ultraviolet rays reaching the Earth. So we need to be careful about exposing ourselves to the Sun and make sure we don't get sunburnt.

Chemists have acted quickly to develop alternatives to CFCs. One short-term solution has been the use of hydrofluorocarbons (HFCs). These compounds are safer as they break down in the lower atmosphere and so don't reach the ozone layer. Most countries have now stopped using CFCs, but it will take many years before the ozone layer recovers. CFC and HFC gases also help to trap heat in the Earth's atmosphere, so they contribute to global warming.

1 What is the ozone layer?

2 What is the main cause of the destruction of the ozone layer?

3 What did chemists do to help solve this problem?

4 Why do you think it will take many years to for the ozone layer to recover?

5 **a** Why is the hole in the ozone layer a problem?

b What can we do to protect ourselves from the extra ultraviolet rays that get through the ozone layer?

6 The hole in the ozone layer is a different problem from global warming. Write a short paragraph to explain the differences between the two problems.

C – Monitoring Pollution

text ref: 84 - 85

Objectives:

- Explain why air pollution needs to be monitored
- Describe different ways in which air pollution can be monitored

Notes:

LAB: Measuring Particulates (LAPTOP)

How can we measure the amount of particles in the air?

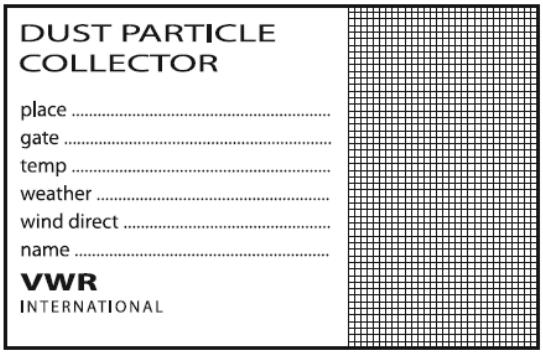
Particulates are tiny solid particles in the air. A lot of particulate pollution consists of specks of soot that are formed when fossil fuels burn. The specks are too small to see without a microscope. Special sticky monitoring cards can be used to find out how much soot is in the air in different places. The instructions below tell you how to use a dust particle collector card. Your teacher will help you to decide where you will place your cards to collect particulate pollution.

Apparatus

- dust particle collector cards
- microscope
- microscope slides
- drawing pins or waterproof sticky tape

Method

Collecting the samples



A Decide where you are going to leave the dust collector card. Write your name on the card and fill in the other information needed.

B Remove the cover that protects the sticky surface. Be careful not to let the sticky surface touch anything and do not touch it with your fingers.

C Use sticky tape or drawing pins to attach the film so that the sticky side is facing the air. You must place the film somewhere where it is protected from rain.

D Repeat steps **A** to **C** for your other cards.

E Leave the films in place for up to a week. They should all be left for the same time. When you collect them, cover up the sticky surfaces again right away.

F Fill in the information asked for on the card.

Measuring your results

G Take the protection off one of your cards and stick the film to a microscope slide.

H Put the slide in a microscope and adjust the lenses until you can see the specks of soot in the squares.

I Count the number of specks in at least five different squares and write the numbers down.

J Work out a mean number of particles per square.

K Repeat steps **G** to **J** for your other films.

×

Recording your results

1 Record your results in a neat table.

Evaluation

2 **a** Why did the sticky film have to be covered up when it was not being used for collecting?

b Why must you avoid touching it with your fingers?

c Why did it need to be protected from rain?

3 Why did you have to leave all the films in place for the same length of time?

4 How did you choose which squares on each card to use for the counting? Explain your answer.

5 Think about all the different variables that could affect the amount of particulates collected at one site.

a List the possible variables and say how each one could affect the results.

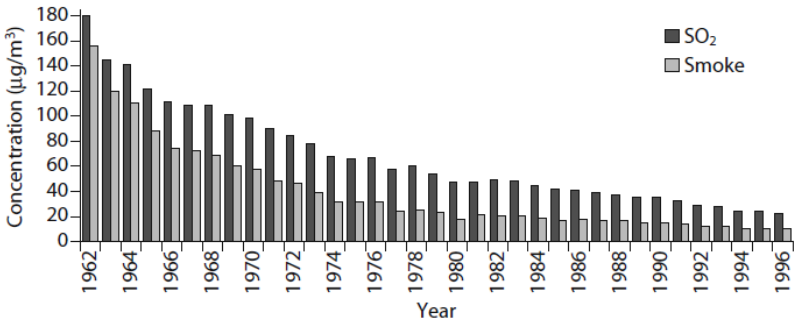
b Which of these variables did you control?

c Why didn't you control the other variables?

