SCIENCE

Textbook for class IX

As per the latest syllabus issued by CBSE

- Dr. JOSHI
- Dr. SAINI
- Dr. TAMBER
- GUPTA

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REVISED EDITION
2020-2021

CHEMISTRY

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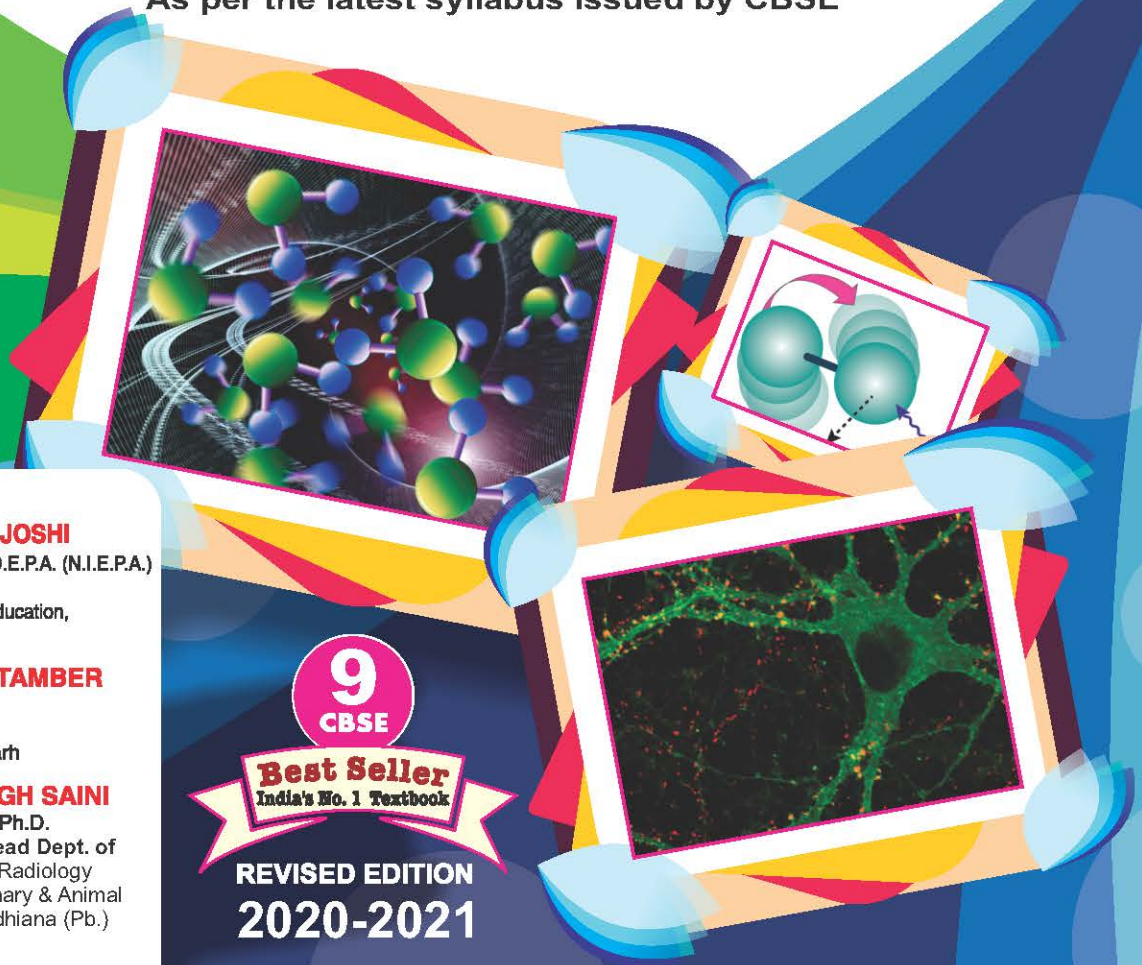

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A FEW INTRODUCTORY WORDS

Science Textbook(Chemistry) has been written for the students of **Class IX** as per the latest syllabus and new instructions issued by CBSE. By making use of the long experience in the field of science education, every possible effort has been made, while writing the present book, to make it most useful to the students in their pursuit of knowledge. ***The following main features are making their appropriate contributions towards usefulness of this book :***

(i) The subject matter has been dealt with giving necessary and requisite details.

(ii) Scientific principles and facts have been written in an interesting and easy style using very simple language.

(iii) A number of neat and labelled diagrams have also been incorporated for the clarity of the subject matter wherever necessary.

(iv) The treatment of the subject matter is neither too brief to be difficult to find out the scientific facts nor it is so wide and spread out that the students may get lost while searching out the desired facts from it.

(v) The essential facts and principles as well as various topics and sub-topics have been given in bold prints so that the students may be able to locate and learn the required and needed information quite easily in the shortest possible time.

(vi) A large number of very short, short, long answer questions including numericals have been incorporated in the form of various exercises after covering the concerned topics or sub-topics so that the students by attempting these may prepare well with ease and self-confidence for the short term and long term examinations.

(vii) One of the unique feature of this book is that "Hints and Answers to Some Questions" have been given for all the questions appearing in the "Exercises" for encouraging and developing the process of self-study among the students.

(viii) A special care has been taken while writing the subject matter of this book that the acquired knowledge should provide a solid base for science subjects to be studied in the higher classes.

(ix) In this book, the subject matter has been given under unitwise heads in the form of concerned chapters as Quick Revision, Very Short Answer Questions (1 mark each), Short Answer Questions–I (2 marks each)], Short Answer Questions–II (3 marks each), Long Answer Questions (5 marks each), Numerical Problems (if any), Higher Order Thinking Skills (HOTS) Questions, Value Based Questions along with required model answers to the questions.

(x) Special effort has been made to add a number of Multiple Choice Questions (MCQ) related to the Theory Topics dealt with and as well as the concerned practicals for the benefit of the students.

(xi) All questions appearing in the Science Textbook for IX class by NCERT have been dealt with in each chapter under sub-head, **"NCERT Textbook Questions"**. **NCERT Science Examplar Questions** (with answers) are also added for follow up by the learners.

I am highly thankful to all persons who have extended their willing help and co-operation in their own way in the preparation of this book. Every effort has been made while writing this book to cater to the needs of the students, therefore, this book will certainly be helpful and useful to the students.

In spite of my sincere efforts, there might have crept in some deficiencies in the preparation of this book. Constructive suggestions for removing the deficiencies and improving the book by the students, teachers and educationists will be gratefully appreciated. Any point concerning improvement of the book may please be shared with the author without any hesitation.

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In spite of our sincere efforts, there might have crept in some deficiencies in the preparation of this book for which the Authors and Publisher should not be held responsible. However, constructive suggestions for further improvement of this book will be highly appreciated and looked forward in our subsequent editions.
For latest update in syllabus and marking scheme visit : www.cbse.nic.in

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SCIENCE (CHEMISTRY) IX

CONTENTS

CBSE SYLLABUS
Class–IX

Theme : Materials

Unit I : Matter-Nature and Behaviour **(50 Periods)**

Definition of matter; solid, liquid and gas; characteristics - shape, volume, density; change of state- melting (absorption of heat), freezing, evaporation (cooling by evaporation), condensation, sublimation.

Nature of matter : Elements, compounds and mixtures. Heterogeneous and homogenous mixtures, colloids and suspensions.

Particle nature, basic units : Atoms and molecules, Law of constant proportions, Atomic and molecular masses. Mole concept : Relationship of mole to mass of the particles and numbers.

Structure of atoms : Electrons, protons and neutrons, valency, chemical formula of common compounds. Isotopes and Isobars.

