We can tabulate the types of chemical substances and their effects.

Sl.no	Type of pollution	Chemical substances responsible for the pollution	Effects
1	Air pollution	Carbon di oxide, Carbon monoxide, oxides of sulphur, oxides of nitrogen, Chlorofluorocarbons, methane etc	Acid rain, Global warming, respiratory problems etc.
2	Water pollution	Waste water containing chemical substances (e.g dyeing industries), detergents, oil spillage etc	Decrease in quality of water, skin diseases etc
3	Land pollution	Fertilizers like urea, various pesticides, herbicides etc.	Spoilage of land, cancer, respiratory diseases etc.

b) What happens to the steel benches and tables during rainy season? They turn into reddish brown. Isn't it?

Do you know why? This is because the iron metal comes into contact with water and oxygen, it undergoes a chemical reaction called RUSTING.

Fig 5.6 Rusted iron barrels and chairs

c) Tarnishing of metal articles: Shiny metal surfaces and other articles lose their shining appearance due to chemical reactions on the surface. For example, silver articles become black on exposure to atmospheric air. Similarly, brass vessels which contain copper as one of constituents develop a greenish layer on exposure to air for a long time. This is due to a chemical reaction between copper and moist air to form basic copper carbonate and copper hydroxide.

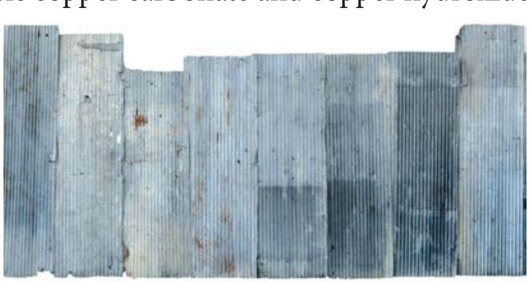


Fig 5.7 Damaged iron sheets

5.7.3 Production of heat, light, sound and pressure

a) Production of heat:

Have you ever rubbed your palms in winter season to keep yourself warm? Have you noticed the heat produced when you use cycle pump? Chemical reactions also produce heat energy. Such reactions are called **EXOTHERMIC REACTIONS**. For example when you add water to quicklime (Calcium oxide), lot of heat is released to produce slaked lime (Calcium hydroxide).

Activity 4

Take two clean test tubes. Take sulphuric acid in one test tube and a solution of sodium hydroxide in another tube. Slowly add sodium hydroxide solution to sulphuric acid carefully. Touch the sides of test tube. What do you feel? What do you infer?

Thus we conclude that some chemical reactions produce heat energy.

b) Production of light:

What happens when you ignite a candle? You get light as a result of burning. Some chemical reactions like these produce light. For example when a piece of magnesium ribbon is burnt in a flame, bright light is produced with heat. Even the fireworks during festival times produce different coloured lights which are all due to chemical reactions. Similarly when we ignite methane gas, it produce heat and light.

So, we can say that light is produced during the chemical reactions .

c) Production of sound:

We produce sound when we speak. When you hit metals like iron, copper etc sound is heard. Some chemical reactions do produce sound when they take place. What happens when you fire cracker during Deepavali? The chemical substances kept in the crackers undergo some chemical reactions to produce sound.

So, sound will be produced in certain chemical reactions.

Activity 5

Take a clean test tube. Add some dilute hydrochloric acid. Drop a piece of magnesium or a piece of zinc metal. What do you see? Now bring a burning matchstick near the mouth of the test tube.

What do you hear? Anything special? What do you infer?

You heard a POP SOUND. Isn't it? When a metal like zinc or magnesium reacts with diluted acids hydrogen gas is produced. Since hydrogen gas is highly flammable it reacts with oxygen in air to produce POP sound.

d) Production of pressure:

What happens when you compress hard a balloon having full of air? Will it burst or not?

Yes, it will burst. This is due to sudden release of air from the balloon as a result of increased pressure on compression. Like this some chemical reactions produce gases which build up the pressure when the reaction takes place in a closed container. If the pressure level goes beyond the limit, we get the explosion. Explosives, fireworks work on this basis. When they are ignited they explode due to pressure generated by gases from the chemical reactions. Thus you hear a huge sound.

So, we conclude that pressure can be generated by certain chemical reactions.

5.7.4 Evolution of Gas, Change in Colour and Change in State

In addition to above effects certain other effects may also take place as a result of chemical reactions.

a) Evolution of gas:

What happens when you open a soda bottle? You can see air bubbles coming out of soda water. Similarly gas evolution may take place as a result of chemical reactions. For example

when dilute hydrochloric acid is added to a solution of sodium carbonate or sodium bicarbonate carbon dioxide gas is evolved.

b) Change in colour:

What happens when you play under hot sun for a long time? Your skin becomes dark. Right?

Like this certain chemical changes produce change in colour. For example when you place a iron nail in a solution of copper sulphate, the blue colour of copper sulphate slowly changes into green due to chemical reaction between iron copper sulphate solution.

c) Change in state:

Take a small ice cube and place it on a plate. What happens after some time? Ice melts into water. Isn't it? Here solid ice cubes change into liquid water. Like this in certain chemical reaction change of state is observed. For example when you burn a piece of camphor, smoke comes out as result of chemical reaction between solid camphor and oxygen. Here, there is a change of state from solid to gas.

Points to remember

- A chemical change is a permanent, irreversible change and produces a new substance.
- In a chemical reaction reactant/reactants give product/products.

- A chemical reaction may take place via physical contact in solid state, solution of reactants, electricity, heat, light and catalyst.
- Rusting is a chemical reaction in which iron objects form hydrated ferric oxide in presence of oxygen and water.
- Electrolysis is a process in which electricity is used to carry out chemical reactions.
- Photolysis is a process in which light is used to carry out chemical reactions.
- Thermolysis is a process in which heat is used to bring about chemical reactions.
- Chemical substance used to alters the speed of the reaction is called catalyst and the process is called catalysis.
- Chemical reactions cause spoilage of food, vegetables and fruits, acid rain, green house effect and damage to materials.
- Global warming is a dangerous condition in which earth's average temperature rises alarmingly due to various human activities.
- Rancidity is a condition in which the food items develop bad odour due to chemical reactions by microbes.

A-Z GLOSSARY

Irreversible	No reverse action
Reactant	Reacting substance in a chemical reaction
Product	Newly formed substance in a chemical reaction
Catalyst	Substance that alters the speed of a chemical reaction
Combustion	Burning with oxygen in air
Rusting	Corrosion of iron objects
Rust	Hydrated iron oxide (ferric oxide)
Precipitate	A new insoluble substance formed in a chemical reaction
Moist Air	Air having water
Decompose	Dissociate/split/broken down
Thermal Decomposition	Dissociation/splitting by heat
Quicklime	Calcium oxide
Ozone	a form of oxygen having three oxygen atoms
Stratosphere	The second layer of atmosphere
Yeast	A kind of single celled fungus
Fertilizer	Artificial manure/ chemically synthesized manure
Spoilage	Deterioration of food items
Rancidity	A chemical change involving food items to produce bad odour
Polyunsaturated Fatty Acids	A long chain carbon based acids present in fats
Oxidation	Addition of oxygen
Splitting Of Fats	Breaking of fats into acid and glycerol
Enzyme	Catalyzing substance in a biological system
Biochemical Reaction	Chemical reaction involving biological substances
Pigments	Colour giving substance/ colourants
Phenomenon	Happening
Acidic	Having acid character
Global Warming	Rise in earth's average temperature
Fossil Fuel	Fuels like coal, petrol obtained from plants and animals once lived and buried beneath the earth
Tarnishing	Losing shine
Lustre	Shine

TEXT BOOK EXERCISE

G8BM4E

I. Multiple choice questions.

1. Burning of paper is a______ change.
   a) Physical b) chemical
   c) physical & chemical d) neutral
2. The burning of matchstick is an example for chemical reaction based on______
   a) Contact b) electricity
   c) light d) catalyst
3. ______ metal undergoes rusting.
   a) tin b) sodium
   c) copper d) iron
4. The pigment responsible for browning of apples is______.
   a) Hydrated iron (II) oxide
   b) melanin
   c) starch
   d) ozone
5. Brine is a concentrated solution of ______.
   a) Sodium sulphate
   b) sodium chloride
   c) calcium chloride
   d) sodium bromide
6) Limestone contains ______ mainly.
   a) Calcium chloride
   b) calcium carbonate
   c) calcium nitrate
   d) calcium sulphate
7. Which of the following factor induces electrtolysis?
   a) Heat b) light
   c) electricity d) catalysis
8. In Haber's process of producing ammonia ______ is used as a catalyst.
   a) Nitrogen b) hydrogen
   c) iron d) nickel
9. Dissolved gases like sulphur dioxide, nitrogen oxides in rain water causes______
   a) Acid rain b) base rain
   c) heavy rain d) neutral rain
10. ______ is responsible for Global warming.
   a) Carbon di oxide b) methane
   c) chlorofluoro carbons d) all the above

II. Fill in the blanks.

1. Reactants → ______.
2. Photosynthesis is a chemical reaction that takes place in presence of ______.
3. Iron objects undergo rusting when exposed to ______ and ______.
4. ______ is the basic material to manufacture urea.
5. Electrolysis of Brine solution gives ______ gases.
6. ______ is a chemical substance which alters the speed of a chemical reaction.
7. ______ is the enzyme responsible for browning of vegetables, fruits.

III. Write TRUE OR FALSE for the following.

1. A chemical reaction is a temporary reaction.
2. Change in colour may take place during a chemical reaction.

3. Formation of slaked lime from quicklime is a endothermic reaction.
4. CFC is a pollutant.
5. Browning of some vegetables and fruits is due to tannin formation.

IV. Match the following:

A	B
1. Rusting	a) photosynthesis
2. Electrolysis	b) Haber's process
3. Thermolysis	c) Iron
4. food	d) Brine
5. Catalysis	e) Decomposition of limestone

A	B
1. Rancidity	a) Decomposition
2. Ozone	b) biocatalyst
3. Tarnishing	c) oxygen
4. Yeast	d) chemical reaction
5. Calcium Oxide	e) fish

V. Give Short Answers For The Following Questions.

1. Define a chemical reaction.
2. Mention the various conditions required for a chemical reaction to occur
3. Define catalysis.
4. What happens when an iron nail is placed in copper sulphate solution?
5. What is pollution?
6. What is Tarnishing? Give an example.
7. What happens to the brine during electrolysis?
8. On heating, calcium carbonate gives calcium oxide and oxygen. Is it exothermic reaction or endothermic reaction?
9. What is the role of a catalyst in a chemical reaction?
10. Why photosynthesis is a chemical reaction?

HOT QUESTIONS

1. Explain the role of yeast in making cakes?
2. Justify the statement. Burning of fossil fuels is responsible for global warming.
3. Discuss acid rain occurs due to emission of smoke from vehicles and industries?
4. Is rusting good for Iron materials? Explain.
5. Do all the fruits and vegetables undergo browning? Explain.
6. Classify the following day to day activities based on chemical reactions by physical contact, solutions of reactants, heat, light, electricity and catalyst.
   a) burning of crackers during festivals
   b) addition of water to quicklime to make it slaked lime
   c) silver ornaments become black on exposure to air for a longtime
   d) copper vessel kept in open air for long time

VI. Answer In Detail

1. Explain how food items are spoilt due to chemical reactions?
2. Explain the three types of pollution.
3. Explain any three conditions that is required for a chemical reaction to take place by citing one example each.

VII. Value Based Questions

1. Kumar is going to build a house. To purchase the iron rods required for construction, he visited an Iron& steel shop nearby. The seller showed him some Iron rods which are fresh and good. He also showed him little older Iron rods which are brownish in appearance. The price of fresh rods are costlier than the older ones, the seller also gave some offer to older ones. Kumar's friend Ramesh advised him not to buy the cheaper rods.

a) Is Ramesh right in his suggestion?

b) Could you explain the reason for his suggestion?

c) What are the values shown by Ramesh?

2. Palanikumar is a Lawyer. He lives in a costly flat. Due to high rent, he wants to shift his residence to a place where he has a chemical industry nearby. There the rent is very cheap and the area is less populated also. Rajasekar, his son studying VIII does not like this and likes to go to some other place.

   a) Is Rajasekar right in his attitude?

   b) Why did he refuse to go there?

   c) What are the values shown by Rajasekar?

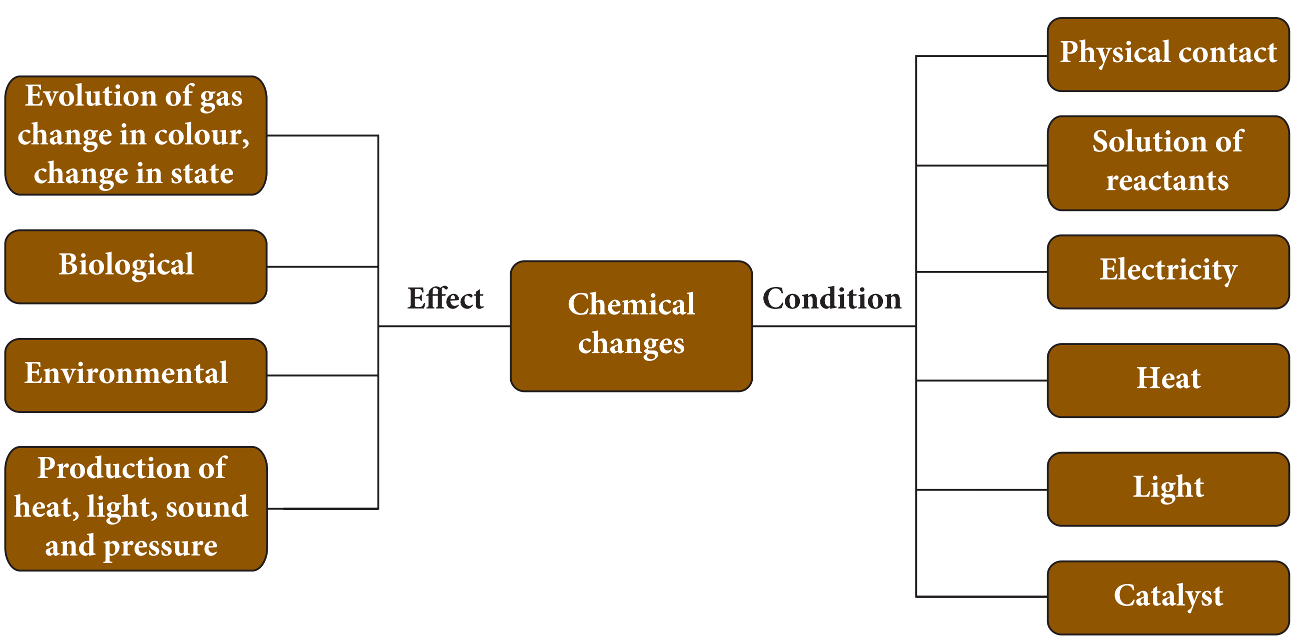
REFERENCE BOOKS

1. Chemistry for degree students by Dr.R.L MADAN,S.Chand publications.
2. NCERT science textbook for class VIII, December 2017 edition.
3. Chemistry for middle class-8 by R.Rana Noms ,S.Chand publications,2017 edition.
4. NewTrends in ICSE Chemistry by Baljinder Kaur,2017 edition.
5. ICSE conscise chemistry,part1,class IX, Selina.
6. Basic chemistry by Karen C.Timberlake and William Timberlake
7. Pradeep's objective chemistry vol-1 by S.N. Dhawan,S.C.Kheterpal,J.R. Mehta
8. Science book for Tenth class chemistry Part-2 by Lakhmir Singh.