Monitoring Changes

Our understanding of air pollution has improved since we set up a network of automatic monitoring stations. There are about 1500 stations at different sites around Britain. Their main job is to take samples of air and measure and record the levels of pollution.

Black smoke and sulphur dioxide are the two pollutants that have been measured for the longest period of time. The graph below shows how the levels of these two pollutants changed over a 35-year period.



Trends in pollution: mean levels of pollution of black smoke and sulphur dioxide (1962–1996).

1 Which forms of pollution have been monitored for the longest time?

2 Describe how the levels of black smoke and sulphur dioxide changed between 1962 and 1996.

3 By how much did the black smoke levels drop between 1962 and 1996?

4 By how much did the sulphur dioxide levels drop between 1962 and 1996?

5 Suggest why the government set up the monitoring stations. Give as many reasons as you can.

6 Suggest a possible reason for the drop in pollution levels.

7 Lichens are organisms that grow only when the air is clean.

a How would you expect numbers of lichen to change between 1962 and 1996?

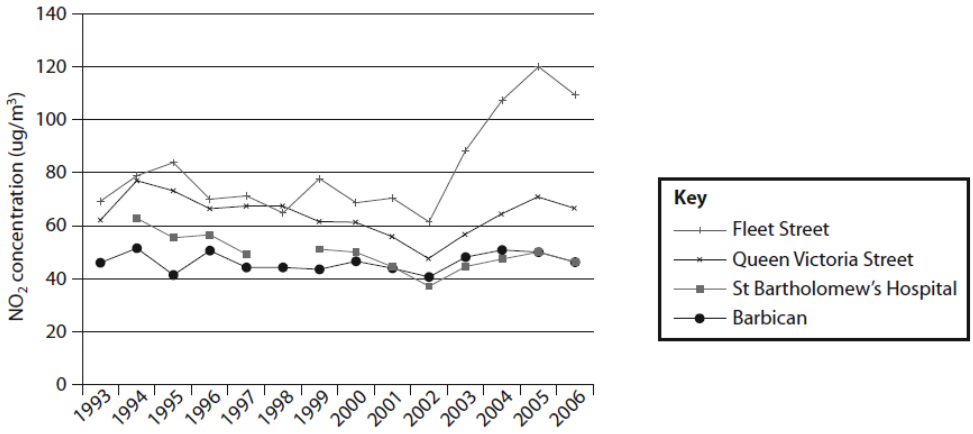
b Explain your answer.

I CAN... • obtain data from a graph • describe what a graph shows.

London Pollution (LAPTOP)

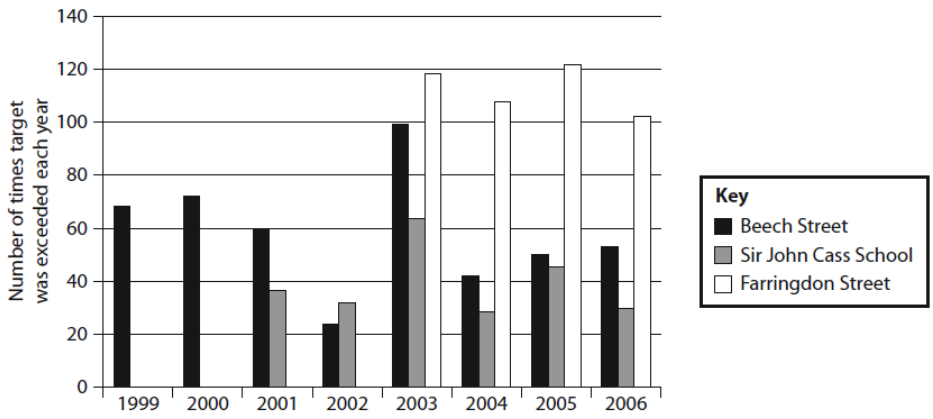
The graphs show different forms of pollution measured in different places in London.

