Chapter 1

SCIENCE SPARKS: PLAY WITH CHEMISTRY

1.1 Make Friendship with Chemistry – You Love It!

Chemicals Everywhere

Everything in the world is made of chemicals, rocks, soil, houses, bridges, cars, plants and animals –and us.

Everything is made from a set of basic chemical substances. Chemistry is the scientific study of how these chemicals are joined to form the objects around us, and how we can split or combine chemicals into new molecules or substances. As you carry out the experiments, you can understand more about how chemicals make up our world.

Chemicals are not just the strangely colored bubbling liquids, solids and gases in the test tubes of the scientist's laboratory. Chemicals are present all around us, forming everything we smell, taste, touch and taste involves chemistry and even things we cannot see, such as air. There is a saying that, the better we know chemistry, the better we know world. Chemicals are changing all the time. Chemistry is happening all the time.

Chemistry is the study of the nature and composition of matter, how these undergo changes and contains in all the material wealth in the planet earth. Matter comes in three different forms; solid, liquids and gases. We are all made of matter, and so is this book.

Chemistry depends on the behavior, structure and properties. When you smash or break matter into its simplest form, we are left with an element. An element can't be broken down further into smaller parts.

Elements are made of ATOMS, which are like tiny building blocks that make up everything on the planet earth. Elements consist of only one type of atom.

A MOLECULE consists of two or more atoms that are bonded together. A chemical bond is an attraction between atoms that keeps them together. Molecules can be made of the same type of atoms or different types of atoms. One simple example is a molecule of water. Two hydrogen atoms bonded with one oxygen atom.

Molecular Formula of water is H_2O

The number 2 after H indicates that there are two hydrogen atoms, and the single O indicates that there is one oxygen atom in a water molecule.

A PARTICLE is so small (piece of matter) we can't see it without a microscope, and it can be either atoms or molecules. For example, water molecule can be called as a water particle.

Now we will introduce some key elements you will come across frequently in this book. One can think of them like a bunch of friends with different personalities and characters.

One of the main character, the key element OXYGEN. Oxygen is everywhere – you are breathing some in right now. Oxygen is the main ingredient to start fire. Without oxygen there is no fire, one can guarantee!

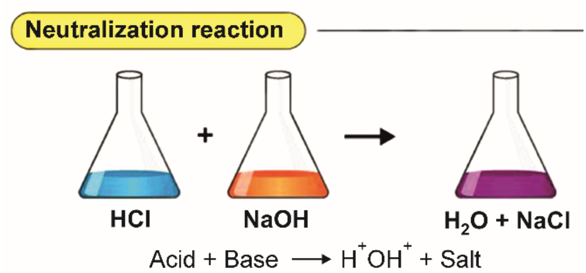
Next important element is HYDROGEN. It is very close with oxygen and they like each other like a happy couple. Hydrogen also having similar properties like it loves to burn too; but they cool each other by bonding together and form very important and life-saving molecule water. It's a solvent, a coolant, a reagent, a medium, a fuel and much more. It's the very solvent of life in which all of our biochemistry bathes. It's the chemists who know water better than anyone.

$$2H_2 + O_2 \rightarrow 2H_2O$$

Bonding, molecular structure, intermolecular forces, density, states of matter, equilibria, solvation, separation, miscibility, pH, reflection and refraction are contained therein and despite centuries of study it still holds mysteries for everyone.

Pure water is a neutral substance because, on ionization it gives equal concentrations of hydrogen and hydroxide ions.

$$H_2O\ (aq) = H+\ (aq) + OH-\ (aq)$$



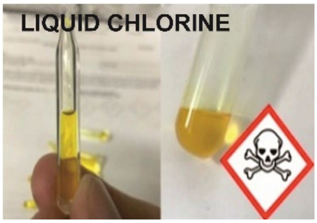
Next important friend of Oxygen, another key element, is CARBON. Carbon is full of energy and it is one of the main elements in many fuels like charcoal and petrol. Carbon likes to make friendship and forming a bond not only with oxygen giving CARBONDIOXIDE but also, with hydrogen giving METHANE. As you all know we breathe out CO_2 gas. Methane is a fuel.

$$C + O_2 \rightarrow CO_2$$

$$C + 2H_2 \rightarrow CH_4$$

We will introduce another important element SODIUM, very soft and shiny. It is really a different property, one has to be careful in handling sodium. For example, it does not like to have a bath in water, by force if we put him in the bath tub it will explode. Hence one has to be careful in handling sodium especially in the presence of water or moisture.

