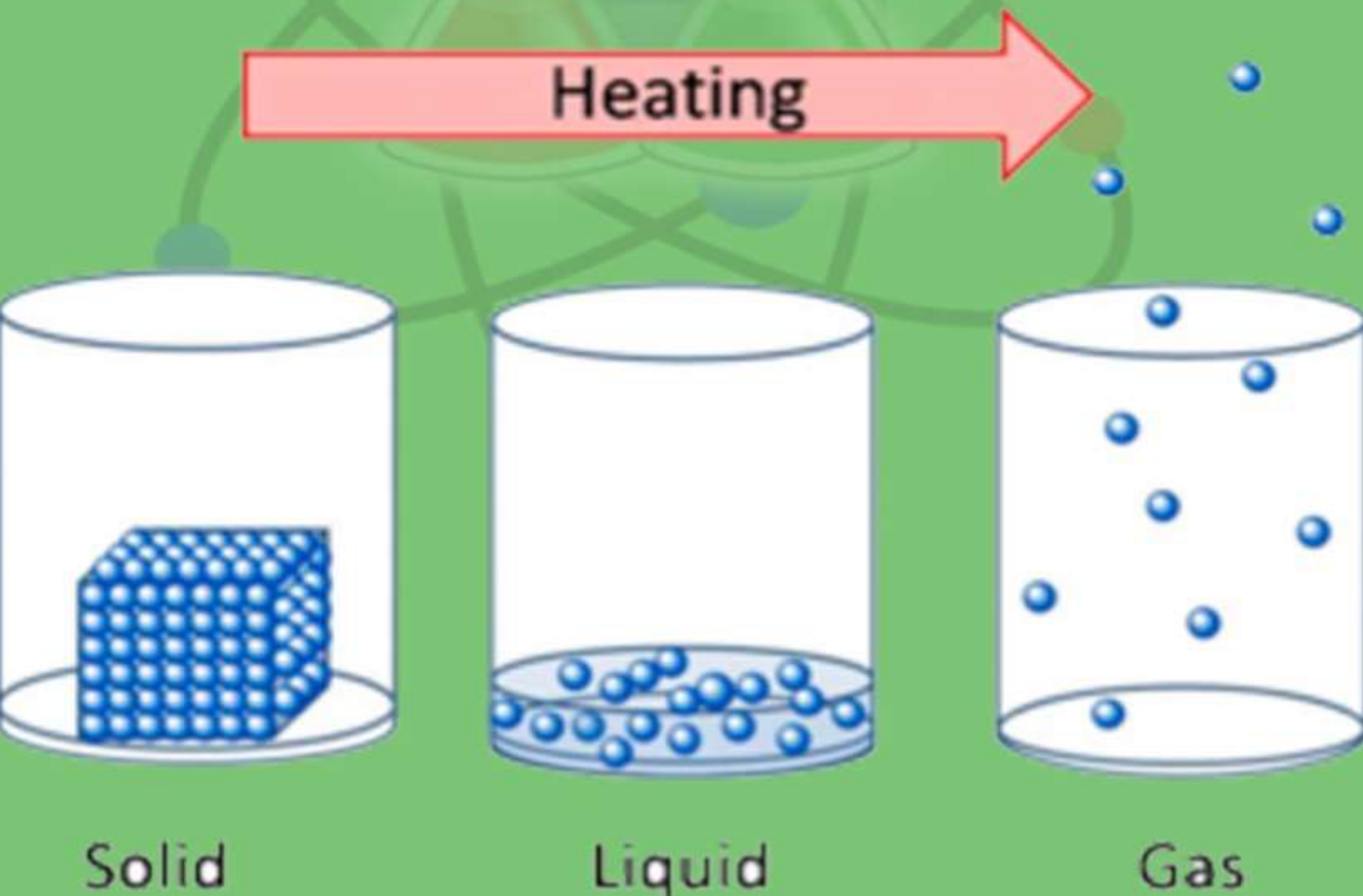


Basic Chemistry Book

First Edition



Cooling

By:
Mr. Mohamed Hersi Farah

Basic Chemistry Book

First Edition



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Preface

This edition of basic chemistry book, were based on Puntland secondary syllabus in high school education. This textbook has been designed to help you in your study of chemistry in Puntland state of Somalia.

Acknowledgements

I would like to thank my best friends Dr. Alsheikh Mohamed Farah, Mr. Hamza Barbara, Mr. Shuiab Mubarak, Mr. Alsheikh Ismail Hassan Abdullahi, Mr. Mohamed Abdulkadir Diriye and Mr. Mona Omar Abdulahi for their never ending patience and encouragement throughout the production of this textbook.

And also, I would like to acknowledge everyone who played a role for the completion of this book. I would like to extend my gratitude to my parents, whom without their support and love I could never have reached where I am today.

Thank you all for your unwavering support.

Dedication

To my mother and father.

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Chapter I

Introduction to Chemistry

1.1 Introduction to Chemistry

Chemistry is the science of matter (that is, of all Physical substances including gases and liquids as well as solids) and the changes that occur between different kinds of matter - especially chemical changes (called "reactions") when types of matter are re-arranged into other types of matter e.g. water splitting into the gases hydrogen and oxygen.

That is, chemistry is a Physical science concerned with the composition, structure, behavior, and properties of matter and with the changes it undergoes during, and as a result of, chemical reactions. It involves study of substances in all of the states of matter (solid, liquid and gas) and knowledge and understanding of the various structures of matter (include e.g. atoms, molecules, crystals and other aggregates) whether in isolation or in combination with others.

1.1.1 How Chemistry Related To Everyday Life, Environmental and Society

Chemistry is a big part of our everyday life. We find chemistry in daily life in the foods we eat, the air we breathe, our soap, our emotions and literally every object we can see or touch.

Chemistry has played a very important role in our life. It has contributed a lot towards the well-being of mankind in form of food, clothing, shelter, medical treatment and in providing environmental facilities. A variety of chemical facilities are being manufactured in thousands of industries every day. Mass productions of commodities are amazing, which save people from station. Crops are being protected by using pesticides. Food processing factories are working day and night

for preparing refined foods. The production of a variety of artificial fibers has brought a revolution in our clothing. We owe colorful and fine dresses for all seasons to chemistry. Cement, iron, bricks glasses and etc. used in the construction of our houses are the result of our knowledge of chemistry.

The attractive and colorful paints are available in the market are used to makes the houses all the more beautiful. Polyester fiber, fiber glass, multi-color glass, glass crockery tikes, steel and alloy of deferent materials are all miraculous product of chemistry.

The Physical and biological factories along interaction that affect organisms such as: CO_2 , O_2 , N_2 etc. all undergo chemistry.

The Role of Chemistry in Society:

(a) Chemistry is used in the following:

(I)Washing/cleaning with soap:

Washing/cleaning is chemical processes that involve interaction of water, soap and dirt so as to remove the dirt from a garment.

(ii)Understanding chemicals of life:

Living thing grow, respire and feed. The formation and growth of cells involve chemical processes in living things using carbohydrates, proteins and vitamins.

(iii)Baking:

Adding baking powder to dough and then heating in an oven involves interactions that require understanding of chemistry.

(iv) Medicine:

Discovery, test, prescription and dosage of drugs to be used for medicinal purposes require advanced understanding of chemistry

(v) Fractional distillation of crude oil:

Crude oil is fractional distilled to useful portions like petrol, diesel, and kerosene by applying chemistry.

(vi) Manufacture of synthetic compounds/substances:

Large amounts of plastics, glass, fertilizers, insecticides, soaps, cements, are manufactured worldwide.

Advanced understanding of the chemical processes involved is a requirement.

(vii)Diagnosis/test for abnormal body functions:

If the body is not functioning normally, it is said to be sick/ill. Laboratory test are done to diagnose the illness/sickness.

1.1.2 Important of Chemistry

1. Everything is made of chemicals such as drugs and food.
2. May all changes we observe in the world around us are caused by chemical reactions example: include changing color of leaves, cooking food and getting clean.
3. Knowing some chemistry can help you make day to day decisions that affect your life.
4. Studying of chemistry gives us the opportunity to better understanding the world that we live in.

1.2 Pure Substances and Mixtures

A pure substance is a sample of matter with both definite and constant composition with distinct chemical properties. Examples: water diamond, gold, table salt (sodium chloride), ethanol and etc.

Mixture is substances (more different substances) which is mixed but are not combined chemically.

A mixture refers to the Physical combinations of two or more substance on which the identities are retained and mixed the form of solution, suspension and colloids.

- Solution is homogeneous mixture composed of only one PHase.
- Suspension is a heterogeneous mixture containing solid particles that are sufficiently large for sedimentation.
- Colloid is a substance in which microscopically dispersed insoluble particles are suspended throughout another substance.



Figure (1.1) pure substance and mixture

Table (1.1): The different between pure substances and mixture

Pure substances	Mixture
1. A pure substance has only one component. E.g. pure water is a pure substances it consist of only water molecules	1. a mixture has variable combination E.g. alcohol-water, both co-exist together.
2. Elements and compounds are substances it is collection of dissimilar particles will not undergo chemical reaction.	2. a mixture can be either homogeneous or heterogeneous

Note: - mixtures are either homogeneous or heterogeneous. When a spoonful of sugar dissolves in water, the composition of the mixture, after sufficient stirring, is

same throughout the solution. This solution is homogeneous mixture. If sand is mixed with iron filing however, the sand grains and the iron filing remain visible and separate. This type of mixture, in which the composition isn't uniform, is called heterogeneous mixture.

Note: - adding oil to water creates another heterogeneous mixture because the liquid doesn't have composition.

1.3 Matter

Matter is everything around you. Atoms and molecules are composed of matter. Matter is anything that has mass and takes up space.

1.3.1 States of Matter

Gas, liquid and solid are all made up particles, but the behavior of these particles differ in the three PHase.

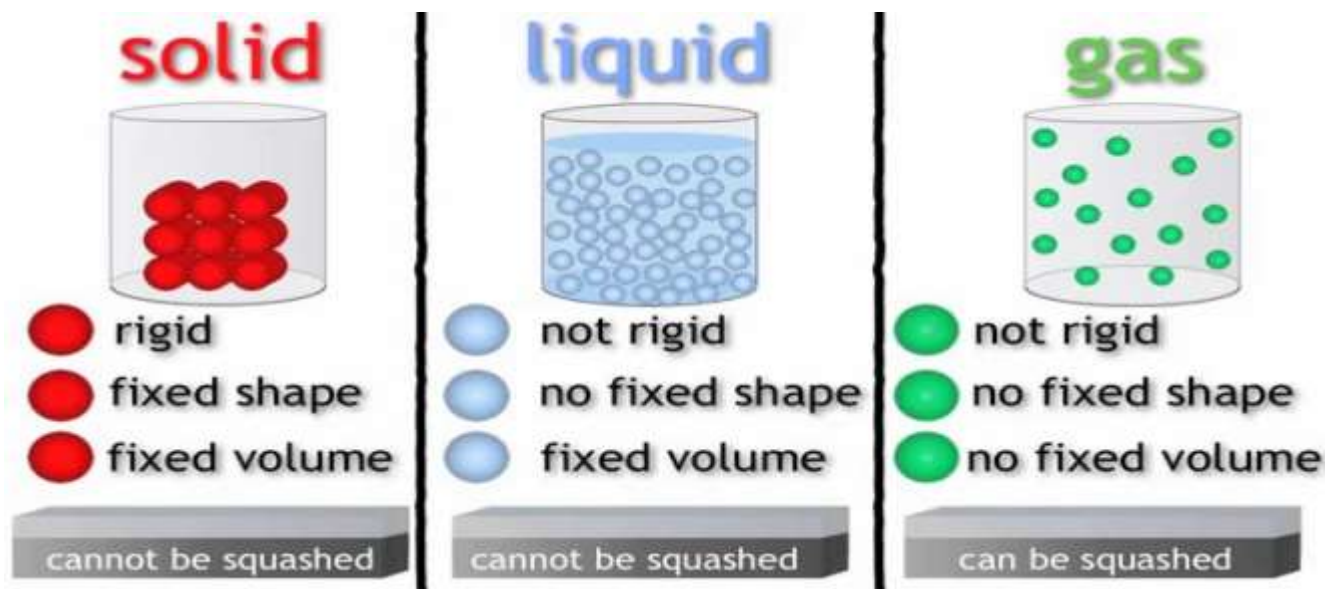


Figure (1.2) states of mater

Table (1.2): Classification of Matter by Physical State

Solids	Liquids	Gases
- Fixed volume - Fixed shape	- Fixed volume - No fixed shape	- No Fixed volume - No fixed shape

• Maintain their shape • Are rigid • Incompressible	• Are fluid • Flow • Incompressible	• Are fluid • Flow • Compressible
---	---	---

Note:

1. The three forms of matter (solid, liquid, gas) are referred to as states of matter
2. This classification is not very meaningful, since the majority of the different forms of matter may exist in all three Physical states, depending on conditions.

Example: water can exist as:

1. Solid water (ice) at very low temperature (below 0°C)
2. Liquid water (between 0°C and 100°C)
3. Gaseous water or water **vapor** (above 100°C)

The term **vapor** is used to refer to the gaseous state of a form of matter that exists as a solid or a liquid at room temperature (25°C)

Table (1.3): Some Characteristics of gases, liquids & solids, and the explanations for their behavior:

Gases	Liquids	Solids
1. Assumes the shape and volume of its container (particle can move past one other.)	1. Assumes the shape of the part of the container which it occupies (particles can move/slide past one another)	1. Retains a fixed volume & shape (rigid-particles 2. locked in to place)
3. Compressible (lots of free space between	2. Not easily compressible (little	2. Not easily compressible (little free space between

particles)	free scape between particles)	particle)
4. Follow easily (particle can move past one another)	3. Flow easily (particle can move/slide past one other)	3.Does not flow easily (rigid- particles cannot move/slide)

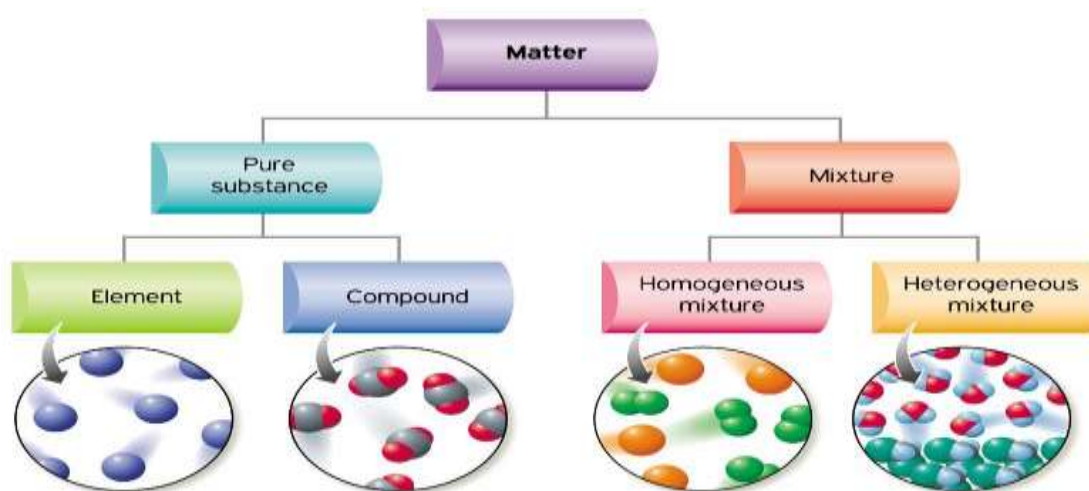


Figure (1.3) states of mater

1.4 Physical Changes and Chemical Changes

A Physical change is any alteration that does not change the identity of the matter. Shredding paper does not change the paper into a different substance. Dissolving salt in water is a Physical change because after the change, the salt and water are both still there.

A chemical change is any alteration that changes the identity of matter. For example, by passing electricity through water it can be broken down into hydrogen and oxygen. Burning paper is a chemical change because after the change takes place, the paper has been changed into different substances (like ash, carbon dioxide, etc.).

Every day we witness changes in matter: ice melts, iron rust, gasoline burn, fruit ripens and water evaporates what happens to the molecules or atoms that compose these samples of matter during such changes? The answer depends on the types of changes. Changes that alter only state or appearance, but not composition, are Physical changes. The atoms or molecules that compose a substance don't change their identity during a Physical change. For example: when water boils, it changes its state from liquid to gas, but the gas remains composed of water molecules, so this is Physical change.

In contrast, changes that alter the composition of matter are chemical changes. During a chemical changes, atoms rearrange, transforming the original substance into different substance. For example, the rusting of iron is a chemical change. The atoms that compose iron (iron atom) combine with oxygen molecules from air to form iron oxide, the orange substance we call rust, Physical and chemical changes are manifestation of Physical and chemical properties. A Physical change is a property that a substance displays without changing its composition whereas a chemical property is a property that a substance displays only by changing its composition via a chemical change the smell of gasoline is a Physical properties.

- Gasoline doesn't change its composition when it exhibits its odor. The flammability of gasoline, in contrast, is a chemical property.
- Gasoline does change its composition when it burns, turning into completely new substance (primarily carbon dioxide and water). Physical properties include odor, taste, color, appearance, melting point, boiling point and density. Chemical properties include corrosiveness, flammability, acidity, toxicity and other such characteristics.

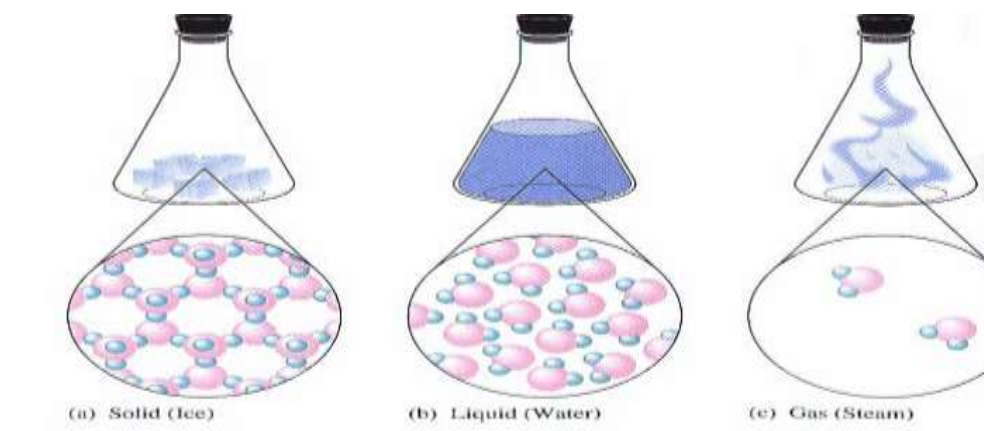


Figure (1.4a) Physical changes

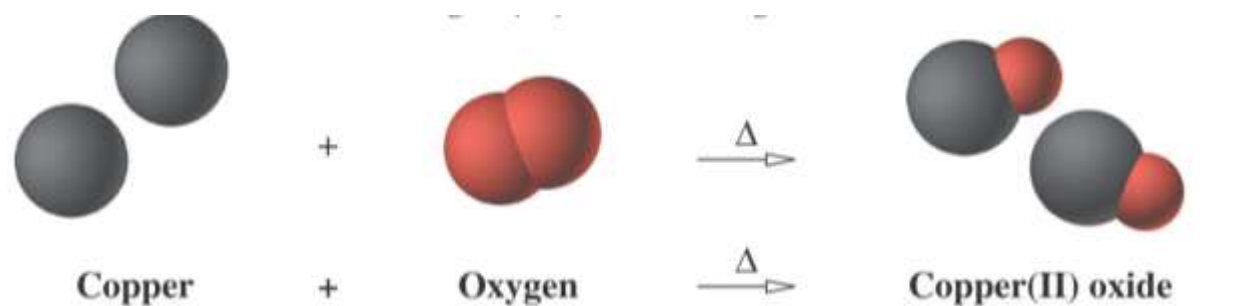


Figure (1.4b) chemical change

1.5 Separation of Mixtures

Separation often wants to separate a mixture into its components. Such separations can be easy or difficult, depending on the component in the mixture. In general, mixtures are separable because the different Physical or chemical properties. Some ways of separation example: filtration, distillation, evaporation, and chromatography.

1.5.1 Separation of Mixture by Filtration

A solid and liquid mixture can be separated by pouring the mixture through a funnel contains filter paper design to allow only the liquid to pass.

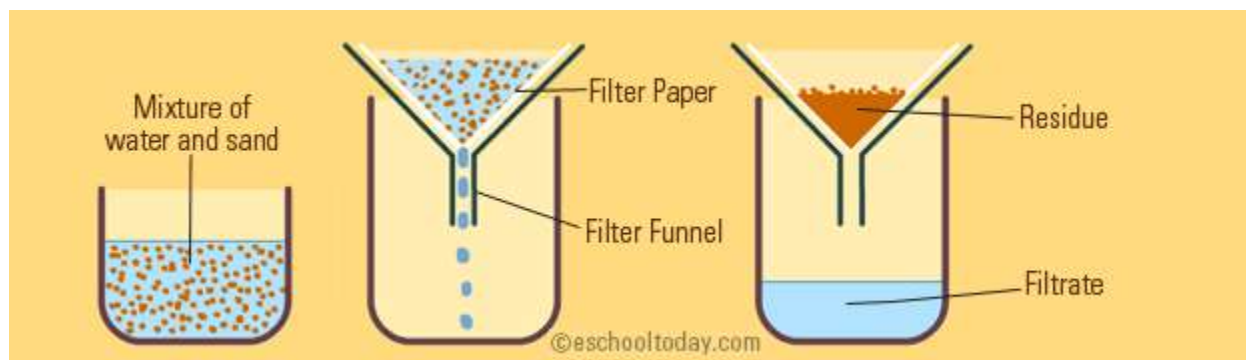


Figure (1.5) separation of mixture by filtration

1.5.2 Separation of Mixture by Distillation

When liquid mixture is heated, the component with lower boiling point vaporizes first. Leaving behind less volatile liquids or dissolved solids. The vapor is then cooled condensing it's back to a liquid and collected.

