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NB Some spellings of scientific terms may vary - words are sometimes used in their internationally accepted format.

CHEMISTRY PACK 2

By Harry Jivenmukta

CHEMICAL REACTIONS

1

A chemical reaction is a process of change during which either two or more substances both change or one substance changes into at least two other substances.

When wood burns, the substances present initially, wood and oxygen in the atmosphere, are converted in a chemical reaction to water vapour, carbon dioxide, and ash. All combustions are chemical reactions. Other types of familiar chemical reactions include:

- decay,
- fermentation,
- the tarnishing of silver,
- the corrosion of steel,
- the digestion of food.

In a general sense, material substances can undergo change in three ways:

- a change of **position**, called movement;
- a change of **form**, such as the freezing of liquid water;
- a change of **substance**, which is a chemical reaction.

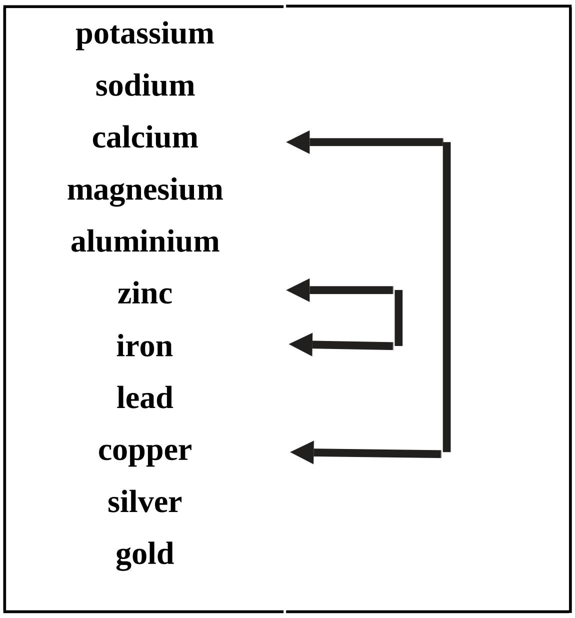
Some people classify changes of form as chemical reactions, but usually the term chemical reaction is applied only to changes of substance. Many factors can influence the course of a reaction. The reactants must be identified and any prereactions investigated. Because of the fleeting nature of the transition state it cannot be studied directly, but it may have properties of its own that can be examined. The properties of the solvent, or reaction medium, can greatly influence the course of a reaction. Raising the temperature of a reacting system generally increases the rate of reaction by supplying energy to the reactants, making it more likely that they will attain the necessary activation energy.

Questions...

1. What is a chemical reaction?
2. Give two examples of simple chemical reactions which occur in everyday life.
3. What factors affect chemical reactions?

THE REACTIVITY SERIES

The **speed** and **rate** of chemical reactions varies enormously depending on the chemical used but there is a method which can be used to predict how chemicals will react together. It is called the **reactivity series**. Simply put, the closer together the substances are on the chart, shown opposite, the less violent the reaction will be, and the further apart they are the more violent the reaction will be. Zinc and iron are next to each other and so we can expect quite a mild and slow reaction between the two. Calcium and copper, on the other hand, are far apart and the reaction between them in an experiment can be expected to be quite fast and violent.



The reactivity series also tells us about how **stable** a chemical is. This means the higher the chemical is in the reactivity series, the more stable it is going to be when it becomes part of a compound. A copper compound is easier to decompose than a compound which includes potassium.

Another way of predicting the speed of a reaction is to experiment with a chemical lower down the scale in the first instance. Calcium fizzes, (effervesces), if placed in water. This is because it is giving off hydrogen gas. We can predict that if a chemical higher up the reactivity scale is placed in water its reaction will be more violent and faster than this. If you try putting potassium in water the reaction is so violent and fast that the hydrogen bursts into flame.

Questions...

1. How useful is the reactivity series for predicting reactions?
2. What does the reactivity series tell us about how stable a chemical is?

AIR

Air is crucial to life on Earth and is made up of several different gases, shown on the table opposite. Air maintains its composition by mixing in the atmosphere, although at higher altitudes the composition changes. One way to understand this is to study mountain climbers. As they reach heights of about 20,000 feet or more, often the amount of oxygen available in the air is insufficient and they have to use use breathing apparatus. Also at greater heights the lighter gases like hydrogen and helium are found in greater quantity.