INTERNET RESOURCES

1. https://www.livescience.com
2. https://hemantmore.org.in/foundation/science/chemistry/chemical reactions/6927
3. https://en.wikipedia.org/wiki/chemical reaction
4. www.ncert.nic.in/ncerts/l/jesc101.pdf
5. www.khanacademy.org/science/chemistry/chemical reactions
6. http://en.wikipedia.org/wiki/freon

Mind Map



UNIT 3

AIR

Learning Objectives

A4P1Y8

After completing this lesson students will be able to:

- know about the occurence and composition of oxygen, nitrogen and carbon dioxide in the atmosphere.
- understand the properties and uses of oxygen, nitrogen and carbon dioxide.
- understand nitrogen fixation.
- identify the causes of Green house effect, Global warming and Acid rain.
- suggest remedial measures for the prevention and control of these effects.

Introduction

Air is a mixture of gases that surrounds our planet earth. It is essential for the survival of all the living things. Air contains 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.04% carbon dioxide and small amount of other gases. We breath in oxygen and breath out carbon dioxide. Plants in turn use carbon dioxde for photosynthesis and release oxygen into the atmosphere. Since men have been cutting down trees for their needs, the amount of carbon dioxide in the atmosphere is increasing. This is responsible for the raising of atmospheric temperature. Industries and vehicles release gases like carbon monoxide and sulpher dioxide into the atmosphere. This has resulted in effects like global warming and acid rain which affect us in many ways. In total, the quality of air is gone in the modern days. In this lesson we are going to study about the effects like green house effect, global warming and acid rain. We will also study about occurrence and properties of the gases oxygen, nitrogen and carbon dioxide.

3.1 Oxygen

All living things in the world need oxygen. We cannot imagine the world without oxygen. Swedish chemist C.W. Scheele first discovered oxygen in 1772. He called the gas **fire air** or **vital life** because it was found to support the process of burning. It was independently discovered by the British scientist Joseph Priestley in 1774. Lavoisier named oxygen. The name oxygen comes from the Greek word 'oxygenes' which means 'acid producer'. It is called so because early chemists thought that oxygen is necessary for all acids.

3.1.1 Occurrence of Oxygen

Oxygen is the most abundant element on the earth by mass and the third most abundant element after Hydrogen and Helium in the universe. It occurs both in free state and combined state. It is present in free state as dioxygen molecule (O_2) in the atmosphere. Most of this has been produced by the process photosynthesis in which the chlorophyll present in the leaves of plants uses solar energy to produce glucose.

Table 3.1 Percentage of Oxygen

Oxygen in free state		Oxygen in combined state	
Source	**Percentage**	**Source**	**Percentage**
Atmospheric air	21 %	Plants and animals	60 – 70 %
Water	88 – 90 %	Minerals in the form of silicates, carbonates and oxides	45 – 50 %

$$6CO_2 + 6H_2O + \text{Energy from the Sun} \longrightarrow C_6H_{12}O_6 + 6O_2$$

In combined state it is present in the earth's crust as silicates and metal oxides. It is also found in the water on the surface of the earth. Tri oxygen molecule (O_3) known as ozone is present in the upper layers of the atmosphere.

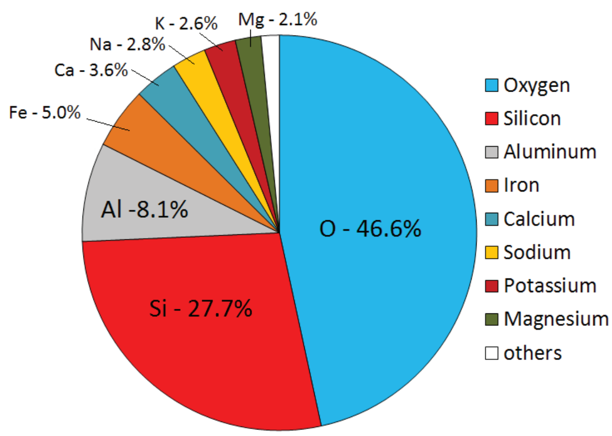


Figure 3.1 Percentage of elements in the Earth's crust

3.1.2 Physical properties of Oxygen

- Oxygen is a colourless, odourless and tasteless gas.
- It is a poor conductor of heat and electricity
- Oxygen dissolves readily in cold water.

DO YOU KNOW? Oxygen is about two times more soluble in water than nitrogen. If it had the same solubility as nitrogen, then less oxygen would be present in seas, lakes and rivers that will make life much more difficult for living organisms.

- It is denser than air.
- It can be made into liquid (liquified) at high pressure and low temperature.
- It supports combustion.

3.1.3 Chemical properties of Oxygen

1. Combustibility

Oxygen is a non-combustible gas as it does not burn on its own. It supports the combustion of other substances.

DO YOU KNOW? If oxygen has the capacity to burn itself, striking a match stick will be enough to burn all the oxygen in our planet's atmosphere.

2. Reaction with metals

Oxygen reacts with metals like sodium, potassium, magnesium, aluminium, iron etc., to form their corresponding metal oxides which are generally basic in nature. But the metals differ in their reactivity towards oxygen.

$$\text{Metal} + \text{Oxygen} \longrightarrow \text{Metal oxide}$$

Example

$$\underset{\text{Sodium}}{4Na} + \underset{\text{Oxygen}}{O_2} \longrightarrow \underset{\text{Sodium oxide}}{2Na_2O}$$

Activity 1

Heat a strip of magnesium ribbon in the flame till it catches fire and introduce it into the jar containing oxygen. It burns with a dazzling bright light and white ash of magnesium oxide is formed.

Table 3.2 Reactivity of Oxygen with metals

Metal	Condition	Product formed
K	Room temperature	Potassium Oxide (K_2O)
Mg	Heating slightly	Magnesium Oxide (MgO)
Ca	Heating slightly	Calcium Oxide (CaO)
Fe Cu Ag	High temperature	Iron Oxide (Fe_3O_4) Cupric Oxide (CuO) Silver Oxide (Ag_2O)
Au Pt	Even at high temperature	No action

3. Reaction with non metals

Oxygen reacts with various non-metals like hydrogen, nitrogen, carbon, sulphur, phosphorus etc., to give corresponding non metallic oxides which are generally acidic in nature.

Non-metal + Oxygen $\longrightarrow$ Non-metallic oxide

Example

$$\underset{\text{Carbon}}{C} + \underset{\text{Oxygen}}{O_2} \longrightarrow \underset{\text{Carbon dioxide}}{CO_2}$$

Table 3.3 Reactivity of Oxygen with non metals

Non metal	Products formed
C	Carbon dioxide (CO_2)
N	Nitric oxide (NO)
S	Sulphur dioxide (SO_2)
P	Phosphorus trioxide (P_2O_3) or Phosphorus pentoxide (P_2O_5)

Activity 2

Heat a small piece of phosphorous and introduce it into the oxygen jar. Phosphorous burns with suffocating smell and gives phosphorous pentaoxide (white fumes).

4. Reaction with Hydrocarbons

Hydrocarbons (compound containing C and H) react with oxygen to form carbon dioxide and water vapour. E.g. Wood, Petrol, Diesel, LPG, etc. When they burn in oxygen, they produce heat and light energy. Hence they serve as fuel.

$$\text{Hydrocarbon} + O_2 \longrightarrow CO_2 + \underset{\text{vapour}}{\text{Water}} + \underset{\text{energy}}{\text{Heat}} + \text{Light}$$

5. Rusting

The process of conversion of iron into its hydrated form of oxide in the presence of air and moisture (humid atmosphere) is called rusting. Rust is hydrated ferric oxide.

$$4Fe + 3O_2 \longrightarrow 2Fe_2O_3$$
$$Fe_2O_3 + X\,H_2O \longrightarrow \underset{\text{(rust)}}{Fe_2O_3 \cdot X\,H_2O}$$

(X = Number of water molecules which is variable)

3.1.4 Uses of Oxygen

- It is used as oxy-acetylene light for cutting and welding metals.
- It is used to remove carbon impurities from steel.

Figure 3.2 Uses of Oxygen

- Plants and animals use oxygen from the air for respiration.
- It is used to oxidize rocket fuel.
- It is used for artificial respiration by scuba divers, mountaineers, astronauts, patients etc.
- Mixed with powdered charcoal it is used as explosives.
- It is used in the synthesis of methanol and ammonia.

3.2 Nitrogen

Nitrogen is one of the most important elements. Animals and plants need nitrogen for their growth. All living organisms (including us) contain nitrogen. It is an essential element present in proteins and nucleic acids which are the 'building blocks' of all living things. It was first isolated from the air by Swedish chemist Carl Wilhelm Scheele in 1772. The name 'nitrogen' is derived from the Greek words 'nitron' and 'gene' meaning 'I produce nitre'. Nitre is potassium nitrate compound of nitrogen. Antoine Lavoisier suggested the name *azote*, from the Greek word meaning 'no life'.

3.2.1 Occurrence of Nitrogen

Nitrogen is the fourth most abundant element in the human body by mass. It accounts for about three percent of the mass of the human body. It is thought to be the seventh most abundant element in the universe by mass. Titan, the largest moon of Saturn, has an atmosphere made up of 98% Nitrogen. Nitrogen occurs both in free state and combined state. Nitrogen exists in free state in the atmospheric air as dinitrogen (N_2). It is present in volcanic gases and gases evolved by burning of coal. Nitrogen is present in combined state in the form of minerals like nitre (KNO_3) and chile salt petre ($NaNO_3$). It is present in organic matters such as protein, enzymes, nucleic acid etc.

3.2.2 Physical properties of Nitrogen

- It is a colourless, tasteless and odourless gas.
- It is slightly lighter than air.
- It is slightly soluble in water.
- Nitrogen becomes a liquid at low temperature and looks like water.
- When it freezes, it becomes a white solid.
- It is neutral to litmus like oxygen.

3.2.3 Chemical properties of Nitrogen

1. Chemical reactivity

Nitrogen is inactive at ordinary conditions. It combines with many elements at high temperature and pressure or in the presence of catalyst.

2. Combustibility

Nitrogen is neither combustible nor a supporter of combustion. So nitrogen in the air moderates the rate of combustion.

3. Reaction with metals

Nitrogen reacts with metals like lithium, calcium, magnesium etc., at high temperature to form their corresponding metal nitrides.

$$\text{Metal} + \text{Nitrogen} \xrightarrow{\Delta} \text{Metal nitride}$$

Example

$$\underset{\text{Calcium}}{3Ca} + \underset{\text{Nitrogen}}{N_2} \xrightarrow{\Delta} \underset{\text{Calcium nitride}}{Ca_3N_2}$$

4. Reaction with non metals

Nitrogen reacts with non-metals like hydrogen, oxygen etc., at high temperature to form their corresponding nitrogen compounds.

$$\text{Non-metal} + \text{Nitrogen} \xrightarrow{\Delta} \text{Nitrogen compound}$$

Example

$$\underset{\text{Hydrogen}}{3H_2} + \underset{\text{Nitrogen}}{N_2} \xrightarrow{\Delta} \underset{\text{Ammonia}}{2NH_3}$$

3.2.4 Uses of Nitrogen

- Liquid nitrogen is used as a refrigerant.
- It provides an inert atmosphere for conducting certain chemical reactions.
- It is used to prepare ammonia (by Haber's process) which is then converted into fertilizers and nitric acid.
- It is used for inflating tyres of vehicles.
- It is used for filling the space above mercury in high temperature thermometer to reduce the evaporation of mercury.
- Many explosives such as TNT (Trinitrotoluene), nitroglycerin, and gun powder contain nitrogen.
- It is used for the preservation of fresh foods, manufacturing of stainless steel, reducing fire hazards, and as part of the gas in incandescent light bulbs.

DO YOU KNOW?

Now a days nitrogen is used as a substitute for compressed air in tyres. Have you noticed it? Why do people prefer nitrogen instead of compressed air in tyres?

Figure 3.3 Uses of Nitrogen

3.2.5 Nitrogen fixation

Nitrogen gets circulated in the air, soil and living things as the element itself or in the form of its compounds. Just as there is a circulation of carbon in nature so also there is a circulation of nitrogen. It is essential for the proper growth of all plants. The plants cannot make use of the elemental nitrogen from the air as such. The plants require soluble compounds of nitrogen. Thus, plants depend on other processes to supply them with nitrates. Any process that converts nitrogen in the air into a useful nitrogen compound is called nitrogen fixation. Fixation of nitrogen is carried out both naturally and by man.

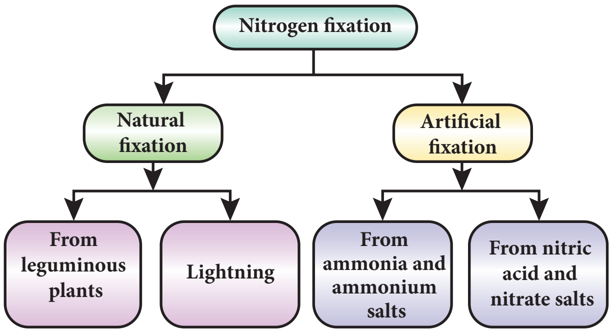


Figure 3.4 Nitrogen fixation in plants

3.3 Carbon dioxide

Carbon dioxide is a chemical compound in which one carbon and two oxygen atoms are bonded together. It is a gas at room temperature. It is represented by the formula CO_2. It is found in the earth's atmosphere and it sends back the solar energy which is reflected by the surface of the earth, to make it possible for living organisms to survive. When carbon dioxide accumulates more in the atmosphere it produces harmful effects.

3.3.1 Occurrence of Carbon dioxide

Carbon dioxide is present in air to the extent of about 0.03% in volume. It is evolved by the plants and animals during respiration and is produced during fermentation reactions. Much of the naturally occurring CO_2 is emitted from the magma through volcanoes. CO_2 may also originate from the bio degradation of oil and gases. Human CO_2 emissions upset the natural balance of the carbon cycle. Man-made CO_2 in the atmosphere has increased global temperatures which is warming the planet. While CO_2 derived from fossil-fuel is a very small component of the global carbon cycle, the extra CO_2 is cumulative because the natural carbon exchange cannot absorb all the additional CO_2.

3.3.2 Physical properties of Carbon dioxide

- Carbon dioxide is a colourless and odourless gas.
- It is heavier than air.
- It does not support combustion.
- It is fairly soluble in water and turns blue litmus slightly red. So it is acidic in nature.
- It can easily be liquified under high pressure and can also be solidified. This solid form of CO_2 is called dry ice which undergoes sublimation.

DO YOU KNOW?

The process of conversion of solid into vapour without reaching liquid state is called sublimation.

3.3.3 Chemical properties of Carbon dioxide

1. Combustibility

It is non-combustible and not a supporter of combustion.

2. Reaction with metals

Lighter metals like sodium, potassium and calcium, combine with CO_2 to form corresponding carbonates whereas magnesium gives its oxide and carbon.

Example

$$\underset{\text{Sodium}}{4Na} + 3CO_2 \longrightarrow \underset{\text{Sodium carbonate}}{2Na_2CO_3} + C$$

$$\underset{\text{Magnesium}}{2Mg} + CO_2 \longrightarrow \underset{\text{Magnesium oxide}}{2MgO} + C$$

3. Reaction with sodium hydroxide (Alkali)

Sodium hydroxide (base) is neutralized by carbon dioxide (acidic) to form sodium carbonate (salt) and water.

$$\text{Base} + \text{Acid} \longrightarrow \text{Salt} + \text{Water}$$

$$2NaOH + CO_2 \longrightarrow \underset{\text{Sodium carbonate}}{Na_2CO_3} + H_2O$$

4. Reaction with Lime water (Calcium hydroxide)

When a limited amount of CO_2 is passed through lime water, it turns milky due to the formation of insoluble calcium carbonate.

$$Ca(OH)_2 + CO_2 \longrightarrow \underset{\text{Calcium carbonate}}{CaCO_3} + H_2O$$

When an excess amount of CO_2 is passed through lime water, it first turns milky and the milkyness disappears due to the formation of soluble calcium hydrogen carbonate, $Ca(HCO_3)_2$.

DO YOU KNOW?

Venus' atmosphere consists of roughly 96-97% carbon dioxide. Because of the amount of carbon dioxide present, the surface of Venus continually retains heat and as such, the surface temperature of Venus is roughly 462°C, making it the hottest planet in our solar system.

