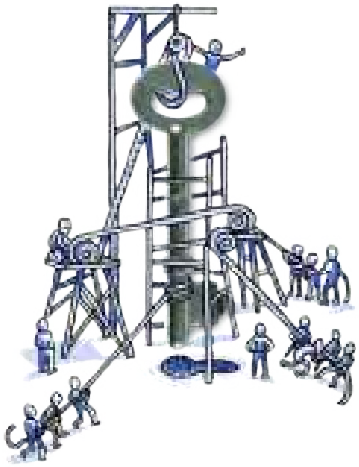
3 Chemical reactions



KEY QUESTIONS:

- What is a chemical reaction?
- What happens to atoms and the bonds between them during a chemical reaction?
- How can we identify the reactants and products of a reaction?
- What examples of chemical reactions are there in indigenous practices?

In the last chapter we looked at the particle model of matter and specifically at changes of state. Do you remember heating and cooling candle wax to observe it melt and then solidify. The wax first changed from a solid into a liquid and then back to a solid again. These are **physical** changes. The chemical properties of the substance does not change.

We are now going to look at what happens when we get **chemical** changes in substances. These take place during **chemical reactions.**

NEW WORDS

- chemical reaction
- reaction flask or reaction vessel

3.1 How do we know a chemical reaction has taken place?

During a chemical reaction, one or more substances are changed into new substances. Do you know of any chemical reactions? Can you mention one or two examples?

How will we know when a chemical reaction is taking place? What are the signs?

We can tell if a chemical reaction has taken place when one or more of the following things happen:

- There has been a colour change inside the **reaction flask**.
- A gas has formed. Usually we know a gas has formed when we can see bubbles. This should not be confused with boiling, which only happens when a liquid is heated to its boiling point.
- A solid has formed. Usually we know that some solid material has formed when we can see a sludgy or cloudy deposit, or crystals forming.

All the signs listed above are visual, or recorded by sight. That means we can see them. Our other senses can also help us to say whether or not there was a chemical reaction:

- Sometimes chemical changes can be smelled, for instance when a new material, that has a strong smell, is formed.
- Other chemical changes can be felt, e.g when the reaction produces heat.
- Some chemical changes can be heard, e.g. when an explosion takes place.

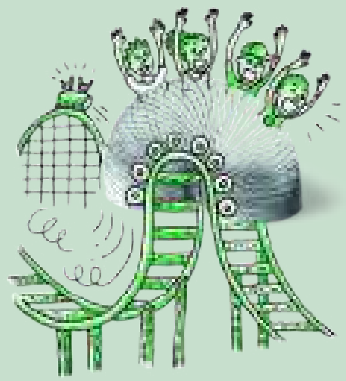
ACTIVITY: The difference between physical and chemical changes

INSTRUCTIONS:

1. Below is a table with some different chemical and physical changes listed.
2. You need to decide whether the change is physical or chemical and write the answer in the last column.

Change	Is it a physical or chemical change?
Cutting up potatoes into cubes	
Boiling water in a pot on the stove	
Frying eggs in a pan	
Whipping egg whites	
Dissolving sugar in water	
Burning gas in a gas cooker	
Your ice cream melts in the sun	
Milk turning sour	
An iron gate outside rusts	

We will now put our checklist into practice by looking at a reaction safe enough to try at home. Have you ever wondered what a raw egg would look like without its shell? We are going to use a chemical reaction to strip away the shell of an egg, without breaking the egg!



ACTIVITY: Can we use a chemical reaction to see inside an egg?

MATERIALS:

- eggs
- a glass
- white vinegar

INSTRUCTIONS:

1. Carefully place the egg in the glass. Be careful not to crack the shell.
2. Cover the egg with vinegar. Wait a few minutes. Can you see anything happening on the surface of the eggshell?
   a) Write your observations below.

_____

   b) What is this observation a sign of?

_____

3. Leave the egg in the vinegar for 4 - 5 days. You should complete the rest of the activity after this.
4. After 4 to 5 days, look at the egg in the vinegar and write down your observations.

_____

_____

5. Carefully scoop the egg out of the vinegar with a large spoon. Touch the surface of the egg. Write your observations below. What has happened to the shell?

