Gaseous state : When inter-molecular force between the constituent molecules is very weak or negligible, inter-molecular space is far more as compared to the liquids and the molecules are free to move to and fro anywhere, matter exists as a gas.

PROPERTIES OF SOLIDS

1. A solid has a definite shape and size (length, area and volume).
2. A solid can not be compressed.
3. A solid can not flow.
4. A solid is highly dense.
5. A solid has its constituent molecules very closely packed.
6. A solid exerts pressure due to its weight only on its base, downwards.
7. A solid has strong inter-molecular force of attraction.
8. A solid has a low thermal expansion, *i.e.* it expands a little on heating.
9. In a solid, the molecules are not free to move from their positions. They simply vibrate on either side of their mean positions.
10. A solid can have *any number* of free surfaces.
11. A solid is highly rigid but can be stretched into wires or beaten into sheets.
12. A solid does not easily diffuse into other solids.

The above mentioned properties of solids can be explained by the molecular model of solid state.

Molecular model of solid state

(1) There is a strong force of attraction (strong inter-molecular force) between the molecules of a solid.

(2) The molecules in a solid are closely packed, *i.e. inter-molecular space is negligible. Therefore, solids cannot be compressed much.*

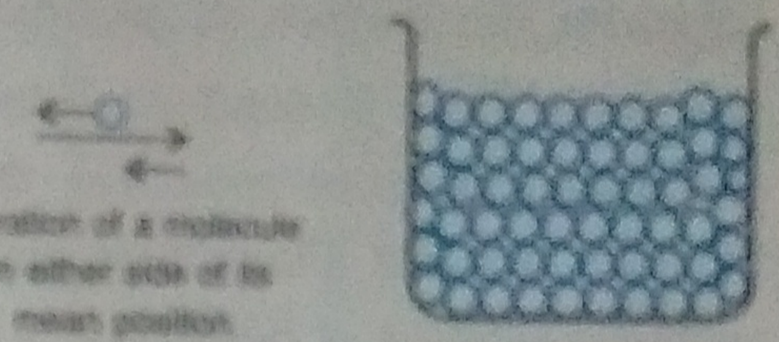

Fig. 1.3 Molecules of a solid are arranged closely and in a definite manner, not free to move about

The molecules are arranged in a definte manner, therefore they have a definite shape.

(3) The molecules vibrate on either side of their mean positions but they do not leave their positions. Therefore solids have a definite size.

(4) The molecules of a solid are arranged in a definite manner. They are packed tightly and so they generally have a high density. Thus,

> the *solids are rigid, they have a definite size and definite shape.*

Note : A rubber band changes its shape when a force is applied to it. But it returns to its original shape when the force is removed. Thus, rubber is elastic but is treated as a solid.

PROPERTIES OF LIQUIDS

1. Liquids have a definite volume, but no definite shape because they acquire the shape of the container in which they are kept.
2. Liquids are almost incompressible.

3. Liquids can flow.
4. Liquids are viscous *i.e.* each liquid opposes the relative motion between its different layers. Hence, each liquid opposes the motion of an object on it.
5. Liquids have a tendency to occupy minimum surface area, *i.e.* they have surface tension. Due to the property of surface tension, a liquid has a tendency to form a spherical drop.
6. Liquids have only *one* free surface.
7. A liquid can easily diffuse into other liquids.
8. Liquids are less rigid.
9. The molecules in a liquid are less closely packed.
10. The inter-molecular force of attraction is weak in a liquid than in a solid.
11. Liquids have high thermal expansion, *i.e.* liquids expand more on heating than solids.
12. The molecules of a liquid are free to move within the boundary of the liquid.
13. A liquid exerts pressure in all directions.

The above properties of liquids can be explained by the molecular model of liquids.

Molecular model for liquids

(1) The attractive force between the molecules of a liquid is not as strong as it is in solids, so they are loosely packed and are not fixed. The molecules can move over one another, within the boundary of the liquid. Thus, a liquid has a definite volume, but no definite shape.

(2) The inter-molecular space in a liquid is greater than in a solid, so they generally have low density as compared to a solid, *i.e.* they are more compressible.