3.3.4 Uses of Carbon dioxide

- CO_2 is used to prepare soft drinks or aerated drinks.
- It is used in fire extinguishers
- It is used in manufacturing sodium carbonate by Solvay process.

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- Solid carbon dioxide, called as dry ice is used as a refrigerant. The gas is so cold that moisture in the air condenses on it, creating a dense fog which is used in stage shows and movie effects.
- It is used along with ammonia in the manufacture of fertilizers like urea.
- CO_2 can be used in the preservation of food grains, fruits etc.

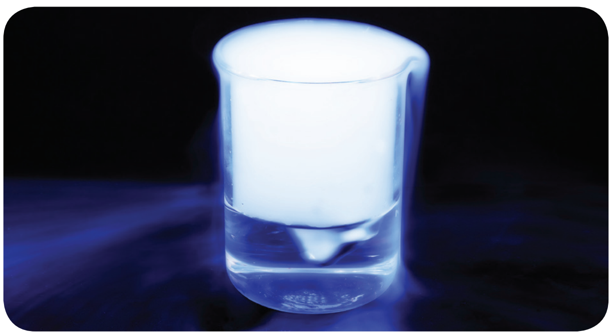

Figure 3.5 Solid carbon dioxide

> **DO YOU KNOW?** Aerated water is nothing but carbon dioxide dissolved in water under pressure. This is also called 'soda water'.

3.4 Green House Effect and Global Warming

The solar radiation is absorbed by the surface of land and ocean. In turn, they release infra red radiation or heat into the atmosphere. Certain gaseous molecules present in the atmosphere absorb the infra red rays and reradiate the heat in all directions. Hence, these gases maintain the temperature of earth's surface. The gases which absorb these radiations are called **green house gases** and this effect is called **green house effect**.

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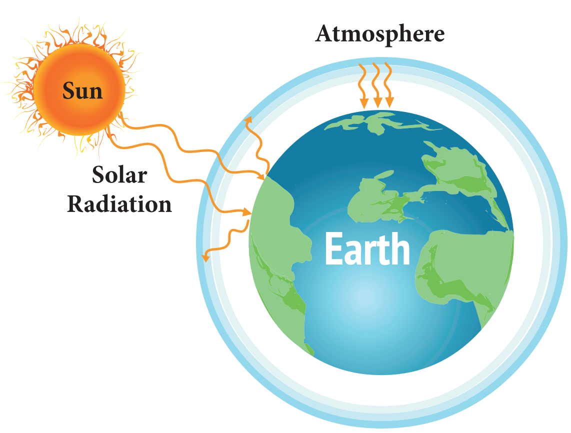


Figure 3.6 Greenhouse effect

The green house gases are CO_2, N_2O, CH_4, CFC (Chlorofluoro carbon) etc. The increase in the levels of these gases results in the gradual increase of temperature of the earth's surface. This increased green house effect is caused due to increase in the air pollutants and it results in the average increase of temperature of the atmosphere. This is called as **Global warming**.

3.4.1 Effects of Global warming

The following are the effects of global warming.

- Melting of ice cap and glaciers.
- Increase in frequency of floods, soil erosion and unseasonal rains.
- Loss of biodiversity due to the extinction of coral reefs and other key species.
- Spreading of waterborne and insectborne diseases.

3.4.2 Preventive measures

In order to save the earth and its resources we need to take certain measures. Some of the measures are given below.

- Reduction in the use of fossil fuels.
- Controlling deforestation.
- Restricting the use of CFCs.
- Planting more trees.
- Reducing, reusing and recycling resources.

3.5 Acid rain

Rain water is actually the purest form of water. However, pollutants such as oxides of nitrogen and sulphur in the air released by factories, burning fossil fuels, eruption of volcanoes etc., dissolve in rain water and form nitric acid and sulphuric acid which adds up to the acidity of rain water. Hence, it results in acid rain.

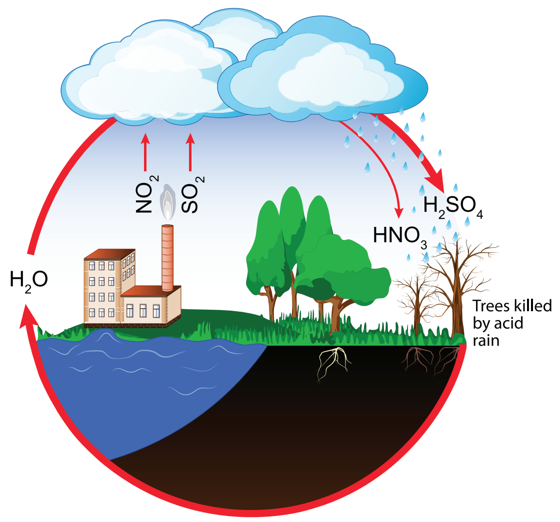


Figure 3.7 Acid rain

> **DO YOU KNOW?**
> Acid rain has pH less than 5.6 whereas pH of pure rain water is around 5.6 due to dissolution of atmospheric CO_2 in it.

3.5.1 Effects of Acid rain

Acid rain affects us in many ways. Some of the consequences are given below.

- It irritates eyes and skin of human beings.
- It inhibits germination and growth of seedlings.
- It changes the fertility of the soil, destroys plants and aquatic life.
- It causes corrosion of many buildings, bridges, etc.

3.5.2 Preventive measures

Acid rain and its effects can be controlled by the following ways.

- Minimizing the usage of fossil fuel such as petrol, diesel etc.,
- Using CNG (**C**ompressed **N**atural **G**as).
- Using non-conventional source of energy.
- Proper disposal of the industrial wastes.

Points to Remember

- Oxygen exists in nature as silicates, carbonates, oxides and water. It also exists in free state as part of air in the atmosphere.
- Oxygen is a colourless and odourless gas; it dissolves sparingly in water; it is denser than air.
- Metals like magnesium, iron and sodium burn in oxygen and give basic oxides.
- Bacteria convert atmospheric nitrogen directly into soluble nitrogen compounds.
- Though nitrogen is inactive at ordinary condition, it combines with many elements at high temperature and pressure or in the presence of catalyst.
- Carbon dioxide cannot exist as a liquid at atmospheric pressure. It occurs as carbonates in nature.
- Carbon dioxide is acidic in nature and turns lime water milky. It is used in fire extinguisher.
- Global warming refers to an average increase in the temperature of the atmosphere or simply it is the warming of the earth.
- The green house gases are carbon dioxide, methane, nitrous oxide, chlorofluoro carbons, etc.

A-Z GLOSSARY

Atmosphere	Gaseous jacket that surrounds the earth.
Fixation of nitrogen	Process that converts nitrogen in the air into a nitrogen compounds.
Global warming	An average increase in the temperature of the atmosphere.
Green House Effect	Trapping of radiation from the sun by green house gases in the atmosphere that leads to rise in the earth's atmospheric temperature.
Haber's process	Synthesis of ammonia from nitrogen and hydrogen with the help of catalyst under 500 atm pressure and 550˚C temperature.

Oxygenes	A Greek word meaning 'acid producers' from which the name 'Oxygen' is derived.
Soda water	Water produced when carbon dioxide is dissolved in water under pressure.
Sublimation	Process of conversion of solid directly to vapour without reaching liquid state.

Z3N6F8

TEXT BOOK EXERCISES

I. Choose the best answer.

1. Which of the following is true about oxygen?
   a) Completely burning gas
   b) Partially burning gas
   c) Doesn't support burning
   d) Supports burning

2. Aerated water contains
   a) air   b) oxygen
   c) carbon dioxide   d) nitrogen

3. Solvay process is a method to manufacture
   a) lime water   b) aerated water
   c) distilled water   d) sodium carbonate

4. Carbon dioxide with water changes
   a) blue litmus to red
   b) red litmus to blue
   c) blue litmus to yellow
   d) doesn't react with litmus

5. Which of the following is known as azote?
   a) Oxygen   b) Nitrogen
   c) Sulpher   d) Carbon dioxide

II. Fill in the blanks.

1. ___________ is called as vital life.
2. Nitrogen is ___________ than air.
3. ___________ is used as a fertilizer.
4. Dry ice is used as a ___________.
5. The process of conversion of iron into hydrated form of oxides is called ___________.

III. Match the following.

1.	Nitrogen	-	Respiration in living animals
2.	Oxygen	-	Fertilizer
3.	Carbon dioxide	-	Refrigerator
4.	Dry ice	-	Fire extinguisher

IV. Answer briefly.

1. What are the sources of oxygen?.
2. Mention the physical properties of oxygen.
3. List out the uses of nitrogen.
4. Write about the reaction of nitrogen with non metals.
5. What is global warming?
6. What is dry ice? What are its uses?

V. Answer in detail.

1. What happens when carbon dioxide is passed through lime water? Write the equation for this reaction.
2. Name the compounds produced when the following substances burn in oxygen.
   a) Carbon   b) Sulphur
   c) Phosphorous   d) Magnesium
   e) Iron   f) Sodium
3. How does carbon dioxide react with the following?
   a) Potassium   b) Lime water
   c) Sodium hydroxide
4. What are the effects of acid rain? How can we prevent them?

VI. Higher Order Thinking Questions.

1. Soda bottle bursts sometimes when it is opened during summer. Why?
2. It is said that sleeping beneath the tree during night is bad for health. What is the reason?
3. Why does the fish die when it is taken out of water?
4. How do astronauts breathe when they go beyond earth's atmosphere?

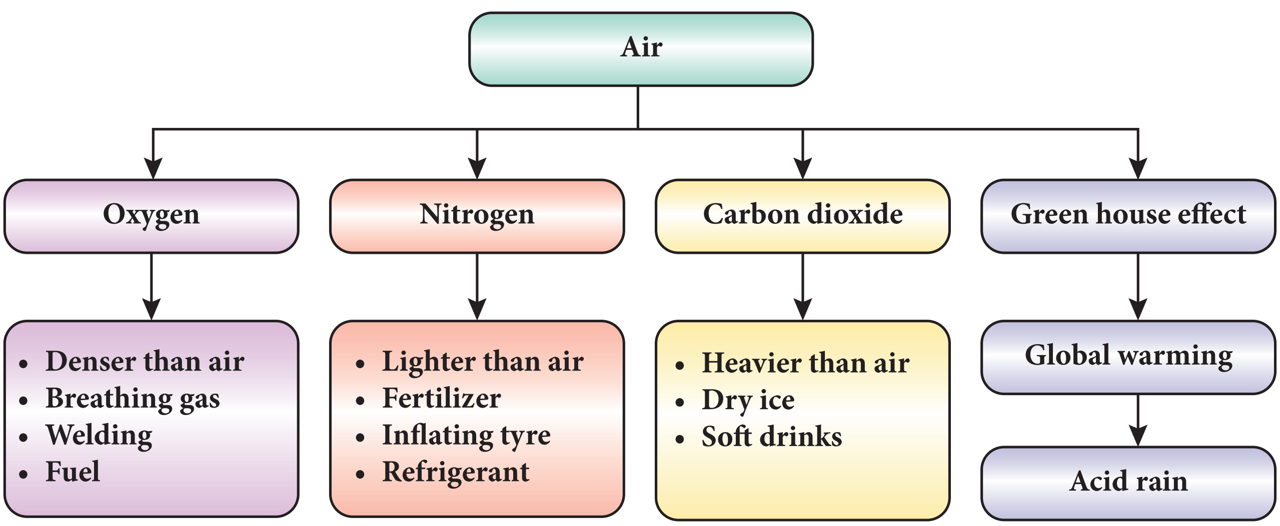
REFERENCE BOOKS

1. Environmental Science - Timothy O Riordan Second edition
2. Basic of atmospheric science - A. chandrasekar
3. Text book of Air pollution and its control - S.C. Bhatia

INTERNET RESOURCES

www.chemicool.com
www.nationgeographic.com
www.environmentalpollutioncenters.org

CONCEPT MAP



ICT CORNER

AIR

Through this activity you will know about carbon emission, climate change, global average temperature etc.

Step 1

- Open the Browser and type the URL given below.
- Click onany one of the items to know about carbon emission, climate change, global average temperature, sea level etc.
- For example, click on the "**Climate Time Machine**" a popup screen will open. In that you can able to see carbon emission global average sea level, temperature, sea ice etc.
- When you click global average sea level, you will find year wise sea level.

Browse in the link: https://climatekids.nasa.gov/menu/play/

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UNIT 4

Matter Around Us

EM7UIX

Learning Objectives

At the end of the lesson you will be able to

- understand the particle's nature of matter
- use particle-model to describe solids, liquids and gases
- list out the characteristics of particles of different states
- discuss about diffusion
- explain the force of attraction between the particles of matter
- explain change of state on the basis of particle model of matter
- explain the effect of temperature on changes of state
- introduced to microscopic models of particles through reasoning based on careful observation of macroscopic behaviour of particles
- inter convert Celsius & Kelvin scales of temperature
- classify substances as elements, compounds and mixtures based on chemical composition
- group mixtures as homogeneous and heterogeneous
- classify solutions based on the size of the solute particles and compare the true solutions, colloids and suspensions based on their properties
- differentiate colloids based on the nature of dispersed phase and dispersion medium
- compare o/w and w/o emulsions
- discuss some important examples and uses of colloids

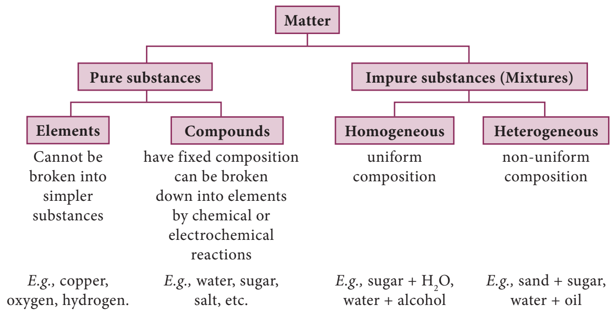
Introduction

As we look-at our surroundings we see a variety of things made of different materials of different shapes, size, textures and colours.

The air we breathe, the food we eat, clouds, stones, plants, animals, a drop of water or a grain of sand everything is matter.

As you will recall, from a tiniest bacteria to a giant planet anything which has mass and occupies space (volume) is matter.

From very early days, human beings have been trying to understand their surroundings. Early Indian philosophers classified matter in the form of five basic elements. Tolkāppiyam says "the world is the mixture of five elements – land,



fire, water, air and space. According to it everything, living and non living, was made up of these five basic elements. Ancient Greek philosophers had arrived at a similar classification of matter. Presently matter is classified based on its physical and chemical properties.

4.1 Is Matter Particulate or Continuous?

Is Matter Particulate or Continuous

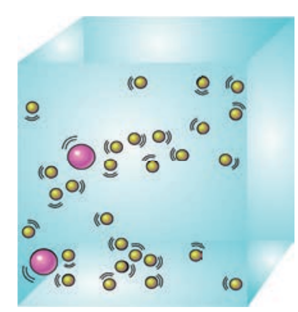
Some people thought that matter is made up of separate tiny particles and is discontinuous, like sands on a beach while some others thought it is continuous like a sea.

You already know that matter is made up of particles. Let us verify this first through some real life experiences and then by simple experiments.

Though **in 1803 John Dalton** proposed his atomic theory, no one could prove that matter was made up of separate particles since they were too small to see. In 1827, a Scottish botanist Robert Brown noticed, Pollen grains jiggling in water. He used a microscope to look at pollen grains moving randomly in water. Initially he thought that these pollen grains were to be some sort of unknown organisms. He repeated the experiment with non-living substances like fine rock dust. To his surprise he saw the same strange dance of the particles in the surface of the water. They were non-living, but they were constantly moving, as if something was making each of them to move. What could be there to make them move? At this point, he could not explain why this occurred.