_____

_____

6. Rub the powdery coating off the egg and place it in some clean water. What does it look like now?

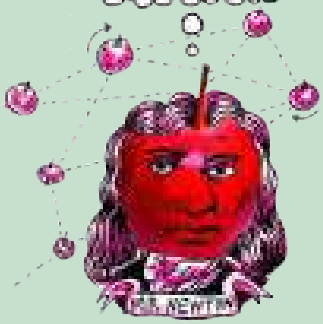
_____

_____

7. Draw and label pictures of what the contents of the glass looked like before and after the reaction took place.

DID YOU KNOW?

Bones, teeth and pearls will all dissolve in vinegar, just like the eggshell did, even though these may take much longer.



QUESTIONS:

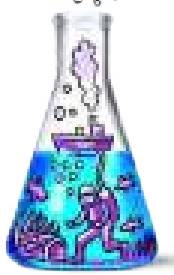
1. What signs did you see that told you a chemical reaction had taken place?

2. Write a short paragraph to explain what happened to the eggshell.

NEW WORDS

- reactant
- product
- chemical equation
- coefficients
- fermentation

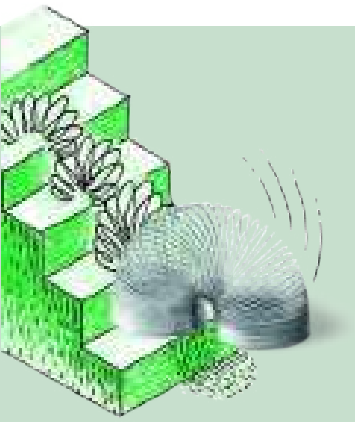
How is it possible to change one compound into another? What happens to the particles when compounds react? In the next section we are going to answer these questions.



3.2 Reactants and products

In Chapter 1 we learnt that compounds are formed by chemical reactions. Can you remember what a compound is? Write a definition here.

Write down the formulae of three different compounds.



ACTIVITY: Analysing the eggshell experiment

In the eggshell activity the calcium carbonate in the eggshell reacted with acetic acid and formed calcium acetate, carbon dioxide and water.

We can write this **chemical equation** as follows:

eggshell + vinegar → calcium acetate + carbon dioxide + water

QUESTIONS:

1. There are two starting substances **before** this chemical reaction takes place. What are they?

2. There are three substances present **after** the reaction. What are these?

3. What are the chemical formulae for the compounds water and carbon dioxide?

4. We call the substances that are present before the chemical reaction has taken place, the **reactants**. What are the reactants of the eggshell experiment?

5. What do you think happened to the reactants during the chemical reactions?

6. We call the substances that are produced during the chemical reaction, the **products**. What are the products of the eggshell experiment?

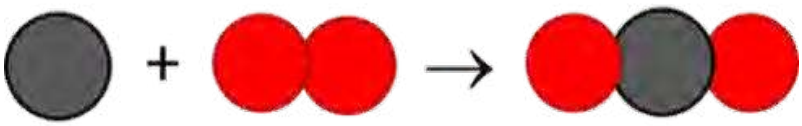
During a chemical reaction, the reactants are used to make the products. The atoms in the reactants have been rearranged into new compounds (the products).

A chemical reaction is a rearrangement of atoms

In order to change a compound into a different compound, we need to change the way in which the atoms in the compound are arranged. This is exactly what a chemical reaction is: a rearrangement of atoms to turn one or more compounds into new compounds.

Any time atoms separate from each other and recombine into different combinations of atoms, we say a chemical reaction has occurred.

We are going to use coloured circles to represent the atoms in the compounds which take place in chemical reactions. If you still have your beads or playdough from previously, you can also make these reactions yourself on your desk. Look at the following diagram.



We have carbon and oxygen on the left of the arrow reacting to make carbon dioxide on the right of the arrow.

To the left of the arrow, we have the 'before' situation. This side represents the substances we have before the reaction takes place. They are called the **reactants**.