Example: pure water from sea water, removing of ethanol from water and ethanol.

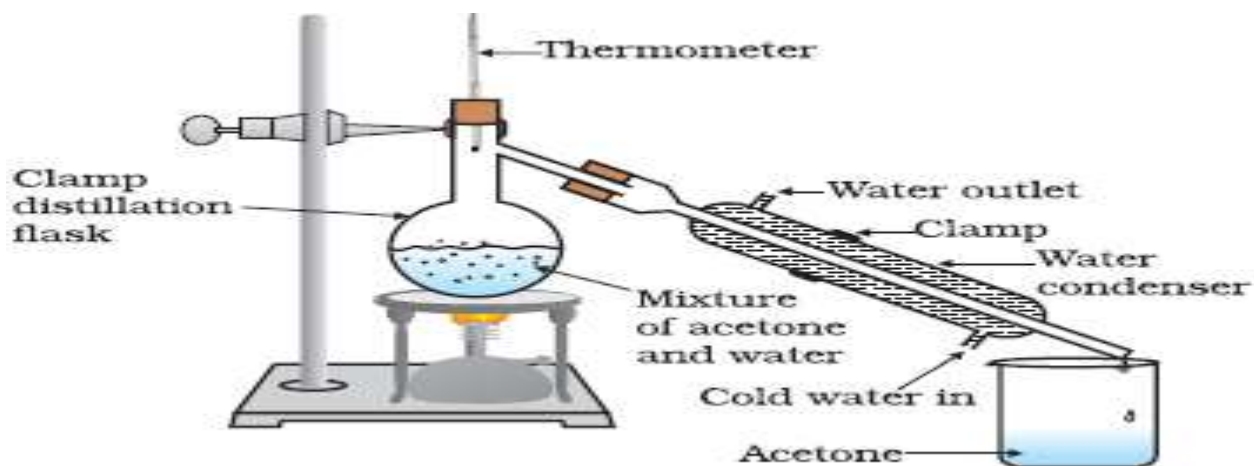


Figure (1.6) separation of mixture by distillation

1.5.3 Separation of Mixture by Evaporation

Evaporation is great for separating a mixture (solution) of a soluble solid and solvent. The process involves heating the solution until the solvent evaporates

(turns into gas) leaving behind the solid residue. And this process can be used to separate a dissolved solute from a solution.

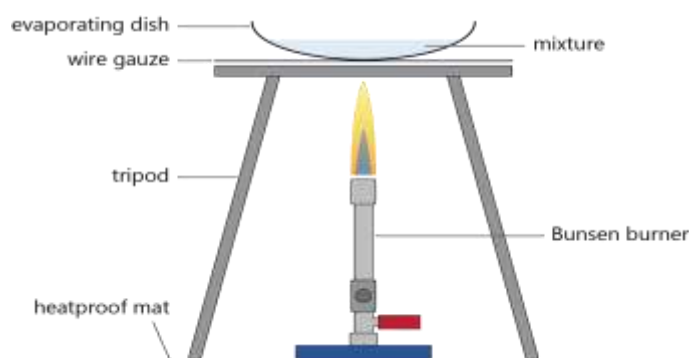


Figure (1.7) separation of mixture by evaporation

1.5.4 Separation of Mixture by Chromatography

Chromatography is a group of similar separation techniques. Each depend on how fast a substance moves, in a stream of a gas or liquid past stationary Phase to which substance may be slightly attracted.

So if a spot of dye solution is a put on to a filter paper and the spot enlarged by slowly dropping solvent on the center of the spot, the different components of the dye spread out at different rates. Each component forms a definite ring on the filter paper.

Chromatography experiments are often carried out using square sheet of filter paper. Spot of dye solutions are put along the baseline of a sheet of filter paper is coiled into a cylinder and the cylinder is put into a tank containing a small volume of solvent the liquid is put on the tank and the solvent slowly rises up the filter paper. When the solvent has nearly reached the top of the filter paper, of the cylinder of the paper is removed and the position that the solvent has reached is marked.

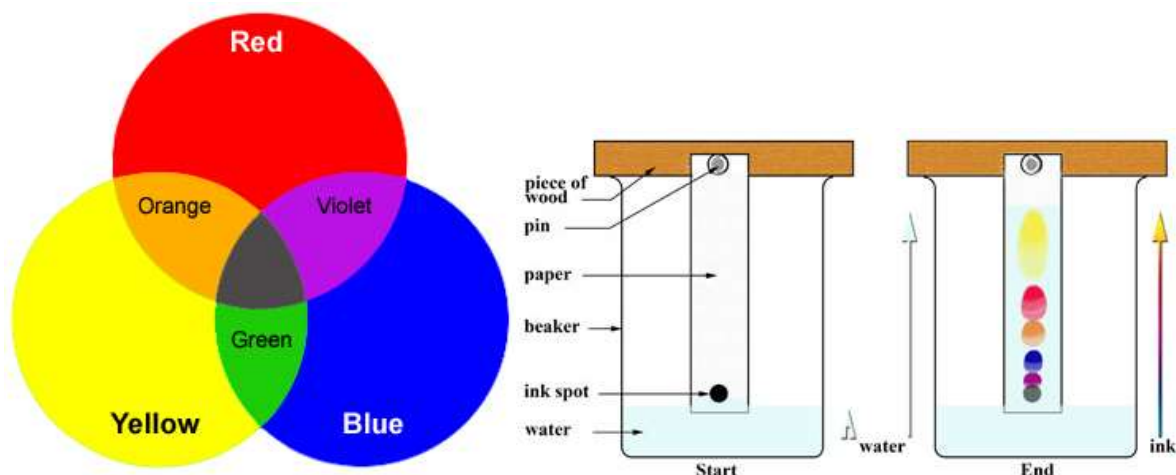


Figure (1.8) simple chromatography (paper chromatography)

1.5.5 Separation of Mixture by Funnel

In this technique, two liquids that do not dissolve very well in each other (immiscible liquid) can be separated by taking advantage of their unequal density. A mixture of oil and water, for example, can be separated by funnel.

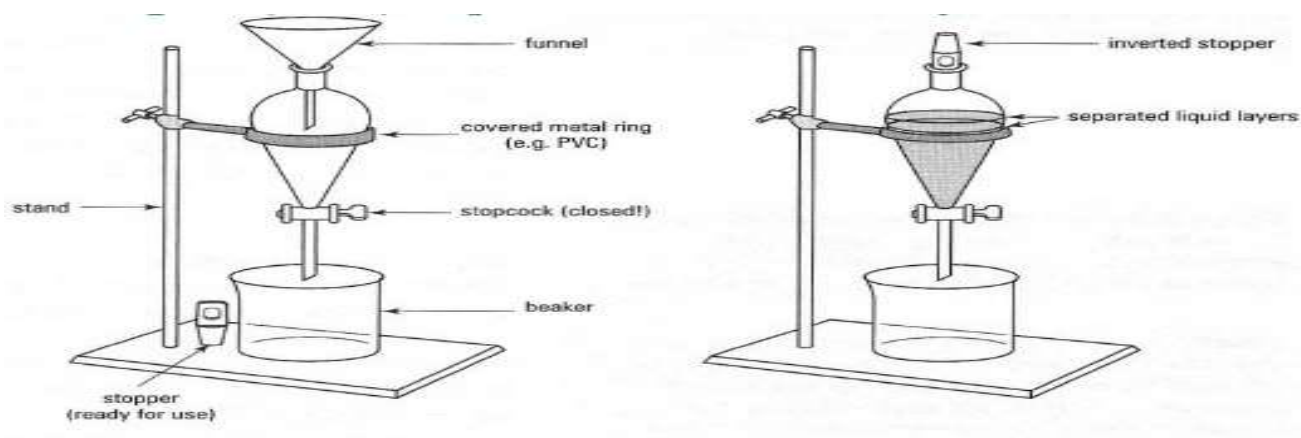


Figure (1.9) separation of mixture by funnel

1.6 Safety Rules and Regulations:

Your school science laboratory is set up so that you can perform science experiments in safety provided that you follow the proper procedures and safety precautions listed below.

Your teacher will give you specific information about the safety routines used in your school.

It is essential for all concerned that certain rules be followed while in the lab.

Read the following carefully and ask questions necessary for clarity:

1. Goggles will be worn at all times. No exceptions. Failure to wear goggles will result in expulsion from laboratory.
2. Full shoes are required. No sandal, flip-flops, etc. are allowed.
3. Lab apron is required when wearing shorts, tank tops, etc.
4. Keep locker drawers closed when not in use.
5. Do not leave flames unattended. Turn burners off when not in use.
6. Remember that most chemicals are flammable, toxic, carcinogenic or all three. Treat them accordingly. Do not ingest chemicals.
7. Acquaint yourself with the eyewash station, safety shower and fire-fighting equipment. You are responsible for knowing their location and use.
8. No smoking, chewing, eating or drinking allowed in the laboratory.
9. If you are taking a prescription or other drug that will affect your alertness, notify your instructor before going into lab.
10. No students are allowed in the stockroom. No lab visitors without permission of the lab instructor.
11. Report all accidents or injuries to the instructor immediately!
12. If you do not understand a procedure or you cannot read a label, contact the instructor.
13. Do not gamble with your (and others) safety when there is a question. What you don't know can hurt you. Ditch the foolish notion that asking questions will make you look stupid.

1.6.1 Some Further Explanations:

1. Do not pipette by mouth

You say, "But it's only water." Even if it is, how clean do you think that glassware really is? Using disposable pipettes? I know lots of people who rinse them and put them back! Learn to use the pipette bulb or automated pipetter. A Material Safety Data Sheet (MSDS) should be available for every chemical you use in lab. Read these and follow the recommendations for safe use and disposal of the material.

2. Dress appropriately (for chemistry lab, not fashion or the weather)

No sandals, no clothes you love more than life, no contact lenses, and long pants are preferable to shorts or short skirts. Tie long hair back. Wear safety goggles and a lab coat. Even if you aren't clumsy, someone else in the lab probably is. If you take even a few chemistry courses you will probably see people set themselves on fire, spill acid on themselves, others, or notes, splash themselves in the eye, etc.

Don't be the bad example to others, remembered for all time for something stupid!

3. Identify the Safety Equipment

And know how to use it! Given that some people (possibly you) will need them, know the locations of the fire blanket, extinguishers, eyewash, and shower. Ask for demonstrations! If the eyewash hasn't been used in a while the discoloration of the water is usually sufficient to inspire use of safety glasses.

4. Don't Taste or Sniff Chemicals

For many chemicals, if you can smell them then you are exposing yourself to a dose that can harm you! If the safety information says that a chemical should only be used inside a fume hood, then don't use it anywhere else. This isn't cooking class - don't taste your experiments!

5. Don't casually dispose of chemicals down the drain

Some chemicals can be washed down the drain, while others require a different method of disposal. If a chemical can go in the sink, be sure to wash it away rather than risk an unexpected reaction between chemical 'leftovers' later.

6. Don't eat or drink in lab

It's tempting, but dangerous... just don't do it.

7. Don't play mad scientist

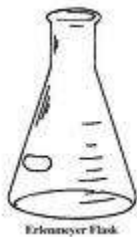
Don't haphazardly mix chemicals! Pay attention to the order in which chemicals are to be added to each other and do not deviate from the instructions. Even chemicals that mix to produce seemingly safe products should be handled carefully. For example, hydrochloric acid and sodium hydroxide will give you salt water, but the reaction could break your glassware or splash the reactants onto you if you aren't careful.

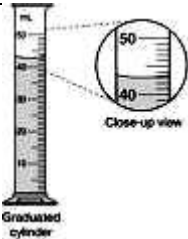
8. Take data during lab Put data directly in your lab book rather than transcribing from another source (e.g., notebook or lab partner). Not after lab, on the assumption that it will be neater. There are lots of reasons for this, but the practical one is that it is much harder for the data to get lost in your lab book. For some experiments, it may be helpful to take data before lab.

Table (1.4): Common Laboratory Equipment

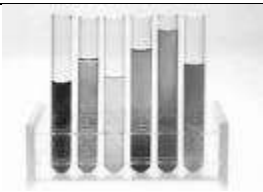
Name	Description and/or use	Picture
Beaker	Glass container, most are pyrex; common sizes are 100 ml, 25 ml, 400 ml; it can be used as a container, shows approximate volume, and	

	may be heated	
Bunsen Burner	A metal heating device connected to a gas outlet with rubber tubing; used to heat chemicals in beakers or test tubes; has adjustable air-hole allowing some control of temperature	
Burette	It is marked with a milliliter scale and fitted with a stopcock; can be used to withdraw and measure accurate volumes of solutions in titrations	
Beaker Tongs	Metal with rubber ends; used to handle hot beakers	
Chemical Apron	Chemical resistant rubberized apron used to protect clothing	
Crucible & Cover	Made of porcelain; used to heat small amounts of solid substances that are being heated strongly at high temperatures	

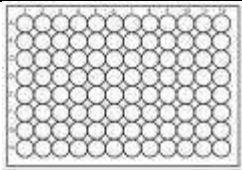
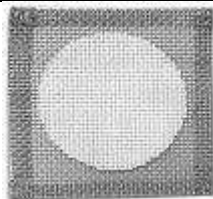
Dropper	Glass tip with a rubber bulb; used to transfer small amounts of liquids	
Electronic Balance	Used for quick, accurate massing	
Erlenmeyer Flask	Container; common sizes are 125 ml, 250 ml, 500 ml; may be heated; it has a thin neck and a wide base; used to hold liquids when carrying out reactions and preparing solutions	
Evaporating Dish	Porcelain dish; used to hold a solution whose solvent is being separated from the solvent by evaporation (often using heat)	
Florence Flask	Used to hold liquids when carrying out reactions (no heat use flat-bottomed; even heating required use round-bottomed)	

Forceps	Metal or plastic, straight-tipped instrument used to isolate and remove small particles	
Funnel	Made of glass or plastic; used to hold a filter paper and can be used in pouring (to avoid spills)	
Goggles	Used to protect eyes	
Graduated Cylinder	Marked with milliliter (ml) scale and is used to measure volume	
Heat Resistant Gloves	Used to handle hot glassware or other hot lab equipment	
Mortar & Pestle	Heavy porcelain dish with grinder; used to grind chemicals to a powder	
Pipestem Triangle (Clay Triangle)	Triangular wire frame with clay material coverings; used to support a crucible	

Pipette	Used to transfer small amounts of liquid	
Plastic Wash Bottle	Squeezable plastic bottle; used to dispense distilled water	
Ring Clamp (Iron Ring)	Iron ring with screw fastener; comes in several sizes; used to fasten to the ring stand as a support for an apparatus	
Ring Stand (Support Stand)	Metal rod that is upright and sits on a heavy base; used as a support and has many uses	
Rubber Stopper	Used to cap the openings of glassware such as test tubes or Erlenmeyer flasks	
Scoopula	Made of metal; used to transfer solid chemicals	
Spatula	Made of metal; has a flat rounded end and a rectangular end; used to transfer solid chemicals	

Spot Plates	Plastic or ceramic reaction surfaces with slight “dips” for containing small amounts of chemicals	
Stirring Rod	Made of glass; used to stir combinations of materials	
Striker	Made of metal and has a flint; used to ignite the Bunsen burner	
Test Tube	Glassware that comes in many sizes; it has many uses and can be heated	
Test Tube Brush	Brush with wire handle; used to scrub thin glassware	
Test Tube Clamp	Metal clamp with a screw fastener, a swivel and lock nut, an adjusting screw, and a curved clamp; used to hold an apparatus (test tube or burette) to the ring stand	

Test Tube Holder	Made of metal; has a clamp with a spring handle; used to hold a test tube	
Test Tube Rack	May be made of wood, metal, or plastic; used to hold test tubes in an upright position	
Thermometer	Made of glass and filled with a red or blue liquid (usually alcohol); used to determine temperature	
Triple Beam Balance	Used for determining the mass, in grams, of a chemical or object	
Volumetric Flask	Used when mixing accurate concentrations of solutions. Each flask has a volume marking which is very exact and can be stoppered.	
Watch Glass	Curved glass; may be used as a beaker cover or for evaporating very small amounts of liquid	

Well Plate	Small plate with several wells; used for reacting small amounts of chemicals	
Wire Gauze	Wire screen with ceramic fibered center; used to spread the heat of a flame	

1.7 Exercise:

1. What is the chemistry?
2. How chemistry related our daily life?
3. What is the important of chemistry?
4. What is the different between pure substance and mixture?
5. Explain the role of chemistry in society?
6. Define matter and explain the states of matter?
7. Compare the different types of matter with their behavior?
8. Discuss physical change and chemical change?
9. How to separate the mixtures and give some examples of separation?
10. Discuss the safety rules and regulations of science laboratory and give some examples of common laboratory equipment?

Chapter II

Elements in periodic table

2.1 Elements, Compounds and Mixtures

A mixture is a combination of two or more substances in which the substances retain their distinct identities.

A substance can be either an element or a compound. An element is a substance that can't be separated into simpler substances by chemical means. At present, 117 elements have been positively identified

Table (2.1): Some common elements and their symbols

Element	Hydrogen	Helium	Lithium
Symbol	H	He	Li

Most elements can interact with one or more other elements to form a compound.

We define a compound as a substance composed of two or more elements chemically united in fixed properties.

2.1.2 Elements

Elements are the simplest substance in nature. There are around 90 naturally occurring elements on the earth. They cannot be broken down into anything simpler by physical or chemical means. They consist only of one kind of atom and they can exist as either atoms (e.g. Argon, calcium, aluminum) or molecules (e.g. Oxygen, nitrogen).

Note that, each element has a symbol which is a single capital letter like H or U or a capital letter + small letter e.g. cobalt Co, calcium Ca or sodium Na. Each element has its own unique set of properties but the Periodic Table is a means of grouping similar elements together. They may exist as atoms like the Noble Gases e.g.

helium (He) or as molecules e.g. hydrogen (H_2) or sulphur S_8 . All the atoms of the same element have the same atomic or proton number.

Note that an element:

- consists of only one kind of atom,
- cannot be broken down into a simpler type of matter by either Physical or chemical means, and
- Can exist as either atoms (e.g. argon) or molecules (e.g., nitrogen).

2.1.3 Compound

Compound is formed when two or more elements chemical combine together. The elements react chemically and form chemical bonds between atoms of the elements. In compounds the constituents elements are always present in fixed proportions and there for a compound has a definite chemical composition.

The components of a compound lose their individual properties and the properties of a compounds are different form their individual components. For example Iron is an element which is metallic in nature and has magnetic properties and oxygen is an element which is a colorless odorless gas. When Iron rust, it react with atmospheric oxygen to form the compound called Iron oxide.

Note that a compound:

- consists of atoms of two or more different elements **bound together**,
- can be broken down into a simpler type of matter (elements) by chemical means (but not by Physical means),
- has properties that are different from its component elements, and
- Always contains the same ratio of its component atoms.

2.1.4 Mixture

A mixture is a combination of two or more substances which are not chemically the same. The composition of mixture is variable. In a mixture, the components are present in any proportion and they can be identified visually within the mixture. In mixture, the individual components retain their own identities. For example: - when a carbon disulphide is added to a mixture of Iron and sulphur. Sulphur first dissolves and then reappears in its solid state. First add a small amount of CS_2 into the mixture of iron filings and sulphur taken in a test tube and shake gently. After shaking the Iron filing settle down to the bottom of the breaker and sulphur dissolves in the CS_2 to give a clear yellow solution into a china dish and after some time the yellow colored sulphur powder reappears in the china dish as CS_2 evaporates.

The properties of a mixture are the same as the properties of individual compounds. Individual components of a mixture may be separated by Physical methods. For example:- an magnet can be used to separate Iron from a mixture of Iron and sulphur.

Mixture can be homogeneous or heterogeneous mixture. Heterogeneous mixtures have uniform composition and appearance throughout. For example: -mixture of iron and sulphure, mixture of sand and table salt etc. A homogeneous mixture is also a true solution. For example: - sugar solution, ocean water, soft drinks etc.

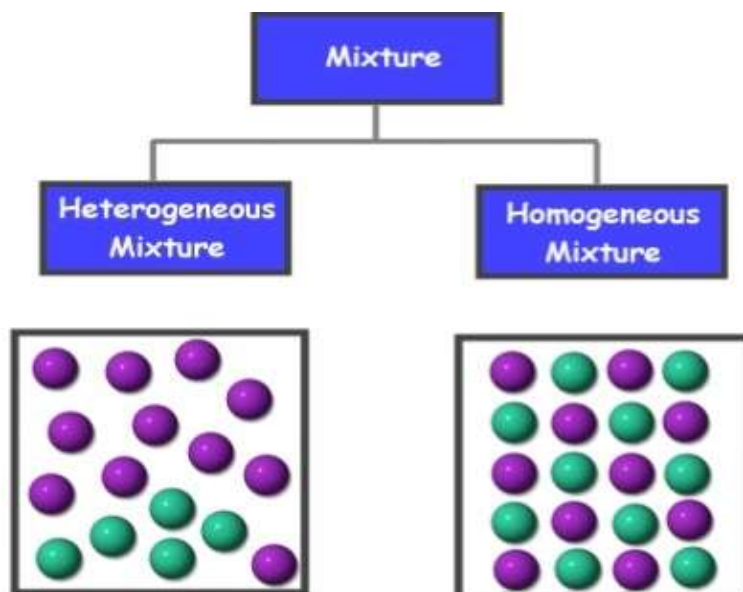


Figure (2.1) mixture

Note that a mixture:

- consists of two or more different elements and/or compounds Physically intermingled,
- can be separated into its components by Physical means, and
- Often retains many of the properties of its components.

Table (2.2): Comparison of mixture and compound

Mixture	compound
1. Properties of the different elements can be varied.	1. Different elements have to be present fixed proportion.
2. Elements can be separated by simple method e.g.: iron using magnet.	2. Difficult to separate into the elements which make up.
3. Properties of the mixture are those of elements mixed up.	3. Properties of the compound are different from the properties of the elements.

