The Gaseous State

In gases, the intermolecular force of attraction is so weak and the intermolecular space is so large that the particles become completely free to move randomly in the entire available space.

General Properties of Solids

1. Shape and Volume: a gas has neither a definite shape nor a definite volume. It takes the shape and volume of the vessel in which it is kept. It occupies all the available space in the vessel because the particles can freely move throughout the space.
2. Density: the density of gases is lower than those of solids and liquids.
3. Melting and boiling points: at normal atmospheric pressure, the melting and boiling points of a gas are below room temperature. They are lower than those of solids and liquids.
4. Compressibility: the compressibility of a gas is very high. The intermolecular space in a gas being large, the particles can be made to come much closer together under pressure. That is why a large amount of air can be pumped into the small volume of a cycle tube or a football bladder. The property of compressibility of gases is made use of in storing fuel gases in cylinders. Butane is called a petroleum gas as it is obtained from petroleum refineries. Butane has been found to be an efficient domestic fuel. It is liquefied under pressure, packed in cylinders and made available for usage as LPG (Liquefied Petroleum Gas). Oxygen supplied to hospitals in cylinders is another example of compressed gas. So is Compressed Natural Gas (CNG), the fuel which is now increasingly being used in vehicles.

5. Effect of heating and cooling: a gas can be made to expand or contract on heating and cooling. On heating, the energy of the gas particles is increased. As a result, the gas particles move faster and also go farther away from each other. This results in the expansion of the gas. On cooling, the energy of the gas particles is decreased and so the movement of the particles is solved down. The particles also come much closer to each other, leading to the increase in the intermolecular force of attraction. This causes the gas to contract.
6. Diffusion of gases: gas particles move with high speeds and the intermolecular spaces in gases are very large. These properties allow a gas to diffuse easily into another. Thus, gases mix together spontaneously, despite their differences in densities. When a bottle of perfume is open in the corner of a room, the fragrance of the perfume spreads in air and covers the entire space of the room. Also the smell of the food being cooked in the kitchen reaches our nostrils, even if we are not physically present in the room. This is because the particles constituting the smell mix with the particles of air, spread out and reach our nostrils. Other examples include virus on sneezing, dissolution of oxygen and carbon dioxide in sea water etc.
7. Condensation of gases: the conversion of gas into liquid is called condensation. It can be carried out by either increasing the pressure on the gas or decreasing its temperature. By doing this, the intermolecular distance is decreased and force of attraction is increased thus changing into liquid state.

• Dry Ice: carbon dioxide gas at very low temperature and under high pressure can be transformed into a solid which appears like ice. The solid so obtained is called dry ice. On reducing the pressure on the surface of the solid, it gets directly

converted into vapour without changing its liquid state. So, dry ice is a sublimable substance.

• Condensation of water vapour: it takes place on a cold surface. By taking ice in a glass container. Ice absorbs heat from the air and starts to melt. The moisture present in air is thus cooled and finally gets condensed on the outer walls of the container as water droplets.

8. Pressure exerted by gas: the particles of gas are continuously moving in all possible directions with different velocities. In this process, they collide with one another and with walls of the container. In doing so, they exert some pressure on the walls of the container. The force applied by the gas particles per unit area on the walls of the vessel is called the 'pressure of the gas.' The pressure of air is called atmospheric pressure. The pressure of air at sea level is one atmosphere. The unit of pressure is Pascal (Pa). I atmosphere = 1.01325×10^5 Pa.

Comparison of the properties of solids, liquids, and gases

Property	Solid	Liquid	Gas
Intermolecular space	Very small	Larger as compared to solids	Largest
Intermolecular force of attraction	Very strong	Weaker	Negligible
Density	High	Low	Very low
Position of particles	Fixed	Not fixed, particles move freely with the bulk	Not fixed, particles move freely throughout the space.
Energy of particles	Low	High	Very High
Shape and Volume	Definite shape and volume	No definite shape but has definite volume	No definite shape and volume
Compressibility	Very low	More than solids	Highly compressible

Interconvertibility of the States of Matter

All the three states of matter are interconvertible i.e. matter can be changed from one state to another.

For example: ordinary water. When water is cooled at 0°C, it is transformed into ice (solid). Heated to 100°C, it begins to boil and goes into the gaseous state (vapours). On cooling, water vapour gradually passes into the liquid state and finally to the solid state (ice).

Explanation:

- Heating increases kinetic energy of the particles of the solid (ice). As a result, the vibration of the particles about their mean position of rest is also enhanced. The heat energy which is supplied is consumed in overcoming the intermolecular forces of attraction between the particles. The particles now move freely with increased speeds. This results in melting of ice.
- The temperature at which sold goes into liquid state at atmospheric pressure is known as melting point of solid. The melting point of ice is 0°C (or 273.15 K). The conversion of a solid into liquid is called fusion of the solid.
- The heat supplied to the ice does not increase its temperature as the heat is used to overcome the intermolecular forces of attraction between the particles.

