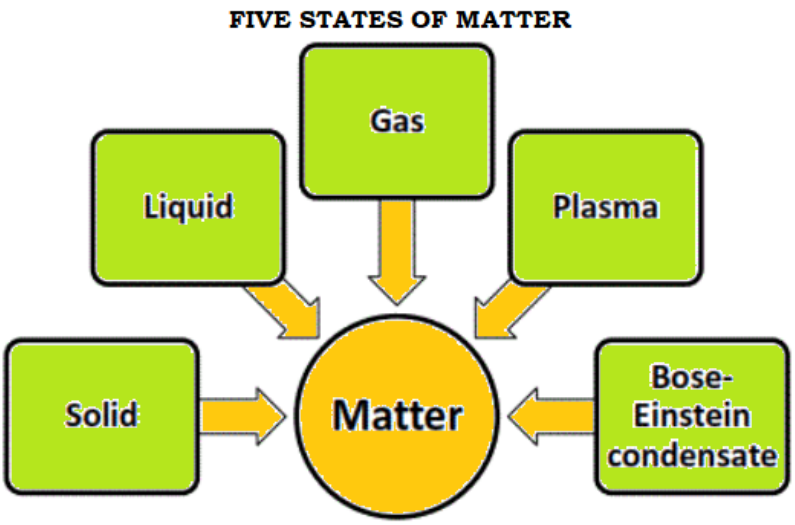
1 NATURE OF MATTER

Satyendra Nath Bose: A Bose-Einstein condensate (BEC) is a state of matter which was first predicted generally, in 1924–25 by **Satyendra Nath Bose** and **Albert Einstein.** Bose first sent a paper to Einstein on the quantum statistics of light quanta (now called photons). Einstein was impressed, translated the paper himself from English to German and submitted it for Bose to the magazine physics, which published it. Einstein then extended Bose's ideas to matter in two other papers.

CONCEPT MAP



Concept 1

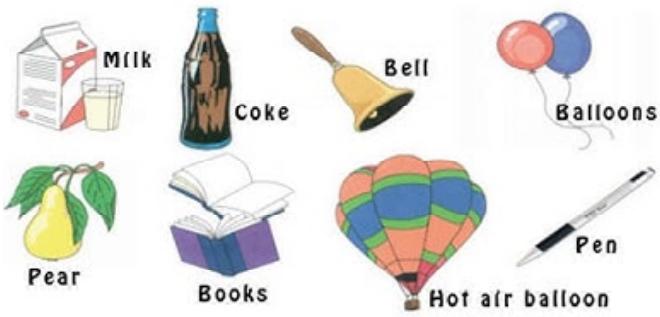
Introduction

The whole universe is composed of **Matter** and **Energy.**

Chemistry is the branch of science which deals with the study of composition, structure and properties of **matter** and the various changes it undergoes. (We study about energy in Physics).

Matter: Matter is anything that has mass and occupies space and can be perceived by our senses. Matter exists in many forms. As we look at our surroundings, we see a large variety of things with different shapes, sizes and textures.

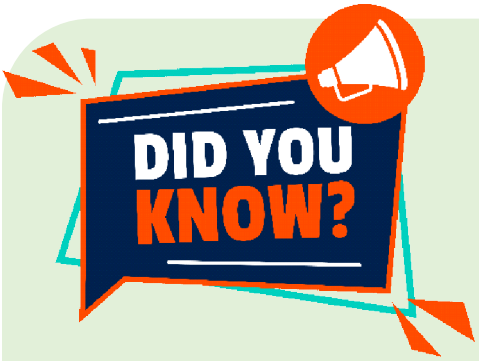
Everything in this universe is made up of material which scientists have named "matter". The air we breathe, the food we eat, stones, clouds, stars, plants and animals, even a small drop of water or a particle of sand each thing is matter.



We can also see as we look around that all the things mentioned above occupy space, that is, volume and have mass.

Matter basically exists in three states namely solids, liquids and gases. Irrespective of the state of matter, the basic units of matter are only molecules. The three states of matter differ with respect to the matter of molecular arrangements which brings about change in physical behaviour of the substances in their respective states.