4. No energy gained or lost when the mixture is made.	4. Energy is usually given out or taken in when the compound is formed.
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2.2 Structure of an Atom

Atoms are the submicroscopic particles that constitute the fundamental building blocks of ordinary matter. An atom consists of **nucleus**, **protons**, **neutrons** and **electrons**.

Although the word “**atom**” comes from a Greek for indivisible, we know that atoms are the smallest particle of matter. Atoms are made from smaller subatomic particles.

An atom is the basic unit of an element that can enter into chemical combination.

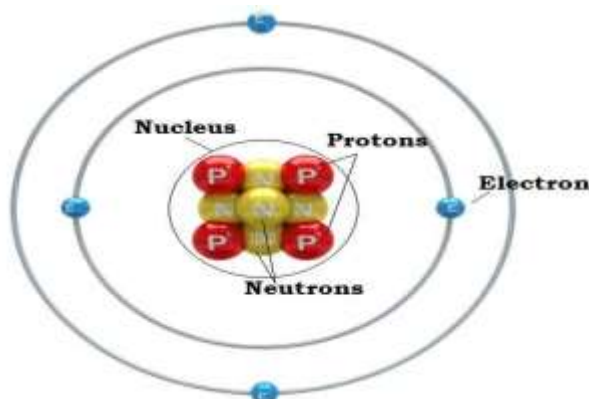


Figure (2.2) structure of an atom

Atoms consist of electrons surrounding a nucleus that contain protons and neutron. The neutron is neutral, but protons and electrons are electrically charged. Protons have relative charge of +1, while electrons have a relative charge -1.

Table (2.3): Atom Properties

Atomic mass unit	Particle	Relative charge
1	Proton	+1

1	Neutron	0
1/1836	Electron	-1

The number of protons in an atom is called its atomic number. In the periodic table atoms are arranged in atomic number order.

Electrons are arranged in energy levels or shells and different energy levels can hold different numbers of electron. The electronic structure of an atoms is a description of how the electrons are arranged, which can be shown in the diagram or by numbers. There is a link between the position of an element in the periodic table and its electronic structure.

Atomic number: - the atomic number is the number of proton in an atom.

The atomic number (Z) is also known as the proton number of the nucleus of a particular element. It is the proton number that determines the specific identity of a particular element and its electron structure. The mass number (A) is also known as the nucleon number, which is the sum of neutrons and protons in the nucleus of an atom.

The neutron number (**N**) = mass number (**A**) - proton/atomic number (**Z**)

Protons and neutrons are the nucleons present in the positive nucleus and the negative electrons are held by the positive nucleus in 'orbits' called energy levels or shells. In a neutral atom the number of protons equals the number of electrons

Mass number: - the mass number is the total number of protons and neutrons in an atom.

Example: the mass number of carbon-12 is 12, and the atomic number is 6. Therefor carbon-12 atom contains 6 protons (**E.g.** atomic number is 6), 6 electrons and 6 neutrons. This is sometimes write as $^{12}_6\text{C}$ (the atomic number is written under the mass number).

For sodium-23, mass number is 23, atomic number is 11(i.e. $^{23}_{11}\text{Na}$) so $P=11$, $E=11$ and $N=23-11= 12$.

It is possible, with many elements to get more than one type for atom. For example there are three types of oxygen atom: oxygen-16, oxygen-17 and oxygen-18.

Table (2.4) Oxygen Atom

Type of oxygen	Number of protons	Number of electrons	Number of neutrons
oxygen-16	8	8	8
oxygen-17	8	8	9
oxygen-18	8	8	10

These different types of atom of the same element are called **isotopes**. They are different because they contain different numbers of neutrons. (If they did not contain the same number of protons and the same number of electrons they would not be isotopes). Isotopes of the same element have the same chemical properties but slightly different Physical properties.

There are two isotopes of chlorine, chlorine-35 and chlorine-37. An ordinary sample of chlorine contains approximately 75% of chlorine-35 and 25% chlorine-37. This explains the fact that the relative atomic mass of chlorine is approximately 35.5 (the relative atomic mass of an element is the mass of an average atom compared with the mas of a carbon $^{12}_6\text{C}$ atom).

Summary

Atoms:

- ❖ Are made up of protons, neutrons and electrons
- ❖ Are the smallest units or building blocks of elements
- ❖ Take part in chemical reactions
- ❖ Of the same element are the same

- ❖ *Of different elements are different due to different numbers of protons, neutrons and electrons*
- ❖ *Have equal number of electrons and protons*

2.2.1 Energy Levels of an Atom

Orbitals are grouped in zone at different distance from atomic center. Electrons in zone close to the center are lower in energy than electron in zones at greater distances from the center.

An atom consists of electrons orbiting around a nucleus. However, the electrons cannot choose any orbit they wish. They are restricted to orbit with only certain energies. Electrons can jump from one energy level to another, but they can never have orbit with energies other than the allow energy levels.

Energy levels for an electron in an atom:- group state and excited stat. after absorbing energy, an electron may jump from the ground state to higher energy excited state.



Figure (2.3) Energy levels of an atom

The protons and neutrons are tightly together in the nucleus of an atom. The electrons move rapidly around the nucleus in distinct energy levels. Each energy level is capable of accommodating only a certain number of electrons.

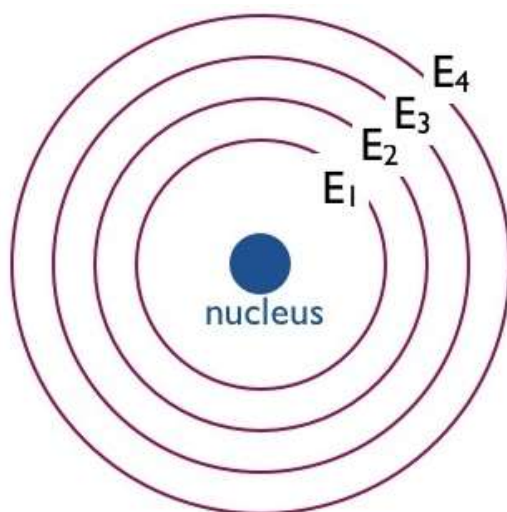


Figure (2.4) Energy levels of an atom

1. The first energy level (sometimes called the K shell and labeled 1 in finger above) can hold only two electrons. This energy level is filled first.
2. The second energy level (sometimes called L shell and labeled 2) can hold only eight electrons. This energy level is filled after the first energy level and before the third energy level.
3. The third energy level (sometimes called the M shell labeled 3) can hold a maximum of 18 electrons. However, when eight electrons are in the third energy level there is a degree of stability and the next two electrons added to go into the fourth energy level. Then extra electrons enter the third energy level until it contains the maximum of 18 electrons.
4. There are further energy levels, each containing a large number of electrons than the preceding energy level. So the general formula is that the N^{th} shell can in principle hold up to $2(N^2)$ electrons.

The table below gives the numbers of protons, neutrons, and electrons in the first 20 elements. The electron structure 2, 8, 1 donates 2 electrons in the first energy level, 8 in the second level and 1 in the third. This called electron configuration of an atom.

Table (2.5): Number of protons, neutrons and electrons in the principal isotopes of the first 20 elements:

Elements	Electron number	Mass number	H of P N E			Arrangement of electrons
			P	N	E	
Hydrogen	1	1	1	0	1	1
Helium	2	4	2	2	2	2
Lithium	3	7	3	3	3	2,1
Beryllium	4	9	4	4	4	2,2
Boron	5	11	5	5	5	2,3
Carbon	6	12	6	6	6	2,4
Nitrogen	7	14	7	7	7	2,5
Oxygen	8	16	8	8	8	2,6
Fluorine	9	19	9	9	9	2,7
Neon	10	20	10	10	10	2,8
Sodium	11	23	11	11	11	2,8,1
Magnesium	12	24	12	12	12	2,8,2
Aluminum	13	27	13	13	13	2,8,3
Silicon	14	28	14	14	14	2,8,4
PHosPHorus	15	31	15	15	15	2,8,5
Sulfur	16	32	16	16	16	2,8,6
Chlorine	17	35	17	17	17	2,8,7
Argon	18	40	18	18	18	2,8,8
Potassium	19	39	19	19	19	2,8,8,1
Calcium	20	40	20	20	20	2,8,8,2

2.3 Periodic Table

In 1869 the Russian Chemist Dmitri Mendeleev (1834-1907) and German Chemist J. Lothor Meyer (1830-1895). Working independently, made similar discoveries. They found that when they arranged the elements in order of atomic mass, they could place them in horizontal rows, one row under the other, so that the elements in each vertical column have similar properties. A tabular arrangement of elements in a rows and columns, highlighting the regular repetition of properties of the elements is called a **periodic table**.

The periodic table is organized into rows (periods) and columns (groups). The legend at the top provides the following information:

- State of matter (color of name):**
 - SA: Solid
 - L: Liquid
 - G: Gas
 - U: Unknown
- Subcategory in the metal-metalloid-nonmetal trend (color of background):**
 - Alkali metals (Red)
 - Alkaline earth metals (Orange)
 - Transition metals (Blue)
 - Lanthanides (Light Blue)
 - Actinides (Dark Blue)
 - Post-transition metals (Light Green)
 - Metalloids (Yellow)
 - Nonmetals (Light Purple)
 - Noble gases (Pink)
- Unknown chemical properties (Grey background):**

The table includes elements from Hydrogen (H) to Oganesson (Og), with Lanthanides and Actinides shown separately at the bottom.

Figure (2.5) Periodic Table

Note: number of shells tells period number, and last number of the element configuration tells group number e.g. Na 2.8.1 period 3 group 1.

The basic structure of the periodic table is its division into rows and columns or period and group. A period consists of the elements in any one horizontal rows of periodic table. A group consists of the elements in any one column of the periodic table.

2.3.1 Group I Elements

The alkali metals lithium, sodium, potassium, rubidium, cesium and francium.

The elements in this group have one electron in their out electronic shell. Thus, each element in this group has a tendency to lose a single charged positive ion, which has the stable electronic configuration on its neighboring Nobel gas elements in the periodic table.

The group one elements, other than hydrogen are called alkali metals.

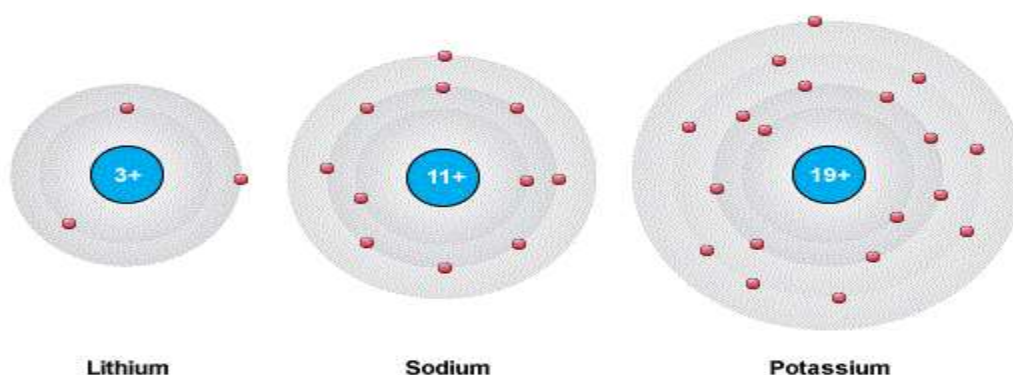


Figure (2.6) group I elements

2.3.2 Properties of Group I elements

1. Soft metals that can be cut with a knife
2. Low density- can float on water
3. Low melting point in comparison with other metals
4. They react violently (in some cases) with water to form alkaline solutions hence the name alkali metals.
5. Reactivity increase as you decrease the group

This group lies in the s-block of periodic table as all alkali metals have their outer most electrons in s-orbitals.

Table (2.6): Electron Configuration of Group I Elements

Property	Li	Na	K	Rb	Cs
Atomic	3	11	19	37	55

number					
Electron configuration	[He]S ¹	[Ne]3S1	[Ar]4S ¹	[Kr]5S ¹	[Xe]6S ¹
Melting point (K)	453.5	371	336	312	301.3

2.3.3 Group II Elements

Magnesium, calcium, and strontium all belong to group II elements.

All group II elements have two outer electrons; therefore they wish to lose two when bonding to create compounds. Losing two electrons allows them to have full outer shell, and achieve stability.

Group II contains soft silver metals that are less metallic in character than the group one elements. The heavier metals such as Ca, Sr, Ba, and Ra are almost as reactive as the group I alkali metals. All the electrons in their valence shells, giving them an oxidation state of +2. This enables the metals to easily lose electrons, which increase their stability and allows them to form compounds via ionic bonds. The following diagram shows the location of these in periodic table.

Properties

1. Silvery metals
2. High melting and boiling point than group I elements
3. Less reactive than group I elements. This because it's more difficult to lose two electrons compared to losing just one electron.
4. React with water to form alkaline solution. Reactivity increase down the group, this because the smaller atom closer the outer electron between the nucleus. Therefore is great attraction between the nucleus and electrons in the magnesium than there is in calcium.

- Melting point and boiling point decrease down the group due to weaker forces of attraction between atoms.
- Hardness increases as you decrease down the group.

Table (2.7): Electron Configuration of Group II elements

Property	Be	Mg	Ca	Sr	Ba	Ra
Atomic number	4	12	20	38	56	88
Electron configuration	$1s^2s^1$	$[\text{Ne}]3s^2$	$[\text{Ar}]4s^2$	$[\text{Kr}]5s^2$	$[\text{Xe}]6s^2$	$[\text{Xe}]7s^2$
Melting point (K)	1560	923	1115	1655	1000	973
Boiling point (K)	2742	1363	1757	1655	2170	2010

2.3.4 Group VII Elements

The group VII elements (halogens) were first discovered from 1776 onward.

The halogens are located on the left of the noble gases on the periodic table. These five toxic, non-metallic elements make up group VII of the periodic table and consist of: - fluorine (F), chlorine (Cl), bromine (Br), iodine (I) and astatine (At). Although astatine is radioactive and only has short-lived isotopes it behaves similar to iodine and is often included in the halogen group. Because the halogen elements have seven valence electrons, they only require one additional electron to form a full octet. These characteristics make them more reactive than other non-metals.

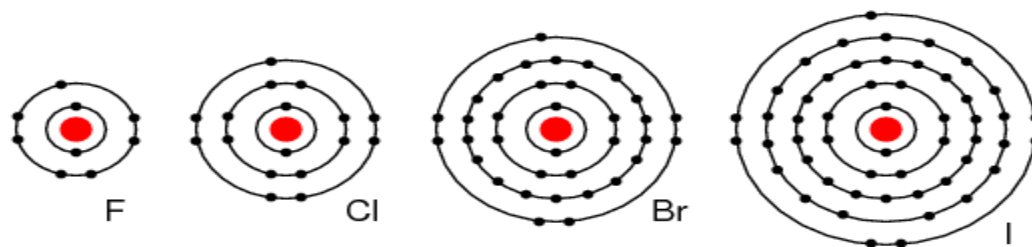


Figure (2.7) Group VII Elements

Table (2.8): Some of the Physical properties

Property	F	Cl	Br	I	AS
Melting point (K)	-220	-101	-7.2	114	302
Boiling point (K)	-188	-35	58.8	184	337

2.3.5 Group VIII Elements

The noble gases (group 8) are located in the far right of the periodic table and were previously referred to as the “inert gases” due to the fact that their filled valence shells (octets) make them extremely non-reactive. The noble gases were characterized relatively late compared to other elements group.

Properties of Group VIII

1. Atomic mass, boiling point and atomic radii increase down a group in the periodic table
2. The first ionization energy decreases down a group in the periodic table
3. All are monoatomic gases under standard condition
4. The attractive forces increase with the size of the atom as a result of an increase.

The full valence electron shells of these atoms makes noble gases extremely stable and unlikely to form chemical bonds because they have little tendency to gain or lose electrons.

Although, noble gases don't normally react with other elements to form compound, there are some exceptions. Xe may form compounds with fluoride and oxides.

Table (2.9): Properties of Group VIII Elements

Property	He	Ne	Ar	Kr	Xe	Rn
Melting point (K)	0.95	24.7	83.6	115.8	161.7	202.2
Atomic mass	2	10	18	36	54	86
Boiling point (K)	4.216	27.1	87.29	120.85	166.1	211.5

2.3.6 Metals, Non-Metals and Semi Metals

The elements in the periodic table can also be divided according to whether they are metals, nonmetals and semi metals. On right hand side of the periodic table is a dark “zigzag” line; these repartees all the elements are metals from those that are non-metals. Metals are found on the left of the line and nonmetals are those on the right. Metal, semi metals and nonmetals all have their own specific properties.

(a) Metals

Example of metals includes copper (Cu), zinc (Zn), gold (Au), and silver (Ag). On the periodic table, the metals are on the left of the zigzag line. There are a large number of elements that are metals.

Properties of Metals

- **Thermal conductors:-**

Metals are good conductors of heat and therefor used in cooking utensils such as pots and pans.

- **Electrical conductors:-**

Metals are good conductors of electricity, and therefor used in electrical conductivity wires.

- **Shiny metallic luster :-**

Metals have characteristics shiny appearance and often used to make jewelry.

- **Malleable :-**

This means that they can bend into shape without breaking

- **Ductile:-**

Metals can stretch into thin wires such as copper, which can then be used to conduct electricity.

- **Melting point:-**

Metals usually have a high melting point and therefore are used to make cooking pots and other equipment that needs to become very hot, without being damaged.

(b)Non-metals

In contrast to metals, nonmetals are poor thermal conductors, good electrical insulator (meaning that they do not conduct electrical charge) and neither malleable nor ductile. The nonmetals are found on the right hand side of the periodic table and include elements such as sulfur (S) PHosPHorus (P), nitrogen (N), and oxygen (O).

(c) Semi-metals

Semi -metals have mostly nonmetallic properties. One of their distinguishing characteristics is that their conductivity increase as their temperature increase. This is opposite of what happens in metals. The semi-metals include elements as silicon (Si), and germanium (Ge) notice where these elements are positioned in the periodic table.

(d) The transition metals

The transition elements are the elements found between the group II elements and group III elements in the periodic table. The group III is sometimes considered transition elements. The transition elements are also called the d-block elements, because while the outer most level contain at most two electrons, than their next to outer most main levels have incompletely filled D sub-orbitals, which are filled-up progressively on going across the periodic table from 8 to 18 electrons. Filling of the D sub-orbitals of the transition elements across a row of the periodic table isn't always regular.

2.4 Combining Elements (molecules)

Molecule is a group of two on more atoms that are attracted to each other by relatively strong forces or bonds.

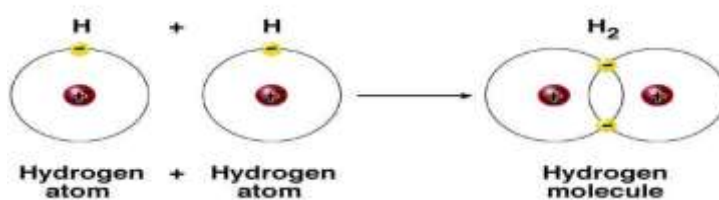
A molecule is an aggregate of at least two atoms in definite arrangement held to gather by chemical forces (also called **bonds**). Molecule my contain atoms of the same elements or atoms of two or more elements joined in a fixed ratios, in accordance with the law of definite proportions. Thus, a molecule is not necessarily a compound, which by definition is made up of two or more elements. For example hydrogen gas is a pure element, but it consists of molecules made up of two H atoms each. Water, on the other hand, is a molecular compound that contains hydrogen and oxygen in a ratio of two Hydrogen atoms and one Oxygen atom. Molecules are electrically neutral.

The hydrogen molecule, symbolized as H_2 , is called a diatomic molecule because it contains only two atoms. Other elements that normally exist as diatomic molecules are nitrogen N_2 and oxygen O_2 , as well as group 7 elements fluorine F_2 , chlorine Cl_2 , bromine Br_2 and iodine I_2 . Of course, a diatomic molecule can contain atoms of different elements. Examples are hydrogen chloride (HCl) and carbonmonoxide (CO).

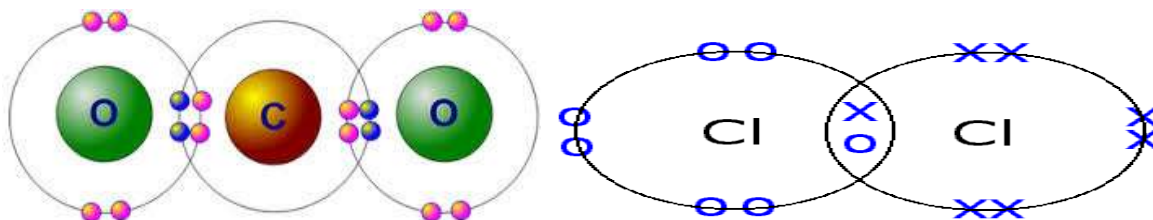
The vast majority of molecules contain more than two atoms, they can be atoms of the same elements, as in ozone (O_3), which is made up three atoms of oxygen, or they can be combinations of two or more different elements. Molecules containing more than two atoms are called polyatomic molecules. Like Ozone, water (H_2O) and ammonia (NH_3) are polyatomic molecules.

