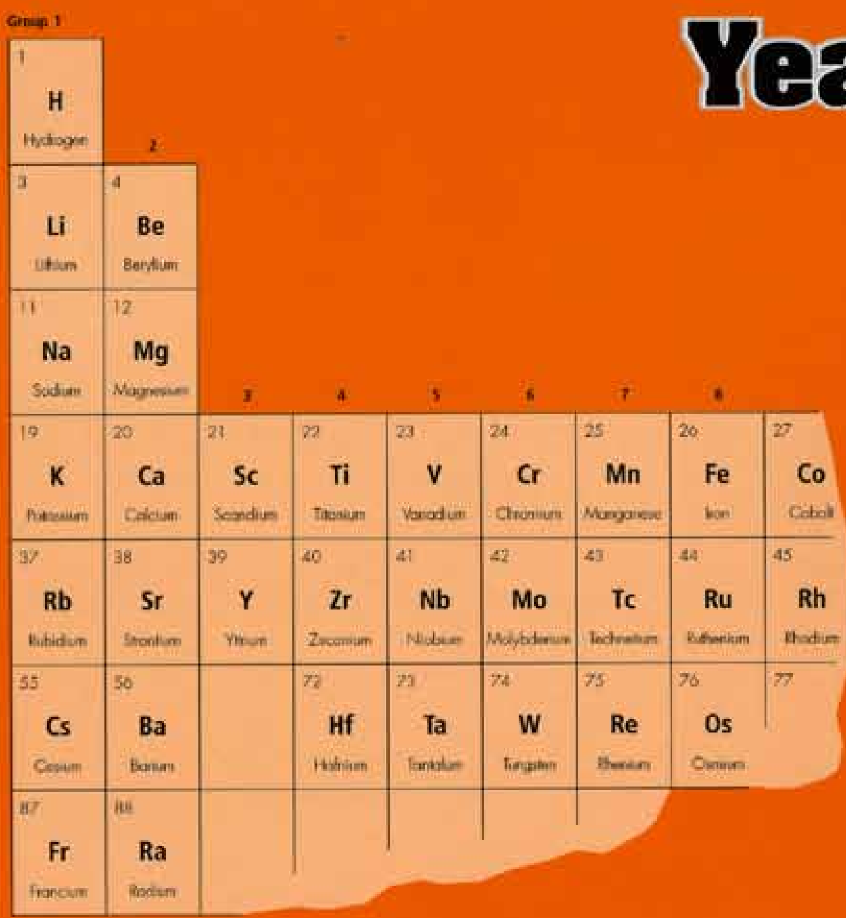
Book 2

Year 9



Science

Science

Year 9 Book Two

GOVERNMENT OF SĀMOA
MINISTRY OF EDUCATION, SPORTS AND CULTURE

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Unit 1: STRUCTURE OF MATERIALS

Introduction
In this unit, you will investigate solids, liquids and gases and find out about changes of state. You will also compare the properties of elements, compounds and mixtures.

Particles in materials
Scientists think all materials are made up of very small particles called **atoms**. Atoms are so small that they cannot be seen with your eye or with a school microscope. Special equipment is needed to investigate atoms. Different materials have their atoms arranged in different ways.

In some materials, such as helium, the atoms are by themselves. In other materials, such as water and oxygen, the atoms join together to form **molecules**. Chemical **bonds** are attractions that hold the atoms (or ions) together.

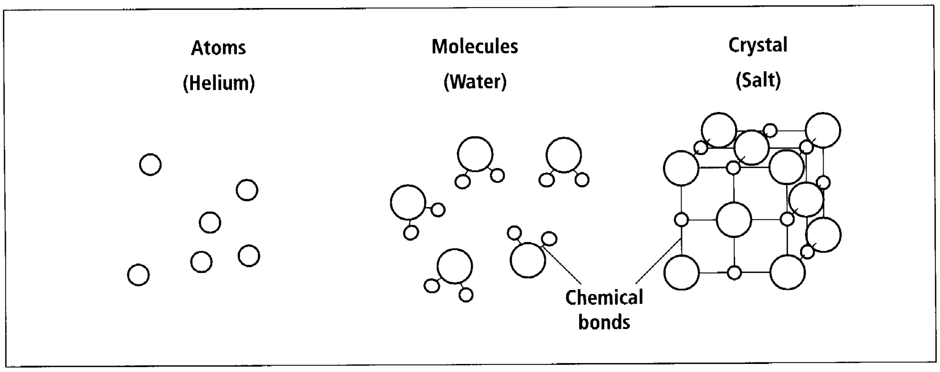


Diagram 1.1
Atoms, molecules and crystals.

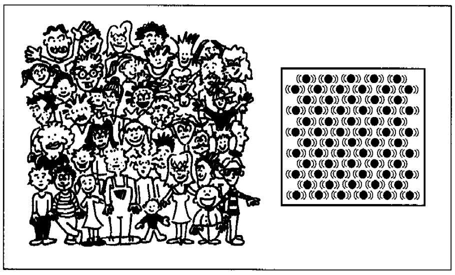
Many materials, such as table salt, are made up of **crystals** in which the ions join to form large networks. The ions in a crystal are held together by strong attractions called ionic bonds.

Activity 1 Particles In Materials

Aim: To record information about particles in materials.

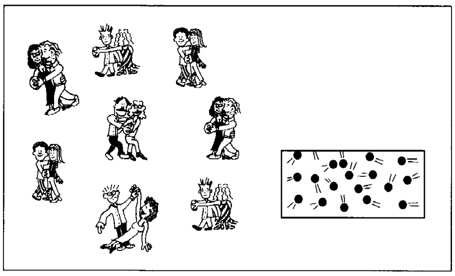
1. Copy and complete the following sentences.
   a. Materials are made up of ______________.
   b. Atoms can be by themselves or together in m______________ and c______________.
2. Copy the diagrams of helium, water and salt (on the previous page) into your exercise book, then explain what each diagram is showing about the particles in different types of materials.

Solids, liquids and gases
Materials can be described as solid, liquid or gas. Solid, liquid and gas are called the states of matter. Some materials, such as water, can be easily changed from one state to another.



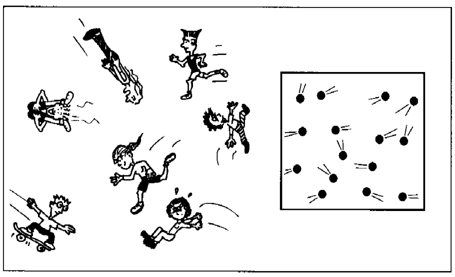
Solids
Metals, wood, suka (sugar) and pulu (coconut husk) are common solids. When a material is a **solid** it is hard and keeps its shape because the particles inside it are tightly held close together. Even when held tightly they are able to move backwards and forwards. This movement is called vibration.

Diagram 1.2
Particles in a solid are like a crowd at rugby.



Liquids
Water, oil and disinfectant are common liquids. When a material is a **liquid** it is runny and wet. Liquids can be poured and take up the shape of the container. They do this because their particles are close together but are still able to move around.

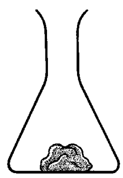
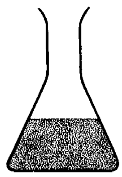
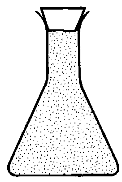
Diagram 1.3
Particles in a liquid are like dancers.



Gases
Oxygen, hydrogen, carbon dioxide and steam are common gases. Many gases, like those in the air, are invisible. When a material is a **gas** it is able to spread out to fill the space it is in. When gases spread out their particles are far apart and are moving very fast.

Diagram 1.4
Particles in a gas are like children on a playground.

The following table compares the properties of materials in each of the three states.

Property	Solids	Liquids	Gases
			
Shape	Have a fixed shape but may be flexible.	Take the shape of a container.	Take the shape of a container.
Crystals	Are often crystals.	Do not form crystals.	Do not form crystals.
Density	Usually dense (heavy).	Dense.	Are not dense.
Compressible	Are not compressible.	Are not compressible.	Are compressible.
Poured	Cannot be poured.	Can be poured.	Can be poured.
Volume	Have a fixed volume.	Have a fixed volume.	Volume changes.
Particle position and movement	Fixed very close together and vibrating.	Close together and moving around.	Far apart and moving around quickly.

The way a gas can be compressed and change volume has many uses. When a gas is forced into a balloon the gas particles are pushed closer together. This increases the pressure and forces the rubber of the balloon to stretch. Car tyres also use the compressibility of gases. The ability of the gas to change shape to fit the container means that a tyre filled with air will give a smoother ride than a solid rubber tyre.

Activity 2 Solids, Liquids And Gases

Aim: To record information about solids, liquids and gases.

1. Copy the diagrams (1.2, 1.3 and 1.4) showing the particles in solids, liquids and gases. Use an example from your everyday life to describe the arrangement and movement of the particles in each diagram.
2. List 10 examples of materials that are solids. List as many gases and liquids as you can.
3. Copy the table that compares the properties of solids, liquids and gases into your exercise books.
4. Use the information in the properties table to complete the following:
   a. Which material is best to remove dirt with when washing clothes? Explain why.
   b. Explain why solids are used for building materials.
   c. Why does water change shape when poured from a bottle to a cup?
   d. Give two reasons why gases are used to fill bike and car tyres.
5. The following diagrams show the results of an investigation to compare the compressibility of ice, water and air. Answer the questions that follow.

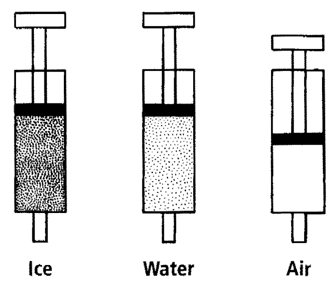


Diagram 1.5
Compressibility investigation.

- What conclusion can you draw about the compressibility of ice, water and air?
- What happened to the air particles when the air was compressed?

6. Copy each of these strips below. Place the symbols S (for solid), L (for liquid) or G (for gas) on the strip to show the properties of solids, liquids and gases. The first one has been done for you.

Energy of particles

High energy	**G**	**L**	**S**	Low energy

Spacing of particles

Spread out	Close together

Temperature of water, when ice, water and steam

Hotter	Cooler

Freedom of particles

Tightly held	Move freely

Changing state

Adding heat to a solid makes the particles vibrate faster and faster until the attractions holding the particles next to each other break and some of the particles change state to become liquid. If more heat is added all the particles in the solid become liquid. This is the **melting point** of the material. Each material has a specific temperature which is its melting point. The melting point of ice is 0°C.

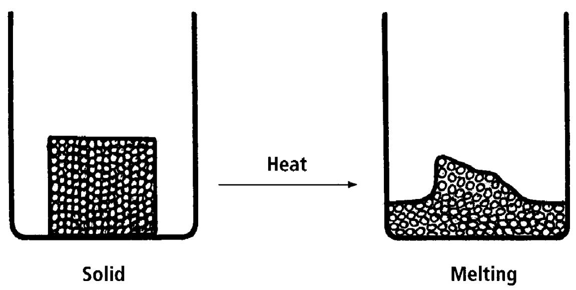


Diagram 1.6
Solid melting.

If more heat is added the particles of the liquid move faster and faster. The **boiling point** is reached when the particles are moving so fast that some of the attractions holding them close together break and the particles change state to become gases. If some liquids are left in the sun their particles gain enough energy to become gases. This change of state is called **evaporation**.