Finally, another important element, you come across in our book is CHLORINE. It is a gas at room temperature. As such it is a dangerous gas to inhale and one has to handle with care by wearing masks for your nose and mouth. It is used in swimming pools to keep the water clean. Sodium and chlorine are different personalities with different properties but they like each other, love to spend lot of time; hence sodium and chlorine react with each other to form new substance sodium chloride (NaCl). They are chemically bonded to each other. It's known as table salt.



$$2Na + Cl_2 \rightarrow 2\ NaCl$$

1.2 Acids and Bases

Chemicals have certain properties that one can detect, such as color, smell etc. Some also have another chemical property: they are either acids or bases. These chemicals can play an important role in chemical reactions. They react to produce a third group of molecules, the salts. Acids, bases and salts, and the chemical reactions between them, are used in hundreds of household and industrial applications.

Acids are usually sour tasting and corrosive. Even a weak acid, like vinegar or lemon juice, has a strongly sour taste. Powerful acids such as hydrochloric and sulfuric acids are so corrosive that they should never be touched, let alone be tasted. Most of the strong acids can cause severe pain and corrode the skin if they come into contact with it. Acids change the color of certain chemicals, known as indicators.

A base is the opposite of an acid. It tastes bitter and has a slimy feel. Strong base, such as sodium hydroxide, is as dangerous as acids and can corrode your skin. However, not all bases are this much strong. A weak base is bicarbonate of soda, used in cooking, which can make ginger bread rise.

1.3 Building Blocks

There are around 200 basic chemicals, called elements. Each element is made of building blocks called ATOMS. These are too small to see even under a microscope. All the atoms of an ELEMENT are the same as each other, and they are different from the atoms of any other element. Atoms can be split into smaller particles, but these don't have the properties of the element.

1.4 Atoms, Molecules and Elements

An element is a pure single chemical. Silver is an example of an element. No matter how many times a piece of silver is divided, it still has the same properties of silver –until, if you could carry on dividing for long enough, you are left with just one atom of silver. An atom is the smallest particle of the element that still has that element's properties. Atoms are rarely found on their own. In general, they are joined to other atoms, to form MOLECULES. A molecule may be made of two atoms, or three or many hundreds.

1.5 Atom

An atom is the smallest part of a chemical element that exhibits all the characteristics of that element. It always consists of nucleus surrounded by one or more light *electrons*, located a great distance away. Most of an atom, in fact, is empty space. Nucleus contains *protons*. We can think of a proton as a spherical, positively charged particle of matter that is very heavy for its size. For example, the nucleus of the hydrogen atom contains one proton, and all other nuclei have two or more protons, equal in number to the number of electrons (negatively charged). In addition to protons, a nucleus almost always contains neutrons. A neutron superficially looks like a proton except that it has no charge.

1.6 Chemical Reaction

In a chemical reaction, substances that are mixed together react or combine in a particular direction. They form a new substance, which is different from the original compound used to make it. Chemical reactions are going on all around us, as we drive a car, cook a meal, build a wall or making a cake.

1.7 Changing States

In science, the state of a substance means whether it is solid, liquid, or gas. The same chemical can exist in each of these states, depending on the temperature and the pressure on it. A familiar example is water. Normally, it is a liquid. On heating above 100 ^{0}c., it changes into gaseous state. At zero degrees centigrade (very cold), it becomes solid called ice**.**

1.8 Carbon Chemistry

Carbon containing chemicals are the basis of everyday life. Atoms of carbon combine with atoms of other elements, such as oxygen, hydrogen and nitrogen, to make the bodies of living things. Every plant and animal from a cat to an elephant, has a body whose chemicals are made up of carbon. The study of carbon chemicals and how they react with other atoms is known as ORGANIC CHEMISTRY.