To the right of the arrow we have the 'after' situation. This side represents the substances that we have after the reaction has taken place. They are called the **products.**

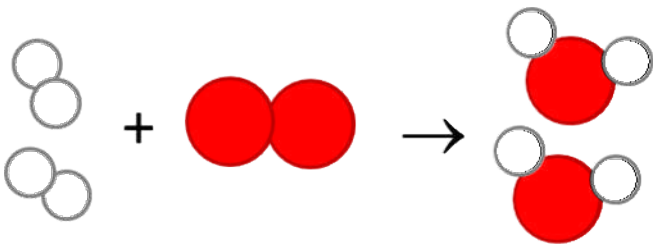
REACTANTS (before the reaction) → PRODUCTS (after the reaction)

Do you see how the atoms have rearranged? This means a chemical reaction has taken place. Label the diagram with 'reactants' and 'product'.

The reaction between carbon and oxygen takes place when we burn coal. Coal is carbon and when it burns in oxygen gas, carbon dioxide is formed.

Burning coal.

The diagram below represents another chemical reaction. We have oxygen (red molecules) reacting with hydrogen (white molecule) to produce water.



What are the reactants in this reaction?

_____

What is the product in this reaction?

Why do you think hydrogen and oxygen are represented as two atoms joined together?

Do you remember when we spoke about **chemical bonds** between atoms in a molecule in Chapter 1? A chemical bond is a force which holds the atoms together. Therefore, during a chemical reaction, the bonds between atoms have to break so that the atoms can rearrange to form the products. New bonds form between the atoms in the product.

Next we will look at a chemical reaction that has been used by humankind for centuries.

Fermentation is a chemical reaction

Have you ever forgotten some milk or juice in a bottle, to find that it has 'gone off' a few days later? If you accidentally tasted it, it may have tasted sour and, in the case of the juice, a bit fizzy as well. Your senses may have warned you not to drink any more of it. Do you remember learning in Gr. 7 that our sense of taste protects us from food that has spoiled?

The sour taste of the milk or juice is caused by the products of **fermentation**. Which compounds have a sour taste?

Fermentation does not only produce unwanted products. Yoghurt, buttermilk and cheese are all fermented milk products. In these examples, the fermentation process creates acids that give these foods a sour taste.

Different dairy products which are made using fermentation.

Two buckets of ginger beer fermenting.

Fermentation is also the process by which a variety of fruits, vegetables and grains can be used to make alcohol. In many cultures the brewing of alcoholic drinks is part of their indigenous knowledge.

ACTIVITY: Studying the fermentation reaction

The basic reaction in the fermentation process can be summarised as follows:

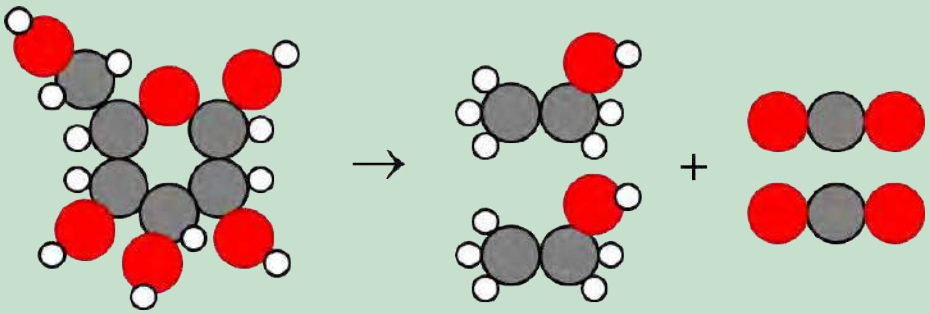
glucose → alcohol + carbon dioxide

What are the reactants and products in this reaction?

_____

_____

We can draw pictures of the molecules to show how the atoms are rearranged during the reaction:



In the diagram above, the grey atoms are carbon (C), the red atoms are oxygen (O) and the small, white ones are hydrogen (H). Write in the names of the compounds in this reaction.

Glucose does not change into alcohol and carbon dioxide by itself! Microorganisms like yeast and bacteria actively ferment glucose.

In South Africa, a popular drink is ginger or pineapple beer! The fizzy bubbles in the ginger beer or pineapple beer are bubbles of carbon dioxide produced by the yeast during fermentation. Let's make some ginger beer!

INSTRUCTIONS:

1. You need to research how to make traditional South African ginger beer.
2. Identify the different ingredients you will need.
3. Once you have done so, you can decide as a class about the best recipe you will use. You can then make ginger beer in class with your teacher.
4. Answer the questions that follow.