One possible explanation was that very small particles in water were actually randomly moving all the time and were striking the pollen particles from all sides, to make them move randomly. This erratic movement of pollen grains later came to be known as **Brownian motion.**

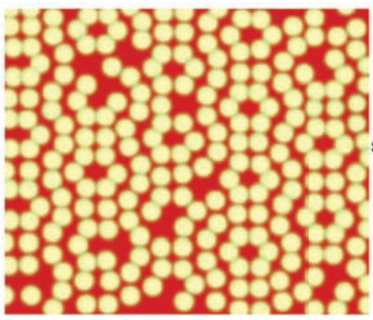
Movement



Brownian motion – Named after the botanist Robert Brown

In 1905, physicist **Albert Einstein** explained that the pollen grains were being moved by individual water particles or molecules. This confirmed that atoms and molecules did exist, and provided evidence for particle theory as well as they were on continuous motion. Particles in both liquids and gases (collectively called fluids) move randomly. They do this because they were bombarded by the other moving particles in the fluid. Larger particles can be moved by light, fast-moving molecules. It was only in 1908, observations backed with calculations had confirmed that atoms were real.

Today we are very convinced that atoms and molecules are not mere speculations. Using very sophisticated methods like Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM), has actually made it possible to see atoms, like in the picture below.



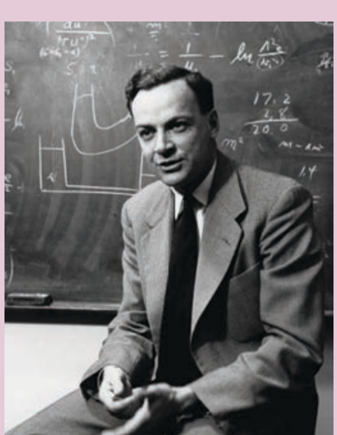
Silicon atoms on a surface via Scanning Electron Microscopy, SEM.

The atomic fact is: "***All things are made of atoms – tiny little particles moving around continuously, attracting each other when they are a short distance apart, but repelling when they are squeezed very close.***"

DO YOU KNOW?

The Most Important Discovery

Richard Feynman, a very famous and extraordinary scientist (1918-1988) had said: The most important scientific discovery of the last ten thousand years is the **Atomic Fact!**



Activity 1

Identify the matters from the given data

Items for identification	Matters	Non-matters
Flower, bee, cloud, rainbow, leaf, fire, baby, torch light, sky, smoke, heat coming from glowing coals, fog, sound coming from a drum, laser beam		

Have you ever seen dust particles 'dancing' when a narrow beam of light enters a dark room?

This is yet another example of Brownian motion. Air is made of tiny particles that move around. These moving particles bump into dust particles making them move irregularly or dance. Air particles are tiny to be seen. Hence, we can see only dust particles.

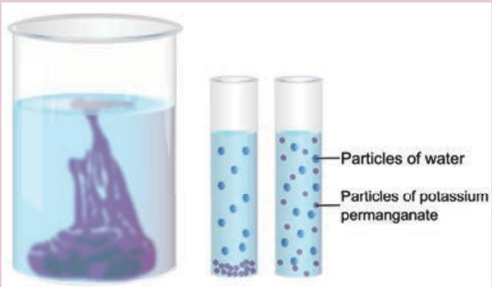
These observations led to the kinetic particle theory of matter. According to this theory all matter is made up of tiny particles and these particles are in constant motion, which possesses kinetic energy.

'Kinetic' means motion, based on this we are going to describe the differences in the properties of solids, liquids and gases and the changes in states of matter.

4.2 Evidence for Existence of Particles?

Activity 2

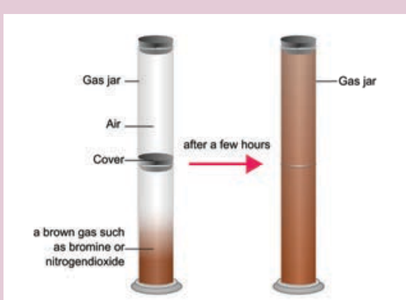
Let us place one or two crystals of Potassium Permanganate in a beaker of water. Leave it undisturbed for a while. What will we observe?



The pink colour spreads throughout the beaker. The colour spreads because the particles of permanganate leave the crystal and mix through the water particles. This process of dissolving is known as dissolution.

Let us see another experiment

Let us place an open gas jar of air upside down on another jar containing some bromine vapours or any other coloured gas. After some time we can see the colour spreads upwards due to the movement of the bromine particles which mixes with air.



In each of the above cases we can see that particles are in motion and they are colliding with each other and bounce off in all directions. This process is called diffusion. This couldn't have happened if particles didn't exist!

DO YOU KNOW?

A grain of common salt contains 1.2 × 10^{18}. Particles- half of which are sodium particles and half of which are chlorine particles

4.3 Kinetic Particle Theory of Three States of Matter- Solid, Liquid and Gas

The table below summarises the arrangement and movement of the particles in solid, liquid and gas and show schematic diagrams for the arrangement of these particles.

4.4 Solids

4.4.1 Why do solids have fixed shape?

According to the kinetic particle theory of matter the particles in solids

1. Are tightly packed in an orderly manner;
2. Are held together by strong attractive forces;
3. Have just enough kinetic energy to vibrate or rotate about their fixed positions
4. Cannot move freely

4.4.2 Why do solids have fixed volume?

Solids cannot be compressed as there is very little space between the particles; they are packed close to each other. The distance between the particle is minimum. Hence they have fixed volume.

4.5 Liquids

4.5.1 Why do liquids not have fixed shape?

According to the kinetic particle theory of matter the particles in liquids

1. Are not arranged in an orderly manner;

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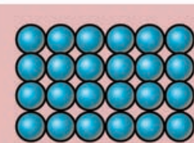
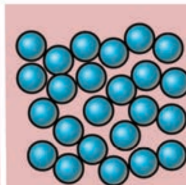
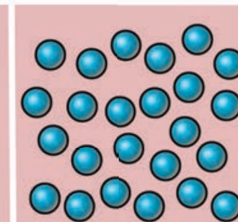
Physical states	Solid	Liquid	Gas
Arrangement of particles	Tightly packed Regular pattern	Loosely packed Low random arrangement	Far apart High random arrangement
Movement of particles	Vibrate on the spot	Move around each other	Move quickly in all directions
Diagram			

2. Are held together by weak forces of attraction;
3. Have more kinetic energy than the particles of solids;
4. Are free to move throughout the medium by colliding over each other.

4.5.2 Why do liquids have fixed volume?

The particles in liquids are slightly away from each other compared to solids. They are packed quite closer to each other. Moreover the forces of attraction between them help to stay together. Thus liquids cannot be compressed and they have fixed volume.

4.6 Gases

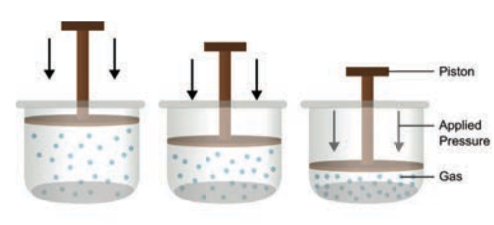
4.6.1 Why do gases not have fixed shape?

According to the kinetic theory of matter the particles in gases

1. Are not close to each other but are spread far apart from each other;
2. Are not held in any fixed positions;
3. Have very weak forces of attraction between each other, lesser than liquids;
4. Have a lot of kinetic energy and can move freely in all directions.

4.6.2 Why do gases not have fixed volume?

Since the particles in gases are far apart there is a lot of space between them. Therefore, they can be forced to get closer or in other words can easily be compressed.



Compression of a gas by applying pressure

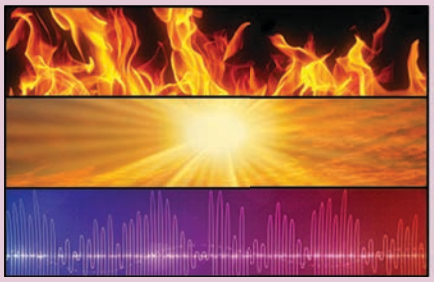
By applying pressure, the particles in a gas can be brought closer. Gases are easily compressible.

Light, sound, heat etc. are not matter. They are different forms of Energy.

4.7 Effect of Temperature on Movement of Particles

Activity 3

Look at the image given below and give reasons to justify why they are not matter



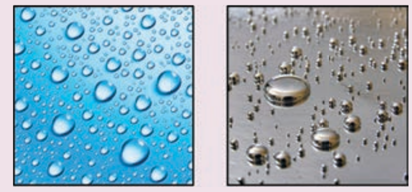
Activity 4

1. Let us take two glass tumblers and fill one with cold water and the other with hot water.
2. Now add a drop of red ink into each of the glasses but do not stir. Observe.
3. In which glass does water turn red faster?
4. Does the rate of mixing change with temperature? What do you conclude?

Ink diffuses faster in hot water than in cold water because with increase in temperature kinetic energy of the particles increases. The particles gain energy on heating and they move faster. Faster they move faster will be the mixing of ink in water. Rate of diffusion increases with increase in temperature.

DO YOU KNOW?

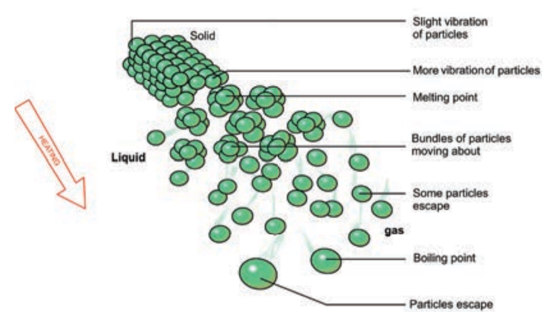
Why do liquids like water, mercury etc. form drops? The tendency for particles of water or mercury to stick together (cohesive forces) causes spheres or drops.



4.8 Changes in States of Matter and the Kinetic Particle Theory

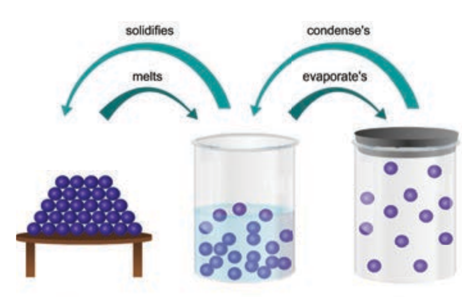
Change of state

CHANGE OF STATE — EFFECT OF HEAT



Matter can change from one state to another. When you taste an ice cream it changes from solid to liquid state due to the transfer of heat energy from your body to the ice cream. According to kinetic particle theory, particles of matter are in constant motion as they possess kinetic energy. As we discussed earlier, gases have more kinetic energy than the liquids and solids. Solids have the least kinetic energy.

When matter is either heated or cooled, heat energy is either absorbed or given out. This causes change in the energy of the particles leading to change of state. These changes are reversible physical changes.



Changes of states

- solid **melts** into liquid
- liquid **vaporises** into gas
- gas condenses into liquids
- liquid **freezes** or solidifies into solid

DO YOU KNOW?

The heat from our hand is enough to change solid metal Gallium into liquid.

According to first law of thermodynamics energy can be neither created nor destroyed but it can be converted from one form to another. During a change of state of matter, heat energy is converted into kinetic energy of the particles.

4.9 Melting

A substance absorbs heat energy and it melts. The temperature at which a substance melts is called as melting point. Different substances have different melting points. Hard substance such as diamond also melts.

Melting points of a few substances

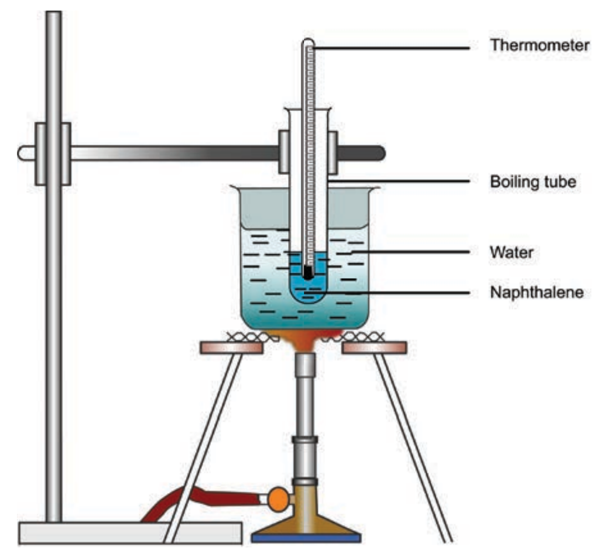
Substance	Melting point/°C
Oxygen	-219
Sodium	98
Iron	1540
Diamond	3550

4.9.1 What happens when a solid is heated until it melts?

Effect of heat on the particles of a solid

How temperature of a solid does varies on heating?

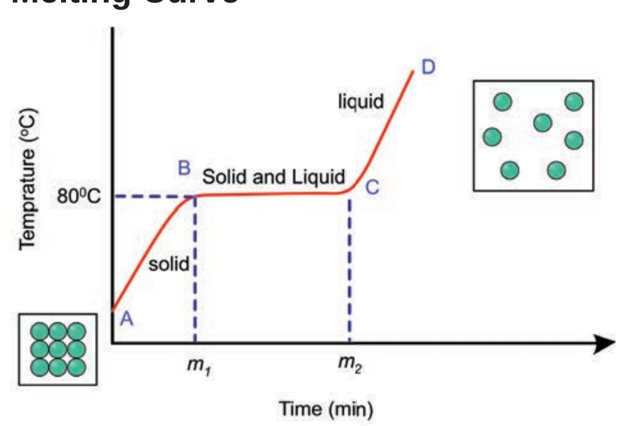
Melting point apparatus set up is as shown below. We can study the melting of solid naphthalene by varying the temperature with time.



Melting of Naphthalene

Let us observe the variation of temperature of the solid while it is heated at regular intervals of time. We can continue heating till entire solid melts and a little beyond. If we plot a graph of temperature versus time, we get a melting curve as shown below.

Melting Curve



From the graph what conclusions can we get?

Let us try to answer the following questions.

At what temperature does the solid start melting?

At what temperature does it melt completely?

What is the melting point of Naphthalene?

What does $m_1 - m_2$ represent?

Let us now analyse the curve.

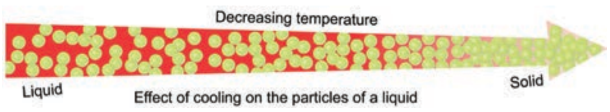
Between $A \rightarrow B$	Between $B \rightarrow C$	Between $C \rightarrow D$
Solid gets heated up	Solid melts	Liquid gets heated up
Temperature steadily Increases till B which is the melting point and the solid begins to melt. Melting point 80°C	Solid continues to melt but there is no change in temperature, though heating is continued. A mixture of both solid and liquid naphthalene exists at this stage.	At C, entire solid is melted. Naphthalene is in liquid state now. There is gradual increase in temperature as heating is continued.

Why the temperature remains constant between B – C?

The entire heat energy absorbed is used to overcome the attractive forces between the solid particles, which are held in fixed positions. Hence, there is no increase in temperature. This hidden energy is called latent heat of fusion, which is exclusively used for change of state from solid to liquid.

4.10 Freezing

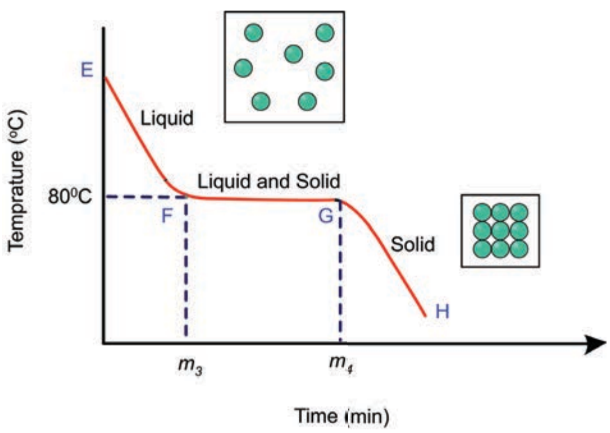
Let us now try to reverse the process. Let us start with the liquid and cool it slowly. What happens?



Effect of cooling on the particles of a liquid

How does the temperature of a liquid vary when it is cooled till it freezes?