One of the greatest dangers to the Earth is air pollution. Whilst this may not alter the composition of air greatly, the pollution does get carried along by the air and is often held in the droplets of moisture which then fall as rain.

Nitrogen	78.08%
Oxygen	20.95%
Argon	0.93%
Carbon dioxide	0.03%
Neon	0.002%
Other noble gases	0.0006%
Methane	0.0001%
Hydrogen & Ozone	Minute traces

Example

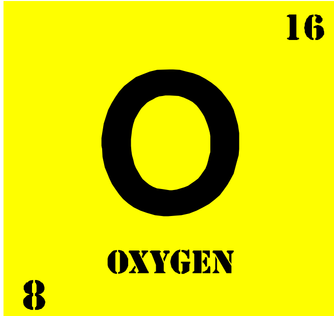
The gases in the air are crucial for photosynthesis to occur in plants. But the same air carrying acidity in the moisture can damage or kill the plants on which it falls.

There are many other examples including the Chlorofluorocarbons (CFCs) which are gases emitted by aerosols or fridges, (older models), which are carried by the air and affect the Ozone layer. The Ozone layer protects us from the harmful rays of the Sun, and a thinner or damaged layer increases the chances of cancer and can have other damaging effects.

Questions...

1. How does Air maintain its composition?
2. How is Air affected by pollution? Give examples.
3. Why does Air have a different composition at higher altitudes?

OXYGEN



Oxygen was discovered in 1772 by a Swedish chemist, Carl Wilhelm Scheele, who obtained it by heating potassium nitrate, mercury oxide, and many other substances. An English chemist, Joseph Priestley, independently discovered oxygen in 1774 by the thermal decomposition of mercury oxide and published his findings the same year, three years before Scheele. A French chemist, Antoine Lavoisier, first recog- nized the gas as an element (1775-80), coined its name, and explained combustion as a union of oxygen with the burning material.

During respiration, animals and some bacteria take oxygen from the atmosphere and return to it carbon dioxide, whereas by photosynthesis, green plants assimilate carbon dioxide in the presence of sunlight and evolve free oxygen. Almost all free oxygen in the atmosphere is due to photosynthesis. About 3 parts of oxygen by volume dissolve in 100 parts of freshwater at 20^{o} C (68^{o} F), slightly less in seawater. Dissolved oxygen is essential for respiration of fish and other marine life.

Below -183^{o} C (-297^{o} F), oxygen is a pale blue liquid; it becomes solid at about -218^{o} C (-361^{o} F).

Questions...

1. How is oxygen produced? Find out about **liquefaction** and **fractional distillation**.
2. Make a list of substances which react violently with oxygen:

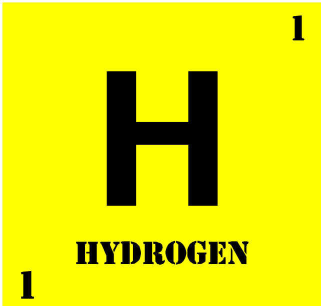
1
2
3
4
5

3. Explain why some substances react so violently with oxygen.

HYDROGEN

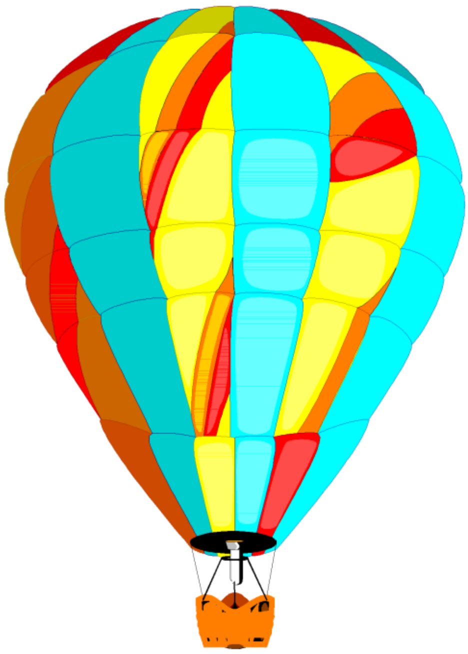
Hydrogen (H) is;

- colourless,
- odourless,
- tasteless,
- a flammable gaseous substance.



It is the simplest member of the family of chemical elements. The hydrogen atom has a nucleus consisting of a proton bearing one unit of positive electrical charge and an electron, bearing one unit of negative electrical charge.