QUESTIONS:

1. What are the reactants in the reaction to make ginger beer?

_____

2. What is the product in the reaction taking place in the ginger beer?

_____

DID YOU KNOW?

Yeast produce special chemicals called enzymes that can break down the bonds in sugars such as glucose to form smaller molecules like alcohol and carbon dioxide.

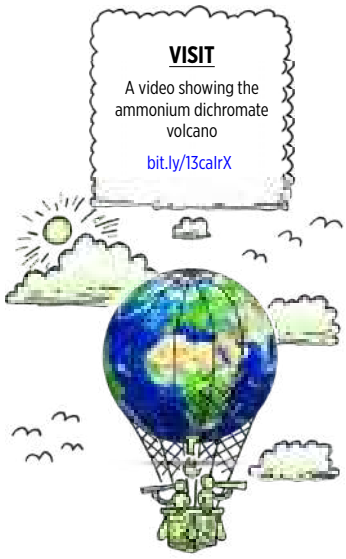
3. Why are there fizzy bubbles in the ginger beer?

4. Where do you think the gas came from?

5. Another example of where we see a chemical reaction taking place is when we burn wood in a fire, either in our homes or to cook food. The wood burns and produces carbon dioxide gas and water vapour. What are the products and reactants in this reactions?

Chemical reactions can help us to detect certain substances

Some chemical reactions can produce results that are unique and even spectacular! Have you ever seen the volcano experiment? This experiment is shown in the video link in the visit box.



When ammonium dichromate burns in oxygen, the reaction produces bright orange sparks. The reaction forms nitrogen gas (N_2), water and a dark-green compound called chromium oxide as products. This reaction is unique. Only ammonium dichromate reacts with oxygen to form these particular products with these particular visual effects.

Ammonium dichromate before it is burned in oxygen.

Chromium oxide is the product.

When two substances react in a unique and characteristic way when they are mixed, one of them can be used to *detect* the other.

ACTIVITY: Some chemical reactions from Life and Living

1. Do you remember we used clear lime water to detect carbon dioxide in our breath in Chapter 1 in Life and Living? What colour did the clear lime water turn when we blew bubbles through it?

   _____

2. Limewater is a solution of calcium hydroxide in water. A reaction occurs between the lime water and the carbon dioxide to produce a white substance in the water called calcium carbonate. What are the reactants and products in this reaction?

_____

_____

3. We say that we used the colour change of the lime water to detect the carbon dioxide in our breath. Carbon dioxide is the by-product of the chemical reaction that takes place during respiration in all organisms. Write a word equation for respiration.

_____

4. In Life and Living we spoke about the ingredients of respiration as we had not yet learned the terms reactant and product. What are the reactants and what are the products in respiration?

_____

_____

5. What are the reactants and products in photosynthesis?

_____

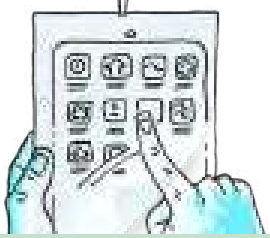
_____

We have also learnt that chemical reactions are simply rearrangements of atoms in molecules, to make different molecules. That is what many chemists do for a living! They find ways of rearranging atoms in order to make new compounds.

Careers in chemistry

TAKE NOTE

Next year you will choose the subjects that you will be studying until Grade 12. Will you choose Physical Sciences, Life Sciences and Mathematics? Before you decide which subjects to take, explore what you can do with each of them after school.

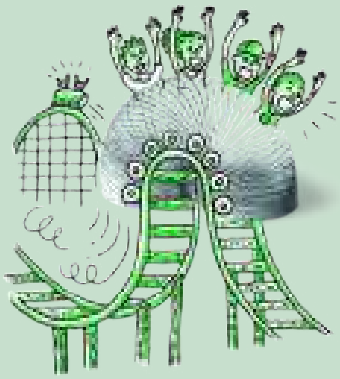


Natural sciences is all about discovery! We want to show you how the things you study in class are useful in the real world. This subject is much too big for us to learn everything about it in school. There are many different careers based in science that you can choose. Be curious about the world around you and explore it with your growing science knowledge!

Let's find out a bit more about the possibilities of fields related to what we have been studying in Matter and Materials.