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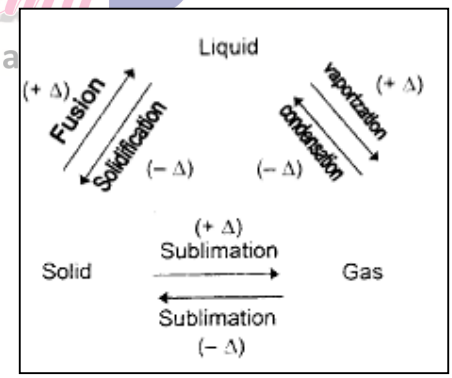
This heat, thus, remains stored in the contents of the beaker and is called the latent heat of fusion.

- The amount of heat energy absorbed when 1kg of a substance changes from solid to liquid at its melting point is called latent heat of fusion of the solid.
- On further heating, the particles of the liquid gain more energy and begin to vibrate more vigorously. They become so energetic that they break the intermolecular forces of attraction. They are now free to leave the liquid and go into the gaseous state. The liquid then begins to boil. The temperature at which a liquid is converted into gas or vapour is known as the boiling point of the liquid.
- At normal pressure (1 atm) the boiling point of water is 100°C (373.15 K).
- During boiling, the temperature of a liquid does not rise despite heating. Instead, the supplied heat energy goes to raise the kinetic energy of the particles. When the particles acquire enough energy, they overcome the attractive forces of other particles and go into vapour state. As the heat energy received by the liquid remains hidden inside the bulk of liquid, it is called the latent heat of vaporization.
- The amount of heat energy absorbed when 1kg of a substance changes from liquid to vapour at its boiling point is called latent heat of vaporization of liquid.
- On cooling, reverse process occurs i.e. gas or vapour when cooled is converted into liquid.
- The process by which the change in state from gaseous to liquid takes place is called condensation or liquefaction. When the liquid is further cooled, it is transformed into solid.
- The temperature at which the change in state from liquid to solid takes place is called the freezing point of the liquid and the process by which such a change takes place is called freezing.

Difference between steam and boiling water

The temperature of both steam and boiling water is the same. But, steam causes more severe burns than boiling water. This is because steam contains extra heat energy in the form of latent heat of vaporization.



The summary of changes in state of matter is shown:

Measurement of temperature

There are three scales for the measurement of the temperature of a system. These are: degree Celsius (°C), degree Fahrenheit (°F) and Kelvin (K).

On Celsius scale the freezing point of water is taken as 0°C, whereas its boiling point is taken as 100°C. So, this scale is calibrated from 0 to 100°C.

On the Fahrenheit scale, the freezing point of water is 32°F and its boiling point is taken as 212°F. So, this scale is calibrated from 32 to 212°F.

°F = 9/5 (°C) + 32

On the Kelvin scale, the freezing point of water is taken as 273.15K and its boiling point is taken as 373.15K. The Kelvin scale is related to the Celsius scale as follows:

t°C = (273.15 + t)K

For convenience, we use 0°C = 273 K

Difference between Gas and Vapour

Usually there is no difference between gas and vapour. The term 'vapour' is used for those gases which exist in the liquid form at room temperature. For example, the gaseous form of water is called vapour. On the other hand, hydrogen, oxygen, nitrogen, carbon dioxide etc exist as gases at room temperature. Hence, each one of these is called a 'gas', not a vapour.

Absorption of Heat

It has been found that black or any dark coloured object is a better absorber of heat than a white or light coloured object. Black object's ability to absorb more heat is utilized in designing solar cookers. During summer, white or light coloured dresses are preferred to black or dark coloured dresses as white dresses absorb less heat.

Plasma: state of matter

Scientists are reported to have discovered a new state of matter which is called 'plasma state'. This state does not fit into any of the hitherto known three states of matter. Hence it is called the 'forth state of matter.'

Plasma state consists of highly ionized gas in which the particles exist in super energetic and super excited state. For example: fluorescent tubes and neon sign bulbs. Fluorescent tubes contain helium or other gases. When electric current is passed through gas, it produces glowing plasma, having a characteristic colour depending upon the nature of gas. Plasma is produced in the sun and in stars due to high temperature. It is the presence of plasma that makes them glow.

Bose - Einstein Condensate

In 1920, Indian scientist Satyendra Nath Bose on the basis of his statistical calculations gave the concept of fifth state of matter. Einstein too, predicted the possibility of such a state. Later, three American scientist succeeded in obtaining this state by supercooling a gas of extremely low density. The process is called Bose – Einstein condensation, and this state of matter is called Bose – Einstein condensate (BEC).

Worksheet

1. Why people sprinkle water on the roof or open ground on a hot sunny day?
2. What is the SI unit of pressure? Give its value in atm unit.
3. How gases can be liquefied?
4. Covert the following temperature to Celsius scale:
   a. 293K b. 470 K
5. Naphthalene balls disappear with time without leaving any solid. Give reason.
6. Why is ice at 273 K more effective in cooling than water at the same temperature?
7. What produces more severe burns, boiling water or steam?
8. Covert the following temperature to Kelvin scale:
   a. 25°C b. 373°C
9. If 40 Kilojoules of energy is required to change 4 kg of substance in a liquid state into vapour state, then what is the latent heat of vaporization of that substance?
10. What is 'humidity'? Why does less evaporation occur in humid environment?