Although on Earth hydrogen ranks ninth among the elements in abundance, making up 0.9 percent of the mass of the planet, it is by far the most abundant element in the universe, accounting for about 75 percent of the mass of all matter. Collected by gravitational forces in stars, hydrogen is converted into helium by nuclear fusion, a process that supplies the energy of the stars, including the Sun. Hydrogen is present in all animal and vegetable substances in the form of com- pounds in which it is combined with carbon and other elements. In the form of hydrocarbons, it is a constituent of petroleum and coal. It also constitutes nearly 11 percent of the mass of seawater. The hydrogen content of the Earth's atmosphere remains low because of the continual escape of the gas into space.



Of its many practical uses, hydrogen was used to fill balloons from 1783 until at least World War II, although, for passenger-carrying airships, helium has the advantage of nonflammability.

Questions...

1. What uses does Hydrogen have?
2. Compare Hydrogen with other gases. What features are common to all gases?
3. Why is Helium preferred to Hydrogen in hot air balloons?

ACIDS

6

An acid is any substance that:

- in water solution tastes sour, changes the colour of certain indicators (e.g., reddens blue litmus paper),
- reacts with some metals (e.g., iron) to liberate hydrogen,
- reacts with bases to form salts, and promotes certain chemical reactions.

Examples of acids include the inorganic substances known as the mineral acids; sulphuric, nitric, hydrochloric, and phosphoric acids, and the organic compounds belonging to the carboxylic acid, sulfonic acid, and phenol groups. Such substances contain one or more hydrogen atoms that, in solution, are released as positively charged hydrogen ions.

Broader definitions of an acid, to include substances that exhibit typical acidic behaviour as pure compounds or when dissolved in solvents other than water include nonaqueous acids like sulphur trioxide, aluminium chloride, and boron trifluoride.

Some features of acids:

- they have a sour taste,
- they have a pH lower than 7,
- they change the colours of indicators,
- they can be very dangerous in concentrated form,
- they can be neutralised by bases,
- they react with metals to give off hydrogen.

Questions...

1. What are the main characteristics of an acid?
2. Why are acids often dangerous, sometimes even in small quantities?
2. Make a list of some common uses of acids:

1
2
3
4
5
6

NEUTRALISING ACIDS

To neutralise an acid it is necessary to add alkalis. The simple way to measure acidity is to measure it on the pH scale, (see relevant page in this pack, **The pH Scale**). One method for neutralising an acid is:

- place the acidic liquid in a container and measure its pH value,
- add an alkali in small amounts,
- measure the pH value again,
- continue adding alkali and checking pH values until the value is 7,
- when the pH value is 7 the acid is neutral.

When an acid is neutralised it produces salt and water:

acid + alkali = salt + water

Hydrochloric acid + sodium hydroxide (alkali) = sodium chloride + water

Neutralisation is sometimes required in everyday situations. Farmers sometimes have problems with acidic soil, whilst some plants prefer either acidic or alkali soil to grow. The farmer has to try to maximise the crop by changing the acidity of the soil. To neutralise acidic soil farmers usually add lime which is alkali.

Sometimes people suffer from acid indigestion. This is when the acid used in the stomach to digest food is produced in excess of that which is needed. A burning pain is the result. Indigestion medicines include weak alkalis to help to neutralise the acid.

Questions...

1. What does **neutralise** mean?
2. How does an alkali neutralise an acid?
3. Explain how an acid and alkali mixed together make salt and water.

CORROSION AND DETERIORATION

8

Corrosion is a chemical reaction in which an object, (often metallic), is slowly weakened or destroyed, (chemically changes), from the original quality in which it was produced. As soon as metals are extracted and purified they start to react with oxygen and become more and more oxide. Rust is iron oxide and the process of corrosion is speeded up by:

- water,
- heat,
- acid,
- salt.

Corrosion first happens when the metal loses its shine and becomes covered with a thin layer of oxide. If left untreated the metal begins to rust and eventually holes appear in the metal or the metal might break.

Deterioration is when something changes from a higher to a lower level in quality. One example of deterioration is how fresh food becomes rotten. This type of deterioration is caused by chemical reactions occurring in the produce. In fact in all organic matter chemical changes are occurring all the time. Deterioration in food also occurs because of outside influences, including the effect of microorganisms feeding on the produce, and the temperature.

Questions...