Theme : The World of the Living

Unit II : Organization in the Living World **(45 Periods)**

Call - Basic Unit of life : Cell as a basic unit of life; prokaryotic and eukaryotic cells, multicellular organisms; cell membrane and cell wall, cell organelles and cell inclusions; chloroplast, mitochondria, vacuoles, endoplasmic reticulum, Golgi apparatus; nucleus, chromosomes - basic structure, number.

Tissues, Organs, Organ System, Organism : Structure and functions of animal and plant tissues (only four types of tissues in animals; Meristematic and Permanent tissues in plants).

Biological Diversity : Diversity of plants and animals - basic issues in scientific naming, basis of classification. Hierarchy of categories / groups, Major groups of plants (salient features) (Bacteria, Thallophyta, Bryophyta, Pteridophyta, Gymnosperms and Angiosperms). Major groups of animals (salient features) (Non-chordates upto phyla and chordates upto classes).

Health and Diseases : Health and its failure. Infectious and Non-infectious diseases, their causes and manifestation. Diseases caused by microbes (Virus, Bacteria and Protozoans) and their prevention; Principles of treatment and prevention. Pulse Polio programmes.

Theme : Moving Things, People and Ideas

Unit III : Motion, Force and Work (60 Periods)

Motion : Distance and displacement, velocity; uniform and non-uniform motion along a staight line; acceleration, distance-time and velocity-time graphs for uniform motion and uniformly accelerated motion, derivation of equations of motion by graphical method; elementary idea of uniform circular motion.

Force and Newton's laws : Force and Motion, Newton's Laws of Motion, Action and reaction forces, Inertia of a body, Inertia and mass, Momentum, Force and Acceleration. Elementary idea of conservation of Momentum.

Gravitation : Gravitation; Universal Law of Gravitation, Force of Gravitation of the earth (gravity), Acceleration due to Gravity; Mass and Weight; Free fall.

Floatation : Thrust and Pressure. Archimedes' Principle; Buoyancy; Elementary Idea of Relative Density.

Work, energy and power : Work done by a Force, Energy, Power; Kinetic and Potential energy; Law of conservation of energy.

Sound : Nature of sound and its propagation in various media, speed of sound, range of hearing in humans; ultrasound; reflection of sound; echo and SONAR. Structure of the Human Ear (Auditory aspect only).

Theme : Natural Resources : Balance in Nature

Unit IV : Our Environment (15 Periods)

Physical resources : Air, Water, Soil. Air for respiration, for combustion, for moderating temperatures; movements of air and its role in bringing rains across India. Air, Water and Soil pollution (brief introduction). Holes in ozone layer and the probable damages.

Bio-geo chemical cycles in nature : Water, Oxygen, Carbon and Nitrogen.

Theme : Food

Unit V : Food Production (10 Periods)

Plant and animal breeding and selection for quality improvement and management; Use of fertilizers and manures; Protection from pests and diseases; Organic farming.

1 Matter in Our Surroundings

MATTER

1.1 (A) What is Matter ?

Anything that occupies space and has mass is called **matter*****.***

On looking around at our surroundings, we find a large number of things having different shapes, sizes and textures. For example, *books, chairs, tables, animals, plants, water, sand, stones, clouds, stars, oxygen, carbon, sulphur, steel, also the air we breathe, the food we eat, the cold drinks we enjoy, etc.,* all the occupy space and have mass. Therefore, *all of these are made up of matter*.

Chair Stone Plant

On the other hand *thoughts, affection, friendship, love, hatred, cold, heat, smell, taste, smell of a perfume or sizzling food etc.,* do not occupy space and have no mass, so from the scientific point of view these are not considered as made up of matter.

Smell of a Perfume

Different variety of things around us and in nature are made up of matter, so it is quite interesting to know something about matter in order to understand in a better way regarding nature of things.

(B) Classification of Matter

Matter can be classified in a number of ways. Ancient Indian philosophers held the view that all the living and non-living matter was made up of five

Chapter Overview

"basic elements" *(Panch tatva): air, earth, fire, sky and water.* Early Greek philosophers were also having similar views concerning classification of matter.

Panch tatva

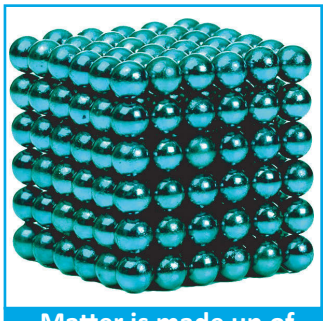
Modern scientists have classified matter into two ways :

(i) based upon its physical properties and
(ii) based upon its chemical properties.

In the present chapter we shall learn about matter in relation to its physical properties and the chemical aspect of matter will be discussed in the chapters given ahead.

PHYSICAL NATURE OF MATTER

1.2 Matter is made up of particles



Matter is made up of particles

Two opposite views regarding nature of matter prevailed for a long period of time. According to *one view* matter was considered to be continuous like a block of wood or a stone. As per *second view* matter was considered to be made up of small particles something like that of sand. Now question arises whether matter exists as continuous or in particulate form. This can very easily be decided with the help of the following simple activity (or experiment).

Activity (or *Experiment*)–1

(i) Fill with about 100 mL water in a 150 mL long type glass beaker having mL markings. Place a clean glass rod into it and note the level of water in the beaker.

(ii) Add about 10 grams* of **cane-sugar** crystals with the aid of a spoon carefully along the sides of the beaker into water and observe the level of water in the beaker.

(iii) Dissolve sugar by stirring slowly with the help of the glass rod and observe again the water level in the beaker.

(iv) What has happened to sugar crystals ?

** If you add lot of sugar, then the experiment will fail.*

Observations : While performing the above experiment you will observe that on adding sugar crystals, there will be slight increase in the level of water in the beaker. But on dissolving sugar, the water level will come to the previous level which shows that volume of solution has not increased on dissolving sugar in water. Sugar crystals on stirring have disappeared.

Discussion : Disappearance of sugar crystals shows that sugar crystals have changed into smaller and smaller particles and ultimately into very-very small particles (molecules). The ultimate particles have dispersed between spaces of very-very small ultimate particles (molecules) of water. Due to this, level of water in the beaker remains at the same mark even on dissolving a small amount of crystals of sugar in water.

Besides providing answers to a few other questions, this experiment particularly shows that matter (sugar) is made up of very-very small ultimate particles (molecules) which are so small that they are not visible to the eye.

Similar results will be obtained if we perform the experiment with *(common) salt.* There will be ultimate very, very small particles *(ions)* in this case also.

Diagrams

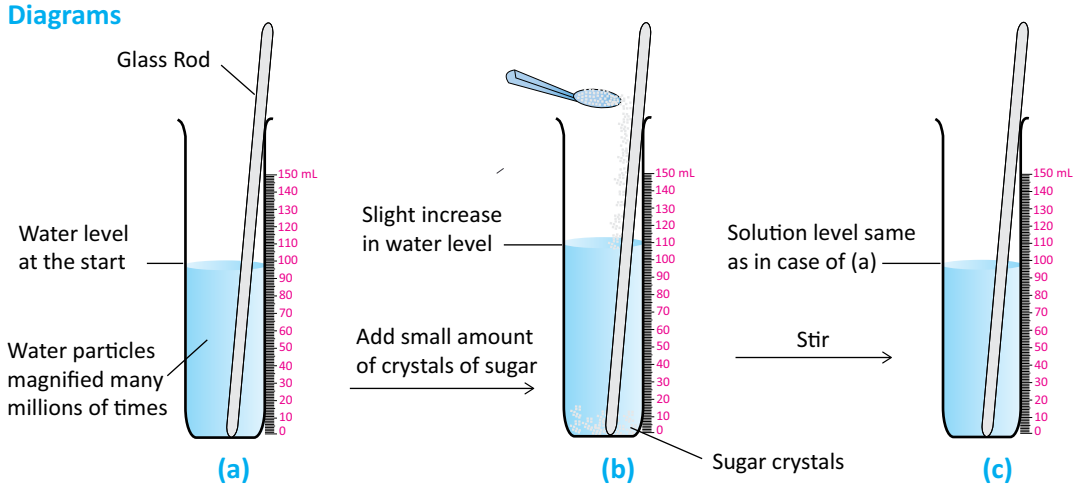


Fig. 1.1 – On dissolving sugar crystals in water, the particles of sugar get into spaces between particles of water.