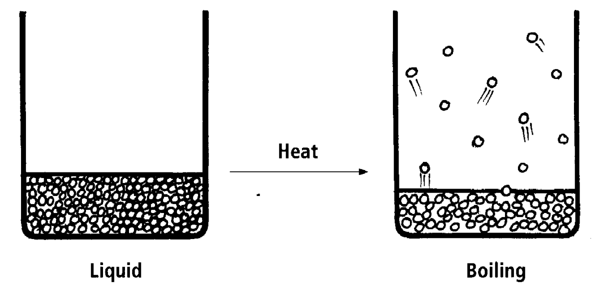


Diagram 1.7
Liquid boiling.

If enough heat energy is removed from a material its particles will lose kinetic energy and come closer together. If this happens the material will change state from gas to liquid or from liquid to solid. The point at which a material freezes is the same as its melting point. Materials such as air fresheners change state from solid to gas. This is called **sublimation**.

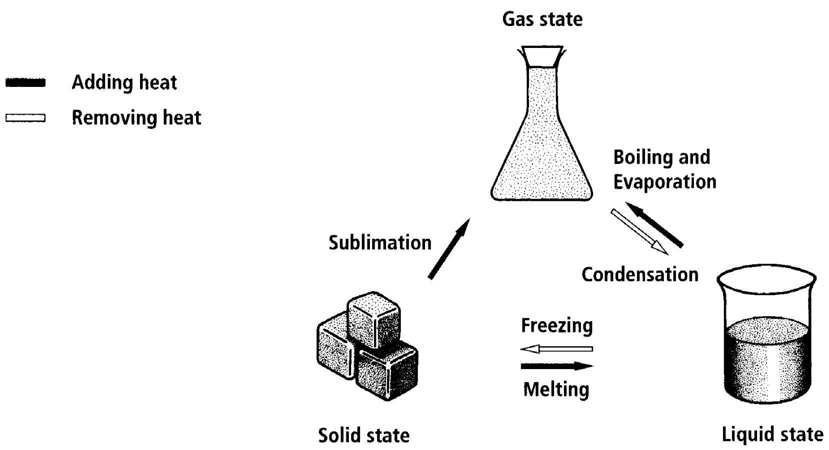


Diagram 1.8
Changes of state.

Activity 3 Change Of State

Aim: To record information on changes in state.

1. Copy the diagrams (1.6 and 1.7) of melting and boiling into your exercise book.
2. Think about what is happening to the particles shown in each diagram. Describe to a partner, in your own words, what is happening and explain why it is happening. Listen to your partner's explanation, discuss your ideas and then record your final ideas beside the diagrams.
3. Copy the diagram (1.8) showing the names for the changes in state.
4. List examples of each change of state.
5. The following data came from an investigation of the temperature changes of liquid wax as it is cooled. Draw a graph of the data, then answer the questions that follow.

Cooling of liquid wax											
Time (minutes)	0	1	2	3	4	5	6	7	8	9	10
Temperature (°C)	50	44	37	31	31	31	31	26	23	16	11

a. What happens to the temperature of the wax as it is cooled?
b. What state is the wax in between 0 and 3 minutes?
c. What is happening to the temperature between 3 and 6 minutes?
d. What is happening to the wax between 3 and 6 minutes?
e. What state is the wax in between 7 and 10 minutes?
f. What is the freezing point of wax?
g. What temperature will be the melting point of this wax?
h. What would you expect to happen to the temperature of the wax if it was cooled for longer than 10 minutes?

6. Read the following article then complete the questions below.

Your body uses changes of state

When you exercise your muscles give off heat. To cool down your body releases sweat, which is mostly water. The water in the sweat evaporates from your skin, using some of your body heat to change state, and this cools you down again.

When you breathe out, the air from your lungs is high in water vapour. The water vapour has evaporated from the surfaces of your lungs — which need to be kept moist to allow oxygen to go from the air into your blood.

a. How does sweating help your body?
b. Why do you feel hotter on humid days?
c. How does evaporation of water help oxygen get into your blood?
d. How does the water vapour get into your lungs?

Activity 4

Materials needed:

A range of materials that change state between 0°C and 100°C such as water, chocolate, wax, ice cream, coconut oil;

Heat source or method of cooling materials;

Other equipment, such as thermometers, will be needed depending upon the investigation plan being followed.

Investigating Changes Of State

Aim: To investigate the changes in physical properties when a material changes state.

1. Select materials that change state between 0°C and 100°C then plan and carry out an investigation to find out how the properties of materials change when they change state.
2. Copy and complete the following investigation plan sheet.

What is the investigation called?
e.g. Changes in materials.

What is the aim or purpose of this investigation?
e.g. To find out how the properties of a material change when it changes state.

How will the amount of heat energy be changed so that the material will change state?
e.g. Heat it with a candle; put it in a fridge or freezer.

What sort of changes will I look for?
e.g. Temperature at which it changes state, how long it takes to change, how runny it becomes, colour change.

3. Hand your plan to your teacher for checking.
4. Carry out your planned investigation.
5. Record your observations in a table.
6. Use your observations to write a comparison of the properties of the material before and after the change of state.
7. Repeat your investigation for another material or a different change of state.

Types of materials

Materials can be grouped in lots of different ways. One common scientific way to do this is to put materials into groups called elements, compounds or mixtures. The following information describes these different types of materials.

Elements

Elements are pure substances. They are made up of only one type of atom, nothing else is mixed in or joined with them. Over a number of years scientists discovered lots of different elements and even made some new ones. The elements were given names and symbols and recorded on a Periodic Table of Elements. The following table shows the **atomic number**, name and symbol for the first twenty elements. The atomic number is the number of protons that the element contains in its nucleus. Hydrogen has an atomic number of 1, which means it has one proton. Aluminium has an atomic number of 13 because it has 13 protons. The elements are listed on the Periodic Table in order of their atomic number.

1 Hydrogen H							2 Helium He
3 Lithium Li	4 Beryllium Be	5 Boron B	6 Carbon C	7 Nitrogen N	8 Oxygen O	9 Fluorine F	10 Neon Ne
11 Sodium Na	12 Magnesium Mg	13 Aluminium Al	14 Silicon Si	15 Phosphorous P	16 Sulfur S	17 Chlorine Cl	18 Argon Ar
19 Potassium K	20 Calcium Ca						

The use of capital letters and lower case letters in the symbols is important. The first letter of the symbol is always capital and the second, if there is one, is lower case. For example magnesium is Mg, not MG or mg.

The symbols of some elements are taken from their original Latin names. Sodium, with the symbol Na and Potassium, symbol K are examples of this.

Compounds
Compounds are materials that are pure substances and made up of two or more elements that have joined together during a chemical reaction to form a molecule. For example, sugar is made up of the elements carbon, hydrogen and oxygen. Water is made up of hydrogen and oxygen. Table salt, which is used in cooking, is made up of ions of sodium and chlorine.

Mixtures
Mixtures are materials that contain elements and/or compounds mixed together but not joined by a chemical reaction. Therefore it is possible to separate the different materials from each other. Fizzy drinks are mixtures of sugar, water, flavours and carbon dioxide gas. If the top of the bottle or can is left off, the carbon dioxide comes out of the mixture. Air is a common mixture of gases. It is made up of 78% nitrogen, 21% oxygen, 0.04% carbon dioxide and small amounts of other gases.

Activity 5

Poster

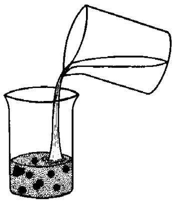
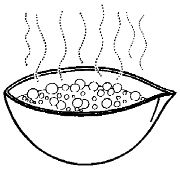
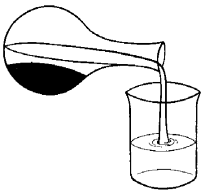
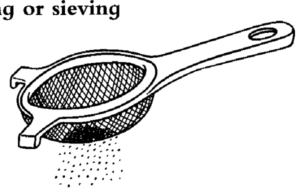
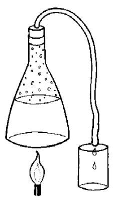
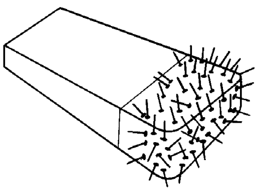
Aim: To gather, process and present information on elements, compounds and mixtures.

1. Copy the following table and complete it using the information in the notes above.

	Element	**Compound**	**Mixture**
What it is			
Examples			

2. Select an element, a compound and a mixture to find out about.
3. Use the above information, your own observations and any other information to produce a poster that gives information about the properties of the chosen element, compound and mixture. Properties can include colour, state, what sort of atoms, molecules or crystals each includes.

Separating the materials in a mixture
Because the parts of a mixture are not joined they can be separated from each other. The separation method used depends upon the properties and the states of the materials in the mixture. The following table describes methods used to separate the materials in mixtures.

Method	How it works
Dissolving 	Two solids can be separated if one will dissolve and the other will not. Water or organic solvents are used to dissolve one of the solids. When cleaning clothes the 'dirt' on the fabric is dissolved.
Evaporation 	Liquids, such as water, can be heated until they change into a gas. This means the liquid evaporates, leaving a solid material behind. Salt is removed from salt water by evaporation.
Decanting 	Two liquids or a liquid and a solid can be separated by pouring the less dense material off. Fats and oils can be separated from water in this way when gravy is being made.
Filtering or sieving 	Filters and sieves are made so that there are holes or gaps of a certain size. Large particles are trapped by the filter or sieve and the smaller particles go through and are collected in a container. Filtering is used to remove leaves and soil from water.
Distillation 	Two liquids can be separated using their different boiling points. The two liquids are heated gently. As the first one reaches its boiling point it changes into a gas and becomes separated from the other liquid. The gas can then be condensed and collected in a different container. Petrol is separated from diesel using distillation.
Magnetic 	Magnets are used to separate out magnetic materials such as iron.

Activity 6

Materials needed:

A range of different types of mixtures that can be separated — water and salt, sand and sugar, sand and iron filings, sand and pebbles or shells, copper sulphate and sodium hydroxide (or any other chemicals that form a precipitate), sand, salt and iron filings, sawdust, sand and sugar, salt and pepper;

Beakers or jars;

Funnels and filter paper;

Magnets;

Burners or flat dishes;

Sieve.

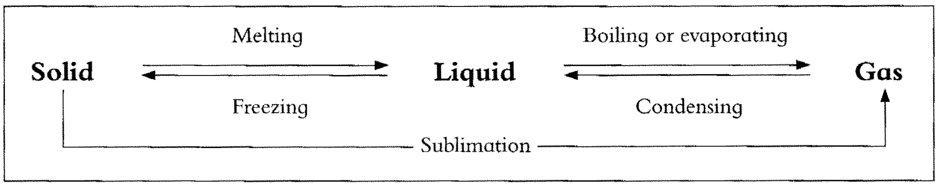
Separating Materials In A Mixture

Aim: To separate the materials in a mixture.

1. Use the information in the table on page 15 to decide which method is the best to use to separate the materials in the mixture. Record the steps you will use.
2. Carry out the steps to separate the materials in the mixture. Record observations of each step, any problems that occurred and the reasons for any changes to your planned method of separating the materials.
3. Repeat using another mixture.