1. How does **corrosion** and **deterioration** differ, or do they mean the same thing?
2. How can you protect metal from corrosion? List three important techniques:

1 2 3

3. Explain why fresh food deteriorates quickly.
4. How does temperature affect the deterioration of food? Give examples.

ALKALIS

Alkalis are any of the soluble hydroxides of the alkali metals;

- lithium,
- sodium,
- potassium,
- rubidium,
- cesium.

Alkalies are strong bases that turn litmus paper from red to blue; they react with acids to produce neutral salts; and they are caustic and in concentrated form are corrosive to organic tissues. The term alkali is also applied to the soluble hydroxides of such alkaline metals as calcium, strontium, and barium and also to ammonium hydroxide. The term was originally applied to the ashes of burned sodium or potassium bearing plants, from which the oxides of sodium and potassium could be leached.

The production of a vast range of consumer goods depends on the use of alkali at some stage. Soda ash and caustic soda are essential to the production of glass, soap, some chemicals, rayon and cellophane, paper and pulp, cleansers and detergents, textiles, water softeners, certain metals (especially aluminium), bicarbonate of soda, and petrol and petroleum derivatives.

People have been using alkali for centuries, obtaining it first from the leachings (water solutions) of certain desert earths. In the late 18th century the leaching of wood or seaweed ashes became the chief source of alkali. In 1775 the French Académie des Sciences offered prizes for new methods for manufacturing alkali. The prize for soda ash was awarded to the Frenchman Nicolas Leblanc, who in 1791 patented a process for converting common salt (sodium chloride) into sodium carbonate.

Questions...

1. What is an alkali?
2. Make a list of some common alkalis found in everyday life:

1
2
3
4
5
6

Exercise

Make a list of acids and alkalis:

Acids	Alkalis
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10

Make a list of everyday uses for acids and alkalis:

Acids	Alkalis
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10

SALTS

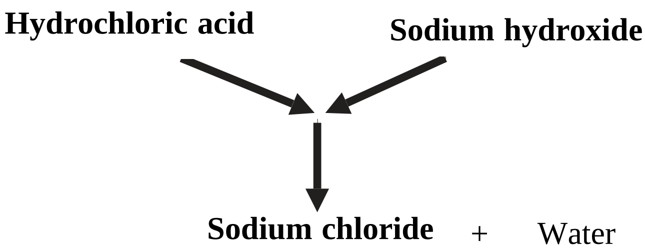
11

In a chemistry definition:

salts are substances produced by the reaction of acids with bases.

A salt consists of the positive ion of a base and the negative ion of an acid. The reaction between an acid and a base is called a neutralization reaction. The term salt is also used to refer specifically to common table salt, or sodium chloride. When in solution or the molten state, most salts are good conductors of electricity.

The parent compound of any salt is an acid. For example, sodium chloride is a salt formed by the reaction between hydrochloric acid and sodium hydroxide, (water is also produced in this reaction).



In the chemical industry, salt is required in the manufacture of sodium bicarbonate (baking soda), sodium hydroxide (caustic soda), hydrochloric acid, chlorine, and many other chemicals. Salt is also employed in soap, glaze, and porcelain enamel manufacture and is used in metallurgical processes as a flux (a substance promoting fusing of metals).

When applied to snow or ice, salt lowers the melting point of the mixture. Large amounts are used in northern climates to help clear roads of accumulated snow and ice. Salt is used in water-softening equipment that removes calcium and magnesium compounds from water.

Questions...

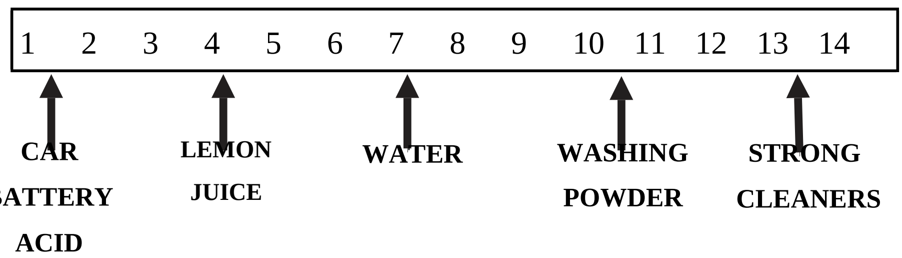
1. Explain the process of how salts are produced when acids and alkalis react together.
2. What is the difference between salts in the chemistry sense, and table or cooking salt?
3. Explain why and how salts:
   - are used to preserve food,
   - are used to treat icy roads.
4. Where and how is common, (cooking) salt produced?