There are many, many applications and uses of chemistry, and many different careers make use of chemistry in some way. Let's find out.

Marie Curie (1867 - 1934) was a famous chemist and physicist, honoured specifically for her research on radioactivity. She was the first woman to win a Nobel Prize, the only woman to win in two fields and the only person yet to win a Nobel Prize in multiple sciences!



ACTIVITY: Careers in chemistry

INSTRUCTIONS:

1. Below is a list of different careers that all use chemistry in some way. Have a look through the list and then select the five careers you find most interesting.
2. Do an internet search to find out what each career is.
3. Write a one line description of this career.
4. If there is a career that really interests you, draw a smiley face next to it and be sure to do some extra reading around the topic and where chemistry might take you! Find out what level of chemistry you will need for this particular career.
5. There are many other careers besides the ones listed here which use chemistry in some way, so if you know of something else which is not listed here and it interests you, follow your curiosity and discover the possibilities!

VISIT

A useful site to find out more about some chemistry-related careers.

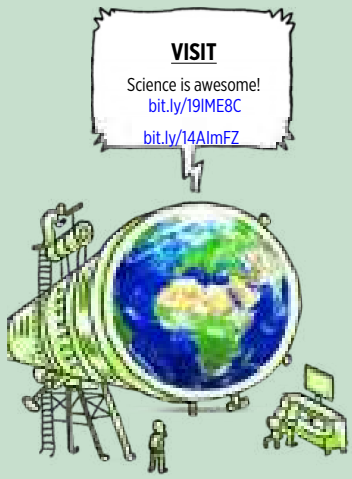
bit.ly/16Ei2tf

Some careers involving chemistry:

- Agricultural chemistry
- Biochemistry
- Biotechnology
- Chemical education/teaching
- Chemistry researcher
- Environmental chemistry
- Forensic science
- Food science/technology
- Geneticist
- Geochemistry

- Materials science
- Medicine and medicinal chemistry
- Oil and petroleum industry
- Organic chemistry
- Oceanography
- Patent law
- Pharmaceuticals
- Space exploration
- Zoology

Your descriptions of the careers you are interested in:



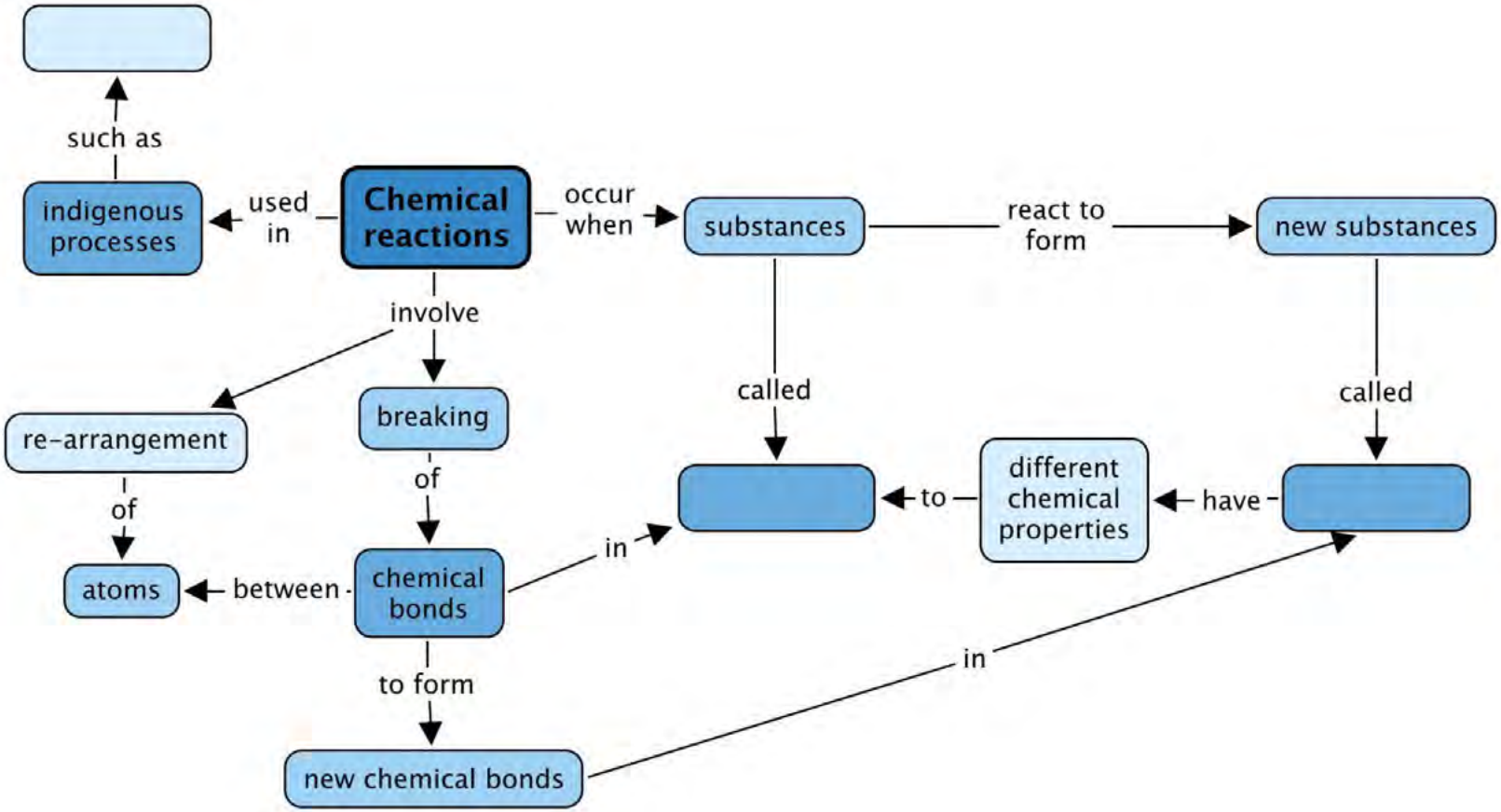
SUMMARY:

Key Concepts

- During chemical reactions, materials are changed into new materials with new chemical and physical properties.
- The materials we start with are called reactants and the new materials that form are called products.
- During chemical reactions, atoms are rearranged. This requires that chemical bonds in the reactants are broken and that new bonds are formed, resulting in product formation.
- Fermentation in brewing is an example of a chemical reaction that is also part of indigenous knowledge.

Concept Map

Fill in the blanks in the concept map for the Chemical Reactions chapter on the next page.


such as
indigenous processes
used in
Chemical reactions
occur when
substances
react to form
new substances
involve
called
called
re-arrangement
breaking
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different chemical properties
have
atoms
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chemical bonds
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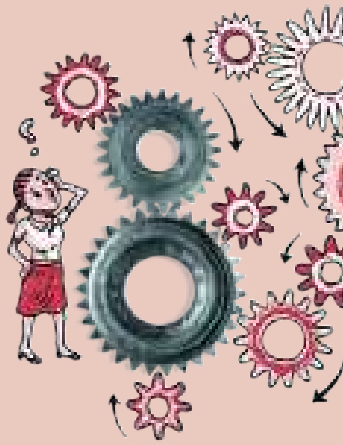
new chemical bonds

REVISION:



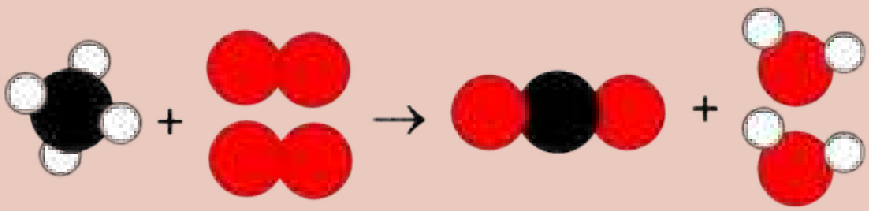
1. Suppose you mix some chemicals in a beaker. How will you know if a reaction has taken place? Write a paragraph describing each of the signals that would indicate a reaction has taken place and what each signal tells you about that reaction. [6 marks]

2. Write your own definition for what a reactant is. [1 mark]

3. Write your own definition for what a product is. [1 mark]

4. Explain what happens to the bonds between atoms in the reactants and products in a chemical reaction. [2 marks]

5. Methane gas (CH_4) is a natural fuel gas that burns in oxygen gas to produce carbon dioxide and water. The reaction can be represented by the following diagram:



Key:
Carbon atoms (C): black
Oxygen atoms (O): red
Hydrogen atoms (H): white

a) Use the diagram and the 'key' below it to write formulae for each of the substances in the reaction. [4 marks]

Name of compound	Formula
Methane	
Oxygen gas	
Carbon dioxide	
Water	

b) What are the reactants of the above reaction? [2 marks]

_____

c) What are the products of the above reaction? [2 marks]

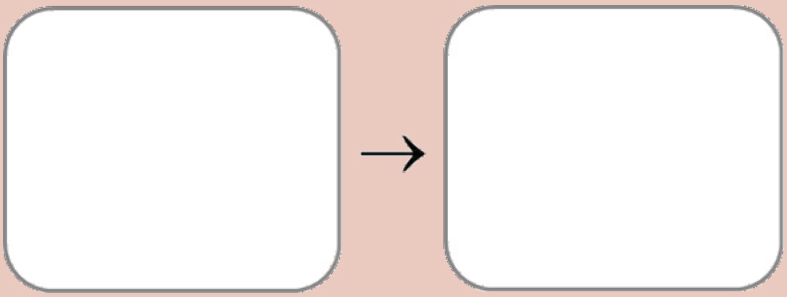
_____

d) Write the names of the reactants and products under the colourful picture representations of each of the molecules. [2 marks]

6. Ammonia (NH_3) is produced from hydrogen gas and nitrogen gas.
   a) Draw one molecule of each of the substances in the reaction in the following table. [3 marks]

Name of compound	Diagram of one molecule of the compound
Hydrogen gas, H_2	
Nitrogen gas, N_2	
Ammonia, NH_3	

b) Use the template below to draw diagrams representing the particles before and after the reaction. Your diagram should also show how many of each type of particle take part in the reaction. [4 marks: 2 marks each for 'before' (left) and 'after' (right) sketch]



c) What are the reactants of the above reaction? [2 marks]

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d) What is the product of the above reaction? [1 mark]

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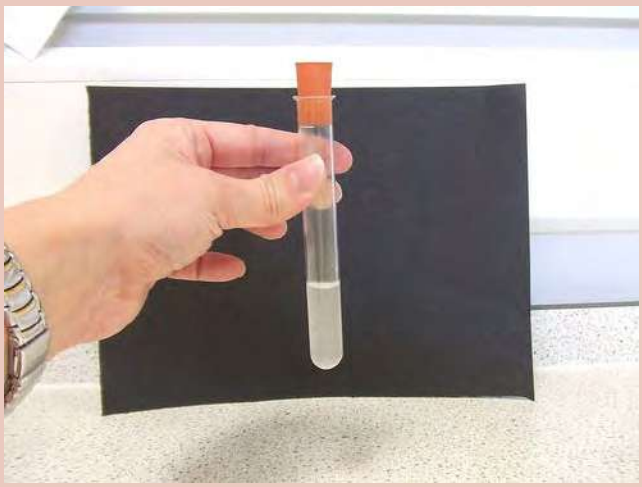
7. Look at the following photo which shows a test tube with milky limewater. What gas must have been bubbled through it to make it turn milky? [1 mark]



Limewater that has turned milky in a test tube.

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8. What are the reactants in this chemical reaction? [1 mark]

Total [32 marks]