Unit Summary

- All materials are made up of particles called atoms or ions. Ions are formed by atoms losing or gaining electrons.
- Atoms can be by themselves or joined to form molecules.
- Materials can exist as one of the three states of matter — solid, liquid or gas.
- Solids are dense, cannot be poured and have a fixed shape and volume. The particles are held tightly together and vibrate. Solids cannot be compressed and often contain crystals.
- Liquids are dense, can be poured, have a fixed volume and take the shape of their container. The particles are held close but are able to move around. Liquids cannot be compressed and do not contain crystals.
- Gases are less dense, can be poured, take the shape of their container and their volume changes depending on the size of the container they are in. The particles are far apart and easily move around. Gases can be compressed and do not contain crystals.
- People make use of the properties of solids, liquids and gases in their everyday lives.
- Adding heat energy to some materials causes them to change state. Each material has its own melting and boiling points.
- Each of the changes of state has a special name. These are shown below.



- Elements, compounds and mixtures are different types of materials.
- Elements are pure materials made up of only one type of atom. The elements are listed on the periodic table in order of their atomic number.
- The atomic number of an element is the number of protons in each atom of the element.
- Compounds are made up of the atoms from two or more elements chemically joined together.
- Mixtures are formed from elements and compounds that are mixed together but not chemically joined.
- The materials in a mixture can be separated using the properties of the materials in the mixture. Dissolving, evaporating, decanting, filtering, sieving, distilling and the use of magnets are all methods used to separate the materials in a mixture.

Unit 2: WAYS MATERIALS CHANGE

Introduction

In this unit, you will investigate the properties of materials and the ways materials can be changed. How a material is made locally will also be investigated.

Materials

'Materials' is a term used to describe all the chemical substances around us. Some of these materials are pure. This means that they are made up of only one chemical substance while other materials can be mixtures of lots of different chemical substances. Some materials are made up of two or more elements that are joined together. Each material has its own special physical and chemical properties that make it different from other materials.

Physical properties

Physical properties of materials are all the properties that do not involve chemical reactions. **Density** is an example of a physical property. Materials with high density feel heavier than materials of the same size with a lower density. A bag full of a material such as iron nails is heavy while the same bag filled with feathers would be much lighter. Iron has a higher density.

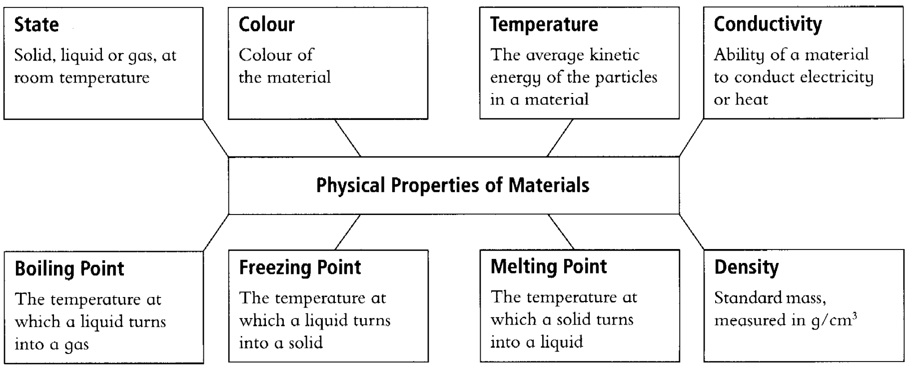


Diagram 2.1
Physical properties of materials.

Chemical properties

Chemical properties of materials are all the properties that involve chemical reactions. Some materials, such as magnesium metal, react with water and some do not. Some react with acids to give hydrogen gas and others react with acids to give carbon dioxide gas. Each different material has its own chemical properties.

Activity 1

Materials needed:

A collection of materials with different properties.

Properties Of Materials

Aim: To investigate the properties of materials.

- Copy and complete the following table by answering each question. Add some materials and questions of your own.

Material	Solid, liquid or gas?	Colour?	Can you see through it?	Hard, soft, brittle, able to be bent?	High or low density?	Does it burn or melt when heated?	Does it dissolve in, or react to water?	Does it react with acid?	
Iron	Solid	Shiny silver	No	Hard and can bend	High	Melts	Reacts to form rust	Yes, slowly	
Glass									
Paper									
Wood									
Water									
Plastic									
Sugar									
Salt									
Siapo									
Baking Soda									

◧ Use the information in the following table to answer the questions about the properties of these three materials.

Physical Property	Ice	Glass	Diamond
State	Solid	Solid	Solid
Colour	Transparent (can see through it)	Transparent	Transparent
Density (g/cm^3)	0.9	1.4	3.51
Melting point (°C)	0	1350	3750
Boiling point (°C)	100	–	5100
Hardness (1 to 10 with 10 the hardest)	3	5	10
Heat conductivity	Poor	Poor	Poor
Smell	No smell	No smell	No smell

1. How much harder is diamond than glass?
2. Which material is the hardest known?
3. Which material is the heaviest?
4. The density of water is 1 g/cm^3. Which material is slightly more dense than water?
5. Materials that have a density less than water will float on it. Which material would float on water?
6. Which materials do not conduct heat well?
7. At what temperature does ice become water?
8. At what temperature does diamond become a gas?
9. Which material will be a liquid at room temperature?

Activity 2 Comparing Properties Of Fabrics

Materials needed:

Fabric and fibres (cotton and cotton fibres, or wool).

Aim: To investigate and compare the properties of a fabric and its fibres.

1. Choose a fabric and the fibre it is made out of: *e.g. An old cotton item and cotton wool, a woollen item and wool, papa* (floor mat) *and fibres from paogo* (*Pandanus* species).
2. Compare the regular, repeating pattern of the fabric with the disorder of the fibres. Record your observations.
3. Tear the fabric and a bundle of fibres in different directions. Record your observations. Is there a pattern with the fabric? Do the fibres do the same?
4. Stretch the fabric and a bundle of fibres in different directions. Record your observations. Is there a pattern with the fabric? Do the fibres do the same? .
5. If the fabric is fine enough, look through it at a point of light. Turn the fabric slowly. Record your observations. Repeat with a thin layer of fibres. Compare your observations.
6. Write a summary that compares the properties of a fabric with the fibres it is made out of.

Physical and chemical changes

The properties of materials change when they undergo physical and chemical changes. Often it is very hard to tell if the change is a chemical change or a physical change.

Chemical Changes

A **chemical change** is a chemical reaction which forms a new material. Wood burning is an example of a chemical change. The wood and oxygen in the air react together to form ash, soot, carbon dioxide and water. There are four signs that a chemical change has occurred.

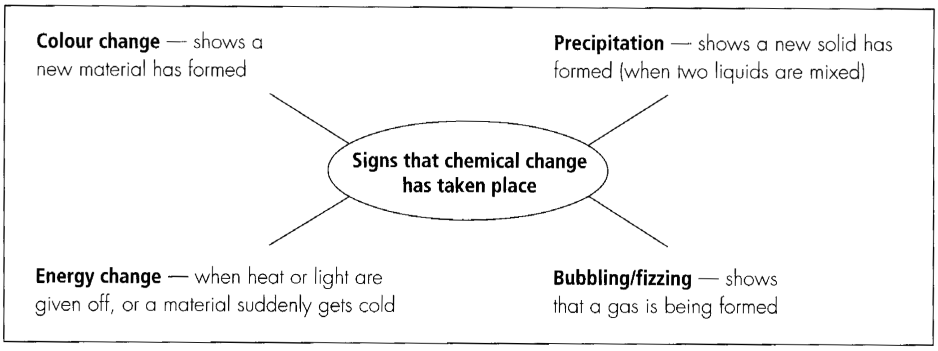


Diagram 2.2
Signs of a chemical change.

In a chemical change the materials present at the start of the reaction are called the **reactants**. The materials formed during the reaction are called the **products**. The products have properties that can be very different to the properties of the reactants. Energy changes occur with chemical changes. Sometimes energy is needed to start the chemical reaction. For example, energy is added to start wood burning. There is also a lot of heat and light energy given out when wood burns.

Fizzing or bubbling means a gas is forming during the chemical change. Hydrogen, carbon dioxide and oxygen are common gases involved in chemical changes. There are simple tests to see if these gases are present. Collect some of the gas being given off by placing your thumb over the top of the test tube. Test the gas using the following tests.

Test for carbon dioxide	**Test for hydrogen**	**Test for oxygen**
1. Add limewater to the gas. If it goes milky then carbon dioxide gas is present.	1. Light a stick/match. 2. Put the burning stick by the opening of the test tube and if it explodes with a popping sound hydrogen gas is present.	1. Light a stick then blow it out to give a glowing stick. 2. Put the glowing stick in the gas and it will catch alight again if oxygen gas is present.

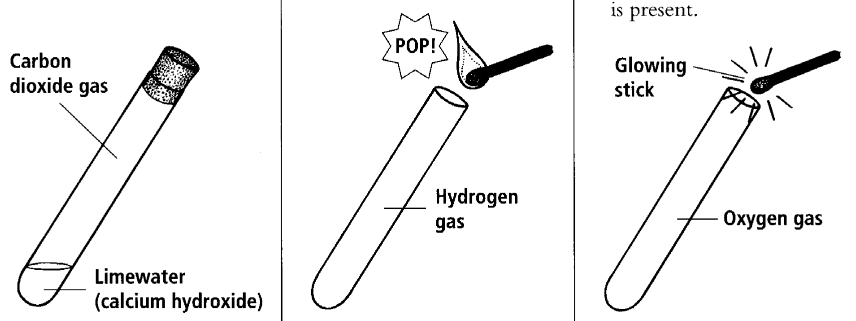


Diagram 2.3
Testing gases.

Burning
Burning is a chemical change where a material joins with oxygen. The change is easy to see because of the flame. Some materials, such as petrol, burn to form carbon dioxide and water which are both gases that go into the air without being seen. Sometimes carbon, in the form of black soot, is made when petrol burns. Magnesium metal burns with oxygen to form a white powder called magnesium oxide.

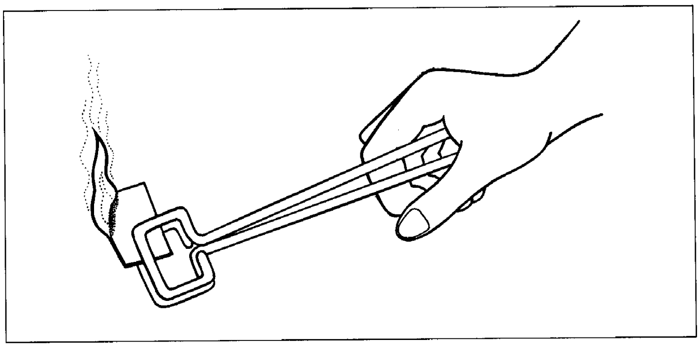


Diagram 2.4
Burning a piece of plastic.

Rusting and corrosion

Rusting is a chemical change in which iron reacts with oxygen in the presence of water to form the orange chemical iron oxide. Iron is the only metal that rusts. All other metals react with oxygen to form oxides on the surface of the metal. This is called **corrosion.** It makes the shiny surface of the metal look dull and grey. Corrosion is like burning except that it happens slowly without lots of heat and light being given off at the same time.