CHARACTERISTICS OR PROPERTIES OF PARTICLES OF MATTER

1.3 (A) Some of the important physical characteristics of particles of matter are as follows :

- The particles of matter are very, very, very small.
- The particles of matter have spaces between them.
- The particles of matter are continuously moving.
- The particles of matter attract each other.

Let us perform simple experiments to show the characteristics of the particles of matter.

(B) Descriptions of Properties of Particles of Matter

1. Particles of matter are very, very, very small

Activity (or *Experiment*)–2

(i) Dissolve 2-3 crystals of **potassium permanganate** in about 100 mL of water taken in a beaker to give deep purple coloured solution.

(ii) Take out about 10 mL of this solution and put it into about 90 mL of clear water taken in a second beaker to give a bit light coloured solution.

(iii) Again take out about 10 mL of solution from the second beaker and put into about 90 mL of clear water taken in a third beaker to obtain solution which is further lighter in colour.

(iv) Keep on diluting the potassium permanganate solution in the similar way for a number of times (say total 5 times). Towards the end, colour of solution will be very light (having pinkish colour).

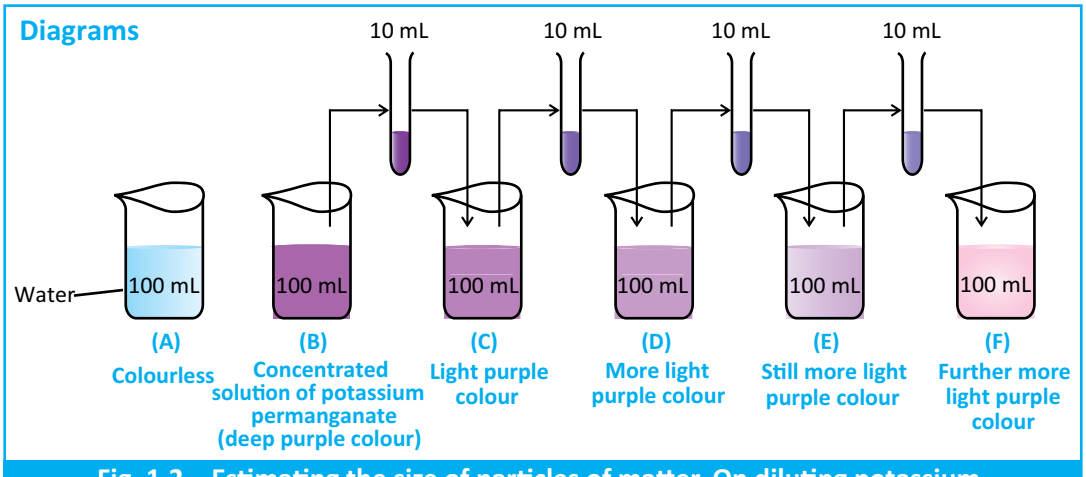


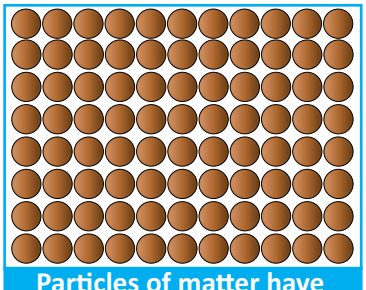
Fig. 1.2 – Estimating the size of particles of matter. On diluting potassium permanganate solution a number of times the colour of potassium permanganate persists indicating that particles of matter are extremely small.

Observations and Conclusions : This experiment shows that just 2-3 crystals of potassium permanganate can impart colour to a large volume of water. This observation leads us to the conclusion that each crystal of potassium permanganate is made up of a very large number of particles (many, many millions) which continue to divide further and further into smaller particles to impart colour to the solution on dilution. Division of a crystal of potassium permanganate continues to a stage to form ultimate particles (ions) which cannot further divide into smaller particles. As each crystal of potassium permanganate is made up of so many millions of particles so the ultimate particles must be very-very small. Thus, we can conclude that ultimate particles of matter are (beyond our imagination) very-very small which are not visible to our eyes.

The above activity (*experiment*) can be repeated using about 2 mL of **dettol** in place of potassium permanganate. Characteristic smell of dettol can be felt on repeated dilution.

2. Particles of matter have spaces between them

We have already seen in *(Activity–1)* that level of solution on dissolving a small amount of crystals of cane-sugar in water remains the same as was in case of water and moreover sugar particles have got distributed evenly throughout water. Similar has been the case with common salt, dettol and potassium permanganate when they have been dissolved separately in water. Again when we prepare tea, coffee or lemonade (*nimbu panni*) then also one kind of particles get evenly distributed into the spaces between the particles of the other. This shows that there are spaces between particles of matter.



Particles of matter have spaces between them

3. Particles of matter are continuously moving

A number of simple activities can be performed to understand this property of matter.

Activity (or *Experiment*)–3

(i) Place unlit **incense stick** in the corner of a room or classroom.

(ii) Move towards it till you get pleasant smell of incense.

(iii) Come to your original place and ask someone to light the incense stick.

(iv) Do you get the pleasant smell of the incense while sitting at a distance from it ?

Movement of particles of incense in gaseous state is very fast as compared to solid state.

Observations and Inferences

In this case you will have to go quite close to the unlit incense stick to get its pleasant smell but when the incense is lit then you get the pleasant smell of it at a distance from it. It may be noted that movement of particles of incense in gaseous state is very fast as compared to that of in solid state.

Conclusion — See at the end of *Activity-5* given further.

Activity (or *Experiment*)–4

(i) Take two glass tumblers or beakers and fill three-fourth of them with water.

(ii) Put a drop of **blue or red ink** quite slowly along the side of one tumbler and a **honey drop** along the side of the other tumbler.

(iii) Leave the contents of the tumblers undisturbed in the corner of your classroom or your room at home.

(iv) Observe for some time the slow activities taking place in the contents of tumblers.

(v) How much time does the contents in each case take to form uniform solution.

Observations : You will observe that ink drop and honey drop in their respective tumblers are very slowly spreading in water. Depending upon the amount of water in the tumblers they would take time (say ½ hr) to form uniform solutions.

Conclusion : See at the end of *Activity 5* given further.

Activity (or *Experiment*)–5

(i) Drop carefully **a crystal of potassium permanganate** in a glass tumbler (or beaker) containing **cold water** and another crystal in a glass tumbler having **hot water**. Allow the crystals to settle down at the bottom of the tumblers.

(ii) Do not stir the contents in the glass tumblers.

(iii) Observe carefully for some time the slow activities going on near the crystals in both the cases.

(iv) What do these observations suggest about the movement of particles of potassium permanganate.

(v) Do you observe some difference in the activities taking place in case of cold and hot water.