A



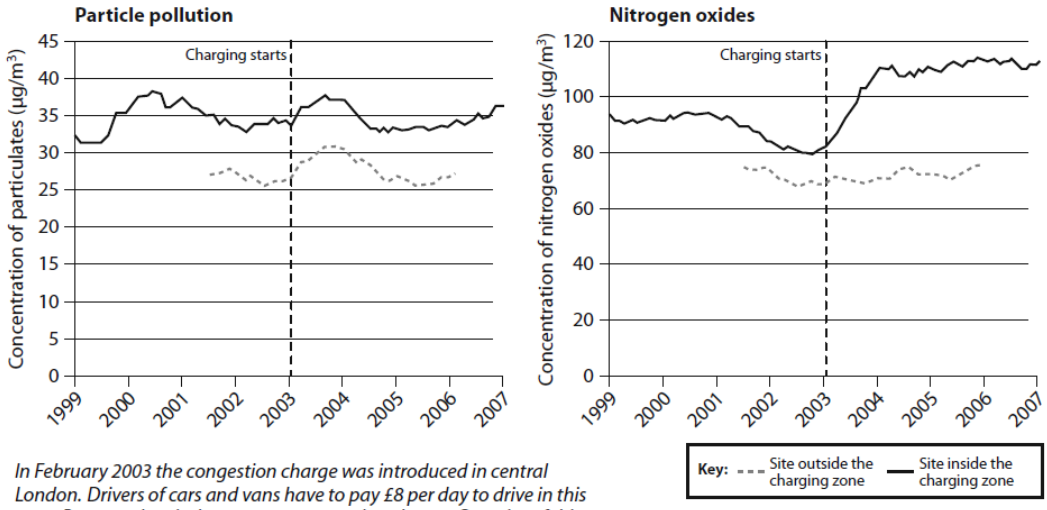
Annual mean nitrogen dioxide concentrations.

B



The number of times the target for the number of small particles of soot in the air was exceeded.

C



In February 2003 the congestion charge was introduced in central London. Drivers of cars and vans have to pay £8 per day to drive in this area. Buses and taxis do not pay a congestion charge. One aim of this charge was to reduce the amount of pollution in the city.

Page 1 of 2

UK air quality targets

Nitrogen dioxide: Annual mean should not be above 40 µg/m³.

PM_{10} (particles measuring 0.01 mm or less): Annual mean should not be above 40 µg/m³. 24-hour mean should not be above 50 µg/m³ more than 35 times per year.

(1 microgram (µg) is 0.000 001 grams.)

1 Why do local authorities set up pollution monitoring stations? Give as many possible reasons as you can.

2 Look at Graph A.

a How did nitrogen dioxide concentrations change between 1993 and 2006?

b Did the places monitored meet the UK air quality targets?

3 A local councillor wants to reduce the amount of traffic to improve pollution. She has commissioned an investigation to find out if traffic is the main cause of the nitrogen dioxide pollution. Describe how you could carry out such an investigation.

4 Look at Graph B.

a In which order were the monitoring stations installed?

b Which location has the least pollution from small particles in the air?

c Did any of the locations meet the UK air quality targets? Explain your answer.

5 The graphs in C show the levels of two pollutants in different places in London.

a Has the congestion charge achieved its aim of cutting pollution? Explain how you evaluated the results.

b Suggest why the pollution *outside* the charging zone went up.

c What benefits (other than reducing pollution) could the congestion charge have?

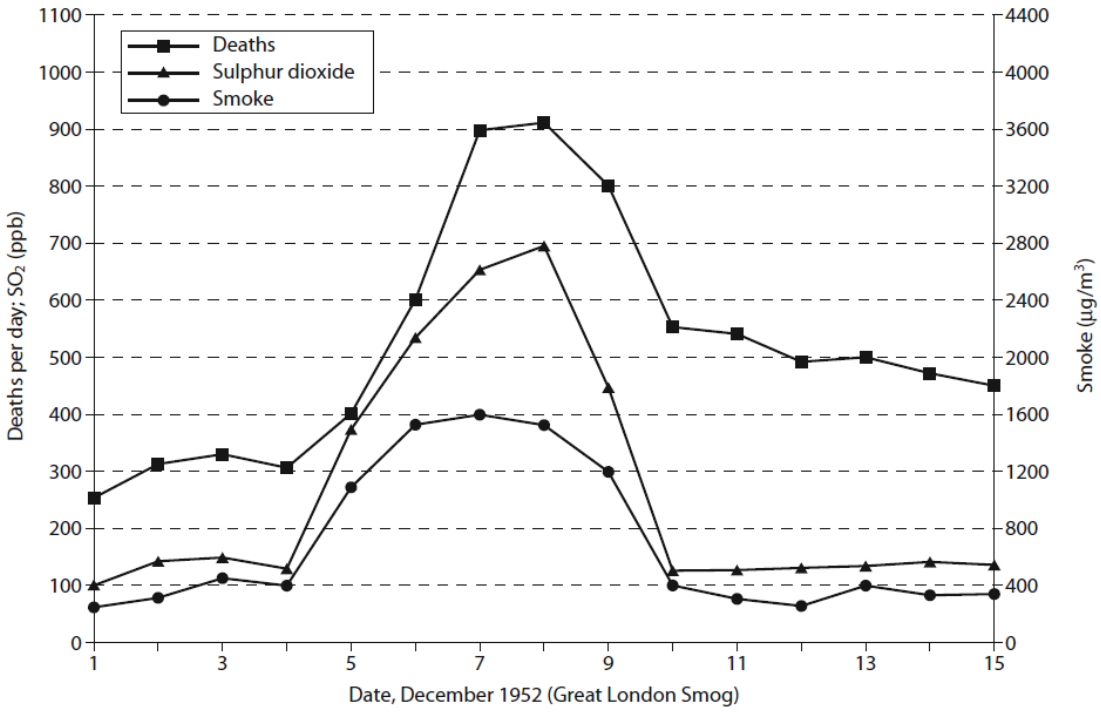
6 A scientist would normally plot the data shown in Graph A as a bar chart.