The arrangement and motion of molecules in solids, liquids, and gases and the characteristics of matter that determine its physical behavior are explained by kinetic molecular theory.



The universe is made of approximately 4.9% matter, while the rest is dark matter and dark energy.

Characteristics of matter :

1. Matter is made up of tiny particles called **Molecules**.
2. The molecules in turn are made up of small particles called **Atoms**.

Misconception :

Misconception : Matter cannot change its state

Correction : Matter can change its state by heating, cooling or changing pressure.

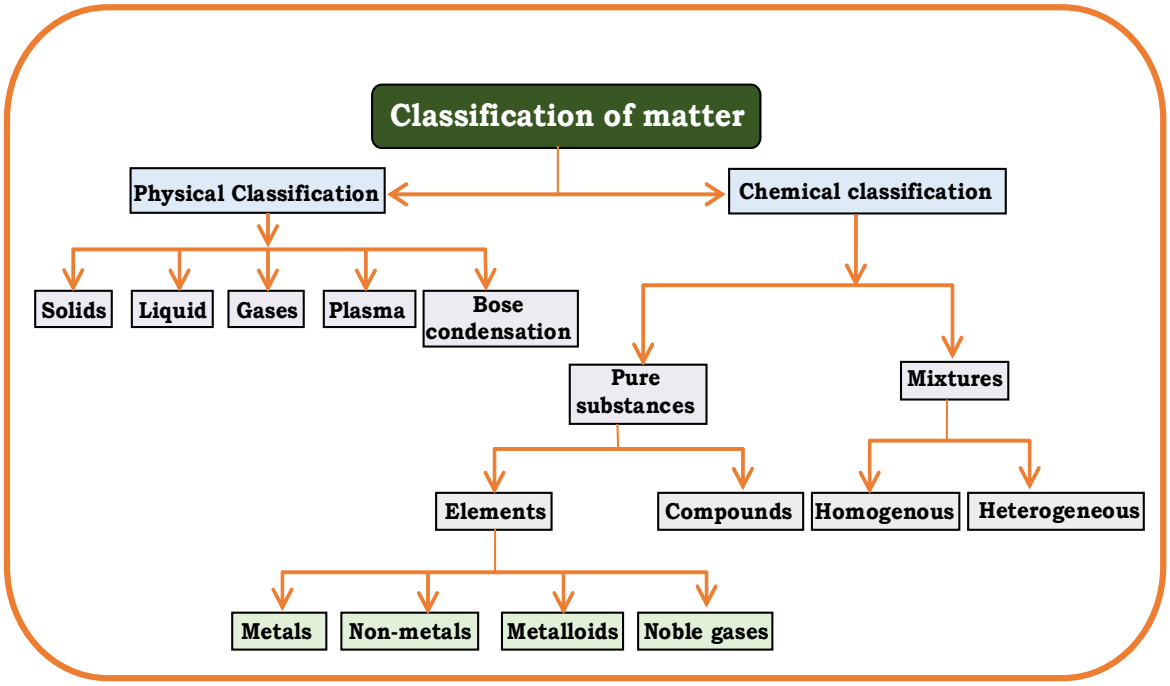
3. The molecules are so small that they are not visible to our naked eye.
4. Molecules of matter are in **constant vibration**.
5. All material bodies have mass and hence have weight.
6. All materials occupy space.

In different states of matter, the arrangement of molecules is different.

Classification of matter :

As there are so many kinds of matter, a scientific study of matter becomes easier if we classify matter based on some characteristics. Matter can be classified based on two factors:

1. Physical classification
2. Chemical classification



Physical classification of matter

Matter is composed of extremely small particles. Based on the arrangement of these particles, matter is mainly divided into three types. They are solids, liquids and gases. These are also called physical states of matter. This classification, is also based on differences of certain physical properties namely, mass, volume, shape, rigidity, density and arrangement of particles.

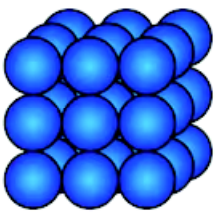
On the basis of molecular theory of matter, we can explain the internal nature of solids, liquids and gases.