GLOSSARY

air valve:	a device that works as a gateway to allow air to flow in only one direction (either into or out of something
atomic nucleus:	a tightly packed cluster of protons and neutrons at the centre of the atom
atoms:	the fundamental particles that all matter is made up of
boiling:	occurs *within a liquid* when it is heated to its boiling point and particles escape as bubbles of gas from the liquid
chemical bond:	a special force that holds the atoms in a molecule together
chemical equation:	a way of representing a chemical reaction in terms of the chemical formulae of the reactants and products
chemical formula:	a combination of element symbols that shows the types and number of atoms in one molecule of a certain compound
chemical reaction:	a process in which chemical bonds are broken and new ones are formed between atoms; atoms in the starting compounds, called reactants, are rearranged to form new compounds, called products
chemical reaction:	an event during which the atoms in molecules are rearranged to form new molecules
cluster:	(verb) to come together and form a tight group
coefficients:	the numbers in front of the atom and molecule formulae in the chemical equation; they represent the ratio of the numbers of individual molecules that take part in the chemical reaction
collide:	(noun: collision) to bump or crash into something
compound:	a pure substance in which atoms of two or more different chemical elements are bonded in some fixed ratio
compress:	(adjective: *compressible*) to squeeze the particles of a material closer together
condensation:	when energy is removed and a gas changes state to a liquid
constant motion:	something that is in constant motion never stops moving
contract:	the physical size of an object gets smaller
controlled experiment:	an experiment in which the variables are controlled so that the results can be compared to those obtained in another experiment
decomposition reaction:	a chemical reaction in which a given molecule is broken up and recombined into smaller molecules
density:	the mass of a substance in a given space (volume)

diffuse:	(noun: diffusion) the movement of particles so that they end up spread out randomly and uniformly in a given space
disordered:	untidy; without regular arrangement
distinction:	the separation of things into different groups according to features or characteristics
electrons:	the smallest of the three types of sub-atomic particles; they are negatively charged and are located outside the atomic nucleus
element:	a pure substance made up only of atoms of the same kind
energetic:	full of energy
evaporation:	when energy is added and the particles *at the surface* of a liquid change state to a gas
expand:	the physical size of an object gets bigger
fermentation:	a chemical reaction that occurs in the presence of yeast and/or bacteria, during which a sugar is converted to an alcohol or an acid
forces of attraction:	forces that particles experience which draw them closer to each other
immiscible:	incapable of mixing or blending
impact:	(noun) effect
mass:	a measure of the amount of matter in an object or material
melting point:	the temperature beyond which a particular material changes from the solid to the liquid state (melts)
melting:	when energy is added and a solid changes state to a liquid
mixture:	a combination of two or more pure substances mixed together
molecule:	two or more atoms that have chemically bonded with each other; the atoms in a molecule can be of the same kind (in which case it would be a molecule of an element), or they can be of different kinds (in which case it would be a molecule of a compound)
neutrons:	a type of sub-atomic particle similar to protons in mass and size, but neutral (without charge); neutrons together with protons make up the atomic nucleus
observation:	an observation is something we can see, hear, taste, smell or feel
phenomenon:	(plural: phenomena) an event or occurrence that we can observe with our senses
physical quantity:	something that can be measured or estimated
postulate:	a claim that can be supported by experimental evidence
pressure gauge:	an instrument used to measure the gas pressure inside something
product:	a substance that forms during the reaction; it will be present after the reaction has taken place

protons:	a type of sub-atomic particle that is positively charged and occurs inside the atomic nucleus along with neutrons
pure substance:	matter that consists of the same material throughout; two classes exist, namely elements and compounds
random:	unpredictable
rate:	how fast or slow an event (e.g. diffusion) occurs
reactant:	a substance that is present before the reaction takes place; it is a starting material of the reaction
reaction flask or reaction vessel:	the container in which the reaction has taken place; small scale chemical reactions done in a laboratory are usually performed in glass beakers or flasks
regular arrangement:	an arrangement of particles in a neatly packed, consistent and repetitive pattern
reinforce:	to make stronger, usually by the addition of another material or other form of support
reverse:	in this chapter reverse means 'opposite', as in: melting and freezing are *reverse* processes (the opposite of each other)
scientific model:	a set of ideas that represents a concept, object, or process in nature to help us understand it
scientific theory:	an explanation of scientific phenomena or aspects of the natural world, supported and confirmed by facts obtained through observation and experimentation
solidifying:	(freezing) when energy is removed and a liquid changes state to a solid
sub-atomic particle:	a particle that is smaller than the atom and occurs inside the atom
transformation:	change; to transform is to change from one form into another
uniform:	the same throughout
vapour:	the gaseous state of a substance that is normally liquid or solid at room temperature, such as water that has evaporated into the air
vibrate:	to move rapidly back and forth
vigorous:	strong and forceful
volume:	a measure of the amount of space occupied by a three-dimensional object or material

Here is your chance to discover the possibilities. What else can this beaker be?

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1 http://www.flickr.com/photos/gr33n3gg/3445868159/ . . . 5
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