Observations

(a) In the beginning, you will observe that without stirring the potassium permanganate crystals start dissolving very slowly in water as is clear from the spreading of purple colour in water. In due course of time uniform coloured solution will be obtained in both the cases.

(b) It will be observed that spreading of purple colour of potassium permanganate will be quite faster in hot water as compared to that of in cold water. Uniform purple coloured solution of potassium permanganate will be formed quite earlier in case of hot water than in cold water.

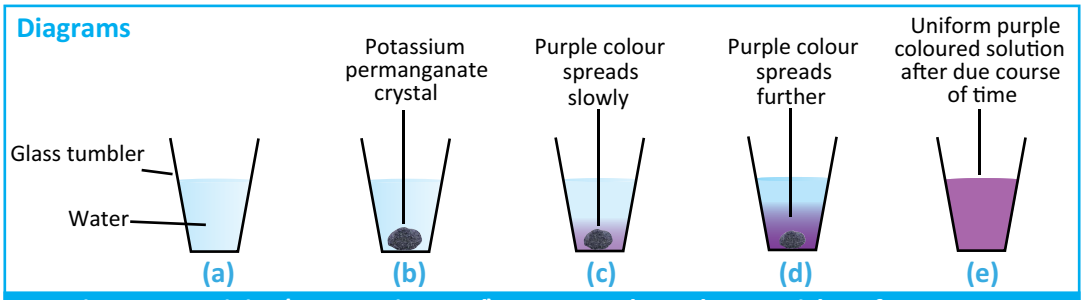


Fig. 1.3 – Activity (*or experimental*) set-up to show that particles of matter are continuously moving.

When above experiments are performed with ***copper sulphate crystals***, similar observations will be obtained. It may be noted that copper sulphate crystals on dissolving in water gives pale blue solution.

Conclusions : From the observations noted down in activities No. 3, 4 and 5 following clear-cut conclusions can be drawn :

(a) *Particles of matter are continuously moving. It means that they possess kinetic energy.*
In the above experiments as the particles of relevant matter i.e. incense, ink, honey, potassium permanganate and copper sulphate got mixed up with water without stirring so they must be in continuous motion. Particles of water are also in motion.

(b) With the increase in temperature, movement of particles of matter becomes faster. In other words, the kinetic energy of the particles of matter increases with increase of temperature.
This conclusion is quite evident from the observations that mixing of potassium permanganate to form uniform solution was faster in hot water than that of in cold water.

Light blue crystals of copper sulphate

Diffusion : While performing the activities concerning movement of particles of matter we have observed that particles of matter have intermixed among themselves of their own without stirring, that is, without the help of any outside agency. The particles of one matter got uniformly dispersed into the spaces between the particles of other matter in due course of time.

***The intermixing of particles of two different types of matter of their own due to movement of particles without the aid of any outside agency is called* diffusion.**

Diffusion becomes faster on heating the concerned different materials because the particles of matter move faster on getting heat energy, that is, the kinetic energy of the particles of matter increases.

4. Particles of matter attract each other

This property of matter can be well understood with the help of following activities :

Activity (or *Experiment*)–6

(i) Make **four groups of students** containing five students in each group. Make three human chains as follows :

(ii) The first group should hold each other from the back and lock arms as are done by dancers in case of Idu-Mishmi (*Bihu*) dance (see Fig.).

(iii) The second group should form a human chain by holding their hands together.

Bihu Dance

(iv) The third group should form a human chain by holding fingers.

(v) The fourth group should try to break the three human chains one by one by running around.

Observations and Conclusions : The third human chain is easier to break as compared to the second chain while the second human chain is easier to break as compared to the first chain. In human chains, the individuals in the third chain are held with lesser force than that of in the second chain. On the other hand, the first human chain is difficult to break as compared to the second chain as individuals of the first chain are held with greater force than that of in the second chain.

Analogy of individuals in the human chains can be extended to particles of matter. Particles of matter are held strongest in the first chain and weakest in the third chain.

Activity (or *Experiment*)–7

(i) Place an **iron nail, a piece of chalk** and **a rubber band** on a hard surface say on a flat piece of stone.

(ii) Hammer the iron nail and piece of chalk and stretch hard the rubber band to break them.

Observations : It is not easy to break iron nail. The piece of chalk breaks easily. Rubber band on stretching breaks more easily.

Activity (or *Experiment*)–8

(i) Open a **water tap**.

(ii) Try to break with your finger, the stream of water coming out of it.

Observation : Stream of water can be cut with the fingers but water comes together again.

Conclusions : The above activities No. 7 and 8 lead us to the conclusion that : *The particles of matter have attractive force acting between them* (which may be called interparticle force). This force keeps the particles of matter bound to each other. The strength of force of attraction varies as kind of matter changes. A particular kind of matter like iron may have stronger force of attraction while others such as chalk and stream of water may have relatively weaker attractive force.

STATES OF MATTER

1.4 (A) What is meant by States of Matter ?

Under different conditions, all matter exists in three different states namely *solid*, *liquid* and *gas*. For example water exists in solid state as ice, in liquid state as water and in gas state as steam or water vapours. ***Three physical forms of matter, that is, solid, liquid and gas are known as the*** **states of matter**.

A few common examples of solids, liquids and gases are :

Solids : Pen, stone, chair, table, book, wood, a piece of thread, a needle, iron, sugar, sodium chloride, etc.

Liquids : Water, milk, cooking oil, petrol, kerosene, ethyl alcohol, acetone, cold drink, juice, etc.

Gases : Carbon dioxide, oxygen, nitrogen, hydrogen, chlorine, air, ammonia, steam, etc.

Different states of matter arise due to variation in the characteristics of the particles of different types of matter. Let us study the properties of these three states of matter in brief.

(B) General Properties of Solids, Liquids and Gaseous States of Matter

Different characteristics of three states of matter are summed up here in a tabular form for easy comparability.

Property	Solids	Liquids	Gases
(i) **Shape**	Solids have definite and fixed shapes which cannot be changed easily and they have distinct boundaries.	Liquids do not have fixed shape and take up the shape of the vessel in which they are put.	Gases do not have fixed shape and they take up the shape of vessel in which they are put.
(ii) **Volume**	They have fixed volume.	They have fixed volume.	They do not have fixed volume.
(iii) **Rigidity**	They are rigid.	They are not rigid.	They are not rigid.
(iv) **Compressibility**	They have negligible compressibility.	They have negligible compressibility.	They are highly compressible.
(v) **Fluidity**	They are not fluids, i.e., they do not flow.	They are fluids and can easily flow.	They are fluids and can easily flow.
(vi) **Spreading**	They stay where they are placed and do not spread out of their own in the whole vessel.	They stay near the base of the vessel in which they are put and do not spread out of their own in the whole vessel.	They spread out in the whole space available to them in the vessel in which they are put.
(vii) **Density**	Solids have high densities.	Liquids have moderate to high densities but usually less than that of solids.	Gases have very low densities. They are very light.
(viii) **Interparticle forces of attraction**	Very strong.	Relatively less strong.	Almost negligible.
(ix) **Diffusion**	Solids diffuse into one another extremely slowly.	Liquids diffuse into one another fast but less fast than that of gases.	Gases diffuse into one another very fast.
(x) **Kinetic Energy**	Particles of solids have minimum kinetic energy.	Particles of liquids have higher kinetic energy than that of solids.	Particles of gases have highest kinetic energy.
(xi) **Packing**	The constituent particles are very closely packed.	The constituent particles are less closely packed.	The constituent particles are very loosely packed.
(xii) **Interparticle distances/ spaces**	The interparticle distances/spaces are the smallest.	The interparticle distances/ spaces are larger than in solids.	The interparticle distances/ spaces are the largest.