Solids:

In solids, the molecules are closely packed up. Their positions are almost fixed. That is why, solids retain their shape and they have a fixed volume. The force of attraction between molecules which is known as 'Intermolecular force' exercises a greater influence in solids. However, the space between molecules is very small.

Example: Ice, a brick, a piece of chalk, a metallic pot does not change their shape or volume on their own.

General properties of solids :



1. Solids have a definite shape and volume.
2. Particles in solids are arranged in a regular pattern.
3. Solids have low compressibility due to the closeness of particles. (Most of the solids cannot be compressed).
4. Solids have very less interparticle spaces and very high interparticle attraction.
5. Solids do not flow.
6. Solids maintain their shape under moderate pressure.
7. Solids retain their properties at a constant temperature.
8. Solids have higher density than that of liquids and gases.
9. Solids expand a very little on being heated.

CLASSROOM DISCUSSION QUESTIONS CDQ 01

1. What is matter?

(A) Anything that has volume but no mass

(B) Anything that has mass and occupies space

(C) Anything that is visible to the naked eye

(D) Anything that cannot be perceived by our senses

2. What are the basic units of matter?

(A) Atoms

(B) Molecules

(C) Electrons

(D) Neutrons

3. How are molecules in solids arranged?

(A) Randomly and loosely packed

(B) Closely packed with fixed positions

(C) Far apart and moving freely

(D) In a liquid state

4. What is the term for the force of attraction between molecules in solids?

(A) Intermolecular space

(B) Molecular force

(C) Intermolecular force

(D) Atomic force

5. Which of the following is a general property of solids?

(A) Solids can be easily compressed

(B) Solids have fixed shape and volume

(C) Solids flow like liquids

(D) Solids expand greatly when heated

6. Why do solids have very little interparticle spaces?

(A) Because they have low mass

(B) Because of high interparticle attraction

(C) Because they are in a liquid state

(D) Because they have fixed volume only

MARK YOUR ANSWERS WITH PEN ONLY. Time Taken ☐ Minutes

1 Ⓐ Ⓑ Ⓒ Ⓓ	2 Ⓐ Ⓑ Ⓒ Ⓓ	3 Ⓐ Ⓑ Ⓒ Ⓓ	4 Ⓐ Ⓑ Ⓒ Ⓓ	5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ	7 Ⓐ Ⓑ Ⓒ Ⓓ	8 Ⓐ Ⓑ Ⓒ Ⓓ	9 Ⓐ Ⓑ Ⓒ Ⓓ	10 Ⓐ Ⓑ Ⓒ Ⓓ

Concept 2

Liquids

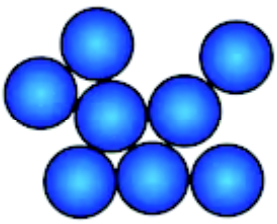
In liquids, the molecules are not packed as closely as in solids. Liquids, therefore change their shape easily but not their volume on their own. The intermolecular space in a liquid is more than that in a solid and, hence, the force of attraction between the molecules is weaker. Hence, the molecules in a liquid are free to move about, but continue to interact with one another. That is why, a liquid does not a possess a definite shape, and takes the shape of the container.

Example: Water, milk, alcohol, tea, coffee etc.

Fun Facts

Liquids are the Gymnasts of matter-they bend and flow but never lose their volume.

General properties of liquids



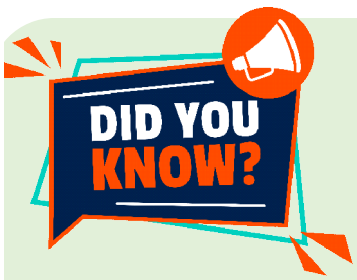
1. Liquids have no fixed shape. They take the shape of their container.
2 Liquids can be compressed only to a small extent.
3. Liquids can flow.
4. Liquids expand (or) contract more than solids.
5. Liquids have more interparticle spaces and less interparticle attraction compared to solids.

Gases :

In gases, molecules are far apart and move freely. This is why gases do not have a fixed shape or volume. Molecules in a gas move very fast, at an average speed of about 1600 km/h. There are large spaces between the molecules, and the force between them is very weak. These forces depend on the gas's density: When the density is low, the forces are almost non-existent.