Examples of combining elements

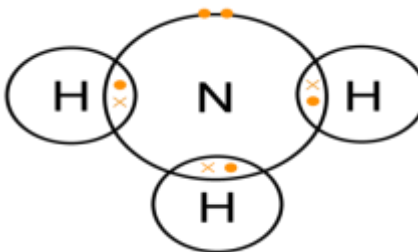
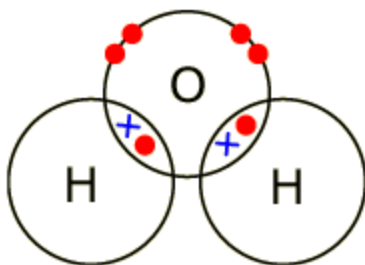
1. Hydrogen (H_2) molecule



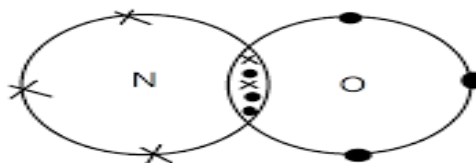
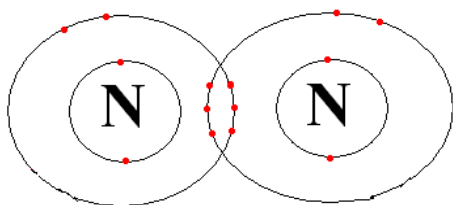
2. Cabrondioxide (CO_2) molecule and Chlorine (Cl_2) molecule



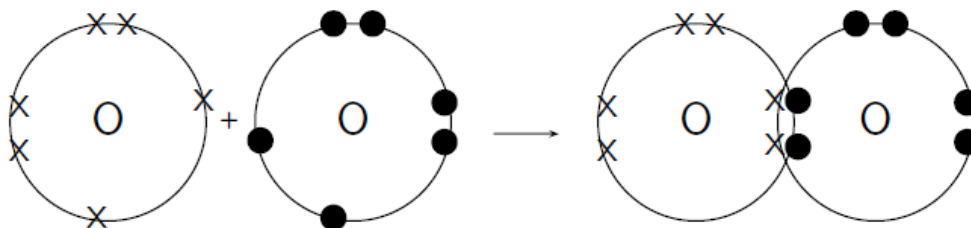
3. Water molecule (H_2O) and ammonia (NH_3) molecule



4. Nitrogen (N_2) molecule and nitric oxide (NO) molecule



5. Oxygen (O_2) molecule



2.4.1 Boiling and Melting Point

The boiling point is the temperature at which materials changes from a liquid to gas (boils) while the melting point is the temperature at which a material changes from a solid to a liquid (melts). Keep in mind that a material's melting is the same as its freezing point.

The main difference between boiling point and melting point is that the melting point is defined as the temperature at which solid and liquid phases are in equilibrium, whereas the boiling point is the temperature at which the vapor pressure of a liquid is equal to the external pressure.

Table (2.10): Melting and Boiling Point of Some Elements

Element	Melting point °C	Boiling point °C	Element	Melting point °C	Boiling point °C
Aluminium	660.25	2519	Manganese	1246	2061
Argon	-189.19	-185.85	Mercury	-38.72	357
Arsenic	817	614	Molybdenum	2617	4639
Barium	729	1897	Nickel	1453	2913
Beryllium	1287	2469	Niobium	2468	4744
Boron	2300	3927	Nitrogen	-209.86	-195.79
Bromine	-7.1	58.8	Osmium	3027	5012
Cadmium	321.18	767	Oxygen	-226.65	-182.95
Calcium	839	1484	PHosPHorus (white)	44.1	280
Carbon (diamond)	3550	4827	Plutonium	640	3228
Carbon (graPHite)	3675	4027	Potassium	63.35	759
Cesium	28.55	671	Radium	700	1737
Chlorine	-100.84	-34.04	Rhenium	3180	5596
Cobalt	1495	2927	Rubidium	39.64	688
Copper	1084.6	2562	Scandium	1539	2836
Fluorine	219.52	-188.12	Silicon	1410	3265
Francium	27	677	Silver	961	2162
Gallium	29.76	2204	Sodium	98	883
Gold	1064.58	2856	Strontium	769	1382
Helium	-	-268.93	Sulfur	115.36	444.6

Hydrogen	-259.98	-252.87	Tantalum	2996	5458
Iodine	113.5	184.3	Tin	232.06	2602
Iridium	2443	4428	Titanium	1660	3287
Iron	1535	2861	Tungsten (wolfram)	3422	5555
Lead	327.6	1749	Uranium	1132	4131
Lithium	180.7	1342	Zinc	419.73	907
Magnesium	650	1090			

2.5 Exercise:

- Define and compare the difference between these:
 - Elements
 - Compounds
 - Mixtures
- Explain the structure of an atom and its properties?
- Define:
 - Atomic number
 - Mass number
 - Isotope
- Explain the energy levels of an atom and discuss the arrangement of electrons in electron shells?
- What is the periodic table and how elements arranged in the periodic table?
- What are the group one elements and discuss their properties?
- What are the electron configurations of Li, and Cs?
- Discuss the group two elements and their properties?
- What are the electron configurations of Ca, Sr and Ba?

10. Explain group seven elements and their properties?
11. Draw an electronic shells of these elements:
 - a. Fluorine
 - b. Chlorine
 - c. Bromine
12. What are the group eight elements and list their properties?
13. Define and list some properties of these:
 - a. Metals
 - b. Non- metals
 - c. Semi metals
14. Discuss what are the transition metals?
15. What is the electronic structure of an atom of the element whose atomic number is 13?
16. Explain how molecules combine together, with examples?
17. What is boiling point and melting point?

Chapter III

Materials

3.1 Materials

Air conditioners are made of different types of metals. Frequently, plastic and other nontraditional materials are used to reduce weight and cost.

Copper or aluminum tubing, critical ingredient in many air conditioner components; provide superior thermal properties and positive influence on system efficiency. Various components in an air conditioner will differ with the application, but usually they are comprised of stainless steel and other corrosion resistant metal.

3.2 Metals and Their ores

3.2.1 Extraction of Metals:

1. Recycling of Metals

Since the Second World War there has been a threefold increase in the amount of copper used each year and six fold increase in the amount of aluminum used. Obviously with this increasing use of the metals, supplies of suitable metal ores will even run out. It has been estimated that all aluminum ores will be used up by 2100.

One way of making these ores last is to reuse or recycle metals. Copper is being recovered from scrap copper wires and pipes. Aluminum is being recovered from soft drink cans and kitchen foil. This is being removed from scrap food cans to be reused in making new food cans. As metals become more expensive recycling becomes more likely.

2. Treatment of Ores:

Some of the least reactive metals, e.g. gold can be found in the form of the unreacted metal in the earth. Other metals can be found as compounds with other unwanted material in the form of an ore. The table below shows the ores of some common metals and purified.

Bauxite (aluminium oxide) is purified by adding the ore to sodium hydroxide solution. The aluminium oxide reacts and forms soluble sodium aluminate. Impurities such as iron (II) oxide can be removed by filtration. The aluminium oxide is then precipitated in a pure form (in fact aluminium hydroxide is precipitated and this is heated to give the pure oxide).

Table (3.1): Metals and Their Ores

Metals	Ores	Chief chemical constituents
Sodium	Rock salt	Sodium chloride
Calcium	Chalk, lime stone, marble	Calcium carbonate
Magnesium	Magnetite (also in sea water)	Magnesium carbonate, magnesium chloride
Aluminium	Bauxite	Aluminium oxide
Zinc	Zinc blende	Zinc sulphide
Iron	Hematite	Iron (II) oxide
Copper	Malachite	Basic copper (II) carbonate
Mercury	Cinnabar	Mercury (II) sulphide

3. Methods of Extracting Metals

The earth's crust contains metal and metal compounds such as gold, iron oxide and aluminium oxide, but when found in the earth these are often mixed with other

substances. To be useful, the metals have to be extracted from whatever they are mixed with. A metal ore is a rock containing metal or metal compounds, in a high enough concentration to make it economic to extract the metal.

The method used to extract metals from their ore in which they are found depends on their reactivity. For example, reactive metals such as aluminium are extracted by electrolysis, while less-reactive metals such as iron may be extracted by reduction with carbon or carbon monoxide.

Thus the method of extraction of a metal from its ore depends on the metal's position in the reactivity series.

Table (3.2) Reactivity and Extraction Methods

Metals	Method of extraction
Potassium Sodium Calcium Magnesium Aluminium	Extracted by electrolysis
Zinc Iron Tin Lead	Extract by reaction with carbon or carbon monoxide
Copper Silver Gold Platinum	Extract by various chemical reactions
<i>NB: Metals decreasing order of reactivity</i>	

3.2.3 Uses of Common Metals

Table (3.3): We use different metals for different jobs as they have different properties

Metals	Properties	Uses
Aluminium	Low density, does not corrode	Suitable for bodies of plane
Copper	Good conductor of electricity, does not react with water	Electrical wires as it is a good conductor. Water pipes due to its low reactivity
Gold	Very good conductor of electricity, unreactive	Electrical connection or circuit board due to its conductivity. Jewelry due to its lack of reactivity
Steel	Cheap and strong	Suitable for building material

3.3 Reaction of Metals

1. Reactions of metals with air

Different metals react with air at very different rates. Reactive metals like potassium burn vigorously in air with characteristic flame, form metal oxides by combining with oxygen and forms metal oxides. Some less reactive metals do not burn in air. They only react moderately even when are heated strongly. Some

metals are very inert and do not react with air/oxygen at all even under very strong heating. The trend of reactivity gives the metal reactivity series.

Table (3.4): Reactions of metals with air:

Metals	Reactivity
Potassium	They are ignited easily by gentle heating. They burn vigorously and give metal oxide.
Calcium	Strong heating is required to ignite the metal. It burn vigorously
Magnesium	Strong heating is required to ignite the metal. They burn with dazzling with flame
Zinc	It burns moderately under strong heating
Iron	It does not burn but gives showery sparks under strong heating
Lead Copper	They do not burn in air. They oxidize in to oxides under strong heating.
Mercury	It does not burn in air but oxidize under heating. Strong heating can decompose the metal oxide back in to the metal.
Silver Gold	They do not react with air under strong heating

2. Reaction of Metals With Water

Alkali metals are so reactive that they react vigorously and exothermically with water. In some cases the heat generated is sufficient to ignite the metal. In general

the reactions of metals with water produce hydrogen gas (H_2), the hydroxides of the metals. Metals with moderate to low reactivity react very slowly with water. However, they react moderately with steam when heated and give hydrogen gas and metal oxides. Metals low in the metal reactivity series do not react with water even at high temperature.

Table (3.5): Reaction of metals with water:

Metals	Reaction with water
Potassium Sodium	They react vigorously with cold water. The heat generated from the reaction can ignite the metal
Calcium	It reacts slowly with cold water
Magnesium	It reacts very slowly with hot water. It reacts with steam when being heated and gives hydrogen gas and metal oxides
Aluminium Zinc Iron	They do not react with cold water or hot water. They react with steam when being heated and give hydrogen gas and metal oxides (iron oxides to hydrated iron oxide (rust) when oxygen is present in the water).
Lead Copper Mercury Silver Gold	They do not react with water or steam

3. Table (3.6): The reaction of metals with acid

Metals	Reaction with acid
Potassium Sodium	They react explosively with HCL acid (dilute hydrochloric acid)
Calcium	It react readily with dilute HCL acid
Aluminium Zinc Iron Lead	They react slowly with dilute HCL acid
Copper Mercury Silver Gold	They do not react with dilute HCL acid

Table (3.7): Reactivity of metals

K, Na, Li, Ba, Sr, Ca	React with water
Mg, Al, Mn, Zn, Cr, Fe, Cd, Co, Ni, Sn, Pb	React with acid
Sb, Bi, Cu, Hg, Ag, Au, Pt	Highly un reactive

The reactivity of metals is due to the difference in stability of their electro configurations as atoms and ions, as they are all metals they will form positive ions when they reacts. Potassium has a single outer shell electron to lose to obtain stable “noble gases” electron configuration; the precious metals which exist in the d-block cannot form structures which are much more stable than their elemental state require the loss of only one electron to form stable. Ions are more reactive than similar metals which require the loss of more than one electron. Group one; metals are the most reactive for that reason.

Metals with a greater total number of electrons tend to be more reactive as their outer electron (the one which will be lost) exist further from the positive nucleus and therefore they are held less strong.

3.4 Rusting

Rusting of Iron:

Corrosion:

The eating up of metals by the action of air and moisture on their surface is called corrosion. The corrosion of iron is called rusting. While other metals are said to ‘corrode’, iron metal is said to ‘rust’.

Rusting of Iron:

When an iron object is left in damp air (or water) for a considerable length of time, it gets covered with a red-brown flaky substance called rust. This is called rusting of iron.

Rusting is the common term for corrosion of iron and its alloys, such as steel. Through oxidation of other metals is equivalent, these oxidize are not commonly called rust. A reddish-brown oxide coating formed on iron or steel by reaction of oxygen and moisture called **rust**.

Iron and steel rusts when they come into contact with water and oxygen. Both water and oxygen are needed for rusting to occur.

Example: in the experiment below, the nail does not rust when air or water is not present. Remember that 21 per cent of the air is oxygen.

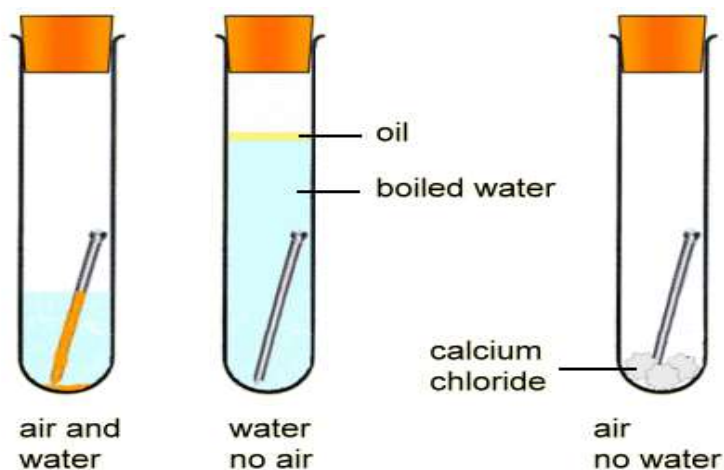


Figure (3.1) iron rusting test

Note: calcium chloride absorbs water in the right-hand tube

Rusting is an oxidation reaction. The iron reacts with water and oxygen to form hydrated iron (II) oxide, which we see as rust.

Iron + water + oxygen $\rightarrow$ hydrated iron (II) oxide

3.4.1 Conditions for Necessary for Rusting

Rusting of iron (or corrosion of iron) needs both, air and water. Thus, two conditions are necessary for the rusting of iron to take place:

1. Presence of air (or oxygen)
2. Presence of water (or moisture)

The chemical composition of rust is hydrated iron (iii) oxide, $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$

Table (3.8): Necessary Conditions for Rusting

Condition	Effect on reaction	Explanation
Oxygen and water present	Allows reaction to take place	Oxygen and water are both necessary, as together they can be reduce to form hydroxide ions.

Electrolyte present	Increases rate	Allows ions to move freely between the site of oxidation and the site of reduction
Impure iron	Increases rate	Impurities may act as the cathode
Iron in contact with less active metal	Increases rate	Less active metal serves as the cathode
Iron under mechanical stress	Increases rate	Individual iron atoms are less tightly bonded together and can move easily break away

3.4.2 How to Prevent Rusting

There are several ways to prevent iron and steel rusting. Some of these work because they stop oxygen or water reaching the surface of the metal:

- Oiling: for example bicycle chains
- Greasing: for example nut and bolts
- Painting: for example car body panels
- Metals like chromium, zinc and magnesium prevent rusting to a great extent and alkalis also help to prevent rusting

Iron and steel objects may also be covered with a layer of metal. Food cans, for example, are plated with a thin layer of tin.



Figure (3.2) “Tin” cans are made of steel coated with a thin layer of tin metal

3.4.2.1 Galvanizing

Galvanizing is a method of rust prevention. The iron or steel object is coated in a thin layer of zinc. This stops oxygen and water reaching the metal underneath- but the zinc also acts as a sacrificial metal. Zinc is more reactive than iron, so it oxidizes in preference to the iron object.

3.5 Lime stone

Calcium carbonate (CaCO_3) is the raw form of lime found in nature and is more commonly referred to as Limestone. Limestone is a rock made mostly of the minerals calcite and aragonite, which are different three-dimensional forms of the chemical compound calcium carbonate (CaCO_3). Calcium carbonate is often found in sea shells and bones of sea creatures, and when these settle on the ocean floor for millions of years it forms limestone. Limestone can also come from the combination of soluble calcium (Ca) and carbon dioxide (CO_2) from water in lakes and oceans.

Table (3.9): Some of the common names we have seen for Lime and generally which compound they refer to:

CaCO_3	CaO	Ca(OH)_2
Calcium carbonate	Calcium oxide	Calcium hydroxide
Lime stone	Quick lime	Hydrated lime
Precipitated calcium carbonate (PCC)	Pebbled lime	Slaked lime
Agricultural lime	Live lime	Powdered lime
Lime scale	Hot lime	Lime slurry
		Milk of lime
		Whitewash

3.5.1 Cement

Cement is a crystalline compound of calcium silicates and other calcium compounds having hydraulic properties. Cements are considered hydraulic because of their ability to set and harden under or with excess water through the hydration of the cement's chemical compounds or minerals.

(a) There are two types:

Those that *activate with the addition of water* And *pozzolanic* that develop hydraulic properties when they interact with hydrated lime Ca(OH)_2 .

Pozzolanic: any siliceous material that develops hydraulic cementitious properties when interacted with hydrated lime.

(b) Raw materials used for cement:

1. Calcareous
2. Argillaceous

1. Calcareous materials used are

- ✓ Cement rock
- ✓ Lime stone

- ✓ Marl
- ✓ Chalk
- ✓ Marine shell

2. Argillaceous materials used are

- ✓ Clay
- ✓ shale
- ✓ slate
- ✓ blast furnace slag

(c) Uses of cement:

- ❖ Building (floors, beams, columns, roofing, piles, bricks, mortar, panels, plaster)
- ❖ Transport (roads, pathways, crossings, bridges, viaducts, tunnels, parking, etc.)
- ❖ Water (pipes, drains, canals, dams, tanks, pools, etc.)
- ❖ Civil (piers, docks, retaining walls, silos, warehousing, poles, pylons, fencing)
- ❖ Agriculture (buildings, processing, housing, irrigation)

3.5.3 Composite Compounds

A composite compound is a material in which two or more distinct materials are combined together but remain uniquely identifiable in the mixture (or we can say a composite material is made by combining two or more materials – often ones that have very different properties. The two materials work together to give the composite unique properties. However, within the composite you can easily tell the different materials apart as they do not dissolve or blend into each other.). The most common example is, perhaps, fibreglass, in which glass fibres are mixed with a polymeric resin.

(a) Natural composites: Natural composites exist in both animals and plants.

Wood is a composite – it is made from long cellulose fibres (a polymer) held together by a much weaker substance called lignin. Cellulose is also found in cotton, but without the lignin to bind it together it is much weaker. The two weak substances – lignin and cellulose together form a much stronger one. The bone in your body is also a composite. It is made from a hard but brittle material called hydroxyapatite (which is mainly calcium Phosphate) and a soft and flexible material called collagen (which is a protein). Collagen is also found in hair and finger nails. On its own it would not be much use in the skeleton but it can combine with hydroxyapatite to give bone the properties that are needed to support the body.

(b) Early composites: People have been making composites for many thousands of years. One early example is mud bricks. Mud can be dried out into a brick shape to give a building material. It is strong if you try to squash it (it has good compressive strength) but it breaks quite easily if you try to bend it (it has poor tensile strength). Straw seems very strong if you try to stretch it, but you can crumple it up easily. By mixing mud and straw together it is possible to make bricks that are resistant to both squeezing and tearing and make excellent building blocks. Another ancient composite is concrete. Concrete is a mix of aggregate (small stones or gravel), cement and sand. It has good compressive strength (it resists squashing). In more recent times it has been found that adding metal rods or wires to the concrete can increase its tensile (bending) strength. Concrete containing such rods or wires is called reinforced concrete.

(c) Making composites: Most composites are made of just two materials. One is the matrix or binder. It surrounds and binds together fibres or fragments of the other material, which is called the reinforcement.

(d)Modern examples: The first modern composite material was fibreglass. It is still widely used today for boat hulls, sports equipment, building panels and many car bodies. The matrix is a plastic and the reinforcement is glass that has been made into fine threads and often woven into a sort of cloth. Its own the glass is very strong but brittle and it will break if bent sharply. The plastic matrix holds the glass fibers together and also protects them from damage by sharing out the forces acting on them. Some advanced composites are now made using carbon fibers instead of glass. These materials are lighter and stronger than fiberglass but more expensive to produce. They are used in aircraft structures and expensive sports equipment such as golf clubs. Carbon nanotubes have also been used successfully to make new composites. These are even lighter and stronger than composites made with ordinary carbon fibres but they are still extremely expensive. They do, however, offer possibilities for making lighter cars and aircraft (which will use less fuel than the heavier vehicles we have now). The new Airbus A380, the world's largest passenger airliner, makes use of modern composites in its design. More than 20 % of the A380 is made of composite materials, mainly plastic reinforced with carbon fibres. The design is the first large-scale use of glass-fibre-reinforced aluminium, a new composite that is 25 % stronger than conventional airframe aluminium but 20 % lighter.

3.6 Recycling

Recycling is a process to change materials in to new product to prevent waste of potentially useful materials, reduce the consumption of fresh raw material, reduce energy usage, and reduce air pollution and water pollution by reducing the need for “conventional” waste disposal and lower greenhouse gas emissions as compared to plastic production. Recycling is a key component of the “reduce, reuse and

recycle” waste hierarchy (waste hierarchy is a set of priorities for the efficient use of resource).

Recyclable materials include many kind of glass, paper, metal, plastic, textiles, and electronics. The composting or other reuse of biodegradable waste (biodegradable waste is any waste that can decomposed in a reasonable amount of time) such as food or garden waste, is also considered recycling. Materials to be recycled are either brought to collection center or picked up from the curbside, then sorted, cleaned, and reprocessed n to new materials bonded for manufacturing.

3.6.1 Factors Affecting Recycling

The opportunities resented for recycling of materials are very much dependent on the individual circumstances of your own institution and your recycling contractors. They likely success of such initiatives may depend on:

1. Collection method (segregated or mixed materials).
2. Space for collection and strong of reusable and recyclables.
3. Geographical location, particularly in relation to markets for reprocessing materials.
4. Size of institutions and volume of recyclable materials.
5. Other important factors include local authority facilities, charging structure and support etc.