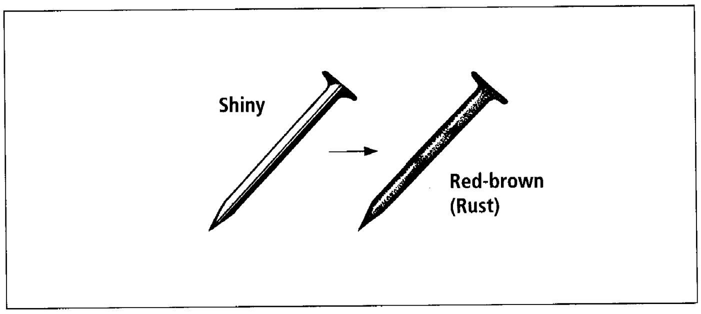


Diagram 2.5
Corrosion of an iron nail.

Decomposition reactions

Some materials break down when heated. This is called **decomposition**. Baking soda (sodium hydrogen carbonate) is a chemical that people use in baking. When baking soda is used in a cake and is heated in an oven it breaks down to give off carbon dioxide gas. The bubbles of carbon dioxide gas given off make the cake rise and form the small holes that can be seen when the cake is cut.

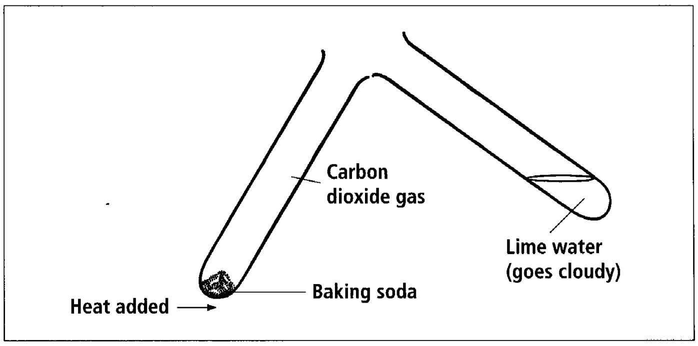


Diagram 2.6
Decomposition: Lime water being used to show carbon dioxide gas is given off.

Neutralisation reactions

Acids and bases react together to form a metal salt and water. Reactions of acids with bases are called **neutralisation** reactions.

Metals react with acids to form a metal salt and hydrogen gas. The hydrogen gas can be seen as bubbles or fizzing. Salts are chemicals with a metal and a non-metal part. Each different type of acid used in an acid/metal reaction forms a different type of salt. For example hydrochloric acid always forms chloride salts and sulfuric acid always forms sulfate salts.

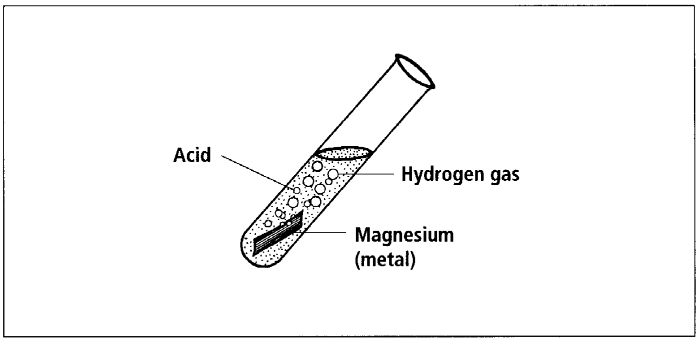


Diagram 2.7
Acid/metal reaction.

Baking soda will react with acids in lemon juice and vinegar to form a salt, carbon dioxide and water. This is an acid carbonate reaction that is used in baking. This reaction can be seen because of the bubbles or froth that form during the reaction.

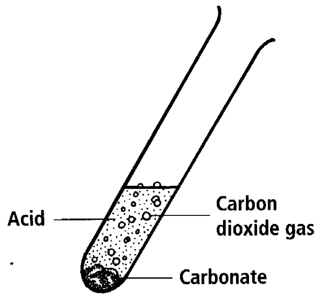


Diagram 2.8
Acid/carbonate reaction.

Activity 3

Chemical Change

Aim: To record information about chemical changes.

Complete the following work in your exercise book.

1. What is a chemical change?
2. List four things that show a chemical reaction is occurring.
3. Explain the difference between 'reactants' and 'products'.
4. Copy Diagram 2.3 (*Testing gases*) into your exercise book.
5. Name the four products that are formed when wood burns.
6. What is the difference between rusting and corrosion?
7. Clean metals look bright and shiny. Explain why most metals we see look dull and grey.
8. How does a chemical reaction cause a cake to rise when it is being baked?
9. What does the term 'neutralization' mean?
10. Give three examples of neutralization reactions.
11. What is formed when an acid reacts with a metal?
12. Name the different types of salts produced by hydrochloric and sulphuric acids.

Activity 4

Equipment needed:

Range of materials as available;

Test-tubes, beakers or jars;

Burner or candle;

Stick or matches for testing gas.

Investigating Chemical Change

Aim: To observe chemical changes.

- Observe some of the chemical changes listed below and record the products and any energy changes seen. If fizzing or bubbling occurs, collect and test the gas to see if it is hydrogen, carbon dioxide or oxygen. Record the properties of the reactants and products.

1. Burn a range of materials such as wood, cloth, candle wax, magnesium, steel wool, plastic.
2. Mix vinegar, lemon or lime juice with baking soda.
3. Mix vinegar with egg shell or shell.
4. Heat potassium permanganate crystals and use a glowing stick in the mouth of the test tube to test for oxygen.
5. Mix pairs of solutions to find out which react and which do not react. Record your observations. Dilute acids and alkalis, copper sulfate, ferric chloride, ferrous sulfate, nickel and cobalt salt solutions, potassium permanganate, potassium dichromate, sodium carbonate.
6. Heat milk to about 37°C and add half a teaspoon of lemon juice. Leave to set.
7. Observe the making and setting of concrete or plaster of Paris.
8. Heat steel wool in a burner.

Word equations

Chemical reactions can be recorded in word equations. Here are examples of general word equations:

lemon juice + baking soda ⟶ salt + carbon dioxide + water

This reaction can also be written using the chemical names of the materials.

citric acid + sodium hydrogen carbonate ⟶ sodium citrate + carbon dioxide + water

The chemicals that were present at the beginning, before any reaction occurred, are written on the left side of the equation. These are called the reactants. On the other side of the equation are the products that are formed during the chemical reaction. Plus signs (+) are used instead of writing 'and'. The arrow (⟶) is used to show that a chemical reaction is occurring in which these reactants are forming these products. Sometimes the energy inputs and energy changes are shown in the equations. When 'heat' is written over the arrow it means that heat is needed to make the reaction happen.

General equations can be written for a number of reactions. Some examples of general and specific reactions follow:

Burning and corrosion of metals	**Metal + oxygen → metal oxide** Magnesium + oxygen → magnesium oxide
Decomposition reaction	**Metal carbonate $\xrightarrow{\text{Heat}}$ metal oxide + carbon dioxide** Calcium Carbonate $\xrightarrow{\text{Heat}}$ calcium oxide + carbon dioxide Sodium hydogen carbonate $\xrightarrow{\text{Heat}}$ sodium carbonate + carbon dioxide + water
Neutralisation reactions	**Acid + base → salt + water** Hydrochloric acid + sodium hydroxide → sodium chloride + water **Metal + acid → salt + hydrogen gas** Magnesium + hydrochloric acid → magnesium chloride + hydrogen gas **Acid + metal carbonate → salt + carbon dioxide + water** Hydrochloric acid + calcium carbonate → calcium chloride + carbon dioxide + water

Activity 5 Word Equations

Aim: To use word equations to describe chemical reactions.

1. Write out the general word equation for each of these types of chemical reactions:

- Burning and corrosion of metals.
- Decomposition.
- Neutralisation: acid/base reactions; acid/metal reactions; and acid/carbonate reactions.

2. Use the information on chemical change and word equations on the previous pages to complete the following word equations.

Coconut husk + oxygen ⟶ ash + ______________ + water

Paper + oxygen ⟶ ______________ + ______________ ______________ + ______________

Metal + ______________ ⟶ metal oxide

Baking soda + lemon juice ⟶ ______________ + ______________ ______________ + ______________

Metal + acid ⟶ ______________ + ______________ ______________

3. Go back to the reactions completed in Activity 4 and write chemical equations for as many of the reactions as you can.

Physical changes

A physical change occurs when there is a change in a physical property of a material. Physical changes are usually able to be undone because no new materials have been produced by chemical reactions. For example, when water is frozen to ice, the ice can be heated to get the water back. Changes of state are also physical changes (see Unit 1 for information about changes of state). The following diagram shows a range of physical changes to common materials.

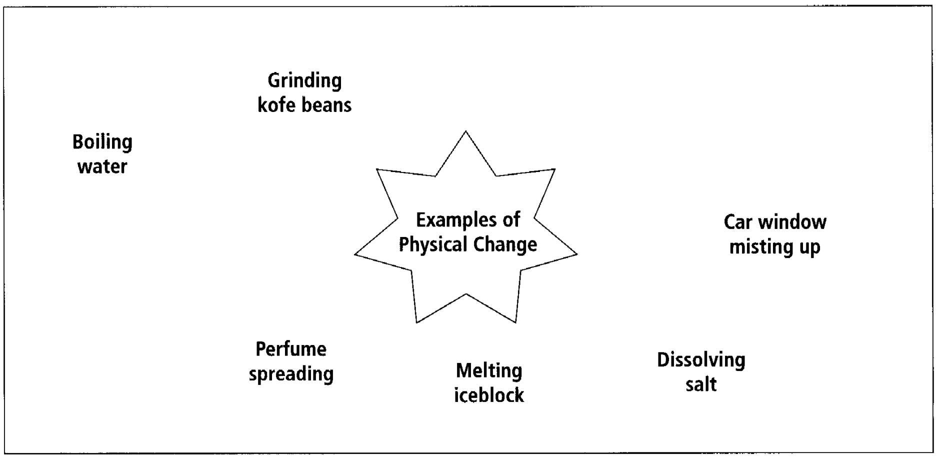


Diagram 2.9
Examples of physical changes.

Changing from lumps to powder

This is a physical change in which materials are either put through a sieve to break up the lumps or are ground up using a heavy piece of wood. For example, rocks are ground into fine powders to make dyes. A powder is still a solid but the pieces of solid material in a powder are much smaller.

Dissolving

This is a physical change in which a solid material breaks down into such very small particles that it 'disappears' into the liquid that it is mixed with. Some people like to have sugar dissolved in their kofe. The water is called a **solvent** and has both kofe and sugar dissolved in it. The solid materials are called **solutes**. The solvent with the solute dissolved into it is called the solution and is a mixture. A material that will dissolve is said to be **soluble**.

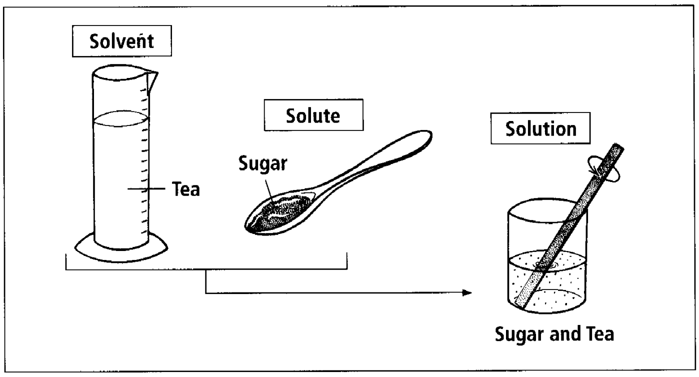


Diagram 2.10
Dissolving sugar in tea.