(C) To which state of matter does a rubber band, (cane) sugar, (common) salt and sponge belong to :

(i) **Rubber band :** Solids have fixed shapes but rubber band changes its shape on stretching. Is it a solid or not ? **Rubber band** *is a solid because it changes its shape* under the effect of force and regains its original shape when force is removed. If excessive force is applied then it breaks like other solids.

(ii) **Sugar and salt :** (Cane) sugar and (common) salt in their tiny crystalline form when put into jars of different shapes takes up the shapes of the jars. This fact no doubt resembles with the properties of liquids and not with that of solids but shape of individual crystals when put in different jars remains fixed, therefore, sugar and salt in crystalline form are solids.

(iii) Sponge : Sponge can be very easily compressed. We consider it a solid because sponge contains so many minute holes which contain air. When it is pressed then air goes out of holes and it gets compressed but regains its original shape when pressure is released.

(D) Description of a few terms and facts

We have used certain terms and facts, while describing properties of solids, liquids and gases. You may already be knowing about them but let us refresh your knowledge about them.

(i) Rigidity : Solids have a specific tendency to maintain their shapes when subjected to outside force. Solids resist change in their shapes, so they are rigid. Solids may break under excessive force but it is difficult to change their shape. Wood, stone, table, etc., are rigid.

The property of a solid to resist change in its shape when subjected to outside force is called **rigidity**.

Rigid Bodies

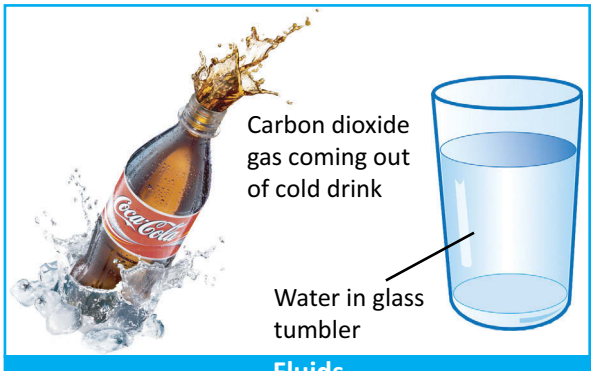
This is the main characteristic which distinguishes solids from liquids and gases because liquids and gases can easily change their shapes in response to outside forces but solids resist the change in their shapes.

(ii) Compressibility : Solids and liquids are negligibly compressible, that is, almost incompressible but gases are highly compressible when compressed. ***The property of decrease in volume, when a substance is compressed is called*** **compressibility**.

Compressibility is an important property to distinguish the gases from liquids. Gases are highly compressible while liquids are not. For example, air, oxygen gas, ammonia gas, nitrogen gas, etc., are highly compressible.

(iii) Fluids and Fluidity : ***A substance, which can flow easily is termed as*** **fluid**.

The property of a substance by virtue of which it can flow easily is known as **fluidity**. Gases and liquids can flow easily, therefore, they are called fluids. For example, water, spirit, kerosene, milk, air, carbon dioxide gas, etc., are fluids.



Fluids

(iv) Kinetic energy : ***Energy possessed by a body or a particle due to its motion is called*** **kinetic energy**. As particles of matter are continuously moving, so they possess kinetic energy. A particle moving with a high speed has higher kinetic energy as compared to the one moving with a slow speed. As particles of a gas move at a very high speed so they possess high kinetic energy as compared to those particles of solids and liquids which move at lower speeds.

(v) A gas fills the whole vessel in which it is put : An interesting property of gases is that they fill the whole closed vessels in which they are placed but liquids and solids remain at or near the base. *The reason for this is that particles of a gas exist far apart and possess high kinetic energy, therefore, they move at very high speed randomly in all directions. Consequently, they spread out in the whole space available to them in the closed vessel and thus fill the whole vessel.*

(vi) Density : ***Mass per unit volume of a substance is called its*** **density**.

Density $= \frac{\text{Mass}}{\text{Volume}}$ or $\rho = \frac{M}{V}$ where ρ stands for density, M for mass and V for volume of a substance.

In general, density of solids is more than that of liquids and that of liquids is more than that of gases. The reason for this is that particles in solids are relatively closely packed than that of in liquids but particles of gases exist comparatively apart. Consequently, mass per unit volume in case of a solid is more as compared to that of a liquid but a gas has very small mass per unit volume. So, density of solids is more than that of liquids but density of gases is very less, that is, they are very light.

Sample Problem

Arrange the following in order of increasing density: air, exhaust of chimneys, honey, water, chalk, cotton, iron. **[NCERT Textbook Q.1-P.6]**

Solution : Exhaust of chimneys < air < cotton < water < honey < chalk < iron

(vii) Shape : Shape of each solid substance is definite and fixed but shapes of liquids and gases are not fixed. Liquids and gases take the shape of the vessels in which they are put. Shapes of solids are fixed as they resist change in their shapes under the influence of outside force but liquids and gases do not do so. **Shape *of a substance is its external form and is determined by its distinct boundaries***. When we put water in a beaker and in a conical flask then it acquires their respective shapes. Similarly, on filling air into balloons of different shapes, air acquires their respective shapes.

(viii) Ice floats on water : Liquids generally have lower density as compared to solids but ice floats on water, why ? In solids, particles are closely packed as compared to that of in liquids, so densities of solids are generally more than that of liquids. But ice which is a solid floats on water due to peculiar behaviour of water when it is cooled to form ice.

Water is most dense at 4°C, that is, density of water is maximum at 4°C. As temperature falls below 4°C water starts expanding and thus ice formed in solid-state at 0°C floats on water being lighter than water.

(ix) A wooden table or a chair is called a solid because it has definite and fixed shape and it resists change in shape under the effect of any outside force.

(x) An ordinary person can move his hand in air easily because air does not resist change in its shape but on the contrary, the same person cannot move his hand through a block of wood because block of wood resists change in shape. Excessive force if applied can break the block of wood. Because a *Karate* expert can apply concentrated force with a stroke of his hand so, he moves his hand through block of wood by breaking it.

(E) To show that a liquid does not have fixed shape but has fixed volume

Activity (or *Experiment*)–9

(i) Take three containers having different shapes.

(ii) With the help of a measuring cylinder, put a 100 mL mark on each of them.

(iii) Pour 100 mL of water in each container after measuring with the help of a measuring cylinder.

(iv) Note down the shape of water and volume of water in the containers.

Observations

(a) Water in different containers takes the shape of respective container.

(b) Volume of water in different containers stands upto the 100 mL fixed mark.

Conclusion : The experiment shows that a liquid (water) does not have fixed shape but has fixed volume (See fig. 1.4).

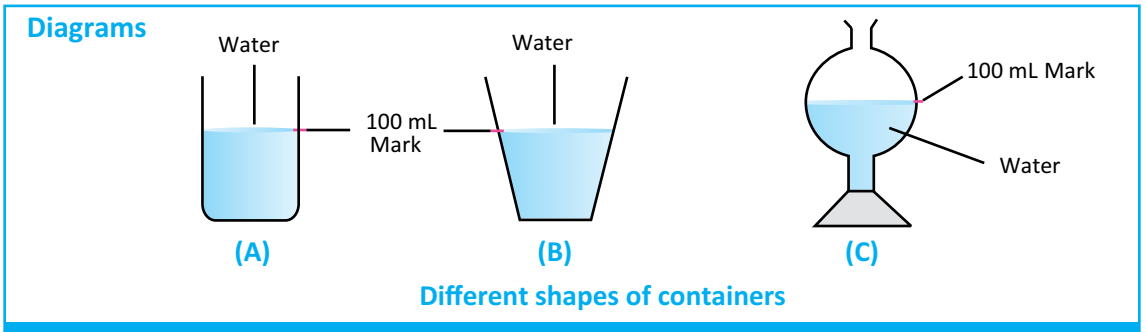


Fig. 1.4 – Set-up of apparatus to show that a liquid does not have fixed shape but has fixed volume.