Now let us start with the liquid naphthalene that we got from the previous experiment. Let us allow it to cool while observing the temperatures at regular intervals of time till the liquid completely freezes or solidifies. Let us plot a graph of temperature versus time. This curve is called the cooling curve. This shows that how the temperature of a pure solid changes as it is cooled to its freezing point and beyond.



Cooling Curve

From the graph what conclusions can we get?

At what temperature does the liquid begins to freeze?

At what temperature does it freeze completely?

What is the freezing point of Naphthalene?

Is the freezing point same as the melting point?

What does $m_3 - m_4$ represent?

Let us now analyse the curve.

Between E → F	Between F → G	Between G → H
Liquid gets cooled	Liquid freezes	Solid cools
Temperature gradually decreases till F, which is the freezing point and the liquid begins to freeze. Freezing point is 80°C	Liquid continues to freeze but there is no change in temperature, though cooling is continued. A mixture of both solid and liquid naphthalene exists at this stage.	At G, entire liquid is frozen. Naphthalene is in solid state now. The temperature of the solid naphthalene gradually decreases as the cooling continues.

Why the temperature remains a constant between F – G?

The entire heat energy is given out at this stage as the particles of the liquid get attracted to each other. This released energy is absorbed by the surroundings. Hence there is no increase in temperature for naphthalene. Both liquid and solid states co-exist at this stage. This hidden energy is called latent heat of freezing which is the same as latent heat of fusion, This latent heat is released when there is a change of state from liquid to solid.

4.11 Boiling

Boiling refers to the process by which a substance changes from the liquid state to the gaseous state at its boiling point. Different liquids have different boiling points.

Boiling points of a few substances

Substance	Boiling point/°C
Oxygen	-183
Sodium	890
Iron	2900
Diamond	4832

What happens when a liquid is heated?

Effect of heat on the particles of a liquid

More to Know

Boiling Point

Atmospheric pressure = prevailing pressure of the system

When a liquid is heated, it eventually reaches a temperature at which the vapour pressure is large enough that bubbles form inside the body of the liquid. This temperature is called the **boiling point**. Once the liquid starts to boil, the temperature remains constant until entire liquid has been converted to a gas.

The normal boiling point of water is 100°C at NTP. But if you try to boil an egg while camping in the Rocky Mountains at an elevation of 10,000 feet, you will find that it takes longer time for the egg to cook because water boils only at 90°C in this altitude. In theory, it is impossible to heat a liquid to temperatures above its normal boiling point.

Before microwave ovens became popular, however, pressure cookers were used to decrease the amount of time it took to cook food. In a typical pressure cooker, water can remain a liquid at temperatures as high as 120°C, and food cooks in as little as one-third the normal time. To explain why water boils at 90°C in the mountains and 120°C in a pressure cooker, even though the normal boiling point of water is 100°C, we have to understand why a liquid boils. By definition, a liquid boils when the vapour pressure of the gas escaping from the liquid is equal to the pressure exerted on the liquid by its surroundings.

The normal boiling point of water is 100°C because this is the temperature at which the vapour pressure of water is 760 mmHg, or 1 atm. Under normal conditions, when the pressure of the atmosphere is approximately 760 mmHg, water boils at 100°C. At 10,000 feet above sea level, the pressure of the atmosphere is only 526 mmHg. At these elevations, water boils when its vapour pressure is 526 mmHg, which occurs at a temperature of 90°C.

Pressure cookers are equipped with a valve that lets gas escape when the pressure inside the pot exceeds some fixed value.

This valve is often set at 15 psi, which means that the water vapour inside the pot must reach a pressure of 2 atm before it can escape. Because water doesn't reach a vapour pressure of 2 atm until the temperature is 120°C, it boils in this container at 120°C. Since the temperature of water is higher, cooking is done faster. The concept of the above facts can be understood by the Gay-Lusaac's law.

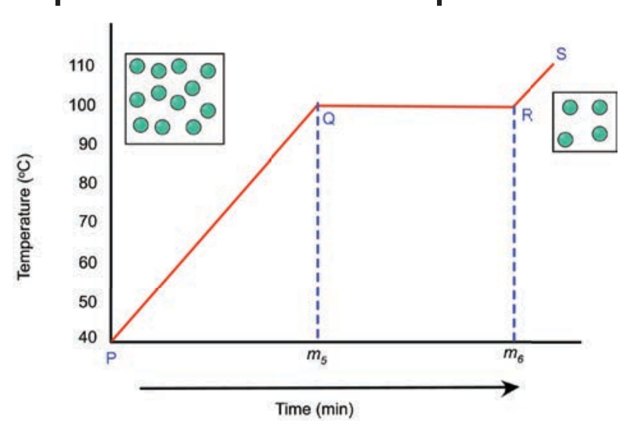
Heating curves and cooling curves

A heating curve is a graph showing the temperature of a substance plotted against the amount of energy it has absorbed. You may also see a cooling curve, which is obtained when a substance cools down and changes state.

How does the temperature of a liquid change when it is heated to its boiling point?

Let us take a liquid say water and heat it slowly till it boils while observing the temperature at regular intervals of time. If we plot a graph of temperature against time we will get one curve similar to the one shown below.

Vaporisation curve of a liquid



Vaporisation curve of a liquid

From the graph what conclusions can we get?

At what temperature does the liquid start boiling?

At what temperature does it boil off completely?

What is the boiling point of the liquid?

Let us now analyse the curve.

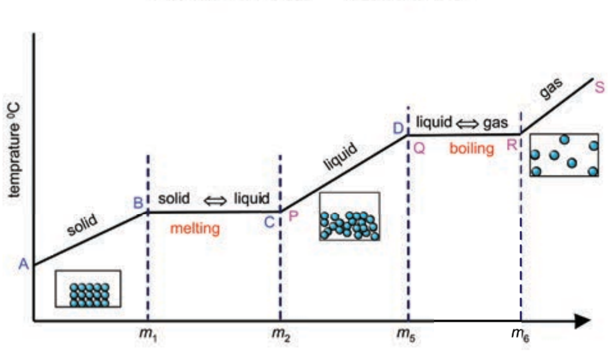
Between $P \rightarrow Q$	Between $Q \rightarrow R$	Between $R \rightarrow S$
Liquid gets heated up	Liquid melts	Gas gets heated up
Temperature gradually increases till Q which is the boiling point and the liquid begins to boil.	Liquid continues to boil but there is no change in temperature, though heating is continued. A mixture of both liquid and gas exists at this stage.	At R, entire liquid is boiled. The liquid is changed into gas (vapour). There is a gradual increase in temperature of the gas as heating is continued.

Why the temperature remains a constant between Q-R?

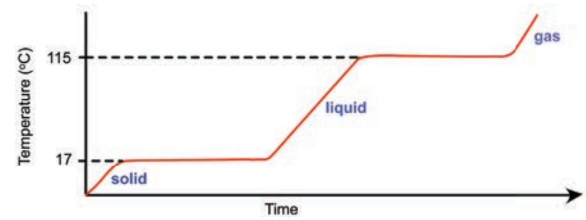
Entire heat energy is absorbed at this stage is used to overcome the attractive forces between the liquid particles which are intact. The particles start moving faster as their kinetic energy increases. Hence there is no increase in temperature. This hidden energy is called latent heat of vaporisation. The heat energy that is absorbed at this stage is exclusively used for change of state from liquid to vapour.

The following curve sums up what we have been discussed so far

Changes of state — heating curve



Heating Curve



What is the melting point of this substance?

What is the boiling point of this substance?

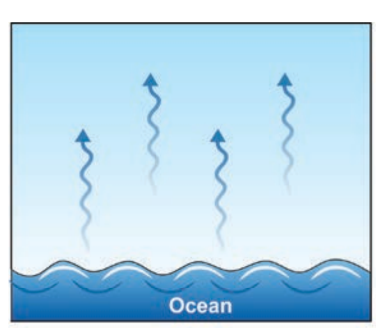
What is the state of the substance at room temperature (21^0C)

Test Yourself

1. Draw a cooling curve when a hot gas is cooled and condensed to its liquid form.
2. When you boil water you see bubbles.

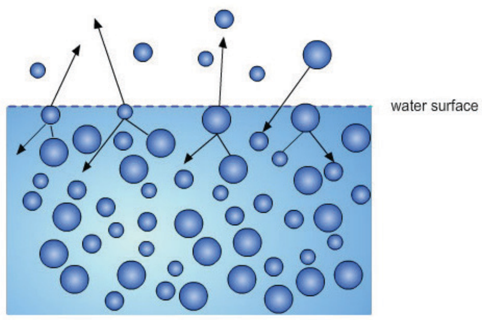
What are these bubbles? How are they formed?

Evaporation and Boiling



Vaporization is a process of phase transition (change of state) in which a substance, change its state from liquid to vapour. It can take place in two ways, i.e. evaporation and boiling. The process of evaporation involves phase transition at a temperature below the boiling temperature. On the other hand, boiling of a substance takes place at boiling point, which may vary with the change in the atmospheric pressure.

4.12 Evaporation



Evaporation takes place at the surface of a liquid, where molecules with the highest kinetic energy are able to escape. When this happens, the average kinetic energy of the liquid is lowered, and its temperature decreases.

Test Yourself

1. Why do clothes dry faster on a hot day?
2. Name two factors other than temperature which will affect the rate of evaporation, taking examples from our daily life experiences.

4.13 Sublimation

Have you noticed that the moth balls which we place in our cloth cupboards disappear after a few days? But you may still get the smell of those naphthalene balls even after they 'disappear'. What has happened?

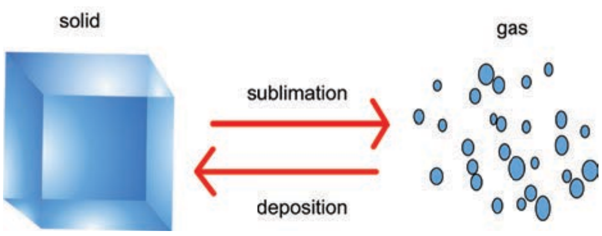
Certain solids change directly to gas without passing through the liquid state. The direct change of a state from solid to gas is called sublimation. On cooling these vapours come back to its original (or) actual state.

Comparison of boiling and evaporation

Basis For Comparison	Boiling	Evaporation
Meaning	Boiling implies a vaporization process that turns liquid into gas, when heated. It is a fast process.	Evaporation is a natural process, wherein the liquid changes its form to gas even without heating. It is a slow process.
Phenomenon	Bulk	Surface
Temperature	Occurs only at boiling point.	Occurs at any temperature.
Appearance	It forms bubbles	It does not forms bubbles.
Energy	Source of energy is required.	Energy is supplied by the surrounding.
Temperature of liquid	Remains constant	Decreases

More to Know

The air freshners are used in toilets. The solid slowly sublimes and releases the pleasant smell in the toilet over a certain period of time. Moth balls, made of naphthalene are used to drive away moths and some other insects. These also sublime over time. Camphor, is a substance used in Indian household. It sublimes to give a pleasant smell and is sometimes used as a freshner.



For example, dry ice (frozen CO_2), naphthalene, ammonium chloride and iodine sublime. The energy required for this change of state can be derived either from the surrounding or from the heat supplied. Inverse of this process is called deposition, in which gas particles lose heat and change their phase to solid.

DO YOU KNOW?

Dry ice, sometimes referred to as "cardice" is used primarily as a cooling agent. It is widely used for industrial refrigeration and transporting frozen food. It can maintain a temperature even lower than ice and it does not leave any liquid behind as it directly changes to gas.

4.14 Effect of Pressure on Gases

When you are blowing air into a balloon, you fill it with air particles moving with high speed. These particles colloide at the sides of the balloon and the applied pressure on it keeps the balloon inflated. In a similar way all gases exert pressure. The pressure depends on the temperature of the gas and the volume it occupies.

Applied gaseous pressure

Higher the temperature, higher will be the kinetic energy of the particles and faster will be the motion of the gas particles. They start hitting harder and more often on the walls of the container and pressure increases. Similarly when the volume decreases the gas gets compressed. The particles of the gas have only lesser space to move around. Therefore they start hitting on the walls of the container more and pressure increases.

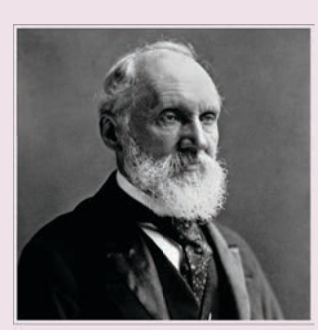
BOYLE's law

The pressure of a given mass of an ideal gas is inversely proportional to its volume at a constant temperature.

https://www.thoughtco.com/definition-of-boyles-law-604842

DO YOU KNOW?

The temperature of gases can be expressed in Kelvin Scale also.



Lord kelvin

Kelvin is the SI unit of temperature.

The Kelvin scale is named after the Belfast-born, Glasgow University engineer and physicist William Lord Kelvin (1824–1907), who wrote of the need for an "absolute thermometric scale".

For conversion of temperature scale remember:

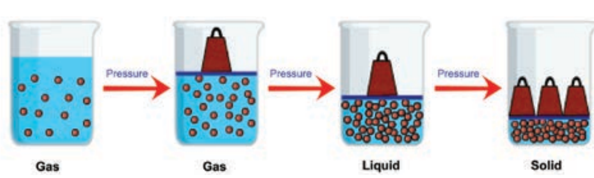
0 ^{0}C = 273.16 K (273 K for convenience)

Test Yourself

Complete the following table

CELSIUS	KELVIN
90 ^{0}C	363 K
?	283 K
63 ^{0}C	?
25 ^{0} C	?
?	303 K

We have seen that in gases the particles are apart and there is only very weak forces of attraction between them. If pressure is applied on a gas the particles are brought in close contact with each other. The attractive forces eventually become strong enough to hold the particles close together, and the gas condenses to the liquid state.



If the pressure is increased still further, the particles are brought in very close to each other that the attractive forces are strong enough to hold them in place in a three-dimensional arrangement. The liquid then becomes a solid.

More to Know

Gas cylinder

LPG – Liquefied Petroleum Gas

It is highly inflammable hydrocarbon gas. It contains mixture of butane and propane gases. LPG, liquefied through pressurisation, is used for heating, cooking, auto fuel etc.

But, increase in pressure alone cannot bring about change of states from gas to liquid to solid. Apart from high pressure, low temperature is also necessary for a gas to be converted into liquid. You may learn more about this in higher classes.

To Summarise

PROPERTY	SOLIDS	LIQUIDS	GASES
VOLUME	Have definite volume	Have definite volume	Not have definite volume
SHAPE	Have definite shape	Not have definite shape	Not have definite shape

PROPERTY	SOLIDS	LIQUIDS	GASES
COMPRESSIBILITY	Cannot be compressed	Can be compressed to some extent	Can be compressed easily
DENSITY	Have high density	Have less density	Have least density
FLUIDITY	Do not flow	Can flow, particles slide over each other	Easily move throughout the available space
PACKING OF PARTICLES	Tightly packed	Loosely Packed	Particles much farther apart when compared to solids and liquids
DIFFUSION	Do not diffuse, vibrate in its fixed positions	Can be diffused	Diffused very easily
ATTRACTIVE FORCES	Strong attractive forces	Attractive forces are not so strong as in solids	Weak or negligible attractive forces
KINETIC ENERGY	Possess low kinetic energy	High kinetic energy	Very high kinetic energy

So far we have been discussing the classification of matter on the basis of their physical states. Now let us see how we can classify matter on the basis of chemical composition.