a Explain why this data would normally be plotted as a bar chart.

b From which of the two types of graph do you find it easiest to see the changes with time? Explain your answer.

EXTENSION - Pollution in the Past

Finding evidence about levels of pollution in the past can be difficult, as there were no direct measurements made. We therefore have to look for other information that may be linked to pollution levels. Where we do have direct measurements we can use them to see if they match up. Look at the graph below.



Think about what the graph tells us about the effects of pollution.

1 Write a paragraph, about 100 to 150 words long, describing what the graph tells us about pollution and its effects. Describe the trends in the graph and how they are related.

2 Think about the health problems caused by air pollution. What kinds of records might we use to get information about pollution in the past?

D – Global Warming

text ref: pages 86 - 87

Objectives:

- Describe the effects of carbon dioxide in the atmosphere
- Explain what climate change means
- Describe how climate predictions are made

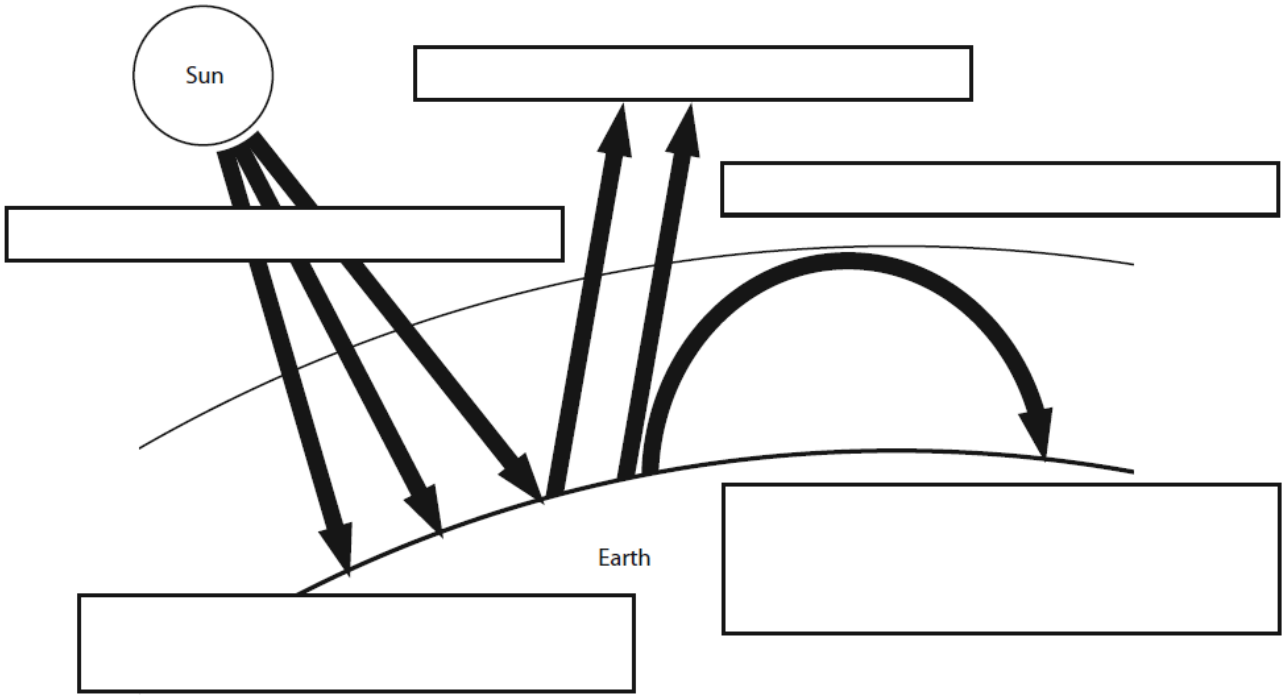
Notes:

Global Warming

1 Draw lines to match up these words with their meanings:

computer models	The Sun's energy being trapped by gases in the atmosphere which helps to keep the Earth warm.
global warming	Any gases that contribute to the greenhouse effect. They include carbon dioxide, methane and water vapour.
greenhouse effect	The gradual increase in mean (average) global temperatures due to extra carbon dioxide being put into the air.
greenhouse gases	Using computers to predict, for example, what the climate might be like in the future.