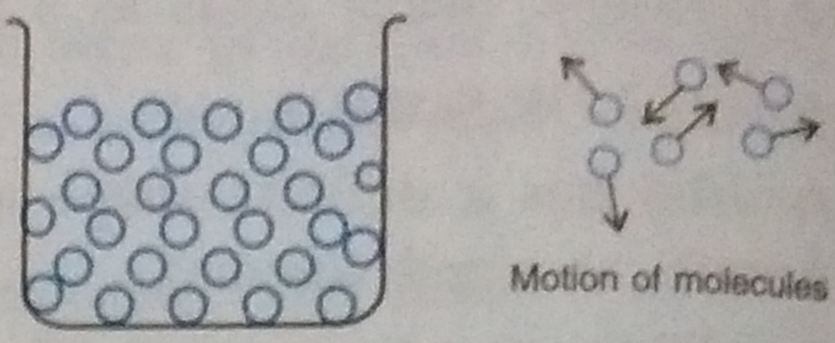

Fig. 1.4 Molecules of a liquid are arranged less closely and are free to move about, within the liquid

(3) The motion of molecules in a liquid is irregular and random within the boundary of the liquid. Thus,

Liquids do not have a definite shape, but have a definite volume and can flow from a higher to a lower level. They show the property of viscosity and surface tension because of the cohesive forces.

PROPERTIES OF GASES

1. A gas has neither a definite shape nor a definite volume. It acquires the shape and volume of its container.
2. Gases are highly compressible.
3. Gases can flow. They are also viscous, but less viscous than liquids.
4. Gases are not rigid.
5. A gas diffuses into other gases very fast.
6. A gas has *no* free surface.
7. In a gas, the molecules are least closely packed.
8. In a gas, there is no force of attraction amongst its molecules.

9. The thermal expansion of gases is very large.
10. In a gas, the molecules are free to move in a random manner in zig-zag paths everywhere.
11. Gases do not show the property of surface tension because they do not have free surfaces.
12. A gas exerts pressure on the wall of its container from all directions due to change in momentum on collisions of its molecules with the wall.

The above properties of gases can be explained by the molecular model of gases.

Molecular model of gases

(1) The molecules of a gas lie much farther apart than they lie in a liquid or a solid. Thus, the density of gases is very low.

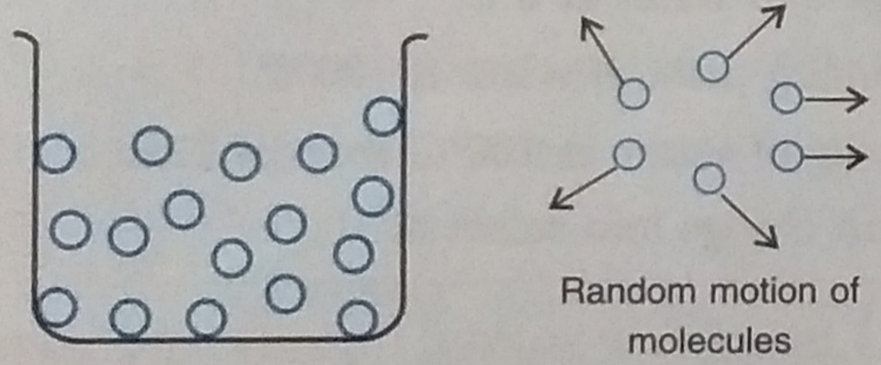

Fig. 1.5 Molecules of a gas are far apart and are free to move about

(2) *There is negligible force of attraction between* the molecules of a gas, so they are free to move in the entire space available to them.

(3) The molecules of a gas move much faster than they move in liquids, and therefore they are infact in a state of *incessant random motion*, moving in all possible directions at all possible speeds.

DISTINGUISHING PROPERTIES OF SOLIDS, LIQUIDS AND GASES

Properties	Solids	Liquids	Gases
1. Mass	Definite	Definite	Definite
2. Shape	Definite	Acquires the shape of the container	Acquires the shape of the container
3. Volume	Definite	Definite	Indefinite, acquires the volume available
4. Compressibility	Not compressible	Negligibly compressible	Highly compressible
5. Fluidity	Not possible	Can flow	Can flow
6. Rigidity	Highly rigid	Less rigid	Not rigid
7. Diffusion	Slow	Fast	Very fast
8. Number of free surfaces	Any number of free surfaces	Only one free surface	None
9. Packing of molecules	Very closely packed	Less closely packed	Least closely packed
10 Intermolecular force	Strongest	Slightly weaker than in solids	Negligible
11. Expansion on heating	Low	More than solids	More than liquids
12. Motion of constituent molecules	Only vibrate on either side of their mean positions	Move in all directions but within the liquid	Move in a random manner in all space available
13. Pressure	Only at base downwards	At all points in all directions inside the liquid	On the wall of the container
14. Viscosity	No	More viscous	Least viscous
15. Surface tension	No	Due to cohesive force tends to occupy minimum surface area	No