THE pH SCALE

The pH scale is a quantitative measure of the acidity or basicity of aqueous or other liquid solutions.

The term translates the values of the concentration of the hydrogen ion, which ordinarily ranges between about 1 and 10 gram-equivalents per litre, into numbers between 0 and 14. In pure water, which is neutral (neither acidic nor alkaline), the concentration of the hydrogen ion is 10 gram-equivalents per litre, which corresponds to a pH of 7.

- A solution with a pH less than 7 is considered acidic;
- A solution with a pH greater than 7 is considered basic, or alkaline.



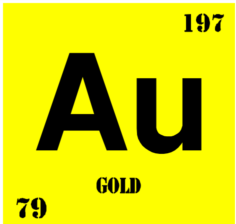
The measurement was originally used by the Danish biochemist S.P.L. Sørensen. The definition is based on a method of measurement and uses a machine or sensitive paper or plastic measuring device.

In agriculture, the pH is probably the most important single property of the moisture associated with a soil, since that indication reveals what crops will grow readily in the soil and what adjustments must be made to adapt it for growing any other crops. Acidic soils are often considered infertile, although conifers and many species of shrub will not thrive in alkaline soil. Acidic soil can be "sweetened" or neutralized by treating it with lime. As soil acidity increases so does the solubility of aluminium and manganese in the soil, and many plants (including agricultural crops) will tolerate only slight quantities of those metals. Acid content of soil is heightened by the decomposition of organic material by microbial action, by fertilizer salts that hydrolyze or nitrify, by oxidation of sulphur compounds when salt marshes are drained for use as farmland, and by other causes.

Questions...

1. What is the pH scale?
2. How does it work?
3. Draw an illustration showing a pH scale from 0 to 14. Test acids and alkalis and mark the points of their acidity or alkalinity on the scale.

1A	2A																									3A	4A	5A	6A	7A		
1 H																															2 He	1
3 Li	4 Be																									5 B	6 C	7 N	8 O	9 F	10 Ne	2
11 Na	12 Mg																									13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	3
19 K	20 Ca															21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	4
37 Rb	38 Sr															39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	5
55 Cs	56 Ba	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	6
87 Fr	88 Ra	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am		97 Bk	98 Es	99 Fm	100 Md	102 No	103 Lr	104 Unq	105 Unp	106 Unh	107 Uns		109 Une											7



Au is the symbol for Gold

Dmitry I. Mendeleyev discovered in the mid-19th century that the chemical elements show a periodic recurrence of properties when they are arranged in a certain order, which is approximately the order of increasing atomic weight. The statement of this fact, is called the **periodic law**. An arrangement in a table format of the elements that brings those with similar properties together is called the **periodic table** or periodic system of the elements.

It was recognized during the second decade of the 20th century that the order of elements in the periodic system is that of their atomic numbers, the sums which are equal to the positive electrical charges of the atomic nuclei expressed in electronic units; and in subsequent years great progress was made in explaining the periodic law in terms of the electronic structure of atoms and molecules. This clarification has increased the value of the law, which is used as much today as it was at the beginning of the 20th century, when it expressed the only known relationship among the elements.

(See appendix page for symbols and corresponding names of chemicals).

Questions...

1. What is the **Periodic Table**?
2. How can the information in the Periodic Table be useful in the study of Chemistry?
3. In the Periodic Table above indicate the clusters of similar elements.

ELECTROLYSIS

14

Electrolysis is a process by which electric current is passed through a substance to effect a chemical change.

The chemical change is one in which the substance loses or gains an electron (oxidation or reduction). The process is carried out in an electrolytic cell, an apparatus consisting of positive and negative electrodes held apart and dipped into a solution containing positively and negatively charged ions. The substance to be transformed may:

- form the electrode,
- may constitute the solution,
- may be dissolved in the solution.

Electric current (i.e., electrons) enters through the negatively charged electrode (cathode); positively charged components of the solution travel to this electrode, combine with the electrons, and are transformed to neutral elements or molecules. The negatively charged components of the solution travel to the other electrode (anode), give up their electrons, and are transformed into neutral elements or molecules. If the substance to be transformed is the electrode, the reaction is generally one in which the electrode dissolves by giving up electrons.