(F) To show that Gases are highly Compressible but Liquids and Solids are Not

Activity (or *Experiment*)–10

(i) Take three 100 mL airtight glass syringes. Remove their needles as well as their pistons.

(ii) Close their nozzles with some adhesive and insert each nozzle in a rubber cork.

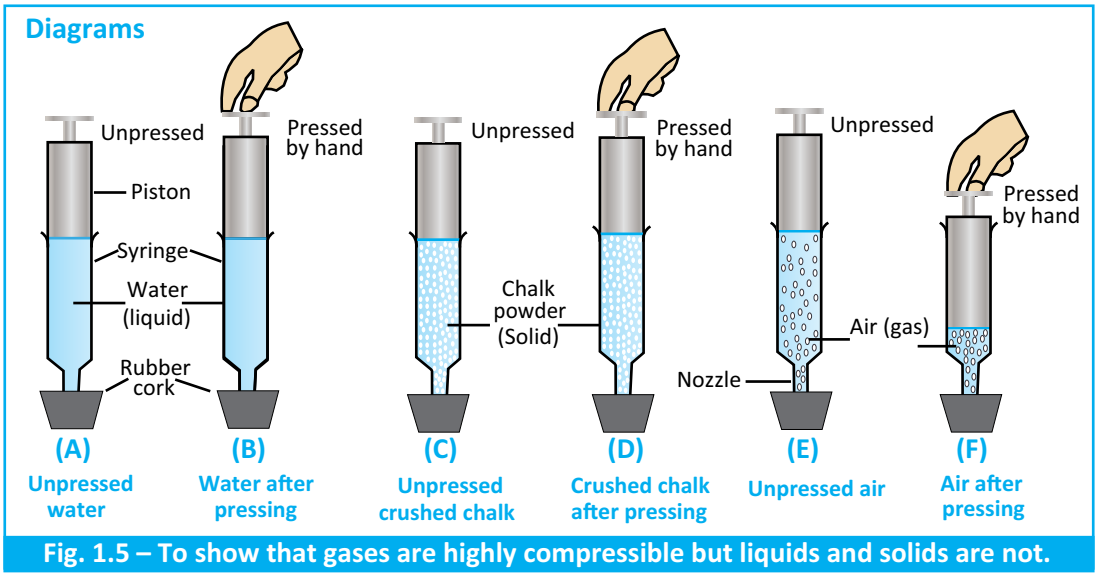


Fig. 1.5 – To show that gases are highly compressible but liquids and solids are not.

(iii) Fill **water** in the first syringe and **crushed chalk** (or sand) in the second syringe upto slightly below the top and leaving the third as such which contains **air**.

(iv) After applying some vaseline on the pistons for smooth movement, insert them back in the syringes so that piston in the first syringe touches water surface, chalk powder surface in the second syringe and is just inside the syringe in third one containing air.

(v) Try to press the contents by pushing the piston in each syringe.

Observations and Inferences

(a) The piston of first syringe containing water almost does not move down on pressing it, therefore, water which is a liquid is not compressible. *In general, liquids are not compressible on applying pressure*.

(b) The piston of second syringe having crushed chalk also almost does not move down on pressing it, therefore, chalk powder which is a solid is not compressible. *In general, it can be concluded that solids are not compressible*.

(c) The piston of third syringe containing air moves down considerably on pressing, therefore, air which is a gas is highly compressible. In general, it can be inferred that *the gases are highly compressible.*

(G) Applications of Compressibility of Gases

Different useful gases are compressed to small volume, put into cylinders and are then supplied for use. For example :

(i) *Liquefied petroleum gas (LPG)* used for cooking purposes is supplied in metallic cylinders as compressed gas.

(ii) Similarly, *oxygen gas* used in hospitals and in industry is supplied in compressed form in metallic cylinders.

(iii) *Compressed natural gas (CNG)* being used as fuel in vehicles is transported easily in metallic cylinders after pressing it.

LPG Cylinder Oxygen Cylinder CNG Cylinder

MOVEMENT OF PARTICLES AND THEIR KINETIC ENERGIES IN THREE STATES OF MATTER

(H) We have already studied that particles of matter are moving continuously. But this movement of particles is different in solids, liquids and gases.

(i) The particles in solids are closely packed and thus attractive forces between the particles are very strong. The empty spaces between the particles are very, very small. Due to close packing, particles of a solid *vibrate* about their mean positions and do not move away. So the *particles of a solid have minimum kinetic energy as compared to that of in other states.*

The particles in solids have orderly arrangement and thus solids have fixed shapes. Due to strong interparticle force of attraction particles of solids only possess vibrational motion.

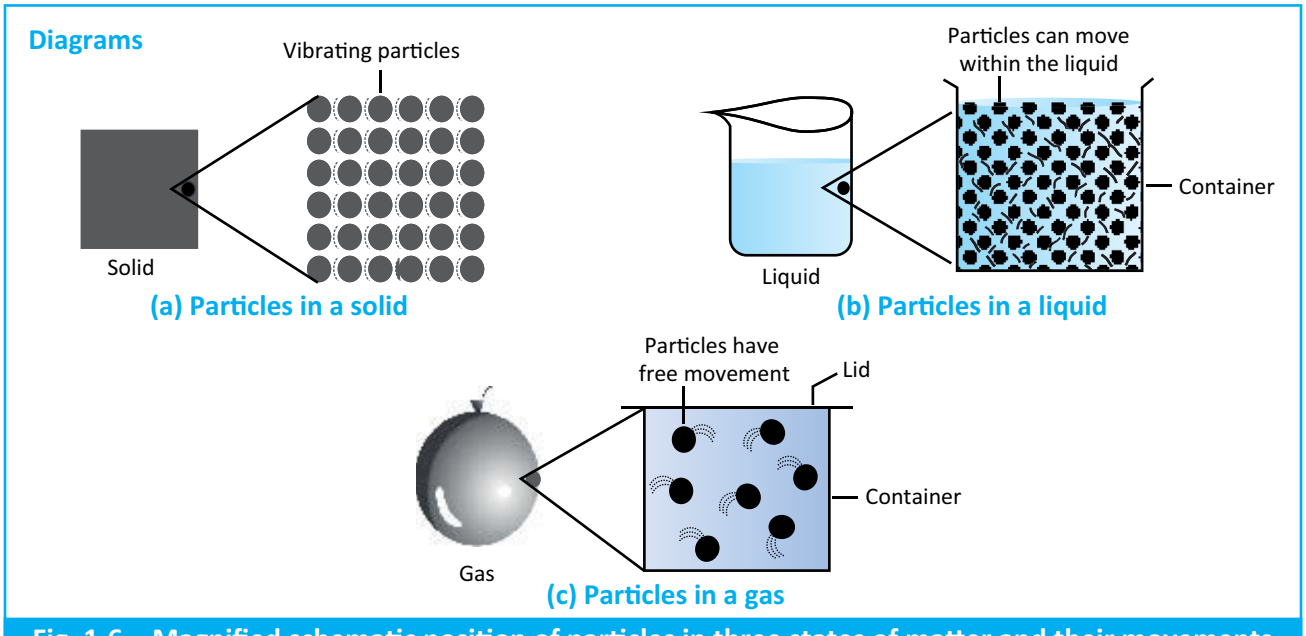


Fig. 1.6 – Magnified schematic position of particles in three states of matter and their movements.