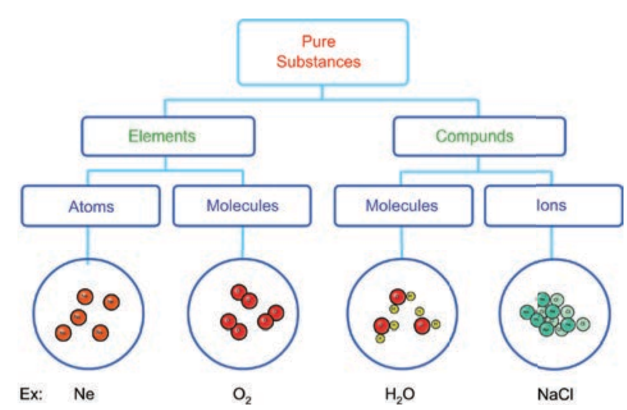
4.15 Classification of Matter Based on Composition

As we know already, the matter is classified into pure substances and mixtures. From the chemistry point of view, pure substances are those which contain only one kind of particles whereas impure substances contain more than one kind of particles. While elements and compounds are considered to be pure substances, mixtures are considered as impure substances.

EHGQKK

Let us look at a few examples.

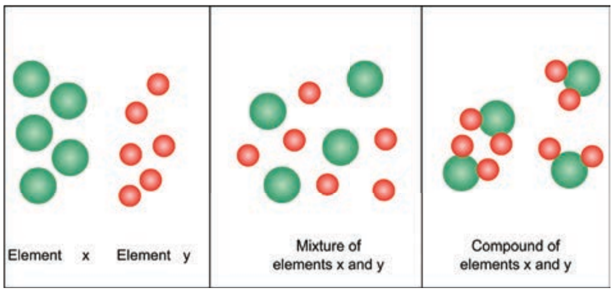
	SOLID	LIQUID	GAS
ELEMENT	Sodium	Bromine	Hydrogen
COMPOUND	Sodium chloride	Water	Carbon dioxide



Let us now try to recall our idea of elements and compounds.

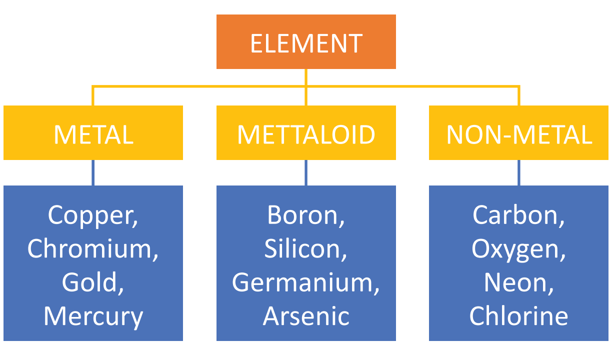
4.16 Element

An element contains atoms of the same kind. It cannot be further broken into simpler particles of matter by chemical methods of action, heat, light or electricity. Elements combine chemically to form compounds. When they are mixed physically they form mixtures.



DO YOU KNOW?

In modern periodic table there are 118 elements known to us, 92 of which are naturally occurring while the remaining 26 have been artificially created. But from these 118 elements, billions of compounds are formed- some naturally occurring and some artificial. Isn't that amazing?



4.17 Compound

A compound is made of two or more of elements combined in a fixed ratio by mass. For example water is made up of two elements, hydrogen and oxygen. Similarly, cane sugar is made up of three elements carbon, hydrogen and oxygen. A compound has a definite formula. Examples - water is H_2O, cane sugar is $C_{12}H_{22}O_{11}$.

The properties of a compound are entirely different from their constituent elements. For e.g. Iron Sulphide does not show the properties of neither sulphur nor iron. Try waving a magnet over Iron Sulphide? Does it get attracted to the magnet? No.

Compare and Contrast

ELEMENTS	COMPOUNDS
Contains only one kind of atoms	Contains more than one kind of atoms
It is a pure substance	It is not a pure substance
Cannot be broken down further in to simpler substances by chemical methods	Can be broken down further in to simpler substances by chemical methods
Has definite physical and chemical properties	Has definite physical and chemical properties

We can classify matter as pure and impure substances

Characteristics of Pure Substances

1. Made up of only one kind of atom or molecule.
2. The ratio of the components of a pure substance is fixed.
3. Have characteristic set of properties. Physical properties like boiling point, melting point, density etc. are fixed. Such properties will vary with the proportions of constituents present in the mixture.
4. Has the same composition throughout i.e. it is homogenous in nature.

Mixtures contain more than one substances. These are made by physically mixing two or more elements or compounds in any random proportion by mass or volume. For example Gunpowder is a mixture of sulphur, potassium nitrate and charcoal. Here individually each component by itself is a pure substance.

You will be able to find several examples of mixtures that we come across and use in our daily life.

Characteristics of Mixtures

1. The constituents of a mixture are loosely held together without any chemical force between the constituents and in such a case the constituents retain their individual properties.
2. A mixture can be prepared by mixing the constituents in any proportion i.e. mixtures do not have any fixed amount of its constituents.
3. Formation of mixtures does not involve any exchange of energy.
4. Mixtures do not have any characteristic set of properties. Physical properties of mixtures like boiling point, melting point etc. are not fixed. Such properties will vary with the proportions of constituents present in the mixture.
5. Components of a mixture can be separated by Physical methods.

Do it yourself: Collect various labels of food products, medicines, juices, etc. and discuss the ingredients present in them and tabulate it.

DO YOU KNOW? Have you come across the word “carat”? It describes purity of gold and weight of diamond.

Let us see the differences between mixtures and compounds.

4.18 Differences between Mixtures and Compounds

S.No	Mixtures	Compounds
1	A mixture can be separated into its constituents by physical processes like filtration, evaporation, sublimation, magnetic separation, solvent extraction.	A compound cannot be separated into its constituents by physical processes but can be only separated by chemical process
2	A mixture retains or shows the properties of its constituents	The properties of a compound are entirely different from those of its constituents
3	Energy (in the form of heat, light etc.) is neither given out nor absorbed in the preparation of a mixture	Energy (in the form of heat, light etc.) is given out or absorbed during the preparation of a compound
4	The composition or proportion is variable in a mixture does not have a definite formula	The composition of a compound is fixed. The constituents are present in a fixed ratio by mass. Compound has a definite formula
5	A mixture does not have fixed boiling point or melting point	A compound has a fixed boiling point or melting point

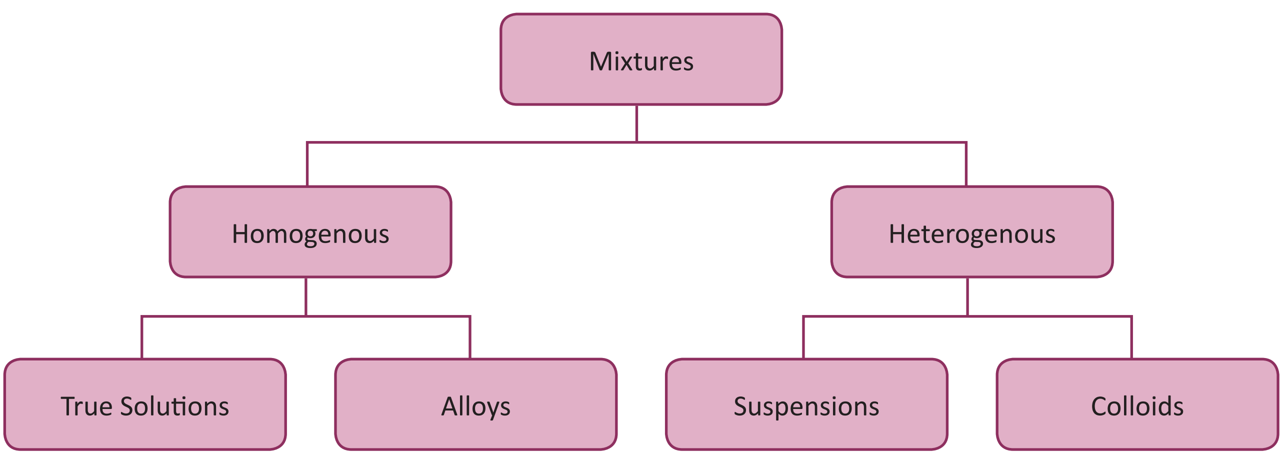
Most of the substances that we use in our daily life are mixtures. In some we will be able to see the components with our naked eyes but in most others the different components are not visible. They appear to have uniform composition. Based on this mixtures can be classified as below.

Activity 5

Test Yourself

1. Is air a pure substance or Mixture? Justify
2. You must have seen brass statues in museums and places of worship. Brass is an alloy made up of approx. 30% zinc and 70% copper. Is Brass a pure substance or a mixture or compound?

4.19 Types of Mixtures



4.19.1 Homogenous and heterogeneous mixtures

Let us try to differentiate a homogenous mixture from a heterogeneous mixture

In a homogeneous mixture the components are uniformly mixed and it will have single phase.

In heterogeneous mixture are not mixed thoroughly or uniformly, and it will have more than single phase.

Mix some Iron filings and common salt in a glass plate. Observe.

Are the constituents distinguishable? Can you see them separately despite mixing?

Now wave a magnet over the mixture. What do you observe?

Next take a pinch of salt and dissolve in water.

What do you get? Can you see the salt particles?

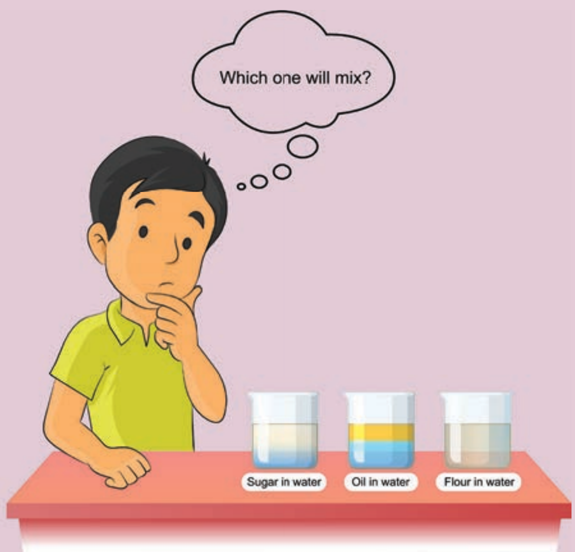
Record all your observations.

Conclusion – The mixture of iron filing and salt is **heterogeneous**. While the salt solution is **homogenous.**

Let us now try to differentiate a true solution from colloidal solution and suspension.

Let us go to the kitchen shelf and pick up bottles containing sugar, oil and rice or wheat flour.

Now let us add one tea spoon full of each one to a glass of water and stir well. Leave it aside for about ten minutes. Let us observe and enter



our observations in the table below.

Observations

	Water + sugar	Water + oil	Water + flour
Mixture- Clear/ cloudy/ turbid			
Particles-not seen/seen			
Particles settle down/ did not settle down			

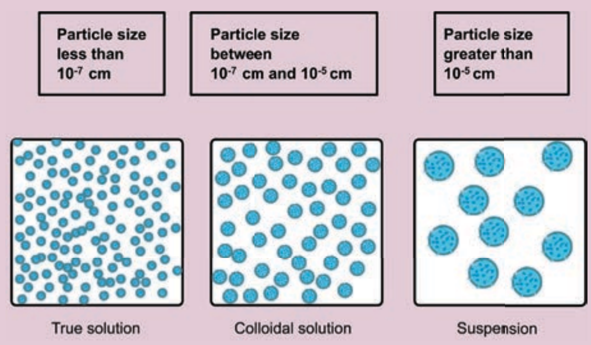
We can see that in the case of sugar we get a clear solution and the particles never settle down. In the case of oil and water we first get a cloudy mixture which separates into layers after a while. In the case of flour mixed with water we get a very turbid mixture and fine particles slowly settle down at the bottom after some time. We can call the first mixture as homogeneous mixture and a true solution. The second one was apparently homogeneous for a while but separated into layers, leaving behind some cloudiness. This is called a colloidal solution. The third one is heterogeneous and is called a suspension in which the particles settle down at the bottom.

4.19.2 Differences between homogenous and heterogeneous mixtures

Homogeneous mixtures	Heterogeneous mixtures
Components are uniformly mixed and it will have single phase, E.g. Alloys, salt solution, lemonade, petrol etc.	Components are not uniformly mixed and it will have more than single phase. Are called suspensions. E.g. chalk in water, petrol in water, sand in water, etc.
No boundaries of separation between the components. Has single phase.	There are visible boundaries between the components. Have two or more distinct phases.
Components are invisible to naked eye.	Components are visible to naked eye.
They will be in solid, liquid or in the gaseous phase.	Can be a solid-liquid or solid-gas or liquid- gas or solid-solid, or liquid-liquid mixtures.

What are the differences between True solutions, suspensions and colloids?

The major difference is the particle size. In fact interconversions of these mixtures are possible by varying the particle sizes by certain chemical and physical methods.



The following table summarises the differences between the three types of mixtures

Differences between Suspension, colloidal solution

Property	Suspension	Colloidal sol.	Solution
Particle size	>100nm	1 to100nm	<100nm
Filtration separation	Possible	Impossible	Impossible
Settling of particles	Settle on their own	Settle on centrifugation	Do not settle
Appearance	Opaque	Translucent (or) Semi transparent	Transparent
Tyndall effect	Shows	Shows	Does not show
Diffusion of particles	Do not diffuse	Diffuse slowly	Diffuse rapidly
Brownian movement	May show	Shows	May or may not show
Nature	Heterogeneous	Heterogeneous	Homogeneous

DO YOU KNOW?

1 nanometre (nm) = 10^{-9} m

or

1 meter = 10^{9} nanometres

Try this on your own

The longest wavelength of red light (almost infrared) that most people can see is 7.5×10^{-7} meters. What is this in nanometres?

Length in nm = (length in m) × (10^{9} nm/m)

More to Know

The Headlights of vehicles work on the principle of Tyndall effect. Blue colour of sky is also a Tyndall effect.

4.20 Colloidal Solutions

A colloidal solution is a heterogeneous system consisting of the dispersed phase and the dispersion medium.

Dispersed Phase	Dispersion Medium
Component present in smaller proportion	Component present in larger proportion
Analogous to solute of a true solution	Analogous to solvent of a true solution

Classification of colloids based on physical state of dispersed phase and dispersion medium

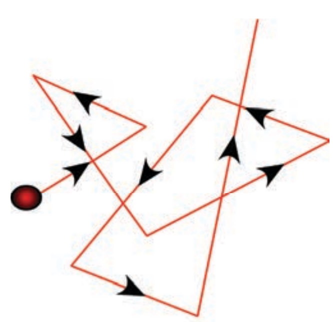
Dispersed phase or the dispersion medium can be a solid, or liquid or gas. There are eight different combinations possible (The combination in which both the dispersed phase and dispersion medium are gases which are completely miscible and can never give rise to a colloidal solution). Because gas in gas formed a true solution.

We can see that the particle size in a colloidal solution is in between that of a true solution and suspension. Because of this particular range in size colloidal solutions show certain special properties like Brownian movement and Tyndall effect. You are already familiar with the Brownian movement and the particle nature of matter is explained on that.

S.No	Dispersed Phase	Dispersion Medium	Name	Examples
1	Solid	Solid	Solid sol	Alloys, gems, coloured glass
2	Solid	Liquid	Sol	Paints, inks, egg white
3	Solid	Gas	Aerosol	Smoke, dust
4	Liquid	Solid	Gel	Curd, Cheese, jelly
5	Liquid	Liquid	Emulsion	Milk, butter, oil in water
6	Liquid	Gas	Aerosol	Mist, fog, clouds
7	Gas	Solid	Solid foam	Cake, bread
8	Gas	Liquid	Foam	Soap lather, Aerated water

4.20.1 Brownian movement

It is a kinetic property. When colloidal solution are viewed under powerful microscope, it can be seen that colloidal particles are moving constantly and rapidly in zig-zag directions. The Brownian movement of particles is due to the unbalanced bombardment of the particles by the molecules of dispersion medium.