(4) The molecules of a gas are far apart and there is enough space available for compression. Thus, *gases can easily be compressed.*

(5) During motion, the molecules of a gas collide with one another and also with the wall of the vessel. In each collision, the direction of motion of the molecule changes, so the momentum changes.

(6) A gas exerts pressure on the wall of its container due to the continuous collisions of its molecules with the wall. Thus,

> *A gas has neither a definite shape nor a definite volume, but it can flow and is easily compressible.*

CHANGES IN STATE OF MATTER

The change in state of matter of a substance from solid to liquid or from liquid to gas is brought about by imparting heat energy to it at a constant temperature.

1. Change from solid state to liquid state

The process of change of a substance from the solid state into its liquid state on absorption of heat at a particular temperature, called the *melting point*, is called ***melting*** or ***fusion*** *i.e.*,

$$\text{Solid} \xrightarrow[\text{Heat absorbed}]{\text{Melting}} \text{Liquid}$$

The heat energy absorbed by the substance increases the amplitude of vibrations of the molecules of the solid and a stage is reached at the melting point when the molecules acquire sufficient energy to overcome the force of attraction between them and they become free to move. The solid thus changes into a liquid.

2. Change from liquid state to gaseous state

The process of change of a substance from the liquid state to its gaseous state at a particular temperature, called the boiling point, is called ***boiling*** or ***vaporisation***. *i.e.*,

$$\text{Liquid} \xrightarrow[\text{Heat absorbed}]{\text{Boiling}} \text{Gas}$$

The heat energy absorbed by a substance in liquid state increases the energy of its molecules due to which they begin to move randomly. Thus a liquid changes into a gas.

Do You Know ?

Melting point of ice is 0°C.

1 kg ice absorbs 336×10^3 Joule heat at 0°C to change into water at 0°C.

Boiling point of water is 100°C.

1 kg of water at 100°C absorbs 2260×10^3 joule heat to change into steam at 100°C.

List of few solids, liquids and gases

Solids	Liquids	Gases
Ice	Water	Steam
Aluminium	Benzene	Air
Silver	Chloroform	Oxygen
Calcium	Oil	Hydrogen
Gold	Honey	Chlorine
Iron	Glycerine	Nitrogen
Salt	Milk	Ammonia
Sugar	Nitric acid	Sulphur dioxide
Wood	Alcohol	Nitric oxide
Plastic	Spirit	Helium
Wax	Dettol	Argon

6. What do you mean by inter-molecular spacing ?
7. Describe a simple experiment to illustrate the existence of inter-molecular spacing.
8. What do you mean by inter-molecular forces ?
9. What are the forces of cohesion and adhesion ?
10. State *three* charactersitics of molecules of matter which determine its solid, liquid and gaseous state.
11. State the approximate spacing between two molecules of a matter.
12. How do solids, liquids and gases differ in their following properties :

    (a) Size (b) Shape (c) Density ?
13. The molecules in a substance are in motion. What type of path do they follow ?
14. Describe a simple experiment to illustrate that molecules are not at rest, but they constantly move.
15. Write down five general properties of solids, liquids and gases.
16. Give the molecular model for a solid and use it to explain why a solid has a definite volume and a definite shape.
17. Describe the molecular model for a liquid. How does it explain that a liquid has no definite shape, but has a definite volume ?
18. A gas has neither a definite volume nor a definite shape. Describe the molecular model to explain it.
19. Distinguish between the *three* states of matter — solid, liquid and gas on the basis of their molecular models.
20. Distinguish between solids, liquids and gases on the basis of their following properties :

    (a) compressibilty

    (b) fluidity

    (c) rigidity

    (d) expansion on heating
21. What do you mean by change of state of matter ? Explain :

    (a) the change of a solid into a liquid at a constant temperature, and

    (b) the change of a liquid into a gas at a constant temperature.