(ii) The particles in liquids are close together but a bit less close than that of in solids. The spaces between the particles are still very small. The interparticle forces in liquids are strong enough to keep the particles within the bulk together but not strong enough to keep the particles in fixed positions. The particles can move within the liquid from one position to another. The particles also vibrate within the liquid. So, *the particles in a liquid have more kinetic energy than that of in a solid. Due to not so strong interparticle force of attraction, particles of liquids, possess some transitional and rotational motion in addition to vibrational motion.*

The particles of a liquid have more disorderly arrangement as compared to the one in solids. Consequently, liquids can change their shapes easily. Liquids possess the property to flow and due to this property liquids fall under the category called as fluids (which also includes gases.).

(iii) The particles in gases are very far apart from one another as compared to that of in solids and liquids. The empty spaces between the particles of a gas are very large. Due to large distances *the attractive forces between the particles of a gas (at room temperature and atmospheric pressure) are negligible.* The particles are free to move at random in any direction with high speeds. Neither the position of particles nor the spaces between the particles are fixed. There is most disorder in the arrangement of particles in a gas due to free movement of particles. Consequently, the shape and volume of the gases are not fixed.

Schematic arrangements and movements of particles in a solid, a liquid and a gas are shown in the diagram (see Fig. 1.6).

Sample Problem : ***Arrange the following substances in increasing order of forces of attraction between their particles : water, sugar, oxygen.***

Solution : Forces of attraction between their particles are as : oxygen < water < sugar

(I) Why do gases exert pressure ?

We have already learnt that in gaseous state, particles move about randomly at high speeds. Due to this movement the particles not only strike with each other but also with the walls of the container with a force due to which gases exert pressure outwards on the walls of the container. ***Force exerted per unit area is called* pressure.**

*Pressure exerted by a gas is measured in atmosphere (atm). *The pressure of air in atmosphere is called atmospheric pressure.* The atmospheric pressure at sea level is one atmosphere and is taken as normal pressure.

S.I. unit of pressure is pascal (Pa).

1 atmosphere = 1.01×10^5 Pa.

Also, 1 atmosphere = 76 cm = 760 mm (of Hg)

DIFFUSION

(J) What is Diffusion ?

***The phenomena of intermixing of particles of two different types of matter of their own due to movement of particles is called* diffusion.**

Diffusion is caused due to movement of particles of matter. Diffusion occurs in gases, liquids and to a very small extent in solids. Diffusion is *fastest in gases, less fast in liquids* and *extremely slow in solids*. Reason for this is that particles in gases possess comparatively high kinetic energy and move at very high speeds. Particles in

**** For additional knowledge.***

liquids contain less kinetic energy and move with less speeds while the particles in solids possess least kinetic energy and thus vibrate with lowest speeds. Moreover, there are lot of empty spaces between the particles in gases as compared to that of in liquids and solids which make the intermixing far easy in case of gases.

With the increase in temperature, diffusion becomes faster because on getting heated, kinetic energy of the particles increases which makes the particles to move faster resulting in faster intermixing, that is, diffusion.

When a drop of blue or red ink or honey is put into water taken in a glass tumbler and left undisturbed (*Activity 4*), then in due course of time colour of the ink or honey spreads evenly throughout water. It shows that liquids diffuse in liquids.

Again on adding potassium permanganate or copper sulphate crystals in water contained in a glass tumbler and then leaving it undisturbed (*Activity 5*), we obtain a uniformly coloured solution in due course of time. This proves that solids diffuse in liquids.

Air of the atmosphere comes in contact with water bodies on the surface of the earth. The gases of the air specifically oxygen and carbon dioxide diffuse and dissolve in water. This shows that gases also diffuse in water (liquids).

From the above discussion it is clear that solids, liquids and gases can diffuse into liquids.

(K) Some Applications of Diffusion (of gases)

(i) **All living creatures and plants need to breathe oxygen (air) for survival.** The aquatic animals and plants under water breathe by taking in **dissolved oxygen** in water, which gets diffused in water from air.

(ii) **Carbon dioxide dissolved in water** (under the process of diffusion) is utilized by aquatic plants during photosynthesis for the formation of their food.

(iii) **The smell of the food being cooked** in the kitchen reaches us in the adjoining room. As a result of that without entering the kitchen, we come to know what is being cooked in the kitchen. The reason for this is that particles of the aroma of food in gaseous state mix with particles of the air and both types of particles being in gaseous state diffuse very quickly and reach us in no time and even beyond us. Gases diffuse very fast due to high speed of their particles and large empty spaces between the particles.

Food being cooked

(iv) **The smell of hot sizzling food reaches** us in seconds as compared to from the cold one. The reason for this is that hot food emits lot of vapours having particular smell that diffuse fast in air and thus reach us quickly. Cold food usually releases a little or limited vapours which do not reach us quickly and we have to go close to it to get the smell.

Open bottle of perfume

Burning incense

(v) **Pleasant smell of perfume** (*or burning incense*) can be felt while sitting several metres away. Reason for this is that perfume is volatile so its vapours get diffused into air. Both perfume and air being in gaseous state diffuse very fast, therefore, sweet smell of perfume is felt by us while sitting several metres away.

INTERCONVERSION OF STATES OF MATTER

1.5 (A) Can Matter Change its State ?

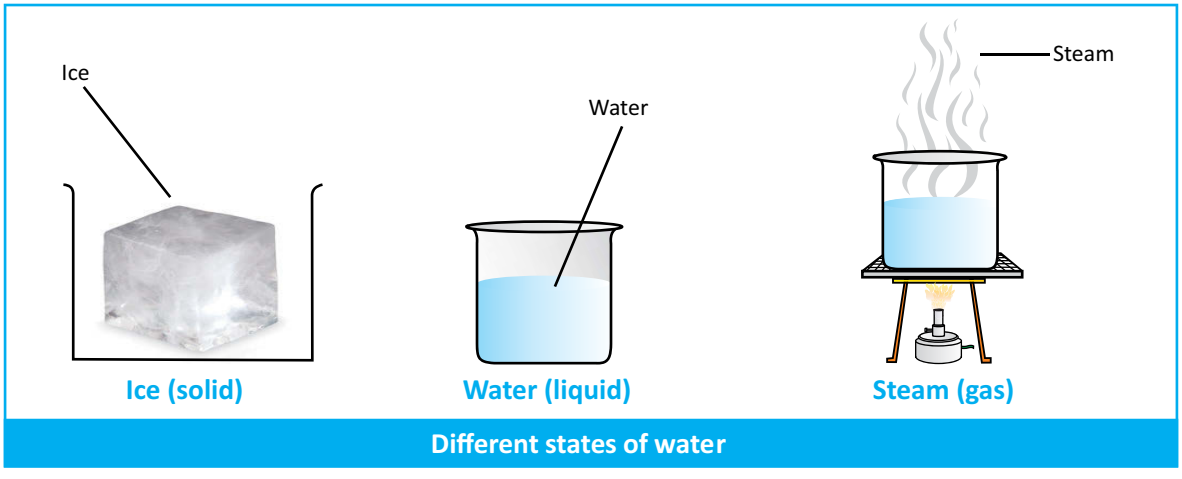
Matter can change its state on changing the conditions. A substance may exist in any of the three states of matter, that is, solid, liquid and gas. We know that water can exist in all the three states of matter as follows:

(i) *Solid* as ice.