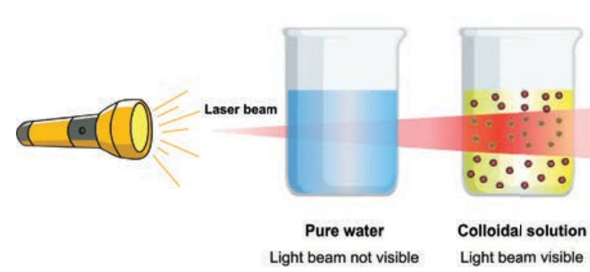


Brownian Movement

4.20.2 Tyndall effect

Tyndall Effect: Tyndall (1869) observed that when a strong beam of light is focused on a colloidal solution the path of the beam becomes visible. This phenomenon is known as **Tyndall effect** and the illuminated path is called **Tyndall cone.** This phenomenon is not observed in case of true solution.

TYNDALL EFFECT



Cause for Tyndall effect

This phenomenon is due to scattering of light by colloidal particles. The colloidal particles become self-luminous due to absorption of light energy which is then scattered from their surface. The maximum scattered intensity in the plane is at right angle to the path of the light and thus the path becomes visible when observed from the sides. The intensity of scattered light depends on the type of colloidal solution and the size of the colloidal particles.

Think and answer

1. Why whole milk is white?
2. Why ocean is blue?
3. Why sun looks yellow when it is really not?

Some Important Types of Colloids

4.20.3 Gels

Gels are colloidal solutions with liquid dispersed in solid. A gel is a semi-solid substance which can flow but not as freely as a liquid. Within a gel the solid (dispersion medium) makes a kind of network which traps the dispersed liquid and makes it unable to flow freely.

Hair creams that are used to keep hair in place are gels that contain water and an oil.

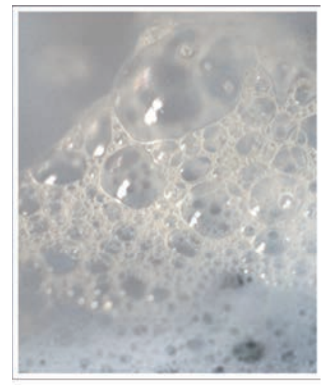
Petroleum gel used to hydrate skin

Hair gel used to style hair

Tooth paste - a gel

Foam and Solid foams: when gas dispersed in a liquid is called a foam. E.g. soap bubbles, carbonated beverages etc.

When the gases are dispersed in a solid structure is called solid foam. E.g. Bread, mattresses.



Soap foam bubbles

Solid foam

Emulsions - a special kind of colloids

An emulsion is a colloid of two or more immiscible liquids where one liquid is dispersed in another liquid. This means one type of liquid particles get scattered in another liquid. In other words, an emulsion is a special type of mixture made by combining two liquids that normally don’t mix. The word emulsion comes from the Latin word meaning “to milk” (milk is one example of an emulsion of fat and water). The process of turning a liquid mixture into an emulsion is called emulsification.

Examples of emulsions

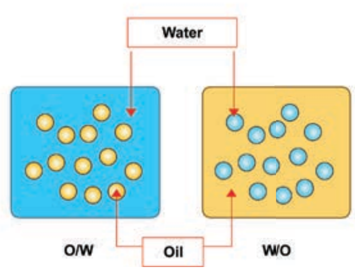
Milk, butter, cream, egg yolk, paints, cough syrups, facial creams, pesticides etc. are some common examples of emulsions.

Types of emulsions

The two liquids mixed can form different types of emulsions. For example, oil and water can form an oil in water emulsion, where the oil droplets are dispersed in water, or they can form a water in oil emulsion, with water dispersed in oil.

Cream: Oil in water   Butter: Water in oil

Type of Emulsions



Emulsions find wide applications in food processing, pharmaceuticals, metallurgy and many other important industries.

Cosmetology

Food industry

Pharmacology

More to Know

Have you seen colourful rainbow patches on a wet road? When oil drops in water on road, it floats over water and forms a rainbow. Find out why.

Have you seen colourful rainbow patches on a wet Road?

Classification of matter based on composition – summary

Flow chart

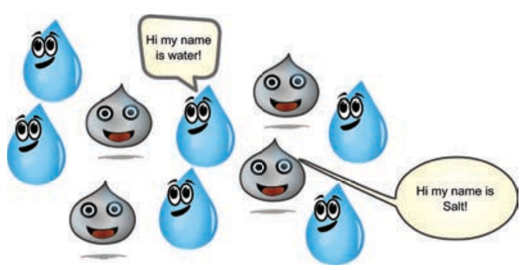
- MATTER
  - PURE
    - ELEMENTS
    - COMPOUNDS
  - IMPURE
    - MIXTURES
      - HOMOGENOUS
      - HETEROGENOUS

4.21 Separation of Mixtures

At the end of the lesson you will be able to

- define key terms such as solute, solvent, solution, filtration, filtrate, distillation, distillate, centrifugation, and chromatography

- analyse and select appropriate methods for separating a given mixture, based on certain difference in physical properties
- describe appropriate methods of separating a given mixture
- perform simple experiments involving separation of mixtures
- identify and assemble the suitable set of apparatus used for separating the components of a given mixture
- explain the basic principles involved in filtration, centrifugation, distillation and chromatography
- gather information about the industrial applications of the different techniques of separation



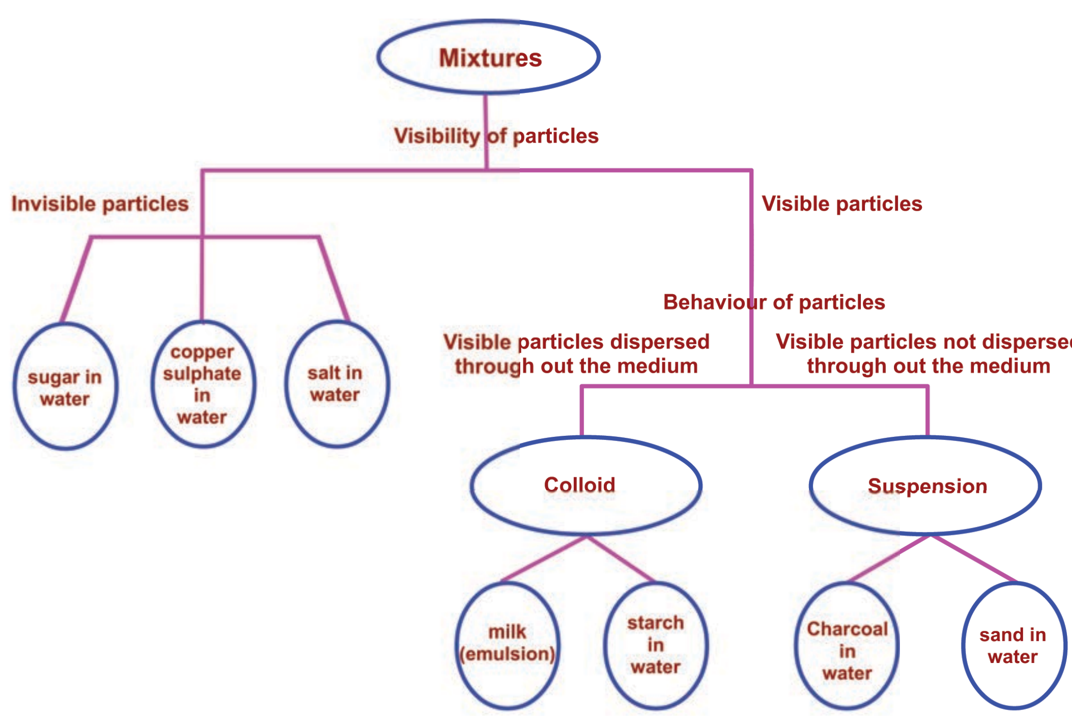
4.21.1 Introduction

A mixture as you know contains more than one substance in which the components can either be elements or compounds or both. We separate the components of a mixture very often as they contain useful substances mixed with harmful or unwanted substances which have to be removed. The choice of a particular method to separate components of a mixture will depend on the properties of the components of the mixture as well as their physical states.

4.21.2 Separation of solid – liquid mixtures

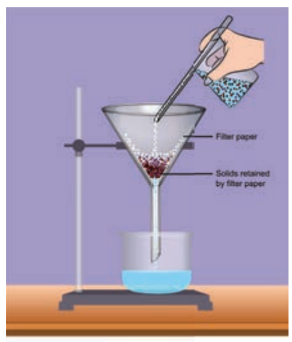
Before we talk about the separation methods let us recall briefly some aspects of solubility of solid and liquid. When a solid is added to a liquid, either the solid will dissolve in the liquid or not.

- When the solid dissolves in the liquid, it is said to be soluble i.e. Solid (solute) + Liquid (solvent) → Solution.
- When the solid does not dissolve in the liquid, it is said to be insoluble.



Separation of insoluble solids from liquids

Filtration and Decantation: You are already familiar with these methods. The illustrations given below will help you to recall these important techniques.



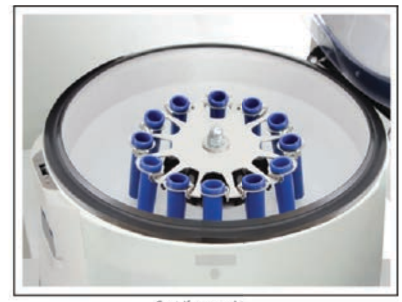
Filteration

Activity 6

Identify whether the given substance is mixture or compound and justify your answer.

S. No.	Substance	Mixture/ compound
1	Sand and water	
2	Sand and iron filings	
3	Concrete	
4	Water and oil	
5	Salad	
6	Water	
7	Carbon dioxide	
8	Cement	
9	Alcohol	

Centrifugation: This is used to separate very fine and tiny particles of solid which do not settle down easily in a liquid. The mixture taken in a centrifuge tube is centrifuged (by rotation) in a centrifuging machine, so that the solid gets deposited at the bottom of the tube and the clear liquid (supernatant) is decanted. E.g. this is used to separate plasma (the liquid) from blood.

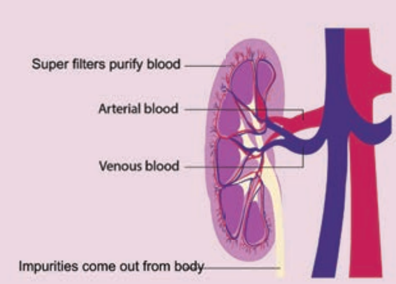


Centrifuge machine

More to Know

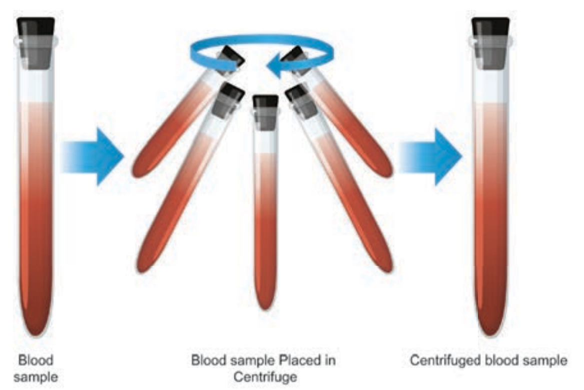
Filters

There are several types of filters: water filters, air - conditioning filters, automobile filters and carbon filters. In the case of colloids, special filter papers are used. They are called as ultra-filters, which have micro pores than ordinary filter papers and will allow only tiny impurities to pass through them and not the colloidal particles. Dialysis is an important method of filtration for purifying colloids.



Natural dialysis

Centrifugation technique is used in cream separator in diaries, in removing fat from milk to produce skimmed milk and in separation of blood components & urine components in forensic science. Medium sized centrifuges are used in washing machine to wring water out of fabrics



Separation of plasma from blood

Separation of soluble solids from liquids

Evaporation and crystallisation: This is used to separate the dissolved solute from the solution. The solution is heated slowly so that the liquid (solvent) evaporates leaving behind the solid as crystals. E.g. Separation of salt from sea water (by solar evaporation in saltern).

Salterns in Tuticorin of Tamil Nadu

Simple distillation: This method is used to separate two liquids whose boiling points differ by more than 25 K. Also by this method, brackish water can be distilled.

Procedure: A distillation flask is fixed with a water condenser. A thermometer is introduced into the distillation flask through a one-holed stopper. The bulb of the thermometer should be slightly below the side tube.

The brackish water (sea water) to be distilled is taken in the distillation flask and heated for boiling. The pure water vapour passes through the inner tube of the condenser. The vapours on cooling condense into pure water (distillate) and are collected in a receiver. The salt are left behind in the flask as a residue.

4.21.3 Separation of liquid – liquid mixtures

a) Type I – Miscible liquids

Fractional distillation: To separate two or more miscible liquids which do not differ much in their boiling points (difference in boiling points is less than 25 K) fractional distillation is employed.

Example: Refining of petroleum product by fractional distillation.

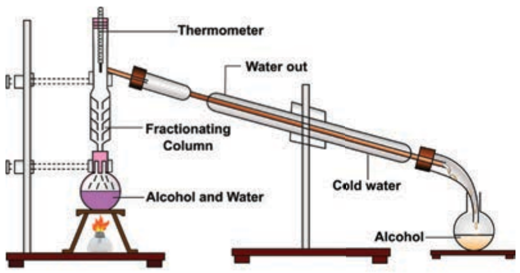
Saltern in Tuticorin of Tamil nadu

Activity 7

Make the students to collect various petroleum products and arrange them according to their boiling points.

Applications of fractional distillation

Fractional distillation is used in petrochemical industry to obtain different fractions of petroleum, to separate the different gases from air, to distil alcohols etc.

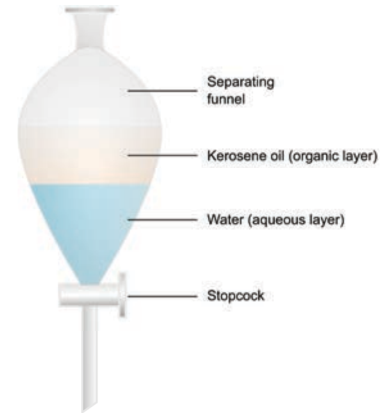


Fractional Distillation

b) Type II: Immiscible liquids

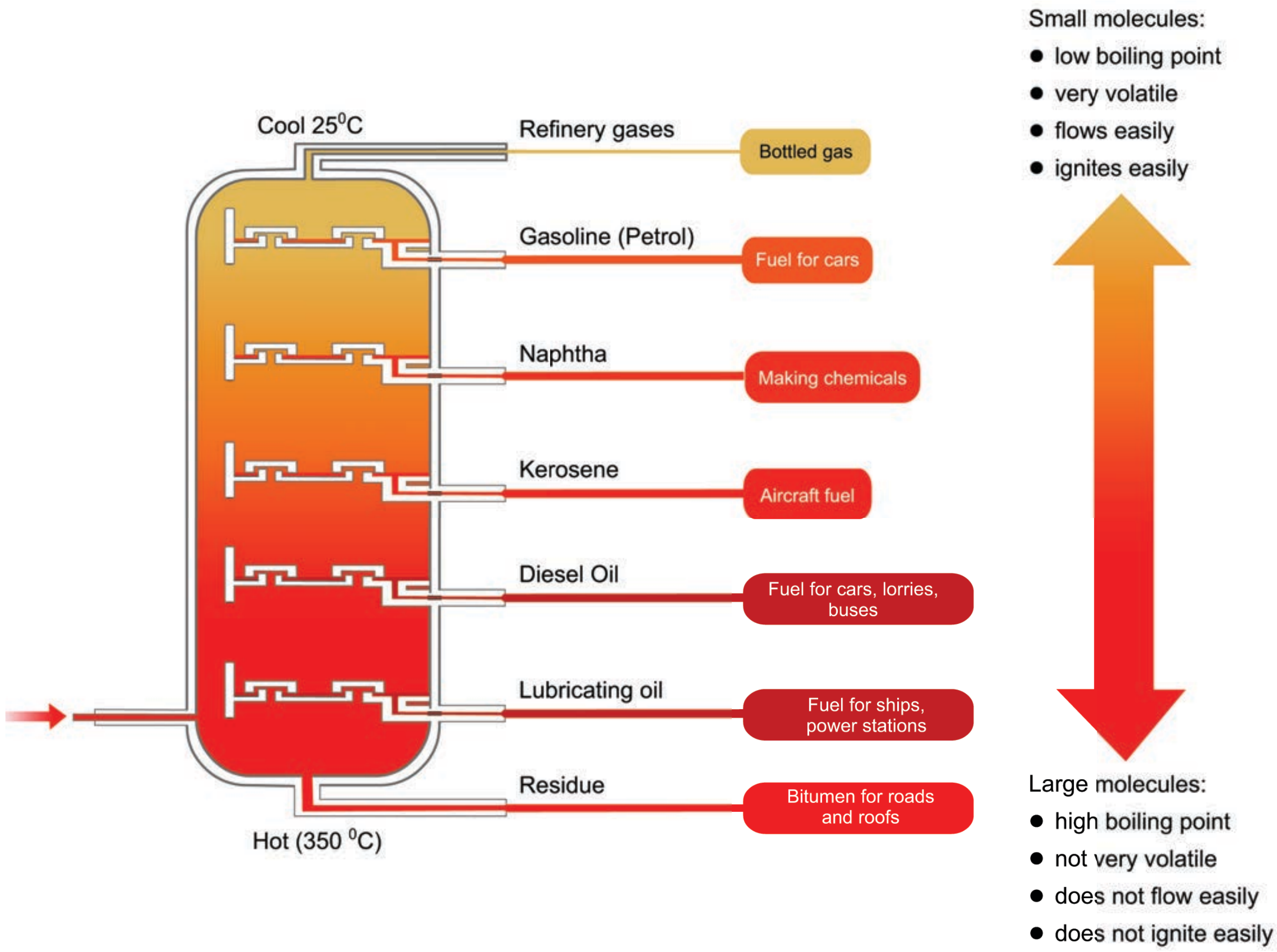
Mixtures of two immiscible liquids are separated by using a separating funnel.