Electrolysis is used extensively in metallurgical processes, such as in extraction or purification of metals from ores or compounds and in electroplating. Metallic sodium and chlorine gas are produced by electrolysis of molten sodium chloride; electrolysis of an aqueous solution of sodium chloride produces sodium hydroxide and chlorine gas. Hydrogen and oxygen are produced by electrolysis of water.

Faraday's laws of electrolysis were first described by the English scientist Michael Faraday in 1833. The laws state that:

- the amount of chemical change produced by current at an electrode-electrolyte boundary is proportional to the quantity of electricity used,
- the amounts of chemical changes produced by the same quantity of electricity in different substances are proportional to their equivalent weights.

The quantity of electricity that will cause a chemical change of one equivalent weight unit has been designated a faraday.

Questions...

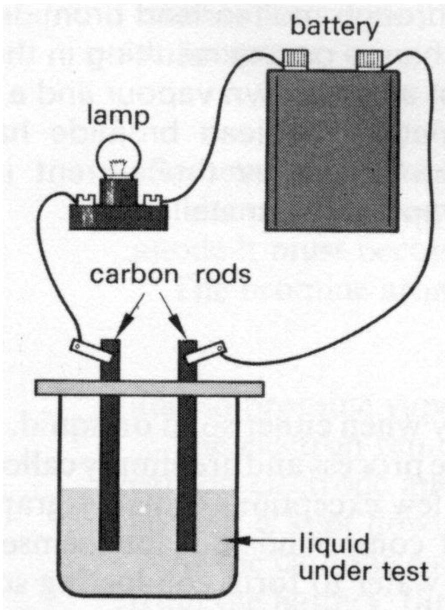
1. What is **electrolysis**?
2. What type of experiment can electrolysis be used in?
3. Write a short biography of Michael Faraday.

ELECTROLYSIS - EXPERIMENT

The experiment shows how you can test to see if an aqueous solution conducts electricity. You need:

- a battery,
- two lengths of wire,
- a lamp and holder,
- two carbon electrodes in a holder,
- a container to hold the liquid,
- deionised water.

The electrodes are placed into the liquid which is being tested. If the lamp lights up this means that the liquid has completed the electrical circuit and is therefore a conductor of electricity.



Some substances are non conductors when they are solid but are conductors when they are molten or are dissolved in water. These are called ionic compounds. The nature of the atoms of these substances when solid means that they are too firmly bonded together and do not allow the flow of electrons between them. When they are molten or dissolved, however, the free movement of electrons and therefore the passing of current becomes possible.

Questions...

1. Why might it be important to find out if a liquid conducts electricity?
2. Why should deionised water be used in such an experiment?
3. Explain why some substances are not electricity conductors when they are solid but become so when they are liquid or molten.

RADIOACTIVITY

Radioactivity is a property exhibited by certain types of matter of emitting energy and subatomic particles spontaneously.

At the beginning of the 20th century the theory that matter consists of atoms was generally accepted by scientists; notions of the inner structure of atoms, however, were entirely guesswork. By 1903 research on radioactive processes and radiations led to the realization that atoms are not necessarily permanently stable. The conclusion by 1911 was that nearly all of the mass of the atom is concentrated in a nucleus occupying only a minute portion of the total volume. Next came the important concept of isotopes (1913); and transmutation, the modification of an atomic nucleus, was achieved in a laboratory experiment six years later. Finally, in 1934, it was discovered that radioactivity could be induced in ordinary matter by transmutation in an artificially contrived arrangement.

Of the various processes resulting in the production of radioactive species, neutron-induced nuclear fission, achieved in 1939, has been the most fruitful. In 1941 it was learned that fission may also occur spontaneously. In this case, certain unstable nuclei of heavier elements split into nearly equal fragments without the introduction of outside energy. With such discoveries, modern theories of nuclear structure became possible, and the large-scale release of nuclear energy was achieved in 1942.

Radioactive substances emit energy in the form of ionizing radiations. Such radiations dissipate their energy in passing through matter by producing ionization and other effects. The radiated energy is either kinetic energy of particles or quantum energy of photons; these are eventually degraded into heat. If the radioactive source is a compact portion of matter, some of the energy of radiations is dissipated in the source itself. The source then tends to maintain a temperature higher than that of its surroundings. The emission is spontaneous, and its rate is uninfluenced by changes of pressure and temperature available to laboratory study. It is, however, not inexhaustible.

Questions...