(ii) *Liquid* as ordinary water and

(iii) *Gas* as steam and water vapour.

How does this change of state takes place?



Different states of water

We already know that the interparticle spaces are minimum in the solid state, intermediate in the liquid state and maximum in the gaseous state. So, if we are to convert a matter from a solid to liquid, the interparticle spaces have to be increased. Similarly, by increasing the distance between the particles in liquid, we can convert it into a gas. This interconversion of matter can be achieved in the following two ways:

(i) By changing the temperature

(ii) By changing the pressure

(B) Effect of Change of Temperature on States of Matter

Let us study the effect of heat on the states of matter by performing the following activity (or *experiment*) :

Activity (or *Experiment*)–11

(i) Take in a beaker about 150 gm of crushed ice prepared from distilled water. Fit up the apparatus as shown in the diagram [Fig.1.7 (a)] taking care that bulb of the laboratory thermometer (–10°C to 110°C) is in the middle of ice pieces.

(ii) Start heating the ice in the beaker while stirring the ice.

(iii) Note the temperature when ice starts melting and also note the temperature at intervals.

(iv) Note the temperature when whole of the ice has just changed into water.

(v) Continue stirring and heating water in the beaker and at the same time go on noting down the temperature at intervals.

(vi) When water boils then note down the temperature of boiling water at intervals for some time as water goes on changing into steam.

(vii) Stop heating and record your observations regarding conversion of ice into liquid state and then liquid into gaseous state.

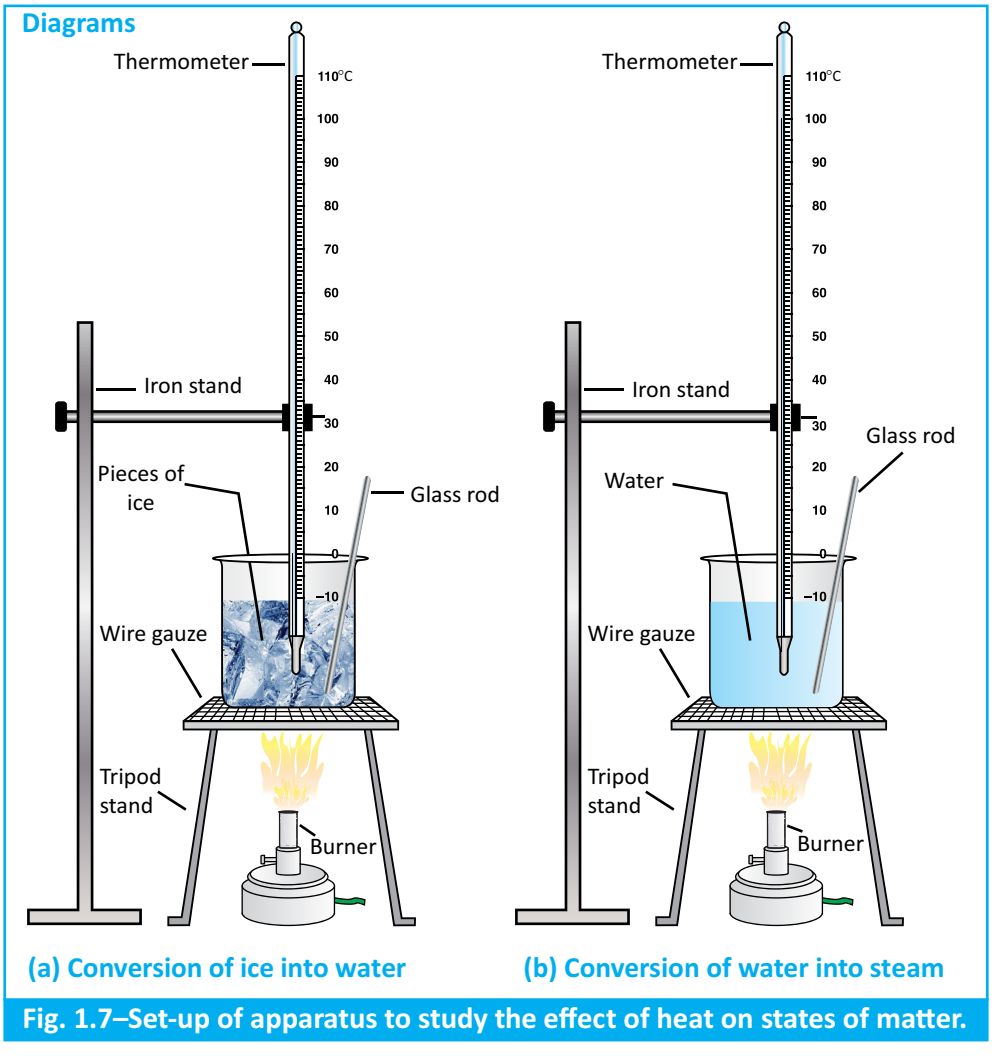


Fig. 1.7–Set-up of apparatus to study the effect of heat on states of matter.

Observations

(a) On heating, ice starts melting into water at 0°C and temperature remains constant at 0°C till the whole of ice melts into water.

(b) After melting of the whole of ice, temperature starts rising and ultimately becomes constant on boiling of water at (about) 100°C. On heating, water changes into steam, i.e., in gaseous state.

Conclusions

On heating, matter in solid state (ice) changes into liquid state (water) and then liquid state changes into gaseous state (steam).

It may be noted that if a substance in gaseous state is cooled then it condenses into liquid form which on further cooling changes into solid form, i.e., it freezes or solidifies.

The conversion of matter from one physical state to another can be depicted as follows :

Fig. 1.8 – Depicting interconversion of physical states of matter.

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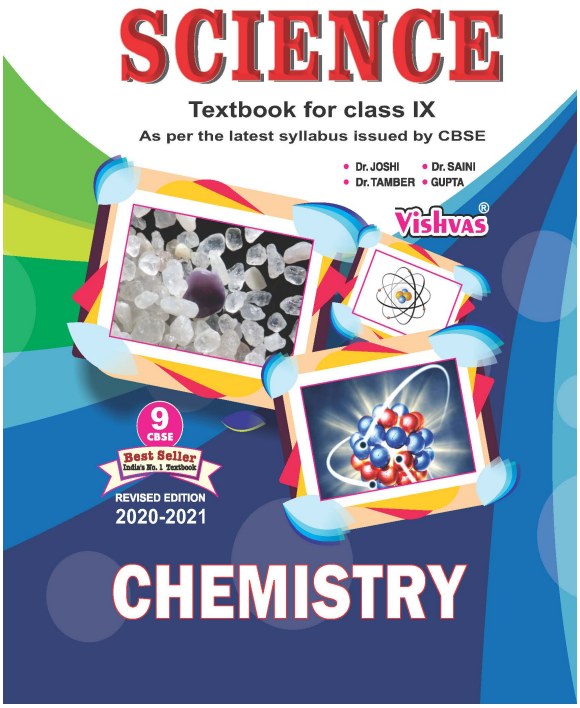

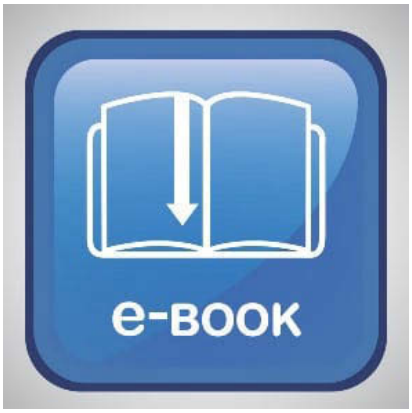

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