During dissolving the solute particles break apart from each other and move throughout the solvent particles.

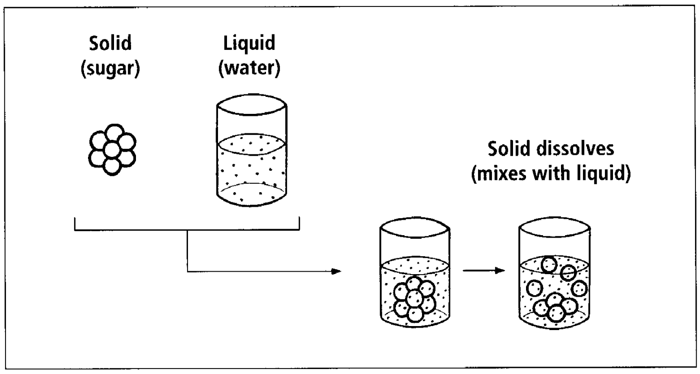


Diagram 2.11
Dissolving.

Some materials dissolve quicker than others. Some are said to be **insoluble** because they do not dissolve. Some materials that will not dissolve in water will dissolve in other solvents such as alcohol or petrol. Some paints are soluble in water and some require other solvents to dissolve them.

Activity 6 Physical Changes

Aim: To record information about physical changes.

Complete the following questions in your exercise book:

1. What is a physical change?
2. List five different types of physical change.
3. Explain the difference between a 'solute', a 'solvent' and a 'solution'.
4. Write out the words in **List A** then match them with the correct phrase from **List B**.

List A	**List B**
1. Solvent.	a. Dirt on the clothes.
2. Solute.	b. Dirt that will dissolve.
3. Solution.	c. Water used for washing.
4. Soluble.	d. Dirt that will not dissolve.
5. Insoluble.	e. Dirty water.

5. When a candle burns, both physical and chemical changes must occur. Read the information on the diagram and then explain how two physical and one chemical change are involved in the burning of the candle wax.

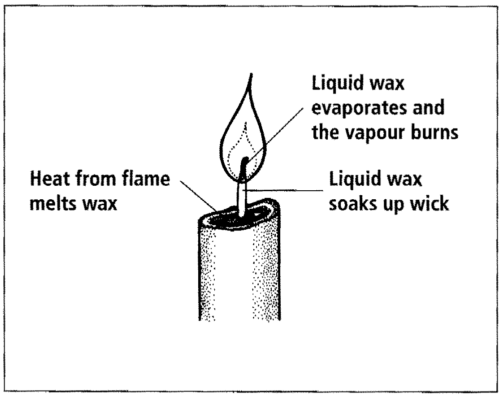


Diagram 2.12
Candle burning.

Activity 7

Investigating Physical And Chemical Changes

Materials needed:

Paper, water, baking soda and two other everyday materials;

Burner or matches;

Hydrochloric acid or vinegar;

Stone for grinding.

Aim: To investigate physical and chemical changes in everyday materials.

1. Copy the tables below into your exercise book.
2. Add into the tables the names of the extra materials you are going to test.
3. Add into the tables extra chemical and physical changes that you are going to try.
4. Carry out the test on each of the materials and complete the tables by describing any chemical and physical changes that occured.

Chemical change	**Material**				
	Paper	Water	Baking soda		
Reaction with oxygen					
Reaction with acid					

Physical change	**Material**				
	Paper	Water			
Changing shape					
Dissolving					
Grinding					
Changing state					

Step 2: Forming paper sheets

Mix water and pulp. The amount of pulp to water concentration determines the thickness of the paper. If the vat looks like heavy cream, the paper will be quite thick. If the vat looks rather like thin milk, the paper will be very thin. Different colours and types can be mixed. For example two cups of pure white pulp and perhaps a handful of brown paper bag and newspaper pulp.

Form a sheet of paper by placing a screen vertically down the side of the vat of pulp. When the screen is on the bottom of the vat, turn it parallel with the bottom and lift straight out. The water will drain off the screen leaving a deposit of pulp. Keep fingers away from the screen as anything on the screen will create a hole in the paper.

Place a piece of moistened newspaper on a table or flat surface or dish (to catch excess water). Put a damp dishcloth on top of the newspaper. Tip the screen over and place it on top so that the pulp will go onto the dishcloth. Sponge excess water off the screen to get it to release the pulp onto the cloth.

If a piece of newly formed paper tears gather all of the pulp up and put it back into the vat then try again.

↓

Step 3: Blotting and drying

Place a screen on top of the newly formed sheet of paper and use a sponge to remove excess water.

Remove the screen and put a piece of re-useable dishcloth and a piece of newspaper on top to continue blotting.

Place the paper in the air to dry or gently peel the newly formed sheet from the dishcloth and iron it dry.

↓

Step 4: Clean up

Pour left over pulp through a sieve to remove the water. Remove the pulp from the sieve and squeeze into a ball. Break it up into tiny pieces and put it in the dish pan to dry. It can be moistened later and put through the blender so that it can be used again.

Activity 8 Locally Made Materials

Aim: To find out the steps used to make a material.

1. People make and use lots of different materials. Some examples are siapo, coconut cream, ice cream, bread, rope, beer, kofe powder, paper from plant materials.
2. Choose a material that is made locally and find out the steps used to make the material.
3. Record the steps in a flow chart and describe what happens at each step. Try to identify the chemical and physical changes that are used to make the material.
4. Present your information to the class.

Unit summary

- Each material has its own physical and chemical properties that make it different from other materials.
- Physical properties are all the properties that do not involve chemical reactions. Physical properties include: colour, temperature, ability to conduct heat and electricity, volume, density, melting point, freezing point, boiling point.
- Chemical properties involve all the chemical reactions that the material will take part in and what sorts of products it will form. Some materials will react with oxygen and some will not. For example, hydrochloric acid reacts with metals to form hydrogen gas and a chloride salt.
- The properties of a material change when it takes part in a chemical reaction. Four signs that a chemical change have occurred are: colour change, bubbling or fizzing, energy change, precipitation.
- The materials present at the beginning of a chemical change are called reactants and those produced by the chemical change are called products.
- Gas tests:

Gas	Hydrogen	Oxygen	Carbon dioxide
Test with	Lit match.	Glowing match or stick.	Solution of limewater.
Positive result	Popping sound.	Stick relights.	Limewater goes milky.

- Types of chemical change:
  Burning — A flame is present and the material joins with oxygen.
  Corrosion — Metal joins with oxygen to form an oxide coating.
  Rusting — Reaction between iron and oxygen to form iron oxide.
  Decomposition — Carbonates break down when heated and give off carbon dioxide gas.
  Neutralization — Acids and bases react to form a metal salt and water. Metals react with acids to form a salt and hydrogen gas. Carbonates react with acids to give a salt, carbon dioxide and water.
- Word equations are a short way of recording the reactants and products of a chemical reaction. They are written with the reactants on the left and the products on the right. An arrow is used to join the two parts of the equation. For example:

Magnesium + sulfuric acid → Magnesium sulfate + hydrogen gas

- Physical changes are changes in the physical property of a material. No new materials are formed in a physical change.
- Types of physical changes:
  Change of state — Melting, evaporating, boiling, condensing, freezing, sublimation.
  Dissolving — A soluble solid 'disappears' into a liquid. The solid is called a solute, the liquid is called a solvent and the resulting material is called a solution. Some materials are insoluble and do not dissolve.
- Physical and chemical changes are used to make materials that people can use.

Unit 3: MATERIALS AND THEIR USES

Introduction

In this unit, you will investigate the physical and chemical properties of metals and non-metals and how people use these properties. You will also gather and present information on the safe and appropriate use of groups of materials.

Metals and non-metals

There are over 100 elements found on Earth. We divide these elements into two main groups, the metals and non-metals. About 80% of the elements are metals and the rest are non-metals.

Metals and non-metals have different physical and chemical properties. For example, almost all of the metals are solids. Many of the non-metals, such as hydrogen and chlorine, are gases. The non-metal gases oxygen and nitrogen make up the atmosphere around us.

Activity 1 The Physical Properties Of A Metal And A Non-metal

Aim: To gather, process and present information on the physical properties of a metal and a non-metal.

- Work in pairs. Choose a metal and a non-metal to focus your research on.
- Use information from the resources in Appendix I, Units 1 and 2, your own experience and from other sources to find out the physical properties of the chosen elements.
- Present relevant information on the physical properties in a poster or project.

Physical properties of metals

The metal you found out about in Activity 1 has many properties similar to all other metals. Here is a summary of the physical properties of metals.

State — Solid at room temperature (except for mercury, which is a liquid at room temperature).

Melting point — All have high melting points that are above 300˚C, except for mercury.

Colour — Most are silvery or grey, except for gold which is yellow, and copper which is red-brown.

Density (mass per unit volume) — Most are dense but aluminium and magnesium are not.

Lustre (shine) — All are shiny when first cut.

Strength — Most are strong, except for lead and mercury.

Malleability (ability to be worked, reshaped) — All can be reshaped easily.

Ductility (ability to be made into wires) — All can be stretched without breaking.

Heat conduction — All are good conductors of heat.

Electrical conduction — All are good conductors of electricity.

Scientists use the structure of metals to explain their properties.

The atoms of metals are packed tightly together in layers called a **lattice**. This tight packing of atoms is what gives metals their high density. The layers of atoms are able to slide over each other which allows them to be malleable and ductile.

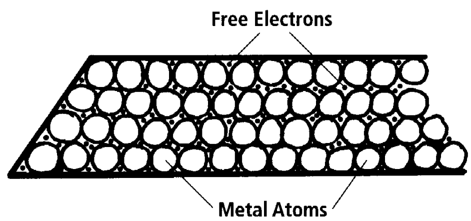


Diagram 3.1
Metal structure.

Some of the outer electrons of metal atoms are able to move from atom to atom. This is what makes metals good conductors of electricity. The strong lattice structure with the free electrons is what gives the metals their strength and high melting points.

Physical properties of non-metals
The non-metals have some properties that are the opposite of the metals.

State — Solids and gases, except bromine, which is a liquid at room temperature.

Melting point — A wide range of melting points.

Colour — A wide variety of colours.

Density (mass per unit volume) — Most have new densities.

Lustre (shine) — Most are dull, not shiny.

Strength — Brittle.

Malleability — Cannot be reshaped.

Ductility — Cannot be stretched.

Heat conduction — Do not conduct heat well. Act as insulators.

Electrical conduction — Do not conduct electricity, except for carbon as graphite.

Activity 2

Materials needed:
Samples of different types of metals and non-metals;
Wax;
Candle or burner;
Torch batteries, lamp and three wires;
Scales or balance;
Measuring cylinder;
Beaker.

Physical Properties

Aim: To record information about the physical properties of metals and non-metals.

1. Use the information on the last two pages to complete the following table for the 10 properties listed. The first one has been done for you.

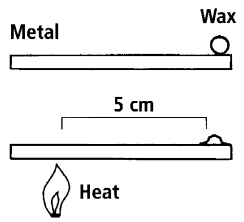
Physical property	Metal	Non-metal
State	Solid except mercury	Solid/gas except bromine

2. Look at a number of samples of different metals and non-metals. Compare the properties of the samples with the properties listed in your table and the information in the table given for number six on page 40.