1. What is **radioactivity**?
2. Make a list of the uses of radioactivity:

1
2
3
4
5
6

FUELS

Those chemicals which react with oxygen to give out heat are called fuels.

There are many fuels including:

wood	**diesel**
coal	**butane**
petrol	**paraffin**
methane	**propane**

A chemical reaction which results in heat being given out is called an **exothermic** reaction. Fuels do not give out heat alone, but may also give out light, sound, movement or electricity. The most efficient use of fuels is in controlled situations so that a maximum amount of energy can be used for a specific purpose. A good example of this is the petrol used to run a car. The output of energy is very carefully controlled in order to maximise the benefit which can be gained from burning the fuel.

Questions...

1. What is a **fuel**?

2. From the list above choose two fuels and write about how they are used and what type of output is achieved, (e.g. heat, light, movement, etc.)

ORGANIC CHEMISTRY

Organic compounds are based on the chemistry of carbon.

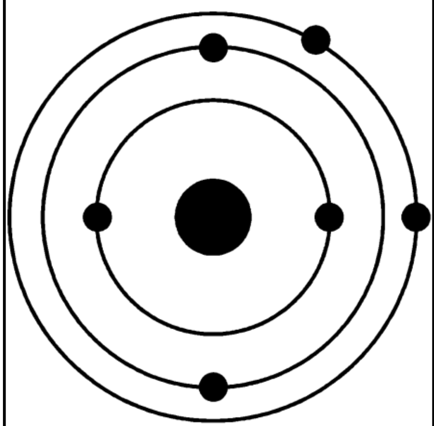
Although widely distributed in nature, carbon is not particularly plentiful (it makes up only about 0.025 percent of the Earth's crust); yet it forms more compounds than all the other elements combined.

More than 1,000,000 carbon compounds have been described in chemical literature, and chemists make many new ones each year. Much of the diversity and complexity of organic forms is due to the capacity of carbon atoms for uniting with each other in various chain and ring structures and three-dimensional conformations, as well as for linking with other atoms. Indeed, carbon's compounds are so numerous, complex, and important that their study constitutes a specialized field of chemistry called organic chemistry, which derives its name from the fact that in the 19th century most of the then-known carbon compounds were considered to have originated in living organisms.

With hydrogen, oxygen, nitrogen, and a few other elements, **carbon forms compounds that make up about 18 percent of all the matter in living things**. The processes by which organisms consume carbon and return it to their surroundings constitute the Carbon Cycle.

Each of the forms of carbon has its own specific character and, therefore, its own particular application:

- coal and coke, for example, are used extensively as fuels,
- charcoal is used as an absorptive and filtering agent and as a fuel,
- carbon is used in making inks, carbon paper, typewriter ribbons, and paints,
- carbon black also is added to the rubber used in tyres to improve its wearing qualities,
- diamonds and graphite are also made from carbon.



A carbon atom

Questions...

1. What does **organic** mean?
2. Find out and write about the Carbon Cycle.
3. Make a list of everyday things which are made of carbon compounds.

FERTILIZERS

19

Fertilizers are a natural or artificial substance containing the chemical elements that improve growth and productiveness of plants.

Fertilizers enhance the natural fertility of the soil or replace the chemical elements taken from the soil by previous crops.

The use of manure and composts as fertilizers is probably almost as old as agriculture. Modern chemical fertilizers include one or more of the three elements that are most important in plant nutrition:

- nitrogen,
- phosphorus,
- potassium.

Of secondary importance are the elements sulphur, magnesium, and calcium.

Most nitrogen fertilizers are obtained from synthetic ammonia; this chemical compound (NH) is used either as a gas or in a water solution, or it is converted into salts such as ammonium salivate, ammonium nitrate, and ammonium phosphate, but treated garbage, sewage, and manure are also common sources of it. Phosphorus fertilizers include calcium phosphate derived from phosphate rock or bones. Potassium fertilizers, namely potassium chloride and potassium sulphate, are mined from potash deposits. Mixed fertilizers contain more than one of the three major nutrients, nitrogen, phosphorus, and potassium. Mixed fertilizers can be formulated in hundreds of ways.

Questions...

1. What is the main function of a fertilizer?
2. Explain how fertilizers work.
3. Make a list of naturally occurring and chemically produced fertilizers:

NATURALLY OCCURRING	CHEMICALLY PRODUCED
1	1
2	2
3	3
4	4
5	5
6	6