1.9 The Chemicals in Food

Food is made up of many natural chemicals, that are part of the plants and animals it is made from. To stay healthy, your body needs the right proportions of three main types of food chemicals. Carbohydrates are found in sugary and starchy foods, such as bread, fruits and vegetables. They are the main energy-providers for the body. Fats and oils occur in dairy products, fatty meats, and oily foods. They are used to make certain parts of cells. Proteins and vitamins are contained in meat, fish, dairy products, fruits and vegetables. These provide most of the building materials for the body, in its growth, repairing, wear and tear.

1.10 Biochemistry

Biochemistry is the study of chemical reactions in living things. Living things such as microscopic bacteria can be programmed to act as tiny 'biochemical factories' and make useful substances such as medicines (insulin, food ingredients etc).

1.11 Chemicals in the Body

In our life everything in the world and the human body is full of chemicals.

1.12 Physical Change

Some chemicals can mix together without change. Stir together powdered chalk and powdered iron fillings and one can notice no change or alteration. But some other chemicals may react to produce a new kind of chemical, which is different from the original chemicals used to make it.

For example, mix a table spoon of common salt in a cup of water, after few seconds the salt begins to disappear! It means salt is just dissolved into the water. In dissolving, a solid chemical disappears into a liquid one. We call the salt as the SOLUTE and the water as the SOLVENT. The two together are known as the sodium chloride solution.

The salt and water do not chemically join together. It's only a physical change.

Examples of Physical change.

In a water molecule, the hydrogen particles have a positive charge and oxygen has a negative charge. In sodium chloride molecule, sodium has a positive charge and chlorine has a negative charge. The negatively charged oxygen particle, in water, pulls the sodium away from chlorine and the positively charged hydrogen pulls the chlorine away from sodium in sodium chloride.

Once they have been separated apart, the sodium and chlorine become separate particles surrounded by water molecules. Separation of the sodium and chlorine apart is due to an electrostatic force. We can separate by boiling the mixture in open saucepan to get rid of water to recover sodium salt crystals without any chemical change.

1.13 Chemical Change

Some other chemicals may react to form a new substance, which are different from the original chemicals used to make it. For example, a fairly fast chemical reaction happens when baking powder, sodium bicarbonate, is added to vinegar (acetic acid), forming new substance carbon dioxide and water, which are different from the original chemicals. The reaction is not reversible. This is called a chemical change.

$$NaHCO_3 + CH_3COOH \rightarrow CH_3COONa^+ + CO_2 + H_2O$$

1.14 Condensation

When a gas turns into liquid it's called condensation. Water vapor cools down into a liquid when it touches the cold surface

1.15 Freezing

When water turns from a liquid state into a solid state, it's called freezing.

1.16 Melting

When a solid turns into liquid state, it's called melting. The temperature at which a solid melts is called melting point.

1.17 Boiling Point

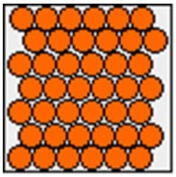
When a liquid water is heated, it absorbs energy, it turns from liquid state into a gas, it's called boiling point.

1.18 Evaporation

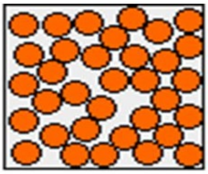
When you boil water, it turns into water vapor, in the form of gas, this process is called evaporation.

1.19 State of the Matter

What is the difference between solid, liquid and gases?

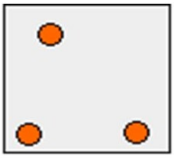


A SOLID is a state of matter that has a definite shape and volume, and is made up of particles that are tightly and regularly packed together. Wood, paper and metals are all examples of solids.



A LIQUID is made up of tiny vibrating particles of matter, such as atoms, held together by intermolecular bonds. Like a gas, a liquid is able to flow and take the shape of a container. The forces of attraction in liquids are weaker, so the particles can separate from each other.

A GAS is a state of matter that has the following characteristics:



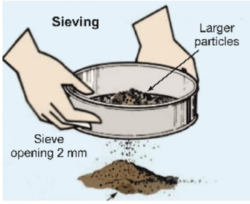
No fixed shape or volume: A gas will fill the container it's in, and if the container isn't sealed, the gas will escape. Gas particles are spread out and randomly organized, far away from each other, so there are bigger gaps between them. Gas particles move fast and free. Some examples of gases are Nitrogen, Oxygen and Carbon dioxide

1.20 Separation Techniques

Separation of a substance: If one wants to separate two solids with different-sized particles, for example separating sand from stones. Difference in size of particles in a mixture is utilized to separate them by using sieve. Sieving is actually a process.