3.6.2 Advantages of Recycling

The main advantages of recycling are that it helps to protect our natural resources, many of which cannot be replenished. While trees and can be easily regrown, we only have a limited amount of certain resource, such as most metals, meaning that we will eventually run out of these thing in the future. Recycling helps to protect these resources by using things that have already been extracted from the ground. Recycling can also help to reduce the emission of harmful gases into the

atmosphere by limiting energy intensive mining operation. Recycling not only helps to reduce the pollution that is caused by gases, but also the problem that are caused by products that do not easily break down. Landfills are created to hold all these debris, many of which can be recycled, where they will sit for hundreds of years, slowly polluting the surrounding environment, the recycling industry also helps to create jobs for a large number of people, since it takes more man power to recycle a product rather than throwing it away.

3.7 Properties of Materials

Different materials behave in different ways. Examples of materials are metals, plastics, glasses, woods and fabrics. So the materials have different properties that make them useful for different obs.

1. Transparent or opaque: transparent materials do let light through (you can see through them). Opaque materials do not let ant light through (you cannot see through them).
2. Waterproof: waterproof materials do not let water through and do not soak up water.
3. Absorbent: absorbent materials soak water and let water pass through them.
4. Strong or weak: strong materials are very difficult to break. Weak materials break easily.
5. Flexible: flexible materials are easy to bend.
6. Rigid: rigid materials are difficult to bend.
7. Hard: hard materials are difficult to scratch (diamond).
8. Magnetic: magnetic materials are attracted to magnets.
9. Conductors: some materials are good conductors of heat. This means heat can travel through them easily. Some materials are good conductors of electricity. This means electricity can travel through them easily.

10. Insulators: some materials are insulators of heat. This means they do not allow heat travel through them very easy. Some materials are insulators of electricity. This means that electricity cannot travel through them.

3.7.1 Solid Materials

Solid materials can differ in one or more of the following ways:

- ⇒ Melting point
- ⇒ Strength in tension (when pulled)
- ⇒ Strength in compression (when pushed)
- ⇒ Stiffness
- ⇒ Hardness
- ⇒ Density

3.7.2 Plastics, Rubbers and Fibers

Many of the products that we use are made using plastics such as polythene and rubbers; and fibers such as cotton. The suitability of a material to a particular job depends on its properties

3.8 Uses of Materials

1. Metals:

We use different metals for different jobs as they have different properties. It's important to choose the right metal for job.

Table (3.10): Uses and Properties of Metals

Metals	Properties	Uses
Aluminium	Low density, does not corrode	Suitable for the bodies of planes
Copper	Good conductor of electricity, does not react with water	Electricity wires as it is a good conductor. Water pipes due to its low reactivity

Gold	Very good conductor of electricity, unreactive.	Electrical connections on circuit boards due to its lack of reactivity
Steel	Cheap and strong	Suitable for building material

2. Plastics:

The relatively low density of most plastic materials means the end products are lightweight. They also have excellent thermal and electrical insulation properties. They are corrosion resistant to many substances which attack other materials, and some are transparent, making optical devices possible. Also they are easy to mould into complex shapes and forms, allowing integration of different materials and function.

3. Glasses:

Glass is an unlimited and innovative material that has plenty of uses. It is an essential component of numerous products that we use every day, most often without noticing it.

Glass is used in the following non-exhaustive list of product:

1. Packaging (jars for food, bottles for drinks, flacon for cosmetics and Pharmaceuticals).
2. Table ware (drinking glasses, plates, cups, and bowls).
3. Housing and building (windows, facades, conservatory, insulation, reinforcement structures).
4. Interior design and furniture (mirrors, partitions, balustrades, tables, shelves and lighting).
5. Electronics and appliances (oven doors, cook top, TV, computer screens, smart-Phones).

6. Transport and automotive (windcreens, backlights, light weight but reinforced structural components of cars, aircrafts, ships, etc).
7. Medical technology, biotechnology, life science engineering and optical glass.
8. Radiation protection from X-Rays (radiology) and gamma-rays (nuclear).
9. Fiber optic cables (Phones, TV, and computer: to carry information).
10. Renewable energy (solar-energy glass, wind turbines).

4. Wood:

Wood is highly suitable for a wide range of applications other than construction, because of its efficiency, versatility, and durability and also is used for:

1. Furniture
2. Hand tools: the main parts of most common hand tools may be metal but their handles remain to be of wood, due to the strength and ability it lends to absorb shock and vibration.
3. Toys and sport equipment: wooden toys are less hazardous for kids to use and play with than plastic, making it a better option for toys manufacturing. Most sports implement have long made use of wood for handles and main parts.
4. Fuel: wood remains to be a top source of energy worldwide.
5. Paper: wood sources out pulp which is then used for producing paper materials.

5. Uses of fabrics:

The most common uses are apparel; personal accessories like scarves, hats, shoes, and bags and home and commercial furnishings like upholstery, rugs and carpets, bed and table linens, and towels.

3.9 Exercise:

1. Explain:
 - a. Recycling of metals
 - b. Treatments of ores
2. What are the ores of sodium, calcium and Iron?

3. Explain methods of extracting metals?
4. List some uses of common metals and their uses?
5. Discuss:
 - a. Reaction of metals with air
 - b. Reaction of metals with water
 - c. Reaction of metals with acid
6. What is a rusting
7. Explain Iron rusting
8. Discuss the necessary conditions for rusting?
9. How to prevent rusting?
10. Explain:
 - a. Lime stone
 - b. Galvanizing
 - c. Cement
11. What is a composite compound?
12. What are the factors affecting recycling and what are the advantages of recycling?
13. What are the properties of materials and list some uses of materials?

Chapter IV

More about Physical and Chemical Change

4.1. The Kinetic Theory of Matter

There are three states of matter; solid, liquid, and gas.

Substances can change from one state to another. Kinetic theory can explain the change of state by considering all matter (substances) to be made particles.

- Solid particles are closely packed in a regular arrangement. The particles vibrate about a fixed position.
- Liquid particles are closely packed in random arrangements. The particle can move through the liquid they cling together.
- Gas, the particles are far apart. Their motion is random and independent of the other particles.

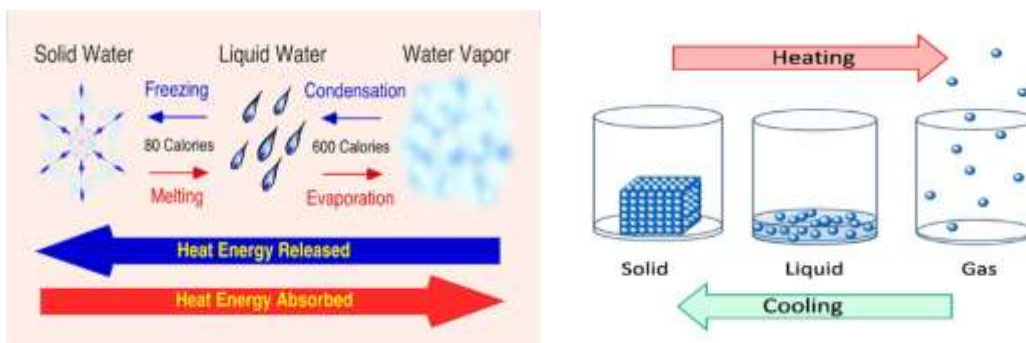


Figure (4.1) shows exchange between states of matter

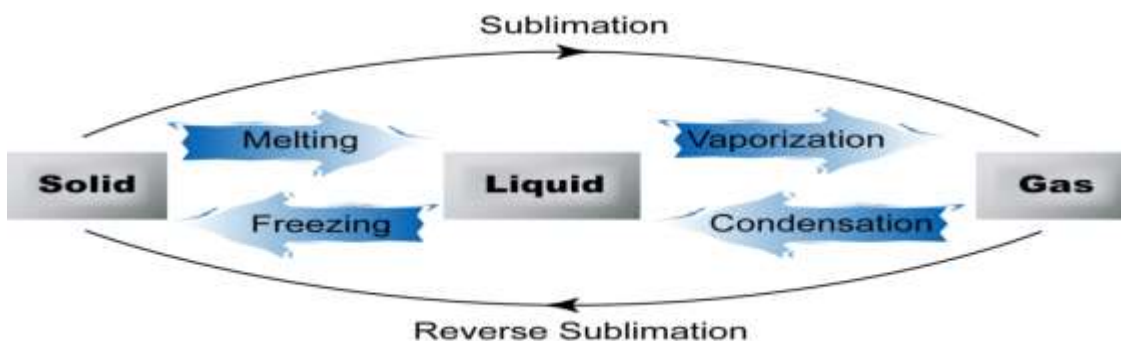


Figure (4.2) shows exchange between states of matter

- The kinetic theory of the matter attempts to explain the Physical properties of matter (in various states) in terms of the motion of its particles.

4.2 Change of States and Kinetic Theory

The kinetic theory of matter gives a clear explanation of the internal processes involved at the particle level when matter undergoes a change state.

4.2.1 Process of Heating

Theoretically, heating a solid to higher and higher temperature changes its phase to a liquid and finally to a gas.

4.2.2 Fusion (Solid to Liquid)

A solid consists of low kinetic energy vibrating particles locked into position by inter particle attractive forces. When heat is applied, energy is absorbed and the particles start vibrating more vigorously.

Finally, the vibrations become energetic enough to overcome the attractive forces, and the particles starting sliding out of their position to flow about. The solid is now melting into liquid.

4.2.3 Vaporization (Liquid to Gas)

On further application of heat to the liquid, the particles move around more energetically, within the volume of the liquid. Finally, they become energetic enough to start escaping from the surface of the liquid, overcoming the backward pull by their neighbor in the volume of liquid. The process of the boiling has begun, wherein the liquid converts to a gas particle escape to move around independently without any constraints.

4.2.4 Evaporation (Liquid to Gas)

According to the kinetic theory, the temperature is a measure of average kinetic energy possessed by the particles of matter. This means that in any sample of

matter, there will be particles with higher kinetic energy than average, balanced by those with lower energy than average.

So, even in a liquid whose temperature is not high enough for boiling to occur, there will be some particles with sufficient kinetic energy to break through the surface of the liquid overcoming the backward pull of others. They slowly escape as gas particles, and the process is called evaporation.

4.2.5 Process of Cooling

Generally, Cooling a gas changes its Phase to a liquid and finally to a solid.

4.2.6 Condensation (Gas to Liquid)

When a gas is cooled (e.g. heat removed) progressively, the free moving particles start losing kinetic energy and slowing down. Finally, the forces of attraction between the lower energy particles colliding with each other are strong enough to hold them together and the gas begins to condense into liquid.

4.2.7 Solidification (Liquid to Solid)

The particles still have energy enough to slide about within the volume of the liquid, but further cooling lowers this energy. Finally, the mutual attractive force overcomes the lower kinetic energies of the particles and locks them into fixed positions, where they continue to vibrate as the liquid freezes to solid.

The Properties of States of Matter and Why They Are Like-This

Table (4.1): Solid

Properties of solid	Why they are like-this
They have a fixed shape and cannot flow	The particles cannot move from place to place
They cannot be compressed or squashed	The particles are close together and have no space to move into

Table (4.2): Liquid

Properties of liquid	Why they are like-this
They flow and take the shape of their container	The particles can move each other
They cannot be compressed or squashed	The particles are close together and have no space to move into

Table (4.3): Gas

Properties of gas	Why they are like-this
They flow and completely fill the container	The particles can move quickly in all direction
They can be compressed or squashed	The particles are far apart and have space to move into

4.3 Combustion and Oxidation

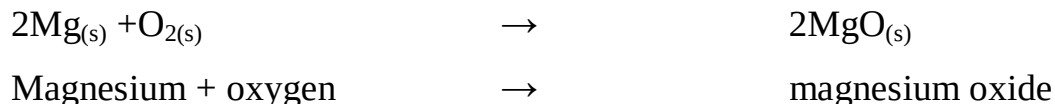
4.3.1. Combustion

Combustion (or burning) is like reaction of a substance with oxygen. When a piece of magnesium is heated in air, the magnesium burns and forms a white ash called magnesium oxide. The white ash weighs more than the original magnesium because it has combined with oxygen from the air. This is an exothermic reaction, because energy is given out to the surroundings when magnesium burns.

In a combustion reaction the mass of all the products is a greater than the mass of the substance which burn to release energy to the surrounding are called fuel. Some fuel, such as natural gas, coal and petroleum have taken millions of years to form and are called fossil fuel. Some fuel, such as wood, can be easily replace and are called renewable fuel.

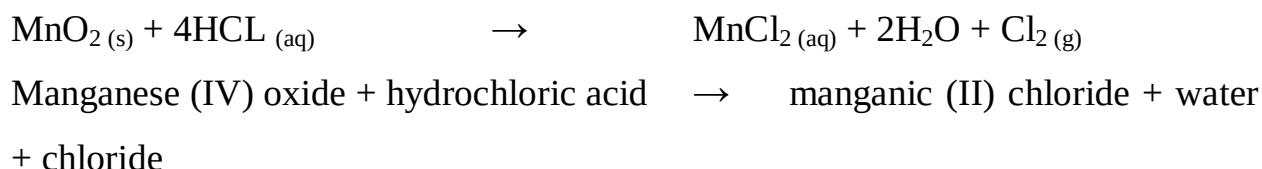
4.3.2. Oxidation

Oxidation occurs when oxygen is added to a substance or hydrogen is lost. For example; in burning of magnesium:-



Magnesium gains oxygen and therefore oxidized.

When manganese (IV) oxide is added to concentrated hydrochloric acid, chlorine is produced:-



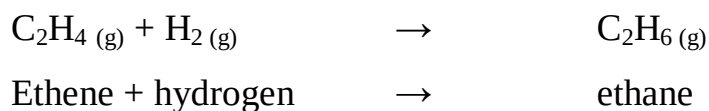
The chloride in the concentrated hydrochloric acid loses hydrogen when being changed to chlorine and therefore oxidized.

Reduction is the reverse of oxidation. Reduction can be defined as the loss of oxygen or the gain of hydrogen.

Example: If hydrogen is passed over heated copper (II) oxide, the copper (II) oxide is reduced to copper. The copper (II) oxide loses oxygen:-



Example: If hydrogen and ethane are passed over a heated catalyst, the ethane is reduced to ethane, ethane gain hydrogen.



4.4 Thermal Decomposition

Metal carbonates such as calcium carbonates break down when heated strongly, this is called thermal decomposition.

Example:



Other metal carbonates decomposed in that way.



Notice that in both examples the products are metal oxide and carbon dioxide. The carbon dioxide gas can be detected using limewater. Limewater turns cloudy white when carbon dioxide bubbled through it.

- Decomposition is a type of chemical reaction and it may be defined as the reaction in which a single compound splits into two or more simple substance under suitable conditions. It is just the opposite of the combination reaction.
- In a combination reaction, a substance is formed as a result of chemical combination, while in a decomposition reaction, the substance breaks into new substance.

4.4.1 The Types of Decomposition Reaction

Decomposition reaction can be classified into three types:-

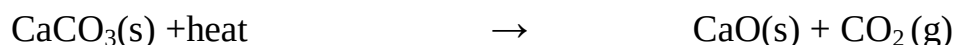
1. Thermal decomposition reaction
2. Electrolytic decomposition reaction
3. Photo decomposition reaction

1. Thermal decomposition reaction (thermalizes)

Thermal decomposition is a chemical reaction where a single substance breaks in to two or more simple substance when heated. The reaction is usually endothermic because heat is required to break the bonds present in the substance.

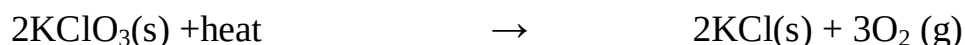
Example: Decomposition of calcium carbonate:

Calcium carbonate (lime stone) decomposes into calcium oxide (quicklime) and carbon dioxide when heated. Quick lime is the major constituents of cement.



Example: Decomposition of potassium chlorate:

Potassium chlorate decomposes into potassium chloride and oxygen. This reaction is used for the preparation of oxygen.



If the decomposition is carried out in the presence of manganese dioxide (MnO_2), it takes place at a lower temperature. In this case, MnO_2 is used as catalyst.

Example: Decomposition of ferric hydroxide:

Ferric hydroxide undergoes decomposition in the presence of heat, giving ferric oxide and water molecule.



Example: Decomposition of hydrated oxalic acid:

Hydrated oxalic acid decomposes into oxalic and water



2. Electrolytic decomposition reaction (electrolysis)

Electrolytic decomposition may result when electric current is passed through an aqueous solution of a compound. A good example is electrolysis of water.

Example: Electrolysis of water: electrolysis of water is the decomposition of water into hydrogen and oxygen due to the passage of electric current through it.



$$2\text{NaCl} + \text{electric current} \rightarrow 2\text{Na} + \text{Cl}_2$$

Example: Decomposition of silver chloride:- place a small quantity of silver chloride (AgCl) taken in a watch glass under sunlight for some time. The crystals slowly acquire a grey color. On analysis, it is found that the sunlight has caused decomposition of silver chloride into silver and chlorine.



White yellow grey

$$2\text{AgBr (s)} + \text{sunlight} \rightarrow 2\text{Ag(s)} + \text{Br (g)}$$
$$2\text{H}_2\text{O}_2 (\text{l}) + \text{light} \rightarrow 2\text{H}_2\text{O} (\text{l}) + \text{O}_2 (\text{g})$$

Most decomposition reaction requires energy either in the form of heat, light or electricity. Absorption of energy causes the breaking of the bonds presents in the reacting substance which decomposes to give the product.

- Write the reaction in words
- Write the symbol for the elements and the correct formulas for compounds.

- (c) Check that the valences in the formulas balance
- (d) Check that the elements hydrogen, nitrogen, oxygen, fluorine, chlorine, bromine and iodine have been represented as diatomic molecules if they are not combined with any other element.
- (e) Balance the equation.

Example: Write a balanced equation for the following reaction: Magnesium combine with oxygen to form magnesium oxide?

Solution:

1. Magnesium + oxygen $\rightarrow$ magnesium oxide
2. $\text{Mg} + \text{O}_2 \rightarrow \text{MgO}$
3. $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$

Example: Write a balanced equation for the following reaction. Sodium reacts with chlorine to form sodium chloride?

Solution:

1. Sodium + chlorine $\rightarrow$ sodium chloride
2. $\text{Na}^+ + \text{Cl}_2 \rightarrow \text{NaCl}$
3. $2\text{Na}^+ + \text{Cl}_2 \rightarrow 2\text{NaCl}$

Example: Write a balanced equation for the follow reaction. Aluminum combined with oxygen to form aluminum oxide?

Solution:

1. Aluminum + oxygen $\rightarrow$ aluminum oxide
2. $\text{Al} + \text{O}_2 \rightarrow \text{Al}_2\text{O}_3$
3. $4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3$

Example: Write a balanced equation for the follow reaction. Hydrogen combined with chlorine to form hydrogen chlorine?

Solution:

1. Hydrogen + chlorine $\rightarrow$ hydrogen chloride



4.5.2 Adding Name Information to Equations

1. The states of reactants and products can be shown by adding state symbols to the equations:

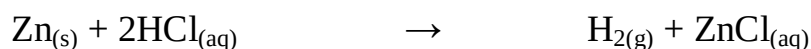
(a) For solid

(b) For liquid

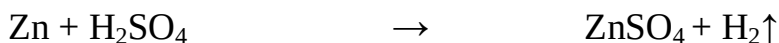
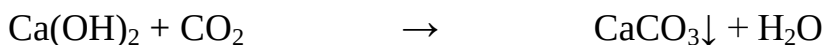
(c) For gas

(d) For aqueous solution

Example:



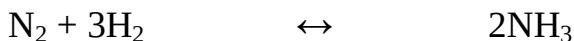
2. To indicate precipitation of a substance an arrow $\downarrow$ is used, and to indicate evolution of a gas, an arrow $\uparrow$ is used;



3. The Physical condition necessary to bring about a chemical change, e.g.:



4. A reversible reaction is shown $\leftrightarrow$ e.g.

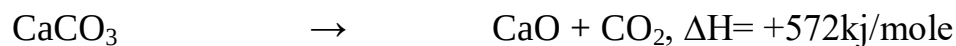


5. The heat exchanged during a chemical reaction is shown by the symbol ΔH .

(a) **Exothermic reaction:**



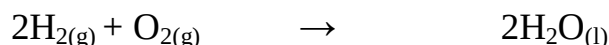
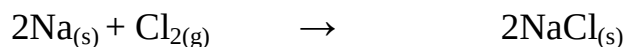
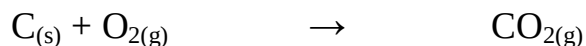
(b) Endothermic reaction:



4.5.3 Types of Chemical Reaction

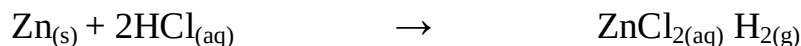
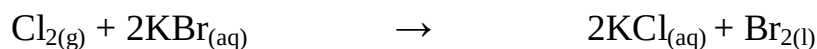
1. Synthesis Or Combination:

In synthesis reactions two or more substances combine to form one new substance:



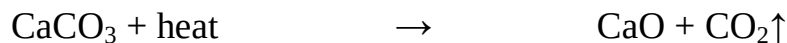
2. Displacement:

In the type of reaction, one element displaces another in a compound:



3. Decomposition:

Much substance will break up into simpler substances when energy is supplied:



4. Double decomposition:

Double decomposition reactions are of the type:

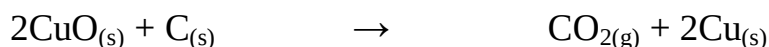


5. Oxidation and reduction reactions:

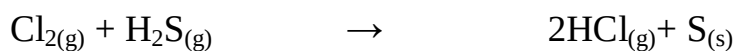
(a) Oxidation:

A chemical reaction in which one of the following occurs is called an oxidation reaction.