Examples: Mixture of water and oil, Mixture of water and kerosene.

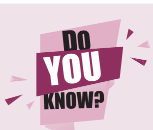


Two immiscible liquids can be separated by solvent extraction method, which is also called as liquid – liquid extraction method. This method works on the basis of difference in solubility of two immiscible liquids in a suitable solvent. Solvent extraction method is used in soap, pharmaceutical and petroleum industries.

Paradip refinery



Fractionating column



Solvent extraction is an old practice done for years. It is the main process in perfume development and it is also used to obtain dyes from various sources.

Oil Spill

DO YOU KNOW? Oil containers are being washed and huge volume of oil-wastages are disposed into river and sea. Oil spill happens by accidents involving tankers, ships and refineries, etc. oil spills also caused by disposal of oil into water bodies. Oil spills affect marine organisms and they may be poisoned or even killed depending on what kind of oil is spilled. Oil spill can take several years to clean-up water bodies depending on location and area located.

Activity 8

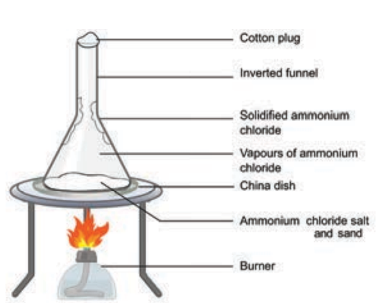
Pair activity: To separate a mixture of oil and water

Take separating funnel. Open the lid and pour the mixture of water and kerosene shake well. Then leave it for 5 minutes. Observe what happens? Water as bottom layer and kerosene floats as upper layer why?

Open the stopcock and collect the water and oil in a separate container.

Separation of mixture containing volatile and non-volatile solids

(i) Sublimation: Certain solid substances when heated change directly from solid to gaseous state without attaining liquid state. The vapours when cooled give back the solid substance. This process is known as sublimation. Examples: (a) Iodine (violet vapours) (b) Camphor, (c) Ammonium chloride etc.



Sublimation

The powdered mixture of Ammonium chloride and sand is taken in a china dish and covered with a perforated asbestos sheet. An inverted funnel is placed over the asbestos sheet as shown in the figure. The open end of the stem of the funnel is closed using cotton wool and the china dish is carefully heated. The pure vapours of the volatile solid pass through the holes in the asbestos sheet and condense on the inner sides of the funnel. The non-volatile impurities remain in the china dish.

Separation of mixture containing volatile and non-volatile solids

Before we discuss the technique we will take a look at two important terms that chromatography involves: Absorption and Adsorption.

Absorption is the process in which the substance is dissolved throughout the bulk of another substance. For example a paper (absorbent) soaks up or absorbs water.

Adsorption is the process in which particles of a substance (it could be gas, liquid or dissolved solid) adhere to a surface of another substance.

For example: charcoal adsorbs gases on its surface. Charcoal is called the adsorbent and the gas is called the adsorbate.

Chromatography is a separation technique. It is used to separate different components of a mixture based upon their different solubilities in the same solvent.

There are several types of chromatography; based on the above basic principles. It involves separation of mixtures by allowing the constituents of the mixture to move between two phases namely

I. Mobile phase
II. Stationary phase

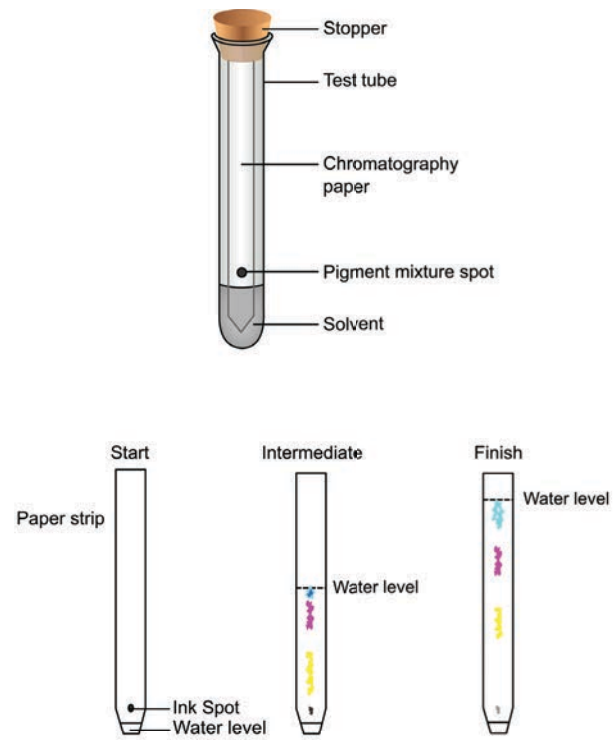
The simplest type is paper chromatography. Here, the stationary phase is the chromatography paper and the mobile phase is the solvent. For example, to separate the different-coloured dyes in a sample of ink, a spot of the ink (e.g. black ink) is put on to a piece of chromatography paper. This paper is then set in a suitable solvent as shown in Figure. The black ink separates into its constituent dyes. As the solvent moves up the paper, the dyes are carried with it and begin to separate. They separate because they have different solubility in the solvent and are adsorbed to different extents by the chromatography paper. The chromatogram shows that the black ink contains three dyes.

We can also draw important inferences from a numerical measurement called Rf (Retention factor) values using the obtained chromatograms. Rf value is defined as the ratio of the distance travelled by the solute spots to the distance travelled by the solvent.

$$\text{Rf} = \frac{\text{Distance travelled by the solute}}{\text{Distance travelled by the solvent}}$$

Applications

Chromatography is used extensively in medical research and forensic science laboratories to separate a variety of mixtures. For example, protein samples are separated by electrophoresis in medical research laboratories.



Chromatographic Separation of Black Ink

More to Know

The substances to be separated need not be coloured. Colourless substances can be made visible by spraying the chromatogram with a 'locating agent'. The 'locating agent' will react with the colourless substances to form a coloured product. In other situations the position of the substances on the chromatogram may be located using ultraviolet light.

EHQLH8

Key words

Matter	Boiling point	Pure substance
Volume	Kinetic energy	Mixture
Diffusion	Inter particle attraction	Homogenous
Force	Inter particle distance	Heterogeneous
Pressure	Change of state	True solution
Latent heat	Melting point	Suspension
Vaporisation	Sublimation	Colloid emulsions

Brownian motion	Emulsion	Adsorbate
Tyndall effect	Centrifugation	Chromatography
Solute	Distillation	Mobile phase
Solvent	Fractional Distillation	Stationary phase
True solution	Solvent Extraction	Dispersed phase / medium
Decantation	Absorption	Retention factor (Rf)
Supernatant liquid	Adsorption	Crystallization
Suspension	Adsorbent	Desalination

Points to Remember

- Matter is made of small particles- atoms in elements and molecules in compounds
- Matter around us exists in three physical states solid, liquid and gas
- The forces of attraction between particles are maximum in solids, intermediate in liquids and minimum in gases and this is responsible for the different properties of the three states of matter
- Matter changes states either by absorbing energy or releasing energy
- Heating and cooling curves describe the changes in temperature with time when a substance is heated or cooled
- Latent heat refers to the hidden heat energy which is utilised for change of state
- Depending upon the chemical composition, matter is classified into elements, compounds and mixtures
- Elements and compounds are considered to be pure substances as they contain only one kind of particles whereas mixtures contain more than one type of particles and they are considered impure substances
- The ratio of the components of a compound is fixed and their components cannot be separated by physical methods
- A mixture contains two or more kinds of particles which are mixed together in any ratio. The components can be separated by physical methods
- In a homogenous mixture (true solution) is the components are uniformly mixed and it will have single phase
- An alloy is a homogenous solution of two or more elements
- A heterogeneous mixture are not mixed thoroughly or uniformly and it will have more than single phase
- Based on particle size heterogeneous mixtures can be classified as colloidal solutions and suspensions
- The properties of colloidal solution are in between that of true solutions and suspensions
- Gels and emulsions are special kind of colloidal solutions which find wide applications in our daily life

A-Z GLOSSARY

1. **Celsius Scale** a scale of temperature in which 0° represents the melting point of ice and 100° represents the boiling point of water.
2. **Colloid** A system in which finely divided particles, which are approximately 1 to 1,000 millimicrons in size, are dispersed within a continuous medium in a manner that prevents them from being filtered easily or settled rapidly.
3. **Compounds** A pure, macroscopically homogeneous substance consisting of atoms or ions of two or more different elements in definite proportions that cannot be separated by physical means. A compound usually has properties unlike those of its constituent elements.
4. **Elements** A substance composed of atoms having an identical number of protons in each nucleus. Elements cannot be reduced to simpler substances by normal chemical means.
5. **Emulsion** a colloid in which both phases are liquids: an oil-in-water emulsion.
6. **Fahrenheit Scale** a scale of temperatures in which 32° represents the melting point of ice and 212° represents the boiling point of pure water under standard atmospheric pressure. Compare Celsius scale.
7. **Force of attraction** The first force that causes attraction is the gravitational force. According to Newton's Universal Law of Gravitation every object in the universe attracts every other object in the universe. Gravity is an attractive force since any object with mass will experience a force of attraction from other objects with mass.
8. **Gas** an air-like fluid substance which expands freely to fill any space available, irrespective of its quantity.
9. **Kelvin Scale** a thermodynamic temperature scale based upon the efficiencies of ideal heat engines. The zero of the scale is absolute zero. Originally the degree was equal to that on the Celsius scale but it is now defined so that the triple point of water is exactly 273.16 kelvins.
10. **Liquid** a substance that flows freely but is of constant volume, having a consistency like that of water or oil.
11. **Matter** physical substance which occupies space and possesses rest mass, especially as distinct from energy.
12. **Mixtures** A composition of two or more substances that are not chemically combined with each other and are capable of being separated.
13. **Solid** Solid is one of the four fundamental states of matter (the others being liquid, gas, and plasma). In solids molecules are closely packed. It is characterized by structural rigidity and resistance to changes of shape or volume.
14. **Absorption** is the process by which atoms, molecules, or ions enter a bulk phase (liquid, gas, solid). Absorption differs from adsorption, since the atoms/molecules/ions are taken up by the volume, not by surface. Examples: absorption of carbon dioxide by sodium hydroxide.
15. **Adsorption** is the adhesion of atoms, ions or molecules from a gas, liquid or dissolved solid to a surface. This process creates a film of the adsorbate on the surface of the adsorbent.

16. **Centrifugation** is sedimentation of particles under the influence of the centrifugal force and it is used for separation of superfine suspensions. At centrifuging forces up to 10 000 times greater than gravity force are used, and at ultracentrifuge up to 600 000 times as great.
17. **Distillation** the separation of the constituents of a liquid by boiling it and then condensing the vapor that results. Distillation can be used to purify water or other substances, or to remove one component from a complex mixture, as when gasoline is distilled from crude oil or alcohol from a mash.
18. **Filtration** is any of various mechanical, physical or biological operations that separate solids from fluids (liquids or gases) by adding a medium through which only the fluid can pass. The fluid that passes through is called the filtrate.
19. **Retention factor** The Rf value is defined as the ratio of the distance moved by the solute (i.e. the dye or pigment under test) and the distance moved by the solvent (known as the Solvent front).
20. **Solution** a solution is a homogeneous mixture composed of two or more substances.
21. **Solute** a solute is a substance dissolved in another substance, known as a solvent.
22. **Supernatant** denoting the liquid lying above a solid residue after crystallization, precipitation, centrifugation, or other process.
23. **Suspension** A suspension is a heterogeneous mixture in which solute-like particles settle out of a solvent-like phase sometime after their introduction. We use the terms 'solute-like' and 'solvent-like' because we are dealing with a heterogeneous mixture, while the terms solute and solvent refer to homogeneous solutions.

EXERCISE 1

I. Choose the correct answer

1. The physical state of water at 373 K is ______________

   a) Solid b) liquid
   c) vapour d) plasma

2. Among the following ____________ is a mixture

   a) Common Salt b) Juice
   c) Carbon dioxide d) Pure Silver

3. When we mix a drop of ink in water we get a _________________

   a) Heterogeneous Mixture
   b) Homogeneous Mixture
   c) Compound
   d) Suspension

4. The constituents that form a mixture are also called

   a) Elements b) Compounds
   c) Alloys d) Components

5. ___________ has the same properties throughout the sample

   a) Pure substance b) Mixture
   c) Colloid d) Suspension

II. State whether the following statements are true or false. If false give the correct statement

a) Liquids expand more than gases on heating.

b) A compound cannot be broken into simpler substances chemically.

c) Water has a definite boiling point and freezing point.

d) Buttermilk is an example of heterogeneous mixture.

e) Aspirin is composed of 60% Carbon, 4.5% Hydrogen and 35.5% Oxygen by mass. Aspirin is a mixture.

III. Match the following

S.No	A	B
i	Element	Settles down on standing
ii	Compound	Impure substance
iii	Colloid	Made up of molecules
iv	Suspension	Pure substance
v	Mixture	Made up of atoms

IV. Fill in the blanks

1. Evaporation is always accompanied by_______________ in temperature
2. 150°C =_________ K
3. A _______________mixture has no distinguishable boundary between its components.
4. An example of a substance that sublimes is _________________
5. Latent heat is the energy used for _________________.

V. Very Short answer

1. Why is it possible to row a boat in water but not pass through a wooden fence?
2. How gaseous pressure arises?
3. Define Sublimation.
4. Which state of matter has the highest kinetic energy?
5. A few drops of 'Dettol' when added to water the mixture turns turbid. Why?

VI. Short answer

1. Why are gases easily compressible whereas solids are incompressible?
2. Hold a 'smiley ball' and squeeze it. Can you compress it? Justify your answer?
3. Which of the following are pure substances? Ice, Milk, Iron, Hydrochloric acid, Mercury, Brick and Water.
4. Oxygen is very essential for us to live. It forms 21% of air by volume. Is it an element or compound?
5. You have just won a medal made of 22-carat gold. Have you just procured a pure substance or impure substance?

VII. Long Answer

1. Write the differences between elements and compounds and give an example for each.
2. Explain Tyndall effect and Brownian movement with suitable diagram.
3. How are homogenous solutions different from heterogeneous solution? Explain with examples.

VIII. Get together and do

1. **Project**

   Make a model to demonstrate any characteristic property of particles in a solid, liquid and gas.