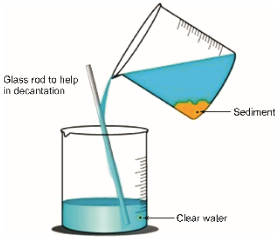
1.21 Sieving

If we put a mixture of sand and stones into a sieve and shake it, the smaller sand particles pass through the holes in the sieve. The larger particles stay in the sieve because they are too large, so they are now separated.



1.22 Decantation

In a mixture of sand and water in a beaker or a glass, the heavier sand particles settle down at the bottom of a beaker and the water is separated by decantation.



1.23 Filtration

The process in which solid particles in a liquid are removed by the use of a filter paper that permits the fluid to pass through and retains the solid particles.

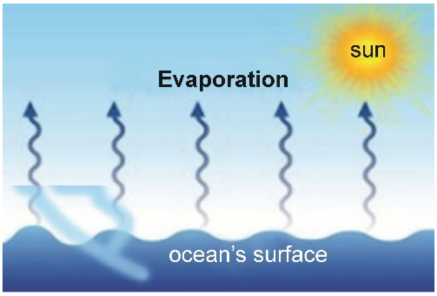
For example, Sand in water

Sand doesn't dissolve in water unlike sodium salt-it just sinks to the bottom. As the sand can't dissolve, we say that it is insoluble in water. Sodium chloride dissolves in water so one can say that it is soluble in water.

To remove the sand from the mixture we need to use a method called filtration. The insoluble solid stays in the paper and the water runs through.

1.24 Evaporation

Evaporation is a process that occurs when a liquid turns into a gas or vapor, and is a key part of the water cycle. Evaporation can be used to separate a solid dissolved in a liquid. For example: common salt preparation: salt is prepared naturally by evaporation of seawater.



1.25 Atomic Mass

Atomic mass and atomic number are the same concept however with different names. This dual name is a common cause of confusion and creation of a misconception.

Atomic mass (mass number) is the mass of the entire atom. A neutron has a mass of one, similar to the proton. However, the neutron will not change the element but only change the mass. The electron has a very small mass. It is $1/1840^{th}$ the mass of a proton or neutron. The mass can be described as $1/1840^{th}$ or negligible. It must never be described a zero or nothing. When looking at the periodic table and at the elements this is the larger number located at the element symbol.

1.26 Charges

There are positive and negative charges in the atom. All the positive charges in the nucleus (center of the atom) and all the negative charges are in the shell/orbits outside the nucleus. The neutron has no charge, be it either positive or negative. The neutron is not involved when looking at charges in the atom. It does have mass but it does not have any charge. The proton has a charge of +1. When protons are added then their charge is accumulative: an atom with one proton has a charge of +1, an atom with two protons has a charge of +2 etc. The electron has a charge of – 1. When electrons are added then their charge is accumulative: an atom with one electron has a charge of -1, an atom with two electrons has a charge of -2 etc.

In neutral atom, the number of positive charges (protons) are equal to the number of negative charges (electrons).

Examples

An atom with five protons (+5) and has five electrons (-5) then the overall/net charge is zero (neutral). Overall charged atoms are called ions, sometimes called charges particles, and they can be overall/net negatively or positively charged.

Atoms with five protons (+5) and four electrons (-4) have an overall/net charge of +1 (positively charged atom). An atom with an overall positive charge is referred to as a cation.

Atoms with five protons (+5) and six electrons (-6) have an overall charge of - 1 (negatively charged atom). An atom with an overall negative charge is referred as an anion.

1.27 Isotope

Isotopes are atoms where the number of protons (atomic number) remains the same and therefore ~~and therefore~~ they remain the same element (remember the number of protons dictates what the element is) and the number of neutrons can vary. In the natural world some combinations of neutrons with the protons produce stable atoms and other combinations produce unstable atoms. An isotope is an element with the same atomic number but varying atomic mass (mass number).