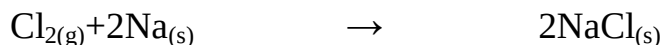
I. A substance again oxygen:



II. A compound loses hydrogen:



III. An atom or ion loses electrons:



(b) Reduction:

Reduction is a chemical reaction in which one of the following occurs:

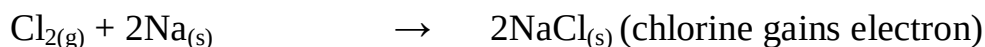
1. A compound loses oxygen:



2. Compound or element gain hydrogen



3. An atom or ion gains electrons:



4.6 Rates of Reaction

The rate of reaction is the speed at which reactants are converted into product. Every chemical reaction proceeds at a definite rate, but can be speeded up or slowed down by changing the conditions of the reaction. Rate of change of a reactant or product with time (corrected for reactant stoichiometry).

4.6.1 Factors That Affect the Speed of Reaction

1. Temperature:

Often the easiest way to change the reaction rate is by changing the temperature of the reactants. Lowering the temperature decreases the reaction rate, and increasing the temperature speeds up the reaction rate. For example, frying an egg is a chemical reaction. Frying an egg on a low stove setting takes several minutes, but frying it on the highest setting takes only a minute or two. As the temperature increases, particles of the reactants move faster, colliding into each

other more frequently. At higher temperatures particles also have more energy, which allows them to bond with each other more readily.



Figure (4.3) the higher you have the temperature, the faster these eggs will fry

2. Concentration:

The reaction rate generally increases when the concentration of the reactants is increased. This is because there are more particles available to bond and the particles collide more often. For example, substances such as coal burn much more rapidly in pure oxygen than in air because air is composed of only 20 percent oxygen. Since the combustion (burning) reaction requires oxygen, extra oxygen increases the speed of the reaction. But sometimes increasing the concentration of a reactant does not increase the reaction rate. Chemical reactions frequently take place in a series of simple steps called a **reaction pathway**. The slowest reaction along this pathway, called the rate **determining step**, determines the speed of the entire reaction pathway. Adding more of a reactant to one of the other pathway steps will not speed up the overall reaction.

3. Catalysts:

Some chemical reactions happen quite slowly and require the presence of another substance to speed up the reaction rate. A substance that increases the reaction rate without being permanently changed is called a **catalyst**. A catalyst is not part of

the final product of a reaction. Sometimes chemists can even recover and reuse catalysts. Catalysts are common in the human body, usually in the form of enzymes, which are proteins. Enzymes can speed up chemical reactions in the human body by a factor of 10,000. For example, an enzyme in human saliva, acting as a catalyst, speeds up the conversion of starch into glucose so it can be digested immediately instead of several weeks later.

4. Surface area:

Increasing the surface area (amount of exposed surface) of a solid reactant increases the reaction rate. A reactant crushed or ground into smaller fragments has more exposed surface area than one larger piece. When more surface area is exposed, particles of the reactants come in contact and bond with each other more frequently. For example, solid zinc reacts with hydrochloric acid to form zinc chloride and hydrogen gas. Cubes of zinc measuring a centimeter on each side have only 6cm^2 of zinc surface area exposed to the acid. But grinding the zinc into powder exposes 10,000 times more surface area to the acid. The larger surface area greatly speeds up the reaction rate.

4.7 Exercise:

1. Explain the kinetic theory of matter?
2. What are the changes of states of matter?
3. What are the differences between states of matter?
4. What is combustion and oxidation?
5. When oxidation occurs and discuss with equation?
6. Explain the thermal decomposition and what are types of decomposition reaction with equations?
7. What are the rules for construction equations?
8. Write a balanced equation for the following reaction: Magnesium combine with oxygen to form magnesium oxide?

9. Write a balanced equation for the following reaction. Sodium reacts with chlorine to form sodium chloride?
10. Write a balanced equation for the follow reaction. Aluminum combined with oxygen to form aluminum oxide?
11. Write a balanced equation for the follow reaction. Hydrogen combined with chlorine to form hydrogen chlorine?
12. What are the types of chemical reaction explain with equations?
13. Define:
 - a. Oxidation
 - b. Reduction
14. What is a rate of reaction and what are the factors that affect the sped of reaction?

Chapter V

Acid and Base

5.1 Introduction to Acid

The term acid was first used in the seventeenth century; it comes from Latin root ac- means “sharp”, as in acetum, vinegar. Some early writes suggested that acidic molecules might have sharp corners or sine-like projections that irritate the tongue or skin.

5.1.1 An Acid Can Be Defined In Various Way, These Include:

An acid is a substance that contains hydrogen which can be wholly or partially replaced by a metal. This hydrogen is called replaceable hydrogen.

An acid is a substance which forms hydrogen ion when it is dissolved in water.

An acid is a proton donor. It provides proton or H^+ ions.

An **acid** may be defined as a substance that turns litmus red.

A **base** may be defined as a substance that turns litmus blue.

An **indicator** is a substance that shows whether another substance is a base/alkaline, acid or neutral

The general reactions of an acid can now be seen as reactions of hydrogen ions in solution.

Example:

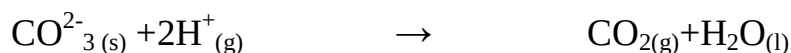
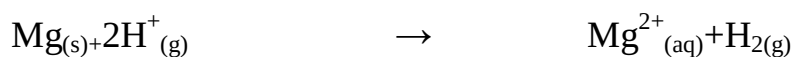


Table (5.1): There are some common and naturally occurring acids as shown in the table below

Name of acid	Occurrence
1.Citric acid	Found in ripe citrus fruits like passion fruit/oranges/lemon
2. Tartaric acid	Found in grapes/baking powder/health salts
3. Lactic acid	Found in sour milk
4. Ethanoic acid	Found in vinegar
5. Methanoic acid	Present in ants, bees stings
6. Carbonic acid	Used in preservation of fizzy drinks like coke lemonade, Fanta
7. Butanoic acid	Present in cheese
8. Tannic acid	Present in tea

Table (5.2): However, acids commonly used and found in a school laboratory are not naturally occurring they are mineral acids as illustrated below

Name of mineral acid	Common use
Hydrochloric acid (HCl)	Used to clean/ pickling surface of metals is found in the stomach of mammals/human beings
Sulphuric(VI) acid (H_2SO_4)	Used as acid in car battery, making battery, making fertilizers
Nitric (V)acid (HNO_3)	Used in making fertilizers and explosives

Mineral acids are manufactured to very high concentration they are **corrosive** (causes painful wounds on contact with the skin) and attack/reacts with garments/clothes/metals. In a school laboratory, they are mainly used when added a lot of water. This is called diluting. Diluting ensures the concentration of the acid is safely low.

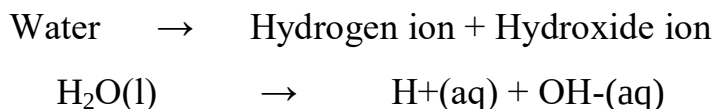
5.1.2 Common Uses of Acids Are

- Steel used in construction is acid treated before painting. Dilute sulphuric or hydrochloric acid will remove any surface rust which would otherwise spread under the painted surface. 'Rust remover' used to repair cars is dilute Phosphoric acid - H_3PO_4 .
- Baking powder contains tartaric acid.

- 'Lime scale' removers contain dilute acids. Try using lemon juice or vinegar (weak acids). Lime scale is calcium carbonate (also called furring).
- A wasp sting is alkaline. It may be neutralized with a weak acid (lemon juice or vinegar).
- A bee sting is acidic. It may be neutralized by an alkali

5.1.3 Water

In a sample of water, a very small number of water molecules will form ions.



This ionization is reversible (shown by the arrow). The hydrogen ion is acidic. The hydroxide ion is alkaline. Water forms equal amounts of both ions, and so water is neutral. Compare this reaction with neutralization.

5.2 Acid and Base Indicators

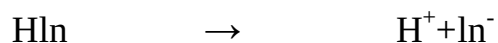
The most common indicators are found on “litmus” paper. It is red below PH 4.5 and blue above PH 8.2.

Table (5.3): Indicators

Color	Blue litmus	Red litmus
Acid	Changes to red	Stays same
Base	Stays Blue	Changes to blue

Other commercial PH papers are able to give colors for main PH unit. Universal indicator, which is a solution of a mixture of indicators, is able to also provide a full range of colors for the PH scale.

A variety of indicators change color at various PH level, a properly selected acid-base indicators can be used to visually “indicate” the approximate PH of a sample. An indicator is usually some weak organic acid or base dye that changes color at definite PH values. The weak acid form (HIn) will have one color and the weak acid negative ions (In⁻) will have a different color. The weak acid equilibriums:-



1. for Phenolphthalein: PH 10=red
2. For bromophenol blue: PH 3=yellow. PH4.6= blue

Table (5.4): Classification of some solutions

Acid	Base or alkali	Neutral
Hydrochloric acid	Sodium hydroxide	Water
Nitric acid	Potassium hydroxide	
Sulfuric acid	Calcium hydroxide	

2.2.2 Common indicators

- Methyl violet
- Methyl yellow
- Bromophenol
- Methyl orange
- Methyl red
- Litmus
- Phenolphthalein
- Thymolphthalein

Table (5.5): The following table shows different results when indicators are used to test different solutions

Substance/ solution	Indicator				
	Litmus	phenolphthalein	Methyl orange	Screened methyl orange	Bromothymol blue
Wood as	Blue	Pink	Yellow	Orange	Blue
Soap solution	Blue	Pink	Yellow	Orange	Blue
Ammonia solution	Blue	Pink	Yellow	Orange	Blue
Sodium hydroxide	Blue	Pink	Yellow	Orange	Blue
Hydrochloric acid	Red	Colorless	Red	Purple	Orange
Distilled water	Colorless	Colorless	Red	Orange	Orange
Sulphuric(VI) acid	Red	Colorless	Red	Purple	Orange
Sour milk	Blue	Pink	Yellow	Orange	Blue
Sodium chloride	Colorless	Colorless	Red	Orange	Orange
Toothpaste	Blue	Pink	Yellow	Orange	Blue
Calcium hydroxide	Blue	Pink	Yellow	Orange	Blue
Lemon juice	Red	Colorless	Red	Purple	Orange

Table (5.6): The following table shows the changes shown by indicators in different types of solution

Indicator	Color of indicator		
	Acid	Base/alkali	Neutral
Litmus paper/solution	Red	Blue	Colorless
Methyl orange	Red	Yellow	Red
Screened methyl orange	Purple	Orange	Orange
Phenolphthalein	Colorless	Purple	Colorless
Bromothymol blue	Orange	Blue	Orange

5.2.3 PH scale

As the reactions of an acid are those of the hydrogen ions in solution, clearly the more hydrogen ions are present, the stronger the acid will be. The strength of an acid is measured on the PH scale. The PH number is measure of the hydrogen ion concentration.

PH1=strong acid

PH2→PH6=weak acid

PH7= neutral

PH8→PH13=weak base (alkali)

PH14= strong base (alkali)

The smaller the PH, is the concentration of hydrogen ion and so the stronger acid.

The PH can be measured with indicator or by using PH meter.

Table (5.7): Strong Acid and Weak Acid

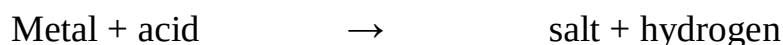
Strong acid	Weak acid
Hydrochloric acid	Ethnic acid
Sulfuric acid	Carbonic acid
Nitric acid	Sulfurous acid

5.3 Properties of Acids

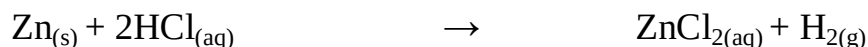
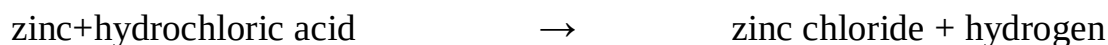
1. A characteristic sour taste (think of lemon juice).
2. Ability to change the color of litmus from blue to red.
3. React with certain metals to produce gaseous H₂.
4. React with bases to form a salt and water.

5.3.1 Reactions of Acid with Metals

- General word equation:-



- Example: The grey silver, solid zinc dissolves with effervescence to involve hydrogen gas and leave a colorless solution of the salt zinc chloride.

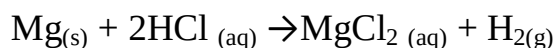


It is same equation or many other Group 2 and transition metals, Example: Mg, Ca, and Fe, Co, Ni.

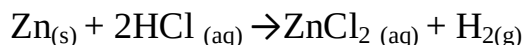
Note: hydrochloric acid gives a chloride salts.

Example: The following are reactions between metals and acids:

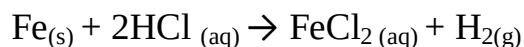
1) *Magnesium + Hydrochloric acid → Magnesium chloride + Hydrogen*



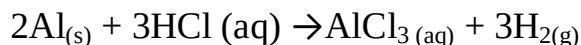
2) *Zinc + Hydrochloric acid → Zinc chloride + Hydrogen*



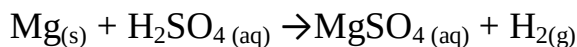
3) *Iron + Hydrochloric acid → Iron(II) chloride + Hydrogen*



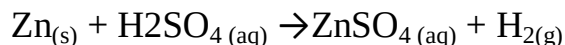
4) *Aluminium + Hydrochloric acid → Aluminium chloride + Hydrogen*



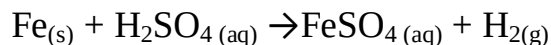
5) *Magnesium + Sulphuric(VI)acid → Magnesium sulPHate(VI) + Hydrogen*



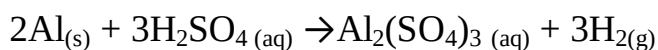
6) *Zinc + Sulphuric(VI)acid → Zinc sulPHate(VI) + Hydrogen*



7) *Iron + Sulphuric(VI)acid Iron(II) sulPHate(VI) + Hydrogen*



8) *Aluminium + Sulphuric(VI)acid → Aluminium sulPHate(VI) + Hydrogen*



5.3.2 Reactions of Acid with Carbonates

Contrary to what some text books may say, but often do not point out. All carbonates are bases and react with acids to form salt, the difference in reaction with alkalis or insoluble bases is that carbon dioxide gas is involved.

On adding a solid carbonate or hydrogen carbonate to an acid you see effervescence from carbon dioxide gas and the general word equation:

Metal carbonate or hydrogen carbonate + acid → a salt + water + carbonate (limestone) dissolves in dilute hydrochloric acid from a colorless solution of calcium chloride and colorless carbon dioxide gas.

Calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide gas

$$\text{CaCO}_{3(s)} + 2\text{HCl}_{(aq)} \rightarrow \text{CaCl}_{2(aq)} + \text{H}_2\text{O}_{(l)} + \text{CO}_{2(g)}$$

Example: The following are reactions between carbonates and acids:

1. *Sodium carbonate + Hydrochloric acid → Sodium chloride +*

Carbon(IV)Oxide+ Water



2. Calcium carbonate +Hydrochloric acid → Calcium chloride + Carbon(IV)Oxide+ Water



3. Magnesium carbonate +Hydrochloric acid → Magnesium chloride + Carbon(IV)Oxide+ Water



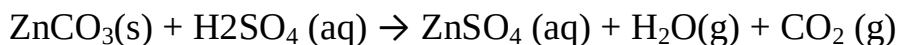
4. Copper carbonate +Hydrochloric acid →Copper(II) chloride + Carbon(IV)Oxide+ Water



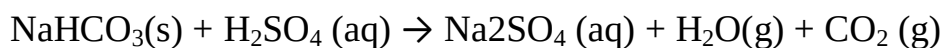
5. Copper carbonate +Sulphuric(VI) acid →Copper(II)sulPHate(VI) + Carbon(IV)Oxide+ Water



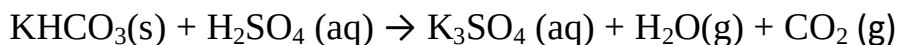
6. Zinc carbonate +Sulphuric(VI) acid →Zinc sulPHate(VI) + Carbon(IV)Oxide+ Water



7. Sodium hydrogen carbonate +Sulphuric(VI) acid →Sodium sulPHate(VI) + Carbon(IV)Oxide+ Water



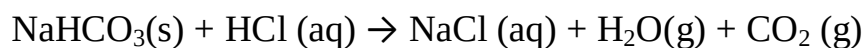
8. Potassium hydrogen carbonate +Sulphuric(VI) acid → Potassium sulPHate(VI) + Carbon(IV)Oxide+ Water



9. Potassium hydrogen carbonate +Hydrochloric acid → Potassium chloride + Carbon(IV)Oxide+ Water



10. Sodium hydrogen carbonate +Hydrochloric acid → Sodium chloride + Carbon(IV)Oxide+ Water



5.4 Bases and Its Properties:

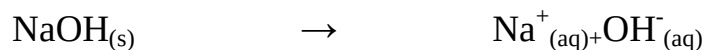
Bases are opposite of acids, so the most bases do not dissolve in water.

The name base has long been associated with a class of compounds whose aqueous solutions are characterized by:

1. A bitter test.
2. A “soapy” feeling when applied the skin.
3. Ability to store the original blue color of litmus that has been turned red by acid.
4. Ability to react with acids to form salt.

Note: It is of Arabic original, but the root word comes from the same Latin kalium (potash) that is the original of symbol for potassium. Word ashes have been the traditional source of the strong base KOH since ancient times.

Just as an acid is a substance that liberates hydrogen ion in solution, a base yield hydroxide ions when dissolved in water



Sodium hydroxide is an Arrhenius base because it contains hydroxide ions. However, other substances which do not contain hydroxide ion can nevertheless produce them by reaction with water and therefore classified as bases. Two class of such substances are metal oxides and the hydrogen compounds of contain non-metals.

5.4.1 Alkali

Bases which dissolve in water are called **alkalis**. Alkali is a basic, ionic salt of an alkali metals or alkaline earth metals of chemical elements. Some authors also define an alkali as a base that dissolves in water. A solution of a soluble base has a PH greater than 7.0.

5.4.2 Common alkalis

Most of the bases are insoluble only very few are soluble:

- ✓ Potassium hydroxide KOH (caustic potash).
- ✓ Sodium hydroxide NaOH (caustic soda).
- ✓ Calcium hydroxide $\text{Ca}(\text{OH})_{2(\text{aq})}$ (lime water).
- ✓ Ammonia solution NH_3

Are the only four soluble bases used in the laboratory?

Table (5.8): Some common alkalis and their uses include

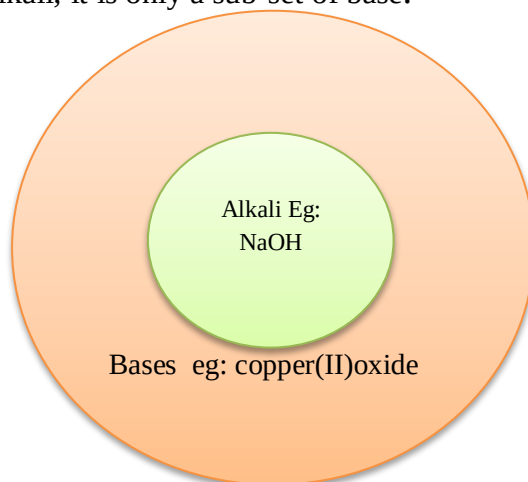
Name of alkali	Common uses
Sodium hydroxide (NaOH)	Making soups and detergents
Potassium hydroxide (KOH)	Making soups and detergents
Ammonia solution (NH_4OH)	Making fertilizers, softening hard water

Common base (which are not alkali)

Name of base	Common uses
Magnesium oxide/hydroxide	Anti-acid to treat indigestion
Calcium oxide	Making cement and neutralizing soil acidity

Note: $\text{Ca}(\text{OH})_{2(\text{s})}$ is only slight soluble in water.

Soluble bases is called alkali, it is only a sub-set of base.



5.4.3 General Properties of Alkalies

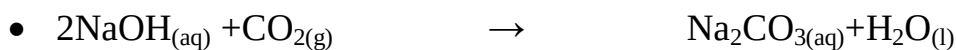
Alkalies are soluble type of bases (a base is a compound which reacts with acid to form a salt and water only). All alkalies are bases, but not all bases are alkalies.

Aqueous alkalies have many common properties these properties are due to the presence of dehydrated hydroxide:

1. Taste: alkalies have bitter test.
2. Feel: dilute solutions of alkalies have a soapy feel.
3. Effect on litmus: alkaline solutions turn red litmus to blue.
4. Electrical conductivity: all alkali conducts electricity.
5. Reaction with acid: alkalies neutralize acids to form a salt and water.



6. Reactions with non-metal oxides: alkalies react with some non-metal oxides which are acidic eg: carbon dioxide



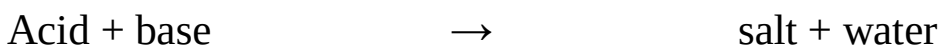
Generally, carbon dioxide gives carbonates, sulfur dioxide gives sulfates and nitrogen dioxide gives nitrates and nitrites.

5.4.4 Uses of Alkalies

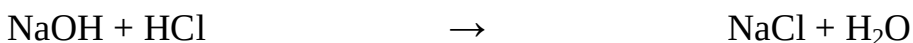
- ❖ Sodium hydroxide is used in the manufacture of paper, soap and ceramics.
- ❖ Calcium hydroxide (called 'slaked lime', or just 'lime'), is added to soils or lakes to make them less acidic (see acid rain).
- ❖ Indigestion may be caused by too much hydrochloric acid in the stomach. Indigestion tablets contain a base such as magnesium oxide, or calcium carbonate to neutralize the acid.
- ❖ A bee sting is acidic. It may be neutralized by a weak alkali such as ammonia solution.

5.5 Neutralization

Neutralization reaction refers to acid and base reaction producing salt and water. The equivalent amounts of acid react with base to form equivalent amounts of salt and water. When the reaction is complete, acid and base are said to neutralize each other. Since water is produced, neutralization reaction is also referred as “water forming reaction”.