2 The diagram explains how the greenhouse effect works. Cut out the labels at the bottom of the sheet, and stick them onto the correct places on the diagram.



I CAN...
- recall how the greenhouse effect works
- recall the meanings of some key phrases connected with global warming.

Temperatures in the Past

Climate Change

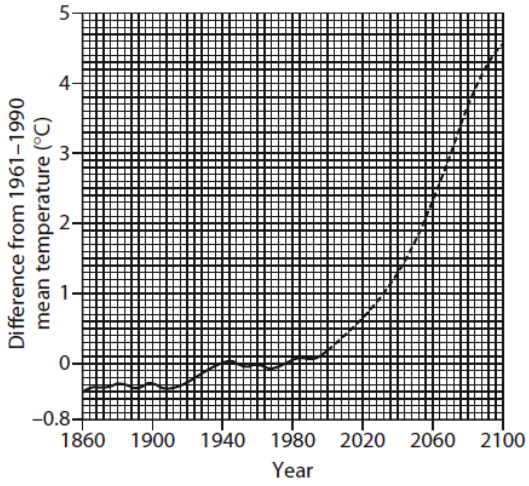
1 a What is a 'greenhouse gas'?

_____

b Which of these gases are greenhouse gases? Tick two boxes.

☐ methane ☐ oxygen ☐ carbon dioxide ☐ sulphur dioxide

The graph shows one representation of global warming. Scientists calculated a mean temperature for the period 1961–1990. This is shown by 0 on the graph. The line on the graph shows how each year's mean temperature compares with that 30-year mean. The graph includes predictions to the year 2100.



2 Mark the point on the graph when the mean temperature started to rise above the 0 level.

3 How has the mean world temperature changed over the last 100 years?

_____

_____

4 What does the graph predict will happen to the mean temperature over the next 100 years?

_____

_____

5 How have scientists made the predictions shown on the graph?

_____

6 What do scientists think is causing the change in temperature shown on the graph?

_____

_____

7 What could happen if the predictions are correct?

8 Suggest one thing that could be done to try to stop climate change happening:

a by you and your friends

b by your parents

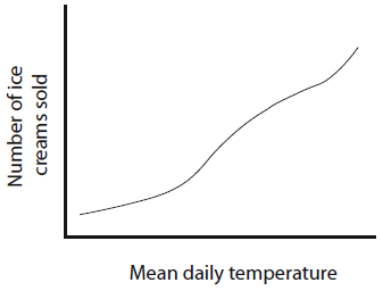
c by your local council

d by the government.

I CAN...
- recall some key facts about the greenhouse effect
- describe how predictions about the Earth's temperature are made
- describe some effects of global warming.

Correlation and Cause

The graph shows how the number of ice creams sold varies with the outside temperature. The graph shows a **correlation** because one variable increases as the other increases.



The correlation shows that these two variables may be linked but does not prove that one change is the **cause** of the other. There are four possibilities:

- hotter weather makes people more likely to buy ice creams
- when people buy more ice creams, the weather gets hotter
- there is some other variable that is affecting both ice cream sales and the temperature
- there is no link between the variables – the correlation is just a coincidence.

In this case, it is fairly clear that when people feel hot they are more likely to want to buy an ice cream to make them feel cooler. This is the *mechanism* for the link and shows that the first possibility above is likely to be the correct one.

1 The following examples all show correlation and an *incorrect* conclusion about the link between the variables. Comment on each one.

a When ice cream sales go up there are more deaths from drowning. So ice cream causes drowning.

b The number of pirates in the world has gone down as the mean temperature of the Earth has gone up. So if we encouraged more pirates the temperature would go down.

c The more firefighters there are at a fire, the more damage there is. So firefighters cause the damage.

A correlation between two variables is often the first clue for scientists looking for the cause of something such as a disease. However, scientists also need to work out *how* a change in one variable causes a change the other before they will accept that one does cause the other.