3. Try the following on the metals and solid non-metals. If the equipment needed to work out the density is not available just take similar sized samples of the materials and compare how heavy they are.

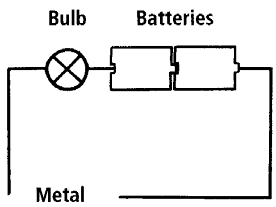
Testing heat conduction

1. Place a drop of wax on the end of a piece of metal.
2. Mark a point 5 cm from the wax. Heat the metal at the point and time how long it takes for the wax to melt.
3. Repeat three times with each sample.
4. Record all your results in a table. Work out the average time it takes to melt the wax over the three trials.



Testing electrical conduction

1. Set up an electrical circuit.
2. Test it by touching the two wires together.
3. Touch the ends of the wires onto a metal sample. If the lamp glows it means that the sample conducts electricity.
4. Record if the lamp glows or not in a table.



Finding the density

1. Use a balance or scales to measure the mass of the sample.
2. Record the mass.

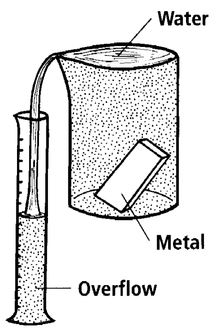
Volume

If the sample will fit in a measuring cylinder:

a. Put 50 ml of water in the cylinder and then add the sample.
b. Record the change in volume of water.
c. Calculate density by dividing the mass by the volume.

If the sample is large:

a. Completely fill a container, such as a beaker, with water.
b. Add the sample and catch the water that overflows in a measuring cylinder or beaker.
c. Record amount of water that overflows and calculate density.



4. Copy diagram 3.1 showing the lattice structure of a metal.
5. Use the lattice structure of metals to explain one of their properties.
6. Copy the following table and complete the symbol and state columns.

Metal	Symbol	Melting point	State	Density
Magnesium	Mg	650°C	Solid	1.7g/cm^3
Aluminium		660°C		2.7g/cm^3
Iron		1535°C		7.8g/cm^3
Copper		1083°C		8.9g/cm^3
Zinc		1500°C		7.1g/cm^3
Silver		961°C		10.5g/cm^3
Gold		1063°C		19.3g/cm^3
Mercury		-39°C		13.6g/cm^3
Lead		327°C		11.3g/cm^3

7. List the metals from the table above in order of the highest density to lowest density.
8. List the metals in order of highest melting point to lowest melting point.
9. Which metal has an unusually low melting point?

Chemical properties

Three important properties of metals are the ways in which they react with acids, water and oxygen. Not all metals react with each of these materials. Some metals are more reactive than others.

Metals with acids

Many metals react with acids to form metal salts and release hydrogen gas. Salts are made up of metal atoms and non-metal atoms. Each acid forms a different salt: hydrochloric acid forms chloride salts, sulfuric acid forms sulfate salts.

Metal + acid ⟶ metal salt + hydrogen gas

Magnesium + hydrochloric acid ⟶ magnesium chloride + hydrogen gas

Zinc + sulfuric acid ⟶ zinc sulfate + hydrogen gas

Activity 3

Materials needed:

Samples of metals — magnesium, zinc, iron, aluminium, lead, copper.

Hydrochloric acid and sulphuric acid or lemon juice and vinegar.

Test tubes or jars.

Stick or matches.

> **Warning!**
> Always be very careful when using acids. Make sure you follow your teacher's instructions exactly.

Reactions Between Metals And Acids

Aim: To investigate reactions between metals and acids.

1. Pour acid into a test tube or jar to a depth of 1 cm.
2. Add a small piece of metal.
3. Observe the reaction and collect the gas by putting your thumb over the mouth of the test tube.
4. When you can feel the pressure of the gas in the test tube put a burning stick in the mouth of the test tube to test for hydrogen gas. A 'pop' means that hydrogen is present.
5. Record your observations in a table like the one below.

Metal	Acid	Observation

6. If you can't see a reaction happening look closely for small bubbles on the surface of the metal.
7. If there is no reaction or the reaction is slow, gently warm the acid.
8. Select the solution from one of the reactions that formed lots of bubbles and evaporate the water by heating it or leaving it on a shelf. Examine and name the salt.
9. Write word equations for each of the reactions.

Metals with water

Few metals react with water to form a hydroxide and release hydrogen gas. Hydroxides are made up of metal atoms and hydroxide ions.

Metal + water ⟶ metal hydroxide + hydrogen gas

Magnesium + water ⟶ magnesium hydroxide + hydrogen gas

Calcium + water ⟶ calcium hydroxide + hydrogen gas

Activity 4

Materials needed:

Samples of metals — magnesium, zinc, iron, aluminium, lead, copper;

Water;

Test tubes or jars;

Stick or matches.

Reactions Between Metals And Water

Aim: To investigate reactions between metals and water.

1. Plan and carry out an investigation of the reaction between metals and water and record your observations. Use the instructions for Activity 3 as a guide for your plan. You will have to use **hot water** instead of an acid.
2. Write word equations for each of the metals that reacted with water.

Metals with oxygen

Oxygen is very reactive and easily joins with other elements. Reactions with oxygen are called **oxidation** reactions. Fast oxidation reactions produce heat and light and are called burning. Slow oxidation reactions happen at normal temperatures and don't give out heat and light. Slow oxidation of metals is called **corrosion**. Many metals react with oxygen to form an **oxide**.

	Metal + oxygen	→	**metal oxide**
e.g.	Magnesium + oxygen	→	magnesium oxide
	Zinc + oxygen	→	zinc oxide

Activity 5

Materials needed:

Two samples of each metal — magnesium, zinc, iron, aluminium, lead and copper;

Sandpaper;

Burner;

Tripod or tongs;

Tin lid to burn sample on.

Reactions Between Metals And Oxygen

Aim: To investigate reactions between metals and oxygen.

1. Clean a sample of each metal and leave it in air for several days to observe if slow oxidation occurs.
2. Record your observations.
3. Place the second sample of each metal on a tin lid, place the tin lid and sample on a tripod above the burner or hold the tin lid in the tongs over the burner. Heat and record your observations.
4. Write word equations for each of the reactions that occurred.

Uses of metals

Metals have lots of uses. Cooking pots are made out of aluminium and cars are mainly iron, but other metals such as chromium, zinc and copper are also used. It is the physical and chemical properties of a material that make it useful for one use but not another. The table below sets out the names of metals, examples of uses and the properties that make the metal suitable for that use.

Activity 6 Metals In Use

Aim: To identify metals in use around your school or village.

Metal	Uses	Property involved
Iron	Roofing, car bodies, building frames.	Malleable, strong, forms strong alloys.
Aluminium	Boats. Aircraft bodies.	Forms an unreactive oxide coating. Light and strong, unreactive.
Gold and silver	Jewellery.	Malleable, ductile, unreactive.
Lead	Roof flashings.	Soft, very malleable.
Zinc	Coating over roofing iron.	Reactive protective coating over the iron.
Tin	Coating over iron in tin cans.	Unreactive protective coating over the iron.
Chromium	Chrome plating.	Unreactive, so it stays shiny.
Mercury	Thermometers.	Liquid, expands evenly when heated.
Copper	Electrical wires. Bottoms of cooking pots. Water pipes.	Best conductor of electricity. Good heat conductor. Unreactive with air and water.

1. Look for examples of metals being used by people, then fill in the following table. The first row has been completed for you.

How metal is being used	Metal	Property of metal being used
Spring inside a pen.	Iron.	Can be made into thin wires.

Uses of non-metals

Most non-metals are important to people not in their elemental form but joined with other elements in a compound.

Oxygen

In the atmosphere two oxygen atoms join together to form an oxygen molecule. Twenty-one percent of the atmosphere is oxygen. Oxygen is important as it is used by all animals and plants in the process of respiration. It is used for medical purposes and for working with metals in cutting and gas welding. Many compounds in the body contain oxygen atoms.

Carbon

We can see three forms of carbon around us. The most common is the black soot formed during burning. The 'lead' in your pencil is not lead but carbon in the form of graphite. This is the second form. The third and most expensive form is diamond which is used in jewellery. Each of these different forms of carbon have very different properties. Diamond is very hard but graphite and soot are very soft. Even though they have very different properties each is only made up of a different arrangement of carbon atoms.

Carbon joins with other elements to form many, many different compounds. Many of the chemicals in the body, such as sugars, fats, oils and proteins, all contain carbon. Carbon also forms all the hydrocarbon compounds that are used for heating and fuels in car engines. Many of the materials we call 'plastics' are made up of mainly carbon atoms.

Nitrogen

Seventy-eight percent of the atmosphere is a gas formed by two nitrogen atoms joined to form a molecule. Nitrogen is an important part of a protein molecule which makes up the muscle structure of animals. Plants also need nitrogen for making proteins. Some plant fertilisers contain nitrogen.

Activity 7 Non-metals

Aim: To research information about non-metals and their uses.

- Work in pairs or groups. Select a non-metal and use a range of sources of information such as the library, Agricultural Department, Conservation Department, and USP to find out about the uses of the non-metal element you have selected.

Safe and appropriate use

Materials used around the fale, village and workplaces have lots of different properties. The properties each has fit the use people are making of it. For example, fasi moli (soap) is used to clean clothes because of its ability to dissolve grease and dirt from clothes without harming the fabric. Disinfectants and antiseptics are both used to kill bacteria and other micro-organisms. Disinfectants can be used to clean food preparation areas. Antiseptics are used to treat wounds and other injuries because they do not harm living tissue.

Petrol and diesel are used as fuels because the hydrocarbon molecules they contain have a lot of energy in each molecule. When they are burnt inside the engine this energy is released and used to make the engine go. Petrol burns easily and can cause fires if not stored and used correctly.

There are lots of different types of materials used by people. Some materials have properties that are harmful. It is very important that these materials are used in safe and appropriate ways. Many materials have labels with information about safe and appropriate use.

Here is some of the information on a bottle of bleach. It gives information on what the material does, how to use it correctly, what chemicals it contains and what to do to ensure safety of people.

Bleach

- Kills germs.
- Whitens.
- Removes stains.

Contains 21.5 g/L Sodium hypochlorite.

Caution

This substance is caustic and is an irritant if splashed on eye and skin. Wash off in running water.

- Do not drink.
- Store out of reach of children, in a cool place away from direct sunlight.
- Do not use on materials that are not colourfast.
- Spills should be cleaned up immediately.
- If swallowed drink lots of milk or water, take egg white, or milk of magnesia.

Laundry

Add $\frac{1}{2}$ cup of bleach with each load of washing.

Pre-soak babies nappies for 15 minutes in a solution of $\frac{1}{4}$ cup of bleach to 4 litres of water to whiten, deodorise and to kill harmful bacteria.

Soaking

Stir $\frac{1}{4}$ cup of bleach in 6 litres of water. Soak whites separately from colours then rinse.

Stains

To remove tea, coffee, fruit, ink, wine, mildew etc from white and colourfast fabrics (not wool or silk). Soak in warm water for 10 to 15 minutes then in a solution of $\frac{1}{2}$ cup of bleach to 9 litres of warm water for 10 to 15 minutes. Rinse well and repeat if necessary.

Toilet

Pour $\frac{1}{4}$ cup of undiluted bleach into the toilet bowl, leave as long as possible before flushing.