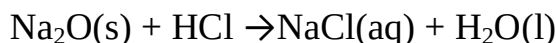


Example:



Example: The following are reactions between acids and bases (neutralization)

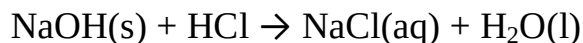
1. Sodium oxide + Hydrochloric acid → Sodium chloride + Water



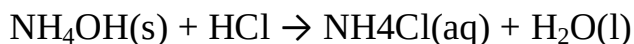
2. Potassium oxide + Hydrochloric acid → Potassium chloride + Water



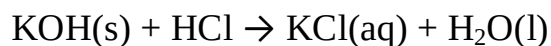
3. Sodium hydroxide + Hydrochloric acid → Sodium chloride + Water



4. Ammonia solution + Hydrochloric acid → Ammonium chloride + Water



5. Potassium hydroxide + Hydrochloric acid → Potassium chloride + Water



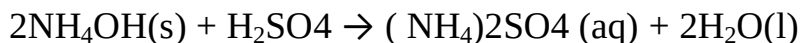
6. Sodium hydroxide + sulphuric(VI) acid → Sodium sulphate(VI) + Water



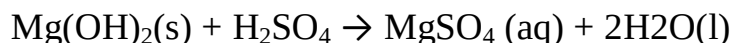
7. Potassium hydroxide + sulphuric(VI) acid → Potassium sulphate(VI) + Water



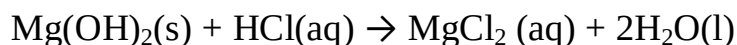
8. Ammonia solution + sulphuric(VI) acid → Ammonium sulphate(VI) + Water



9. Magnesium hydroxide + sulphuric(VI) acid → Magnesium sulphate(VI) + Water



10. Magnesium hydroxide + Hydrochloric acid → Magnesium chloride + Water

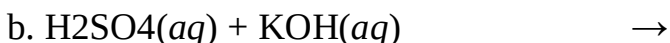
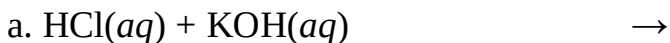


However, salts formed with other combinations like “strong acid - weak base” and “weak acid — strong base” are not neutral. They produce salts, which are either acidic or basic in nature.

Acid-base reaction as neutralization reaction even though products are not neutral (PH=7). As a matter of fact, product solution is acidic (PH<3) for strong acid — weak base reaction. We need to add more of base solution beyond equivalence volume to make the product solution neutral. Similarly, product solution is basic (PH 7) for weak acid — strong base reaction. Here, we need to add more acid beyond equivalence volume to make the product solution neutral.

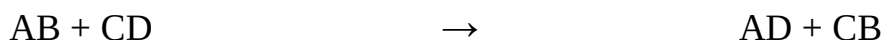
Example:

Write the complete equations for the neutralization reactions that take place when the following water solutions are mixed. *(If an acid has more than one acidic hydrogen, assume that there is enough base to remove all of them. Assume that there is enough acid to neutralize all of the basic hydroxide ions.)*

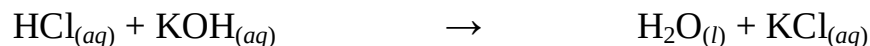


Solution:

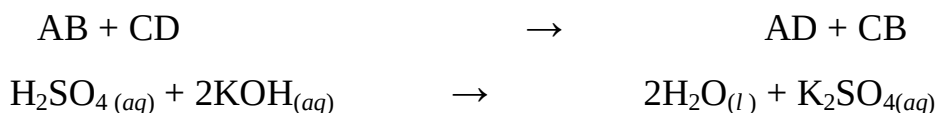
a. Neutralization reactions between strong monoprotic acids, such as $\text{HCl}_{(aq)}$, and ionic compounds, such as KOH , are double-displacement reactions, so they have the form:



For HCl , A is H^+ , and B is Cl^- . For KOH , C is K^+ , and D is OH^- . Therefore, AD is HOH or H_2O , which we know is a liquid, and CB is KCl , which is a water-soluble ionic compound and thus aqueous.

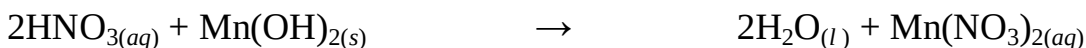


b. For H_2SO_4 in a double-displacement reaction, A is H^+ , and B is SO_4^{2-} . (In neutralization reactions, you can assume that all of the acidic hydrogen atoms are lost to the base. Monoprotic acids lose one H^+ ion, diprotic acids such as H_2SO_4 lose two H^+ ions, and triprotic acids such as H_3PO_4 lose three H^+ ions.) For KOH , C is K^+ , and D is OH^- . Thus AD is H_2O , and CB is K_2SO_4 , a water-soluble ionic compound. The two H^+ ions from the diprotic acid H_2SO_4 react with the two OH^- ions from two units of KOH to form two H_2O molecules.



c. For HNO_3 in a double-displacement reaction, A is H^+ , and B is NO_3^- . For $\text{Mn}(\text{OH})_2$, C is Mn^{2+} , and D is OH^- . Thus AD is H_2O , and CB is $\text{Mn}(\text{NO}_3)_2$, a

water-soluble ionic compound. Two H^+ ions from two nitric acid molecules react with the two OH^- ions from the $\text{Mn}(\text{OH})_2$ to form two H_2O molecules.



5.6 Exercise:

1. Define:

- a. Acid
- b. Base
- c. Indicator

2. What are the common uses of acids?

3. What is PH scale?

4. What are the common indicators?

5. What are the properties of acid?

6. Explain how acids react with carbonates, with equations?

7. What are bases and explain their properties?

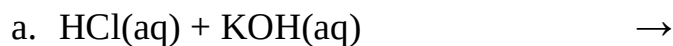
8. What is the difference between alkali and base?

9. What are the common alkalis?

10. List the uses of Alkalis and their properties?

11. Explain neutralization reaction with equations?

12. Write the complete equations for the neutralization reactions that take place when the following water solutions are mixed.



Chapter VI

Air, Earth and Water

6.1 Air and Its Uses

The air in the atmosphere consists of nitrogen, oxygen, which is the life-sustaining substance for animals and humans, carbon dioxide, water vapor and small amounts of other elements. Higher in the atmosphere air also contains ozone, helium and hydrogen. People can only clearly notice the percentage of air when the wind bellows.

Table (6.1): Composition of Dry Air

Substance	% by volume
Nitrogen	78.08
Oxygen	20.95
Argon	0.93
Carbon dioxide	0.033
Neon	0.0018
Helium	0.00052
Methane	0.00022
Krypton	0.00011
Nitrogen dioxide	0.00005
Hydrogen	0.00005
Xenon	0.0000087
Ozone	0.000001

The air contains a number of gases the amount of water vapor in the air varies from place to place, and day to day. For this reason, the properties of gases in the air are

usually given for dry air. Some of the gases in the air are elements like (nitrogen, oxygen, argon and etc.). But carbon dioxide is a compound (as water, vapor, H₂O).

6.1.2 Oxygen in the Air

The atmosphere is made up of air, a mixture of colorless, odorless gases which is felt as wind. There are various gases in the atmosphere a listed below with their percentage composition;

- (i) Nitrogen - 78%
- (ii) Oxygen - 21%
- (iii) Carbon (IV) Oxide - 0.03%
- (iv) Noble gases - 1%
- (v) Water Vapour - varies by region

There are different experiments that could be used to demonstrate presence and composition of the above gases in air some of them include

The percentage of oxygen in the air can be measured by passing a known volume of air over hot copper, and measuring the decrease in volume as the oxygen reacts with it. Here is the equation for reaction:



Gas syringes are used to measure the volume of gases in the experiment. Starting volume of air is often 100cm³ to make the analysis of the result easy but it could be any convenient volume in the simulation, there is 100cm³ of air at the start.

6.1.3 Important Notes

- The cotton wool in the experiment copper turnings from being blown into the syringe/out of the glass tube.
- Air is passed through the glass tube repeatedly to ensure all the active part of air is used up.

- Passing air through the glass tube slowly allows enough time of contact between the active part of and the heated copper turnings.
- Colour changes from brown to black due to the reaction of brown copper metal with oxygen to form copper (II) oxide.
- The reaction reduces the amount/volume of oxygen in syringe “B” leaving the inactive part of air, because copper only reacts with oxygen when heated.
- The percentage of active part of air is theoretically higher because not all the active part of air reacted with copper.
- If the copper turnings are replaced with magnesium shavings the % of active part of air obtained is extraordinary very high because magnesium is more reactive than copper and the reaction is highly exothermic. Hence it generates enough heat for magnesium to react with both oxygen and nitrogen in the air.

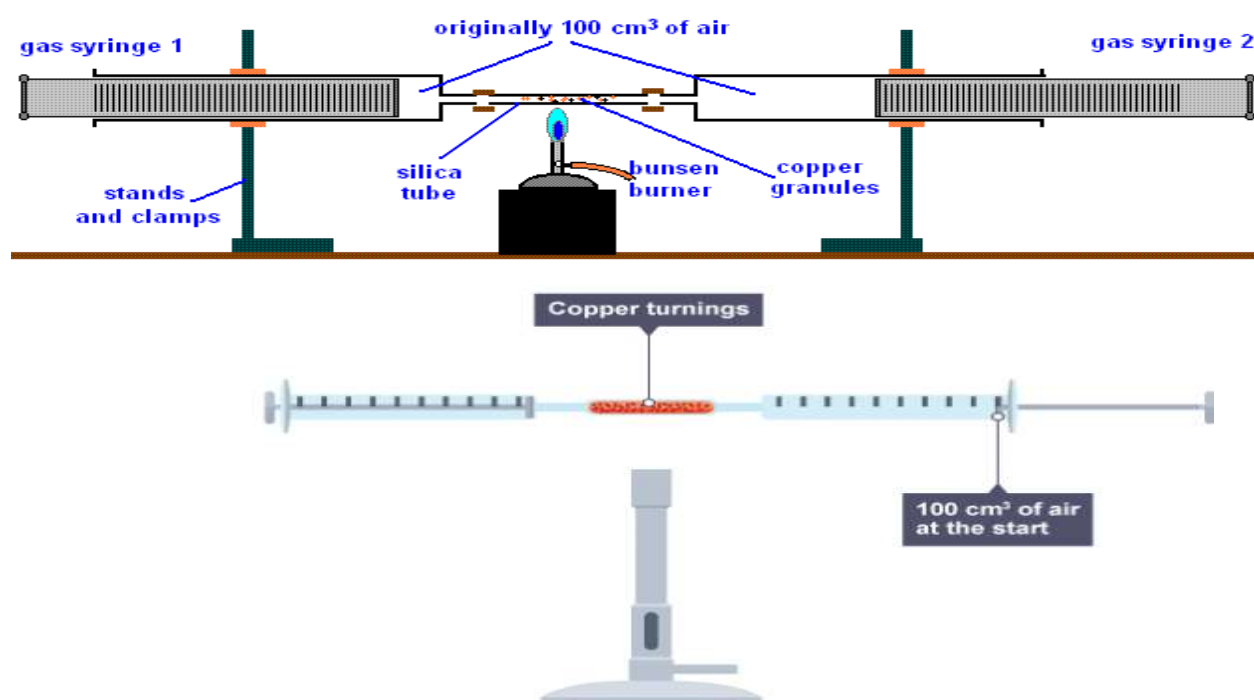


Figure (6.1) measuring of percentage of oxygen in air

Note that, there is some air in tube with the copper turnings. The oxygen in the air will also react with the hot copper, causing a small error in the final volume

recorded. It also important to let the apparatus cool down at the end of the experiment, otherwise the final reading will be too high.

6.1.4 Living Things Use Air in Many Different Ways

- Animals need air to breathe
- Plants need air to make their own food
- Birds use the air to flay
- Human can generate electricity using air (wind)
- Air is used to fertilizers

6.2 Air Pollution

It is defined as the excessive concentration of foreign material in the atmosphere, which affects the health of individuals and also causes damage to the property. So, a part that gases normally found in air, other gases such as sulfur dioxide, oxides of nitrogen and carbon monoxide can be present. These gases can cause air pollution and are called pollutants.

Sources:

Air pollution results from gaseous emission from mainly industry, thermal power stations, automobiles, domestic combustion etc.

- 1. Industrial chimney wastes:** There are a number of industries which are source of air pollution. Petroleum refineries are the major source of gaseous pollutants. The chief gases are SO_2 and NO_x . Cement factories emit plenty of dust, which is potential health hazard. Stone crushers and hot mix plants also create a menace. Food and fertilizers industries which emit gaseous pollutants and chemical manufacturing industries which emit acid vapours in air.
- 2. Thermal power stations:** There are a number of thermal power stations and super thermal power stations in the country. The National thermal power corporation (NTPC) is setting up four mammoth coal-powered power stations

to augment the energy generation. The coal consumption of thermal plants is several million tones. The chief pollutants are fly ash, SO₂ and other gases and hydrocarbons.

3. Automobiles: The toxic vehicular exhausts are a source of considerable air pollution, next only to thermal power plants. The ever increasing vehicular traffic density posed continued threat to the ambient air quality. Chief sources of emission in automobiles are (i) exhaust system, (ii) fuel tank and carburettor and (iii) crankcase. The exhaust produces many air pollutants including unburnt hydrocarbons, CO, NO_x and lead oxides. There are also traces of aldehydes, esters, ethers, peroxides and ketones which are chemically active and combine to form smog in presence of light. Evaporation from fuel tank goes on constantly due to volatile nature of petrol, causing emission of hydrocarbons. The evaporation through carburettor occurs when engine is stopped and heat builds up, and as much as 12 to 40 ml of fuel is lost during each long stop causing emission of hydrocarbons.

6.2.1 Criteria Air Pollutants: The five primary criteria pollutants include the gases- Carbon Monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO₂), and solid or liquid particulates (smaller than 10 µm), and particulate lead.

6.2.1.1 Effects of air pollution: Air pollution is known to have many adverse effects, including those on human health, building facades and other exposed materials, vegetation, agricultural crops, animals, aquatic and terrestrial ecosystems, and the climate of earth as a whole.

6.2.2 Ways to reduce air pollution

There are simple steps you can take in your everyday life to help improve air quality. Every time you drive to work or school, use your heater or air conditioner, clean your windows or even style your hair, you make choices that can reduce of

increase air pollution. Some of measures to reduce and control air pollution are as follows:

1. The forest cover should be protected. Trees absorb carbon dioxide and release oxygen.
2. Green belts should be created.
3. Automobile engines should be redesigned in such a way that their emissions cause minimum pollution.
4. Use of railway steam engine should be stopped.
5. Industrial areas should be located at a safe distance from the residential areas.
6. Forest fires should be checked.
7. In industries there should be the arrangement for pollution control.
8. Cheap devices for controlling air pollution should be developed.
9. Air pollution can be checked only through the joint efforts of the government, non-government organizations and the general public.

6.3 Water cycle

Water is all around us. There is water in seas, rivers, lakes pond, clouds, and even in the air. Did you know that water is always moving from one place to another?

The sun wars the bodies of water like rivers, lakes and seas. The changes water to water vapor .this forms clouds, the clouds that get heavy fall as rain or ice precipitation. This collect in bodies of water on the surface of the earth it also collects underground. The sun heats this water again so that completes the water cycle.

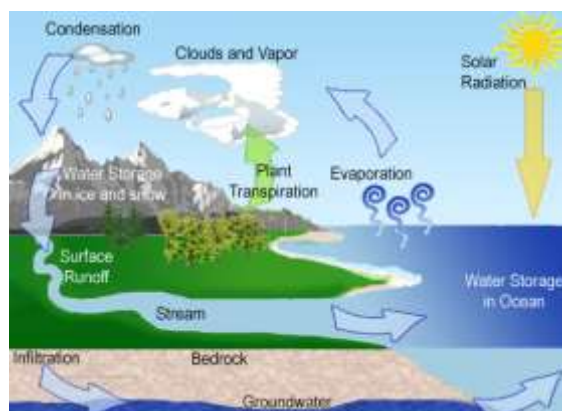
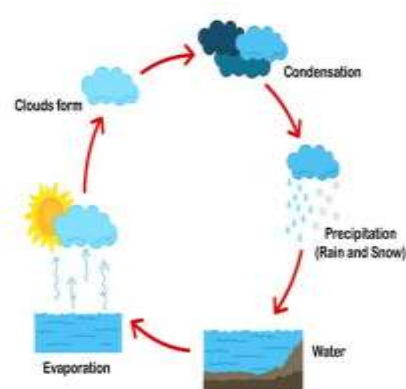


Figure (6.2) water cycle

6.3.1 Evaporation

Evaporation is the process where water gradually changes from liquid to a gas. It is a stage in the water cycle. The sun warms the bodies of water then changes water to water vapor, the vapor rises up in the sky.

6.3.2 Cloud formation

Water vapor cools as it rises in the sky. As it cools, it changes from gas to a liquid. Clouds are made of tiny drops of liquid water, clouds also be made of ice crystals. This happens when the air temperature is below freezing. The water vapor cools to form ice crystals.

6.3.3 Precipitation

Precipitation is the water falling from clouds it can fall as rain or snow.

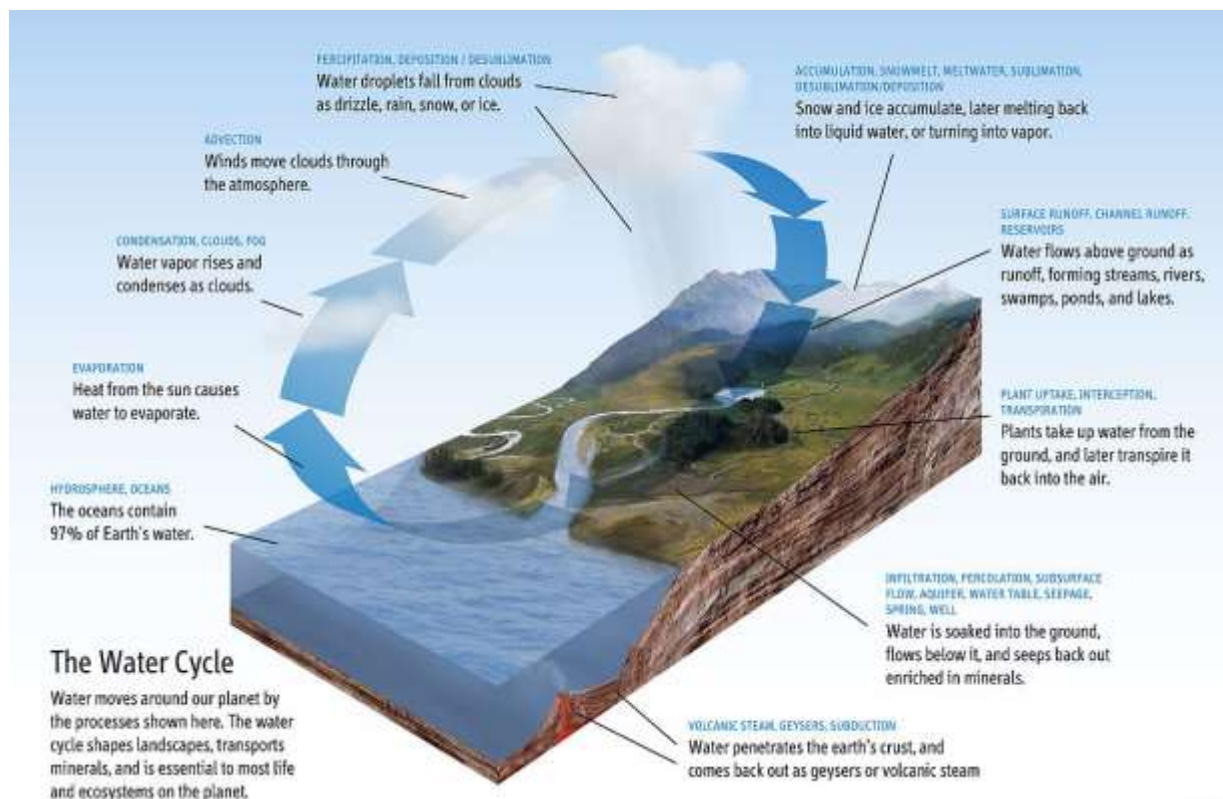


Figure (6.3) water cycle

6.3.4 Water collection

Water that falls from the sky collects in the bodies of water like seas, rivers and lakes. Some of the water seeps below the ground.

6.3.5 Uses of water

1. To drink
2. To cook
3. To clean
4. We uses water in agriculture an in cattle industry
5. To produce electricity
6. Factories
7. As an habit:- many animal and plants live in water

Note: To ensure a safe water supply before supplying it to customers:

Treatment processes are determined by a range of factors including:

- 1. The catchment area*
- 2. The chemistry and biology of the water*
- 3. Mandatory requirements, such as disinfection and fluoridation.*

6.3.6 The Sewage Treatment Process

As well as getting safe. Clean and reliable water to you, we also have to take it away once you have used it. So, when you empty the bath flush of the toilet or use your washing machine, it's our job to make sure that all that used water. Now called "sewage" or "waste water" is put safely back into rivers.

In some areas we collect the rain water that runs off roofs, roads and pavements in the separate system, called a surface water sewer. Surface water goes straight in to a river, which is why you must not pour any waste water into surface water drains.

- 1. Taking the waste water away:** when you flush the toilet or empty the sink, the waste water goes down the drain and into pipes, which takes it to a large sewer pipe under the road. The sewer then joins our network of other sewers and takes the wastewater to a sewage treatment works. Sometimes it needs to be pumped there. At the sewage works we put the wastewater through several cleaning processes so that it can be put back safely into river.
- 2. Screening:**
 - The first stage of cleaning the waste water is to remove large objects that may block or damage equipment, or be unsightly if allowed back into the river. This includes items that should never have been put down the drain in the first place. Such as nappies, face wipes, sanitary items and cotton buds, but often can be things like bricks, bottles and rags.

- The wastewater often contains a lot of grit that gets washed in the sewer, so we have special equipment to remove this as well.

3. Primary treatment: the wastewater still contains organic solid matter or human waste. The next stage is to separate this from the water and to do this; we put the wastewater into large settlement tanks, which cause the solids to sink to the bottom of the tank. We call these settled solids “sludge”. In a circular tank, large arms, or scrapers, slowly move around the tank and push the sludge towards the center it is then pumped away for further treatment. The water passes over a wall near the top of the tank and is taken to the next stage of the treatment process.