2 The concentration of carbon dioxide in the atmosphere correlates with the change in the mean temperature of the Earth. Suggest what laboratory experiments scientists could carry out to find out if carbon dioxide could be the *cause* of the rise in mean temperature.

I CAN... • explain the difference between a correlation and a cause.

EXTENSION: Feedbacks

Climate models predict that the Earth will get warmer. A warmer Earth will mean that some of the ice on Greenland and in the Antarctic will melt and sea levels will rise. That sounds quite straightforward. However, some effects of global warming such as melting ice will themselves affect the temperature. Climate modellers need to take account of all these extra effects in their models. Unfortunately, it is very difficult to know how much effect each change will have.

Ice is white and reflects a lot of sunlight. If some of the ice melts, there will be less of it to reflect sunlight. More heat will be absorbed by the ground and the Earth will become warmer. So melting ice will make global warming even worse. This kind of change is called **positive feedback** because the change increases the original effect.

Warmer conditions will lead to more water evaporating from the land and oceans. More clouds will form when this vapour condenses to form water droplets or ice crystals. Most clouds reflect sunlight, so these additional clouds may prevent some heat from the Sun warming the Earth. This kind of change is called **negative feedback** because the change acts in the opposite way to the original change.

However, the effect of clouds is not quite that simple. It depends on the *types* of clouds that form. For example, thin cirrus clouds at high altitudes allow most of the sunlight reaching them to shine through, but they are very good at reflecting heat radiated by the Earth. If the extra clouds that form due to global warming are cirrus clouds, then they will provide positive feedback, not negative.

1 What is the difference between positive and negative feedback?

2 Explain how, in terms of global warming, clouds can provide:

a negative feedback

b positive feedback.

3 Increasing temperatures will make more water evaporate. Water vapour is a greenhouse gas. Will the increased amount of water vapour in the air provide positive or negative feedback?

4 Plants need carbon dioxide to grow and many plants grow faster if the climate is warm or if there is more carbon dioxide in the air. Will plants provide positive or negative feedback for the amount of carbon dioxide in the air?

5 Aerosols are tiny particles in the atmosphere. Some aerosols, like droplets of sulphuric acid, reflect sunlight. Others, such as particles of soot, absorb heat.

a Which types of aerosol provide negative feedback for global warming?

b In what way could trying to reduce acid rain be considered a bad thing to do?

6 In some parts of the world, methane is stored in permafrost (permanently frozen ground).

a What could happen to these deposits if the world warms up?

b How will this affect the climate? Explain your answer.

c Would this be positive or negative feedback?

I CAN...
- describe the difference between positive and negative feedback
- describe some factors that may provide feedback for global warming.

Level Ladder

My Target Level is: ☐ **My final level is:** ☐

Tick the boxes that apply. Or use traffic lights to show how confident you are (red = 'I don't know this'; orange = 'I'm not very confident about this'; green = 'I'm confident I know this').

Level	At the end of the Unit:	I can do this	This needs more work
Working towards Level 4			
	Explain what pollution is.	☐	☐
Level 4			
HSW	Select relevant equipment and sources of information to investigate how acid rain affects plant germination and growth.	☐	☐
HSW	Make accurate observations and decide the range of measurements to be taken.	☐	☐
	Classify pollution as natural or caused by humans and explain some simple effects of pollution.	☐	☐
Level 5			
HSW	Use a model to explain how the greenhouse effect works.	☐	☐
HSW	Recall some ways in which the acid rain problem is being reduced.	☐	☐
HSW	Recall that many scientists believe that the mean global temperatures will rise, but that not all agree.	☐	☐
HSW	Explain why particular pieces of equipment are useful for a certain investigation.	☐	☐
	Explain how acid rain can be caused.	☐	☐
	Recall that the greenhouse effect traps the Sun's energy.	☐	☐
Level 6			
HSW	Use molecular models to represent reactions.	☐	☐
HSW	Draw and use word equations as part of an explanation.	☐	☐
HSW	Discuss the usefulness of a greenhouse as a model for how greenhouse gases act in the atmosphere.	☐	☐
HSW	Discuss how responsibility for cutting emissions should be shared between different countries.	☐	☐
HSW	Form a theory about the causes of particulate pollution in the local area and plan an investigation to test it.	☐	☐
HSW	Identify many variables in an investigation and plan how to control them.	☐	☐
	Give some reasons why pollution is monitored.	☐	☐