When using materials, to avoid harm to people and other materials it is important to follow the instructions for their safe and appropriate use.

Activity 8 Safe And Appropriate Use

Aim: To record information about the safe and appropriate use of materials.

Complete the following in your exercise book.

1. Describe an important property of antiseptics that makes them different from disinfectants.
2. Explain what happens when fuels are used correctly and what can happen if they are not.
3. Use the information on the bleach label to answer the following.
   a. What does the material do?
   b. What chemical does it contain?
   c. How should it be stored?
   d. What can be taken if the bleach is swallowed?
   e. What dilution is used for soaking white clothes?
   f. How should the bleach be used to remove stains?
4. Read the label on another material. Record information on:
   a. Name of the material.
   b. What type of material it is: *e.g. Disinfectant, fuel, pesticide, cleaner*?
   c. What the material does.
   d. How to use it correctly.
   e. What chemical(s) it contains.
   f. What to do to ensure safety of people.

Activity 9 Safe And Appropriate Use Of Groups Of Materials

Aim: To present information about the safe and appropriate use of a group of materials.

1. Read the labels of household cleaners and other materials such as fertilisers, pesticides and other sprays to identify the safety information.
2. Record the name of the material and the main points from the safety information on it.
3. Work in pairs or groups. Choose a group of materials (such as fertilisers, cleaners, pesticides, fuels, detergents, plastics etc) and make a poster that summarises the key points about their safe and appropriate use.
4. Present your information to the class.

Unit summary

- There are over 100 elements which can be divided into metals and non-metals.
- Metals are shiny, strong, good conductors of heat and electricity, malleable and ductile, have high melting points and are solids except for mercury, which is a liquid at room temperature. Most metals are silvery or grey in colour.
- Metals are made up of a tightly packed lattice of atoms that have some electrons free to move from one atom to the next. This lattice structure can be used to explain the physical properties of metals.
- The non-metals have a wide range of melting points and are solid or gas at room temperature. The solids are many different colours and their surfaces are dull, not shiny. Non-metals do not conduct heat and electricity except for graphite, which conducts electricity. They have low density and are brittle.
- Chemical properties of metals include their reaction with acid, water and oxygen.

  Metal + acid $\longrightarrow$ metal salt + hydrogen gas

  Metal + water $\longrightarrow$ metal hydroxide + hydrogen gas

  Metal + oxygen $\longrightarrow$ metal oxide

- Metals have similar but slightly different properties and it is these properties that people make use of. Aluminium can be used for boats because of the unreactive oxide coating that forms on the outside of aluminium. Lead is used to finish a roof because it is soft and able to be shaped to fit into the shape of the iron.
- Non-metals are important around us in the atmosphere and in a variety of chemicals. Each non-metal has many different properties which make it useful.
- It is important to use materials in safe and appropriate ways. Sometimes the property of a material that is being used can also cause harm if not used correctly. Instruction labels should be read carefully before use and storage guidelines carefully followed.

APPENDIX I: IRON

Iron

The pure metal is very reactive chemically and rapidly corrodes, especially in moist air or at high temperatures. It has four forms or ferrites, known as alpha, beta, gamma, and omega, with transition points at 700, 928, and 1530°C. The alpha form is magnetic, but when transformed into the beta form, the magnetism disappears although the lattice remains unchanged. The relations of these forms are peculiar. Pig iron is an alloy containing about three percent Carbon with varying amounts of Sulfur, Silicon, Manganese, and Phosphorus.

Iron is hard, brittle, fairly fusible, and is used to produce other alloys, including steel. Wrought iron contains only a few tenths of a percent of carbon, is tough, malleable, less fusible, and usually has a 'fibrous' structure.

Carbon steel is an alloy of iron with small amounts of Mn, S, P, and Si. Alloy steels are carbon steels with other additives such as nickel, chromium and vanadium. Iron is a cheap, abundant, useful, and important metal.

Source: http://pearl1.lanl.gov/periodic/elements/26.html

Standard state:	Solid.
Colour:	Lustrous, metallic, greyish tinge.

The use of iron dates back to prehistoric times, and even Genesis mentions the use of iron. In Delhi, India, a large iron pillar, dating back to 400 A.D., still stands today. Iron is found abundantly throughout the universe, from the Sun to many types of stars. Iron is found native as a principal component of a class of meteorites known as 'siderites', and is a minor constituent of the other two classes.

Source: http://www.tamuk.edu/chemistry/WebElements/iron_element.htm

Density of solid: 7874 kg/m^3
Molar volume: 7.09 cm^3
Electrical resistivity: 9.7mW/cm
Melting point: 1538°C
Boiling point: 2861°C

Source: http://www.webelements.com/webelements/scholar/elements/iron/physical.html

A child's story about iron

Once upon a time there was an element named Iron. It had a melting point of 1808°K, and a boiling point of 3023°K. It had an abbreviation of Fe, and is in a solid state at room temperature. There was a time in Iron's life where it could be hammered into thin sheets. And then there was a time in Iron's life where it could be drawn into fine wires. Iron comes from the Latin word ferrum, and has a cubic crystal structure. It can be obtained from iron ores. Then Iron ore is converted into usable Iron in a giant structure called a blast furnace. Everyone needs Iron. If you are a plant or an animal and/or a human being you need Iron to survive. Iron is definitely the cheapest and most useful element. Iron will also live on to be the most common chemical substance found in the earth's crust. And Iron will live happily ever after with its 26 protons and 26 electrons.

Source: http://acgc.k12.mn.us/Chemistry/iron.htm

Description: Malleable, ductile, silvery-white metal. Fourth most abundant element in the earth's crust (56 300 ppm). Ninth most abundant element in the universe. Discovered by: unknown. Sources: obtained from iron ores. Pure metal produced in blast furnaces by layering limestone, coke and iron ore and forcing hot gasses into the bottom. This heats the coke red hot and the iron is reduced from its oxides and liquified. Used in steel and other alloys. Essential for humans. It is the chief constituent of haemoglobin which carries oxygen in blood vessels. Its oxides are used in magnetic tapes and disks.

Source: http://www.vcs.ethz.ch/chemglobe/ptoe/_/26.html

From the Anglo-Saxon word '*iron*' (the origin of the symbol Fe comes from the Latin word '*ferrum*') meaning '*iron*'.

Symbol: Fe	Atomic Number: 26
Atomic Mass: 55.845 u	Melting Point: 1811°K
Boiling Point: 3134°K	Density: 7874 kg/m^3

Physical Properties: A soft, malleable, and ductile metal.

Chemical properties

- Very magnetic until heated to a temperature of 790°C at which point the element loses its magnetic properties.
- In the presence of water combines with atmospheric oxygen to form a hydrated iron oxide, referred to as rust.
- Combines with halogens (such as fluorine, chlorine, bromine, iodine, and astatine), sulfur, carbon, silicon, and phosphorus.
- Does not react to acid and other substances when dipped into concentrated nitric acid (a corrosive, transparent liquid) due to a layer of oxide that forms.

Common uses

- Virtually useless unless in a processed form (i.e. wrought iron, cast iron, and steel).
- Major ingredient in galvanized sheet metal and electromagnets (in its processed form).
- Used in tonics.
- Used to treat anaemia (condition where the number of red-blood cells is lowered).
- Iron is the cheapest and most abundant, useful and important of all metals.

Historical background

- Iron was (and still is) an extremely important element. The Iron Age was marked with the use of iron as ornaments and weapons.
- Iron artifacts have been identified from around 3000 B.C.

Source: http://www.fordhamprep.pvt.k12.ny.us/gcurran/3rdquart/feelem.htm

APPENDIX II: ALUMINUM

Aluminium

Imagine a world without aluminium. There would be no commercial air travel. It is used to build fuel-efficient engines in aircraft as well as cars and buses. Its low weight reduces fuel use. It helps in the construction of corrosion-resistant and low maintenance cost buildings. Aluminium in packaging preserves food quality and avoids waste. Around the world, most high voltage overhead electricity lines over long distances are made of aluminium.

Source: http://www.world-aluminium.org/applications/index.html

When aluminum is combined with other metals it becomes very strong. It is so strong that engineers use it to build planes and ships. Did you know that there is even a type of plastic that has aluminum inside? The next time you sit down to eat dinner at a restaurant you should know that aluminum was used to make the utensils. When you see forks, knives, and spoons they usually have some aluminum inside. There is a very special stone called a ruby. It is found in all sorts of jewellery. It has a very deep red colour. There are aluminum atoms inside all rubies.

Sometimes when you go to school your mum might put your sandwich in foil. That foil is made out of aluminum. Some people save that tin-foil for years and make big balls out of it. There are power lines all over the United States. Sometimes those cables are made with aluminum. Aluminum is very good at sending electricity from one point to another. It is a good conductor.

Aluminum is a really light metal. When it is mixed with other elements it can also become very strong. Engineers found out that they could build airplanes with aluminum because it is strong and light. Wow! Aluminum is in a lot of gem stones. First you learned that it is in rubies and now you're learning that aluminum is inside sapphires. Maybe rubies and sapphires aren't that different!

This one's easy! You should know what an aluminum can is. All of your soda usually comes in cans and those cans are usually made of aluminum.

http://chem4kids.com/files/elements/013_where.html

Aluminium is used in cookware because it is light and strong, so even a large sturdy pan is easy to handle. It gives no taste or odour to food, is durable and conducts heat well. It loses only about seven per cent of the heat it receives, leaving 93% of the heat to cook your food. This means that aluminium cookware transfers heat very efficiently and evenly to the food inside, rather than to the air outside.

Source: http://www.world-aluminium.org/applications/packaging/cooking.html

Aluminium is used extensively for the protection, storage and preparation of food and beverages. It conducts heat extremely well, making it very energy efficient for preparing and serving both hot and cold food.

Aluminium is also very light, this helps to reduce transportation costs and means it is suitable for packaging applications where weight is important. Aluminium is used in several types of packaging because of its excellent barrier function, it keeps out air, light and micro-organisms in order to preserve the contents.

Aluminium foil has outstanding characteristics; it is light, strong, flexible and durable. Solid aluminium is an effective barrier against light, air and water. Foil only one-hundredth of a millimetre thick is completely impermeable.

Aluminium can be rolled into ultra-thin foils which are light, strong and have unique barrier and insulation qualities to preserve food, and protect from ultra-violet light, odours and bacteria. Aluminium packages are secure, tamper-proof, hygienic, easy to open and recyclable.

Aluminium foil finds its largest use in containers and packaging for food, cosmetics and pharmaceutical products. Aluminium withstands both heat and cold. It's easy to sterilise for food and medical applications. It's an excellent barrier against liquids, vapours and light. It's non-toxic and imparts no taste or odour. It is an excellent electrical conductor. It transmits conducted heat, and reflects radiant heat. That's why you can oven-bake a potato in foil or insulate your home with it.

Aluminium oxide, which forms on the surface of all aluminium metal in the presence of air, is stable in the pH range of 4.5–8.5, making aluminium suitable for storage of many different food types. Aluminium beverage cans and food cans have a protective polymer coating applied on the inside to prolong storage life. This polymer coating ensures that the acids and salts in beverages or food never actually comes into contact with the metal.

Aluminium cans are excellent containers: strong, light-weight, compact, impermeable, recyclable. Most beer and soft drink cans are now made of aluminium.