4. Secondary treatment: although the visible bits of sludge have been removed, we have to ensure that the smaller and sometimes invisible nasty bugs are also taken out. At our larger sewage treatment works, the wastewater is put into rectangular tanks called “aeration lanes” where air is pumped into the wastewater. This encourages the good bacteria to break down the nasty bugs by eating them. The more they eat, the more they grow and multiply until all the nasty bugs have gone.

5. Final treatment: the treatment wastewater is then passed through a final settlement tank where the good bacteria sink to the bottom. These form more sludge some of it is recycled back to the “secondary treatment” stage and the rest goes to “sludge treatment”. The now clean water passes over a wall near the top of the tank.

Sometimes, additional treatment is needed if the river that the treated wastewater will be returned to is particularly sensitive. The treated wastewater is slowly acts as a filter and catches any remaining particles.

6. Sludge treatment: the sludge we collect at the start of the process is then treated and put to good used. Most of its recycled to agricultural land for farmers to generate energy. We do this in three ways:

- Combined: heat and power- this process treats the sludge using a process called “anaerobic digestion”. This is where the sludge is heated to encourage the bacteria to eat it. This creates biogas that we burn to create heat, which in turn creates electricity.
- Gas to grid: - we can also clean the biogas to higher standard (known bio methane) so that we can put into the national gas grid to power homes, businesses and schools.
- Thermal destruction: - this process involves drying the sludge into blocks called “cake” which are burned to generate heat. We capture this heat and turn into electricity.

7. Back to the river: now the wastewater is clean, it can be returned to local rivers and streams. In some areas, the water we put back into the river is very important as it helps to keep them healthy.

The quality of the cleaned wastewater is strictly regulated by the environment agency and we test it to make sure that it meets high-quality standards.

6.3.7 Importance of Water to Living Organism

Water is one of the main constituents on earth, two thirds of the earth is covers by water. Approximately 75% of human body is formed of water. Every form of life on the earth depends on water in one form or other for its subsistence. In human beings, water helps with transporting and replenishing nutrients it helps with cleansing the human body. Water bodies like seas, lakes and ponds are home to thousands of creature.

- 1) Living cell is 70% to 90% water.

- 2) Much of the environment of the earth is water based (about 75% of the earth is covered by water).
- 3) Water can exist in the three Phases (solid, liquid and gas) and can purify its self in the “water cycle”.
- 4) Water has a very high specific heat (it retains heat better than most other materials). This necessary for temperature regulation.
- 5) Water is the solvent (medium) for most of chemical reactions that support live.

6.4 Hard Water and Soft Water

Hard water contains significant quantity of dissolved minerals, such as calcium and magnesium. In general, hard water is not harmful for health. In fact, it may confer some benefits because it is rich in mineral and reduces the solubility of potentially toxic metals ions such as lead and copper. However, there are some industrial applications where water may lead to inefficiencies or damage to containers and pipes. In which instances, water soften methods are used. When water is softened, metal contains are exchanged for sodium ions.

6.4.1 Comparison of hard and soft water

Table (6.2): Comparison of Hard and Soft Water

	Hard water	Soft water
Contains minerals	Calcium and magnesium	Sodium
Reaction with soap	Film	Suds
Problems	Leaves deposit called “scale”	None
Removed by	Permuted process by exchange of ion	None

6.4.2 What Causes Hardness in Water?

A high concentration of multivalent cations (eg: charge great than 1+) leads to hardness in water. Calcium and magnesium (Ca^{2+} and Mg^{2+}) are the most common sources. Water usually collects these minerals from the ground as flows. Rain water and distilled water are soft water.

6.4.3 Temporary vs. permanent hardness of water

Hardness that cannot be removed by boiling the water is called permanent hardness. Temporary water hardness is called by the presence of bicarbonate minerals (calcium bicarbonate and magnesium bicarbonate). Boiling causes the formation of carbonates from bicarbonate and precipitates it out; leaving soft water upon cooling permanent water hardness is usually caused by chlorides or calcium and magnesium sulfate. Note that permanent hardness is not really permanent in that it can also be softened (just nit by boiling).

6.4.4 Hard Water Treatment

Hard water can be softened by reducing the concentration of calcium, magnesium and other minerals. Temporary hardness of water can be treated either by boiling it or by adding lime (calcium hydroxide). Permanent hardness of water can also be treated with ion exchange resins in which hardness ions (Ca, Mg, and other metallic cations) are exchanged for sodium ions. Chemicals such as (chelators) may also be used as water softeners. Citric acid is used in soap, shampoo and laundry detergents to soften water.

6.4.5 Advantages and disadvantages of hard and soft water

1. Hard Water:

Advantages:-

The dissolved compounds in hard water are good for health. Calcium compounds help:

- in the development of strong bones and teeth
- to reduce heart disease

Disadvantages:-

- Using hard water leads to the formation of deposits (scale) in heating systems. This can block pipes and can increase electricity costs.
- Using hard water leads to the formation of deposits (scale) in kettles.
- Using hard water can increase costs because more soap is needed.

2. Soft water

Advantages:-

- keeps water using/heating appliances clean and deposit free.
- Soap works better (suds up (soap forming) better, gentler washing cycles). Soft water

Disadvantages:

- often adds salt to environment
- can have slimy/soapy feeling even when completely rinsed
- not as good for you to drink (less minerals).
- Soft water contains more sodium ions than hard water does. Sodium is linked to heart disease.
- Soft water dissolves metals such as such as cadmium and lead from metal pipes.

6.4.6 Methods of Softening Water

Water can be softened in the following methods:

1) Distillation:

Distilling water gets rid of both sorts of hardness. The water is heated and boils off as steam, leaving any dissolved calcium and magnesium ions behind. The steam is condensed to pure water. Distilled water is the softest water available. Distillation is not used on a large scale because of the high fuel costs.

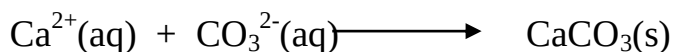
2) Boiling:

This removes temporary hardness. Calcium and magnesium hydrogen carbonates, which are soluble in water, decompose on heating to give the insoluble carbonates, which form a precipitate. The calcium and magnesium ions are, therefore, no longer in solution.



3) Adding Sodium Carbonate (Washing Soda):

When sodium carbonate is added to hard water, the carbonate ions in the washing soda combine with the calcium or magnesium ions in the hard water to form a precipitate of calcium or magnesium carbonate. The calcium and magnesium ions are, therefore, no longer in solution.



Bath salts consist mainly of sodium carbonate.

4) Ion-Exchange Resins:

Ion-exchange resins soften water by removing all calcium and magnesium ions. An ion-exchanger is a container full of small beads of ion-exchange resin, a special negatively-charged plastic which has positive ions weakly attached to it; typically the positive ions are sodium ions. When hard water flows through the ion-exchanger, the calcium and magnesium ions dissolved in it change places with the sodium ions and attach themselves to the resin. The sodium ions dissolve in the water.

After a time, when all the sodium ions from the resin have gone, no more hardness can be removed until the resin has been regenerated. To do this, a concentrated solution of sodium chloride (salt) is poured in. The sodium ions push the calcium and magnesium ions off the resin and replace them, making the resin ready for use again.

6.5 Water Pollution:

Water pollution takes place when undesirable substances are added into the water.

Sources of water pollution include:

- ❖ Industrial chemicals being disposed into water bodies like rivers, lakes and oceans.
- ❖ Discharging untreated /raw sewage into water bodies.
- ❖ Leaching of insecticides/herbicides from agricultural activities into water bodies.
- ❖ Discharging non-biodegradable detergents after domestic and industrial use into water bodies.
- ❖ Petroleum oil spilling by ships and oil refineries
- ❖ Toxic/poisonous gases from industries dissolving in rain.
- ❖ Acidic gases from industries dissolving in rain to form “acid rain”
- ❖ Discharging hot water into water bodies. This reduces the quantity of dissolved Oxygen in the water killing the aquatic fauna and flora.

6.5.1 Water Pollution Can Be Reduced By:

- Reducing the use of agricultural fertilizers and chemicals in agricultural activities
- Use of biological control method instead of insecticides and herbicides
- Using biodegradable detergents

6.6 Exercise:

1. Explain air and its uses?
2. What is the percentage of oxygen, nitrogen and carbon in the air?
3. What are the different ways that living things use air?
4. Explain air pollution?
5. Explain the sources of air pollution?

6. How to reduce air pollution?
7. Discuss the water cycle and how it completes?
8. What are the uses of water?
9. Discuss the sewage treatment process?
10. Explain the importance of water to living things?
11. What is hard water and soft water?
12. Compare the different between hard water and soft water?
13. What causes hardness in water?
14. What is the difference between temporary hardness and permanent hardness of water?
15. What are the advantages and disadvantages of hard and soft water?
16. Explain the methods of softening water?
17. What is water pollution?
18. How to prevent water pollution?

Revision

Question 1:

(a) Define the following terms:

I. A saturated solution.

II. Crystallization.

(b) (I). Describe how copper (II) Sulphur crystals can be obtained from copper (II) Sulphate solution

(II). Give two industrial applications of crystallization as a method of separating soluble substances from their solutions.

Answers 1:

(a)(i) A saturated solution is a solution that has maximum solute and that cannot dissolve any more solute at a given temperature.

(ii) Crystallization is the process of obtaining salt crystals from a saturated solution by cooling.

(b)(i) Evaporate the solution to dryness. Allow the saturated solution to cool to form crystals.

(ii) Extraction of salt from salty water

Extraction of sugar from sugar cane

Extraction of medicinal substances from plants

Question 2:

Ahmed, a form one student at Omar Samatar Secondary accidentally mixed sulphure and iron filings:

(a) Suggest an appropriate method of separation you would advise him to use to separate the mixture.

(b) Give a reason for the choice of your answer.

(c) Describe how he would use the method named in 5(a) above to separate the sulphur and iron filings.

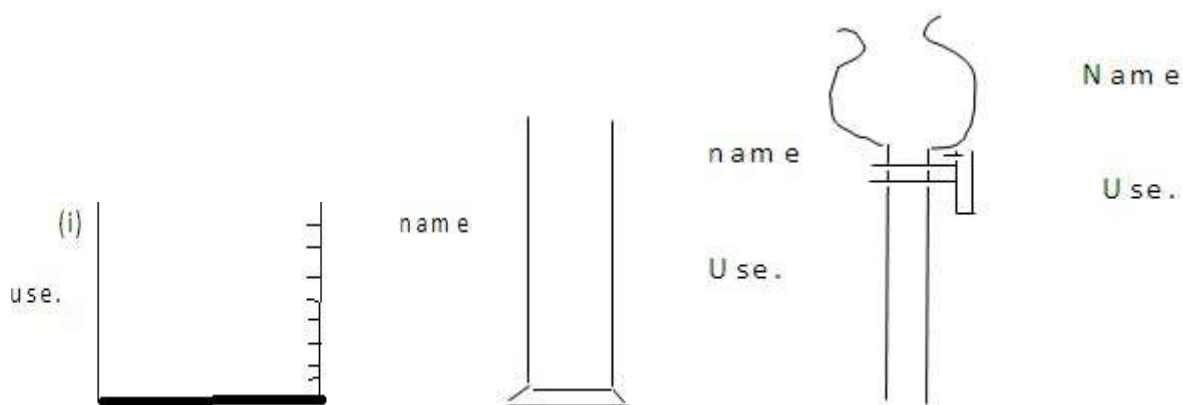
- (d) Name two substances that sublime when heated.
- (e) Give two reasons why dry ice (solid carbon (IV) oxide) is preferred to be used in cold boxes by ice cream vendors over ordinary ice.

Answers 2:

- (a) Use of a magnet.
- (b) Iron filings are magnetic while sulphur is not.
- (c) Spread the mixture on a plain cardboard. Pass the magnet through the mixture.
Iron filings are attracted to the magnet and are removed while sulphur is left on the cardboard
- (d) anhydrous iron (iii) chloride, aluminium chloride, benzoic acid, carbon (iv) oxide (dry ice), iodine
- (e) - it sublimates leaving no wetness
- it is a better coolant compared to ordinary ice

Question 3

- (a) The following are laboratory apparatus used in Chemistry. Name them and give their uses.



- (b) Give two reasons why most laboratory apparatus are made of glass.

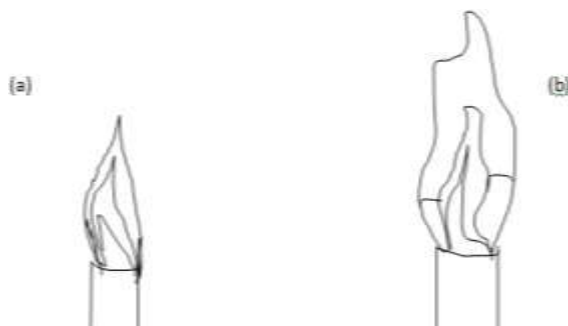
Answers 3:

- (a)
- (i) Beaker: used to measure approximate volumes of liquids.

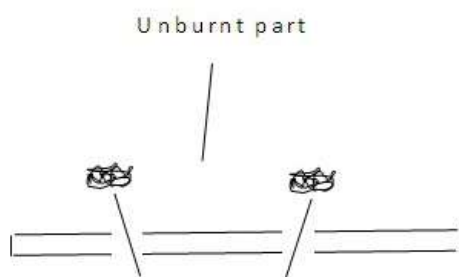
- (ii) Gas jar: used for gas collection.
 - (iii) Dropping funnel: Used to add controlled amounts of liquids into reaction vessels.
- (b) To allow easy observation as the experiment progresses transparent glasses do not easily react with chemicals.

Question 4

- (i) What is a flame?
- (ii) The following diagrams represent the two types of flames produced by a Bunsen burner.



- (a) Identify the flames (a) and (b).
- (b) Which type of the flames identified above is preferred for heating? Give a reason for your answer.
- (c) Give four differences between the flames (a) and (b) above.
- (d) (i). Give two reasons why flames (a) and (b) in 4(ii) above differ.
- (ii) A wooden splint was slipped through a region of a particular flame of the Bunsen burner in the laboratory. The splint was burnt as shown in the diagram below.



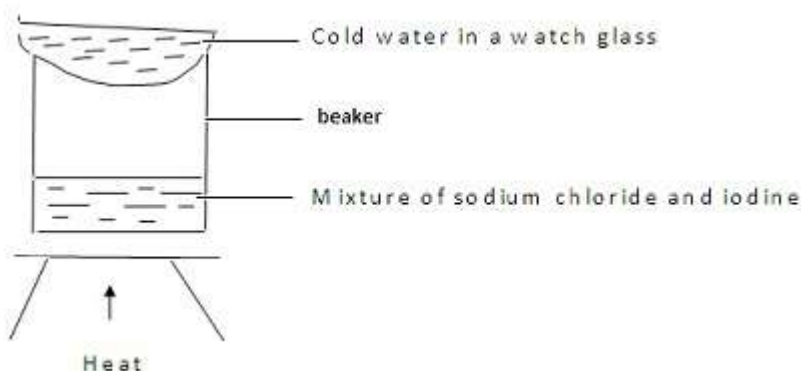
- (a) Name the type of flame the splint was slipped through.
- (b) Explain why the splint was burnt the way it is shown in the diagram.
- (iii) After use, the non-luminous flame should be put off or adjusted to luminous flame. Explain.
- (iv) Putting off flames is one of the laboratory safety rules. State four other rules.

Answers 4:

- (i) A flame is a mass of burning gases.
- (ii)(a) a- non-luminous flame
b-luminous flame.
- (b) a- non-luminous flame. Produces much heat.
- (c) Table Empty
- (d) (i) a-non-luminous flame is produced when the air hole is open while the luminous flame (b) is produced when the air hole is closed.
- (ii)(a) Non luminous flame.
- (b) The inner part has unburnt gases hence not hot while the outer part has completely burnt gases and is therefore hotter.
- (iii)- To preserve the gases, to avoid fire accidents because non-luminous flame is not easy to see.
- (iv) chemicals already used should be disposed of immediately to avoid contamination, if a chemical gets into your skin or mouth, rinse it immediately with a lot of clean water, always extinguish flames that are not in use to avoid accidents and to minimize fuel wastage, never taste or eat anything in the laboratory to avoid poisoning, label all the chemicals you are using to avoid confusion.(accept any correct)

Question 5:

Zakariye, a form one student at Omar Samatar Secondary School wanted to separate and obtain iodine and sodium chloride (common table salt) from a mixture of the two. he set the experimental set up shown below.



(a) The mixture was heated for some time and left to cool. On cooling, shiny black crystals and white crystals were observed on the surface of the watch glass and in the beaker respectively. Name:

I. Shiny black crystals

II. White crystals

(b) what was the purpose of the cold water in the watch glass?

(c) Explain how the shiny black crystals on the surface of the watch glass are formed.

(d) What property of iodine makes it be collected on the watch glass as shown?

(e) Explain why it is possible to separate a mixture of iodine and sodium chloride.

Answers 5:

(a)(i) - shiny-black crystals are iodine crystals

(ii) white crystals are sodium chloride solid

(b) To cool and condense the iodine vapour to form iodine solid.

(c) When the mixture is heated, iodine sublimes into purple vapour. On reaching

the surface of the watch glass, it is cooled and condensed into shiny black crystals of iodine

(d) Iodine sublimes when heated

(e) Iodine sublimes while sodium chloride does not.

Question 6:

(i). Define Chemistry.

(ii) Give three importance of studying Chemistry.

Answers 6:

(i). Chemistry is the study of the structure, properties and compositions of matter and the changes that matter undergoes.

(ii). The knowledge of Chemistry helps in the following fields:

-manufacture of drugs, food production, manufacture of cheaper fabrics such as nylon, manufacture of plastics such as PVC, manufacture of detergents, production of fuels for transport and domestic use.

Question 7:

(a) What is a mixture?

(b) State two Physical means of separating a mixture?

Answers 7:

(a) A mixture is a Physical combination of two or more substances which can be separated by Physical means

(b) Winnowing, sieving, filtering, Evaporating, decanting, use of magnets.

Multiple Choices:

- 1) Separating a solid from a liquid by evaporating the liquid is called ____.
a. Filtration
b. Condensation
c. Solution
d. Distillation
- 2) A substance that can be separated into two or more substances only by a chemical change is a(n) ____.
a. Solution
b. Element
c. Mixture
d. Compound
- 3) The chemical symbol for iron is ____.
a. Fe
b. *FE*
c. **Fe**
d. Ir
- 4) Which of the following is a chemical property?
a. Color
b. Hardness
c. freezing point
d. ability to react with oxygen
- 5) Which of the following is NOT a Physical change?
a. grating cheese
b. melting cheese
c. **fermenting of cheese**
d. mixing two cheeses in a bowl
- 6) Which of the following does NOT involve a Physical change?
a. Mixing
b. Melting
c. Grinding
d. Decomposing
- 7) A chemical change occurs when a piece of wood ____.
a. is split
b. **is painted**
c. **Decays**
d. is cut
- 8) The atomic number of an element is the total number of which particles in the nucleus?
a. Neutrons
c. Electrons

- b. **Protons** d. protons and electrons
- 9) The sum of the protons and neutrons in an atom equals the ____.
- a. atomic number c. atomic mass
- b. nucleus number d. **mass number**
- 10) All atoms of the same element have the same ____.
- a. number of neutrons c. mass numbers
- b. **number of protons** d. Mass
- 11) How does the energy of an electron change when the electron moves closer to the nucleus?
- a. **It decreases.** c. It stays the same.
- b. It increases. d. It doubles.
- 12) The smallest particle of an element that retains the properties of that element is a(n) ____.
- a. **Atom** c. Proton
- b. Electron d. Neutron
- 13) The particles that are found in the nucleus of an atom are ____.
- a. neutrons and electrons c. **protons and neutrons**
- b. electrons only d. protons and electrons
- 14) The nucleus of an atom is ____.
- a. **the central core and is composed of protons and neutrons**
- b. positively charged and has more protons than neutrons
- c. negatively charged and has a high density
- d. negatively charged and has a low density
- 15) All of the following are Physical properties of matter EXCEPT ____.
- a. Mass c. melting point
- b. Color d. **ability to rust**

16) Which state of matter has a definite volume and takes the shape of its container?

- a. Solid
- c. Gas
- b. Liquid**
- d. both b and c

Short Answer Questions:

1. What is the first element on the periodic table? (*Answer Hydrogen*)
2. What is the center of an atom called? (*Answer a nucleus*)
3. True or false? Acids have a PH level below 7. (*Answer True*)
4. What is the main gas found in the air we breathe? (*Answer Nitrogen (around 78%)*)
5. True or false? An electron carries a positive charge. (*Answer False*)
6. Famous New Zealand scientist Ernest Rutherford was awarded a Nobel Prize in which field? (*Answer Chemistry*)
7. What is the chemical symbol for gold? (*Answer Au*)
8. K is the chemical symbol for which element? (*Answer Potassium*)
9. What orbits the nucleus of an atom? (*Answer Electrons*)
10. At room temperature, what is the only metal that is in liquid form? (*Answer Mercury*)
11. True or false? A neutron has no net electric charge. (*Answer True*)
12. A nuclear reaction where the nucleus of an atom splits into smaller parts is known as nuclear fission or nuclear fusion? (*Answer Nuclear fission*)
13. What is H_2O more commonly known as? (*Answer Water*)
14. What is the third most common gas found in the air we breathe? (*Answer Argon (around 1%)*)
15. What is the name given to substances that are initially involved in a chemical reaction? (*Answer Reactants*)

16. True or false? Bases have a PH level below 7. (**Answer False**)
17. Is sodium hydroxide (NaOH) an acid or base? (**Answer Base**)
18. Atoms of the same chemical element that have different atomic mass are known as? (**Answer Isotopes**)
19. True or false? A proton carries a positive charge. (**Answer True**)
20. What is the fourth most abundant element in the universe in terms of mass? (**Answer Carbon**)

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