Page 1 of 2

Level	At the end of the Unit:	I can do this	This needs more work
	Describe how pollution is measured by a network of monitoring stations.	☐	☐
	Explain the importance of using sulphur precipitators and catalytic converters, and of reducing carbon dioxide emissions.	☐	☐
	Describe some ways in which the problems of acid rain and climate change can be reduced.	☐	☐
Level 7			
HSW	Recall some of the arguments for and against global warming being caused by humans.	☐	☐
HSW	Explain how fossils and ice core samples can be used to estimate climatic and atmospheric conditions in the past.	☐	☐
HSW	Critically analyse air pollution data, identifying whether it is sufficient to support a particular conclusion.	☐	☐
	Describe some ways in which the composition of the atmosphere has changed.	☐	☐
	Describe how the chemicals produced by human activities affect the carbon cycle.	☐	☐
Level 8			
HSW	Derive balanced symbol equations, with help.	☐	☐
HSW	Choose and justify data collection methods in investigations, which produce reliable and accurate data.	☐	☐
	Explain why the pH of the soil can affect plant growth.	☐	☐
	Explain how pollution levels in the past can be estimated.	☐	☐

9G Summary Sheets

Acid rain

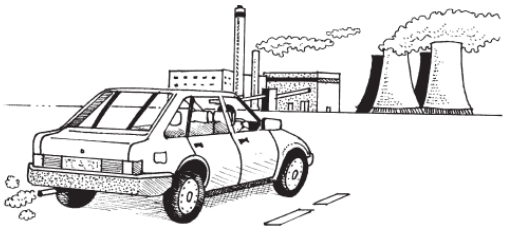
The air naturally contains small amounts of the following gases:

- **carbon dioxide**, produced by **combustion** of fuels and **respiration**
- **sulphur dioxide**, formed when sulphur burns in volcanoes
- **nitrogen oxides**, produced when lightning makes oxygen and nitrogen in the air combine.

9G

These gases dissolve in water to form acids, so rainwater is naturally acidic (pH between 5.6 and 5.9). If there are more acidic gases in the atmosphere then the pH of the rain can decrease further. For example, an erupting volcano can put a lot of sulphur dioxide into the air, and cause very acidic rain nearby.

Our rainwater has become even more acidic (pH between 3 and 5.5) due to air pollution from burning fossil fuels. This is what we call **acid rain**. The main sources of this pollution are power stations and cars. Both burn large amounts of fossil fuels and release more carbon dioxide, sulphur dioxide and nitrogen oxides. Sulphur dioxide and nitrogen oxides are the main contributors to acid rain.



Problems caused by acid rain

Acid rain causes damage to our environment in several ways:

- Metals and carbonate rocks (like limestone and marble) react faster with acid rain than with normal rainwater.
- Plants and water life are harmed by acid rain. The damage to plants can affect animals further up the food chain.

Pollution by acid rain has been reduced by several actions:

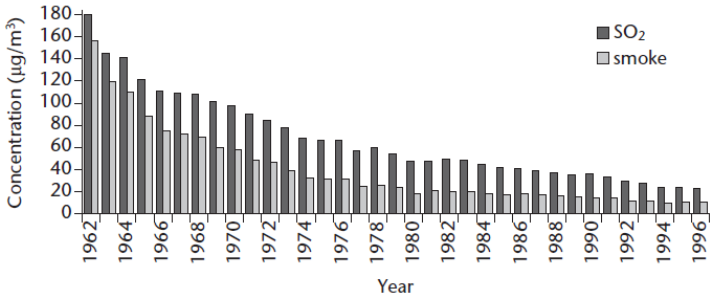
- reducing the sulphur content in diesel and petrol so less sulphur dioxide is produced by combustion
- fitting **catalytic converters** in car exhausts, which change harmful gases (such as carbon monoxide and nitrogen oxides) into less harmful gases (such as carbon dioxide and nitrogen)
- fitting **sulphur precipitators** in the chimneys of power stations to remove sulphur dioxide.

9G Summary Sheets (continued)

Monitoring air pollution

A network of air-quality monitoring stations provides us with information about levels of air pollution. A range of pollutants is measured, including rainwater pH. The data collected tells us that our air quality is improving, but there are still serious problems.

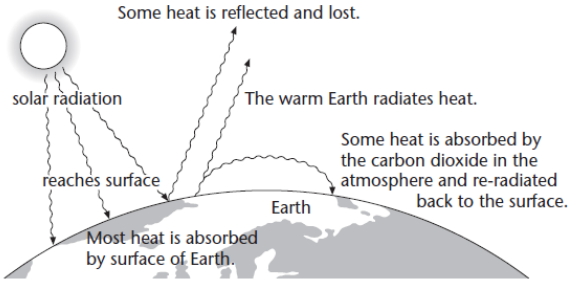
Using less energy would help to reduce pollution because we would burn less fossil fuels.