Why is the aluminium can so popular? It imparts no taste. It keeps flavour and carbonation in, and oxygen, light and moisture out. It's shatter proof. Attempts at possible tampering are easily detectable. One of its great assets is that the aluminium can is totally recyclable.

The lightness of aluminium cans makes it easy to ship them to wholesalers, retailers, carry home, and collect for recycling. They also stack better in delivery trucks, on shelves and in the refrigerator than glass or plastic bottles. They need less protection during shipment than glass.These attributes save a lot of energy in shipping and distribution.

Source: http://www.world-aluminium.org/applications/packaging/index.html

Aluminium or aluminium alloy electrical conductors are now widely used in the following areas:

- Overhead lines.
- Electrical energy distribution and transport cables.
- Energy cables for industrial use.

Aluminium is particularly suited to these uses because of its high electrical conductivity, low weight and good resistance to corrosion.

Almost all electric lights, motors, appliances and power systems depend on a vast grid of aluminium wire.Around the world most high-voltage overhead transmission and distribution lines and many underground lines are made of aluminium. Aluminium replaced copper in high-voltage transmission lines after 1945 and today is the most economical way to transmit electric power.

Aluminium weighs only one-third as much as copper and one kilogram of aluminium can carry twice as much electricity as one kilogram of copper. Aluminium power lines are therefore lighter and require fewer, and lighter support structures.

Source: http://www.world-aluminium.org/applications/electrical/index.html

APPENDIX III: NON-METALS

Non-metals

Non-metals are most of the elements in groups 14–17 of the periodic table. Non-metals are not able to conduct electricity or heat very well. As opposed to metals, non-metallic elements are very brittle, and cannot be rolled into wires or pounded into sheets. The non-metals exist in the three states of matter at room temperature: gases (such as oxygen), liquids (such as bromine) and solids (such as carbon). The non-metals have no metallic lustre, and do not reflect light.

The non-metal elements include:

- Hydrogen.
- Carbon.
- Nitrogen.
- Oxygen.
- Phosphorus.
- Sulfur.
- Selenium.

Source: http://www.chemicalelements.com/groups/nonmetals.html

Oxygen

This gas is colourless, odourless, and tasteless. The liquid and solid forms are a pale blue colour.

Oxygen, which is very reactive, is a component of hundreds of thousands of organic compounds and combines with most elements.

Plants and animals rely on oxygen for respiration. Hospitals frequently prescribe oxygen for patients with respiratory ailments.

Source: http://pearl1.lanl.gov/periodic/elements/8.html

Melting Point: −218.4°C
Boiling Point: −183.0°C

Source: http://www.chemicalelements.com/elements/o.html

Oxygen is very important. Life on earth could not exist without it. Animals need to breathe oxygen to survive. Luckily, there is enough oxygen in the air for everyone to breathe. You just read that there is oxygen in the air. Here's something else: fifty percent of the earth's crust is made up of oxygen. That means that no matter what you pick up or dig up from the ground, there's a good chance that one half of it is made up of oxygen.

Over half of the earth is covered with water. Mixed in that water is oxygen. In the same way we breathe the oxygen in the air, fish breathe the oxygen in the water. You probably know that you breathe oxygen and need it to live. Did you know that if you breathe too much oxygen you could die? What about this? If you have a room filled with oxygen and hydrogen and someone lit a match the whole room would explode! That's because oxygen is very **reactive**.

Source http://chem4kids.com/files/elements/008_where.html

Ammonia

Ammonia (NH_3) is the most important commercial compound of nitrogen. It is produced by the Haber Process. Natural gas (methane, CH_4) is reacted with steam to produce carbon dioxide and hydrogen gas (H_2) in a two step process. Hydrogen gas and nitrogen gas are then reacted in the Haber Process to produce ammonia. This colourless gas with a pungent odour is easily liquefied. In fact, the liquid is used as a nitrogen fertiliser. Ammonia is also used in the production of urea (NH_2CONH_2), which is used as a fertiliser, in the plastic industry, and in the livestock industry as a feed supplement. Ammonia is often the starting compound for many other nitrogen compounds.

http://pearl1.lanl.gov/periodic/elements/7.html

Chlorine

Chlorine is widely used in making many everyday products.

It is used extensively in the production of paper products, dyestuffs, textiles, petroleum products, medicines, antiseptics, insecticides, food, solvents, paints, plastics, and many other consumer products.

Most of the chlorine produced is used in the manufacture of chlorinated compounds for sanitation, pulp bleaching, disinfectants, and textile processing. Further use is in the manufacture of chlorates, chloroform, carbon tetrachloride, and in the extraction of bromine.

Source: http://pearl1.lanl.gov/periodic/elements/17.html

Chlorine is a special gas. It lives in a group called **halogen** gases. Flourine is also a halogen. It is also very reactive like chlorine

Have you-ever been in a swimming pool? When you go in the pool you're swimming with chlorine. People put chlorine in the pool to kill bacteria and disease. That addition makes the pool clean for you so you won't get sick. You know when you write on paper? People use chlorine to make paper white. It bleaches the paper of all colour.

Whenever you go to wash your clothes and you use bleach, that's chlorine you're using! The chlorine in bleach makes your white clothes really white. It can also take the colour out of your darker clothes. That would be bad. Chlorine is also used to kill micro-organisms in drinking water.

The salt on your table is made with chlorine. Scientists discovered that salt is made of one chlorine atom combined with one sodium atom. It's in the ocean first and then on your table. Think about sprinkler systems. Whenever you put sprinklers in a yard people use white plastic pipes for the water. Those pipes are made using chlorine. It is a special plastic called PVC. That's Poly-Vinyl-Chloride.

http://chem4kids.com/files/elements/017_where.html

Sulfur

Sulfur is pale yellow, odourless, brittle solid, which is insoluble in water but soluble in carbon disulphide. In every state, whether gas, liquid or solid, elemental sulphur occurs in more than one form.

In 1975, University of Pennsylvania scientists reported synthesis of polymeric sulfur nitride, which has the properties of a metal, although it contains no metal atoms. The material has unusual optical and electrical properties.

Sulfur is a component of black gunpowder, and is used in the vulcanization of natural rubber and a fungicide. It is also used extensively in making phosphatic fertilisers. A tremendous tonnage is used to produce sulfuric acid, the most important manufactured chemical.

It is used to make sulfite paper and other papers, to fumigate, and to bleach dried fruits. The element is a good insulator.

Sulfur is essential to life. It is a minor constituent of fats, body fluids, and skeletal minerals.

Source: http://pearl1.lanl.gov/periodic/elements/16.html

Sulfur is a yellowish colour and often found as a crystal. At normal temperatures, sulfur is **non-reactive**. Whenever you fertilise your plants there is a good chance that sulfur is in the fertiliser. Sulfur is an element that helps make the fertiliser healthy for plants. Sulfur is an important element in medicines. If you have bronchitis and are coughing all the time, sometimes doctors give you sulpha-drugs. This medicine is made with sulfur and helps kill the bacteria making you sick. There is a lot of sulfur near volcanoes. Volcanoes are actually holes in the surface of the Earth. All sorts of chemicals come out of these holes and sulfur is one of them. If you ever get close enough to a volcano you'll be able to smell the sulfur. It smells like rotten eggs. Fireworks are also a good place to find sulfur. Fireworks and firecrackers are filled with gunpowder. One of the main ingredients of gunpowder is sulfur. Whenever you see someone light a match, they're using sulfur. Just like fireworks, there is sulfur in matches that sparks and starts the flames.

Source: http://chem4kids.com/files/elements/016_where.html

Nitrogen

Standard state: Gas at room temperature.
Color: Colourless.

Nitrogen makes up 78% of the earth's atmosphere, by volume. When nitrogen is a liquid, it is colourless and odourless making it look similar to water. Nitrogen is used primary as a coolant; most commonly used in rockets and as a refrigerant in food storage.

http://www.tamuk.edu/chemistry/WebElements/nitrogen_element.htm

Nitrogen makes up about 78% of the atmosphere by volume but the atmosphere of Mars contains less than 3% nitrogen. The element seemed so inert (unreactive) that Lavoisier named it azote, meaning 'without life'. However, its compounds are vital components of foods, fertilisers, and explosives. Nitrogen gas is colourless, odourless, and generally inert. As a liquid it is also colourless and odourless.

When nitrogen is heated, it combines directly with magnesium, lithium, or calcium. When mixed with oxygen and subjected to electric sparks, it forms nitric oxide (NO) and then the dioxide (NO_2). When heated under pressure with hydrogen in the presence of a suitable catalyst , ammonia forms (Haber process). Nitrogen is 'fixed' from the atmosphere by bacteria in the roots of certain plants such as clover. Hence the usefulness of clover in crop rotation.

Source: http://www.webelements.com/webelements/elements/text/N/key.html

Sodium nitrate ($NaNO_3$) and potassium nitrate (KNO_3) are formed by the decomposition of organic matter with compounds of these metals present. In certain dry areas of the world these saltpeters are found in quantity and are used as fertilisers. Other inorganic nitrogen compounds are nitric acid (HNO_3), ammonia (NH_3), the oxides (NO, NO_2, N_2O_4, N_2O), cyanides (CN^-), etc.

The nitrogen cycle is one of the most important processes in nature for living organisms. Although nitrogen gas is relatively inert, bacteria in the soil are capable of 'fixing' the nitrogen into a usable form (as a fertiliser) for plants. In other words, Nature has provided a method to produce nitrogen for plants to grow. Animals eat the plant material where the nitrogen has been incorporated into their system, primarily as protein. The cycle is completed when other bacteria convert the waste nitrogen compounds back into nitrogen gas. Nitrogen has become crucial to life being a component of all proteins.

YEAR 9 GLOSSARY

Word/phrase	Meaning
Atomic number	Number of protons in the nucleus of an element.
Atoms	Small particles every material is made of.
Boiling point	Temperature at which a liquid boils.
Bonds	Attractive forces that holds atoms or particles together.
Burning	Burning is a chemical change where a material joins with oxygen.
Chemical change	When a chemical changes from one material to another during a chemical reaction.
Compound	Molecule having atoms of 2 or more different elements.
Corrosion	Corrosion occurs when a metal reacts with oxygen to form a metal oxide. The oxide forms a coating on the surface of the metal.
Crystals	An orderly arrangement of ions in a crystal, or atoms in a solid.
Decomposition	When a material splits to give other materials.
Density	The amount of mass in a volume of material.
Evaporation	Occurs at low temperature when the particles of a liquid gain enough energy to change state and become a gas.
Gas	A state of matter in which the material is able to spread out to fill the space it is in.
Ion	At atom that has lost or gained electrons.
Insoluble	A material that will not dissolve.
Lattice	The atoms of metals are packed tightly together in layers in a crystal.
Liquid	A state of matter in which the material is runny and wet.
Melting point	Temperature at which a solid melts.
Molecules	Two or more atoms joined together.
Neutralisation	A reaction where acids and bases react together.
Oxidation	Reaction with oxygen.
Products	Materials formed during a chemical reaction.
Reactants	Materials present at the start of a chemical reaction.
Rusting	A chemical reaction in which iron reacts with oxygen in the presence of water to form the orange chemical iron oxide.
Solid	A state of mater in which the material is hard and keeps its shape.
Soluble	A material that will dissolve.
Solute	Solid material that is dissolving.
Solution	Solvent with the solute dissolved into it.

Solvent Material that solutes are dissolved into.

Sublimation A change of state from solid to gas.