Annual mean concentrations of black smoke and sulphur dioxide (1962–1996).

Global warming

Carbon dioxide and other gases in the atmosphere help to keep the Earth warm by trapping energy in the atmosphere. This is sometimes called the greenhouse effect. Without the greenhouse effect the Earth would be much colder than it is today.



There has been a small, but steady, increase in mean world temperatures in the last 100 years. These rising temperatures have been linked to increasing levels of carbon dioxide in the atmosphere. Scientists use computer models to predict how the temperature and climate will change in the future, and most scientists agree that there will be even greater rises in mean world temperatures in the future. If global warming does happen, it will cause changes in weather and rising sea levels.

The increased levels of carbon dioxide in the atmosphere are caused by the increased burning of fossil fuels and the destruction of large areas of forest. Scientists and politicians are trying to find ways to reduce the amount of carbon dioxide that is produced and so reduce the likelihood of global warming. The situation is complex, however, and not all scientists agree that global warming will definitely occur.

Quick Quiz (Revision Aid)

9Ga

1 Which statement about the Earth's atmosphere is *not* true?
- **A** It originally had no oxygen in it.
- **B** The oxygen in the atmosphere was produced by volcanoes.
- **C** Volcanoes can change the composition of the atmosphere.
- **D** When algae evolved, they produced a gas that poisoned many other organisms.

2 Which of the following is not responsible for making rainwater acidic?
- **A** iron dioxide
- **B** carbon dioxide
- **C** sulphur dioxide
- **D** nitrogen dioxide

3 Which list shows how acidic gases are produced naturally?
- **A** plants produce them in photosynthesis
- **B** plants and power stations
- **C** volcanoes and earthquakes
- **D** volcanoes, lightning and fires

4 How can an erupting volcano affect the climate around the world?
- **A** It can't. A volcano only affects people close to it.
- **B** Heat from the lava makes the Earth warmer.
- **C** Chemicals given off reflect sunlight and make the climate cooler.
- **D** Chemicals given off absorb heat and keep the Earth warmer.

9Gb

1 What is acid rain?
- **A** rain with a pH above 5.6
- **B** rain with a pH below 5.6
- **C** rain with a pH below 7
- **D** rain with a pH above 7

2 Which of the following is one of the main causes of acid rain?
- **A** weathering of rocks
- **B** photosynthesis in plants
- **C** power stations burning fossil fuels
- **D** farmers putting peat on their soil

3 Which of these is a way in which acid rain affects plants?
- **A** It removes nutrients from the soil.
- **B** It helps the plants by killing insects.
- **C** It makes their leaves greener.
- **D** It washes dust off the leaves.

4 A catalytic converter helps reduce air pollution and acid rain.
Where in a car will you find a catalytic converter?
- **A** fuel tank
- **B** air filter
- **C** oil filter
- **D** exhaust system

9Gc

1 The network of air-quality monitoring stations has been set up to:
- **A** reduce air pollution.
- **B** improve weather forecasting.
- **C** measure levels of air pollution.
- **D** neutralise acid rain before it enters rivers and lakes.

2 Which of the following might a scientist use to monitor pollution in rainwater?
- **A** universal indicator
- **B** limewater
- **C** thermometer
- **D** burning splint

3 Which of the following is not a reason for monitoring pollution?
- **A** finding out the source of pollution
- **B** finding out if ways of controlling it are working
- **C** providing air quality forecasts
- **D** measuring the amount of traffic

4 You find lots of lichens growing in an area. What does this tell you?
- **A** The air is very cold.
- **B** The air is very clean.
- **C** It rains a lot.
- **D** There is a lot of soot in the air.

9Gd

1 What is meant by global warming?
- **A** the destruction of the ozone layer
- **B** that some places on Earth are getting hotter
- **C** the surface temperature of the Sun increasing
- **D** the increase of mean air temperatures around the world

2 Which of the following has helped to increase to carbon dioxide levels?
- **A** the effect of acid rain
- **B** the destruction of the ozone layer
- **C** cutting down large areas of forest
- **D** increasing numbers of lightning storms

3 Which of the following is one of the effects of global warming?
- **A** more acid rain
- **B** fish being killed in lakes
- **C** flooding of low-lying areas
- **D** increased numbers of skin cancers

4 Some scientists do not agree that global warming is occurring. Why are some scientists not sure what will happen?
- **A** Acid rain will cause temperatures to decrease.
- **B** The situation is very complex and difficult to predict.
- **C** Our temperature measurements are not accurate at present.
- **D** An ice age is about to start and so temperatures will definitely fall.