As the density increases, the forces become stronger. Hence, a gas has neither a definite volume nor a definite shape.

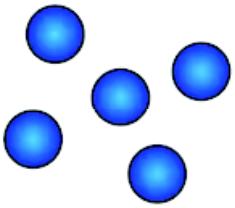
Example: Oxygen, Carbon dioxide, and Nitrogen etc.



Gases exert pressure in all directions due to the random motion of particles.

General properties of gases

1. A gas has neither a fixed volume nor a fixed shape. It assumes the volume and shape of the container.
2. Gases can be compressed to a much larger extent than solids and liquids.
3. A gas expands to a greater extent on being heated.
4. Gases freely mix with one another. Because the molecules of a gas can easily occupy the large intermolecular spaces of another gas. This property is known as **diffusion**.



5. Gases have very large interparticle spaces and negligible interparticle attractions.

What causes a difference in states?

Molecules attract each other with a force. This force is called **intermolecular force**. There is also some space between the molecules. This space is called **intermolecular space**.

The greater the intermolecular force, the closer will be the molecules to each other. The weaker the intermolecular force, the further apart will be the molecules.

Plasma state (Fourth state of matter) :

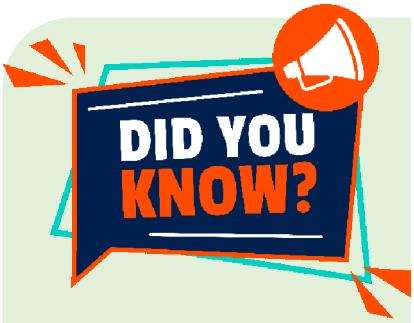
Plasma is the fourth state of matter. Plasma is similar to the gaseous state. Plasma is made by heating a gas. Atoms and molecules in the gas lose all electrons and form ions and electrons to coexist. The plasma is produced in sun and stars because of very high temperature. The sun and stars glow because of the presence of plasma in them. Plasma occurs naturally and makes up the stuff of our sun, the core of stars and occurs in supernovas. On earth, plasma is naturally occurring in flames, lightning, the northern and southern lights.

Plasma state

Plasmas have a very low density, for example the Solar wind which averages only 10 particles per cubic cm. Inter-particle collisions are unlikely - hence these plasmas are termed collision less.

Finding a plasma :

While natural plasmas aren't found around you that often, man-made plasmas are everywhere. Think about fluorescent light bulbs or neon sign tubes. They are not like regular light bulbs. Inside the long tube is a gas. Electricity flows through the tube when the light is turned on. The electricity acts as an energy source and charges up the gas. This charging and exciting of the atoms creates glowing plasma inside the bulb, having a special colour depending on the nature of gas.



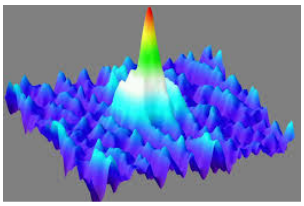
Plasma makes up 99% of the visible universe!

Bose-Einstein condensate or BEC (Fifth state of matter) :

In 1924, **Albert Einstein** and **Satyendra Nath Bose** predicted the "Bose-Einstein Condensate" (BEC), which is referred as the fifth state of matter.

A Bose-Einstein condensate (BEC) is a state of matter of a dilute gas of bosons cooled to temperatures very close to absolute zero (that is, very near 0 K or –273.14 °C). Under such conditions, a large fraction of the atoms collapse into the lowest quantum state, producing a superfluid.

The Bose-Einstein condensate occurs at ultra-low temperature, close to the point that the atoms are not moving at all. A Bose-Einstein condensate is a gaseous superfluid phase formed by atoms cooled to temperatures very near to absolute zero.



Bose-Einstein condensate

Properties of BEC

i. Super fluidity : A state of zero viscosity allowing fluid to flow without energy loss.

ii. Bose-Einstein condensates are super conductors, conduct electricity with virtually zero electrical resistance.

BEC is like a "chill party" for atoms- they get so cold they start acting as one!

CLASSROOM DISCUSSION QUESTIONS CDQ 02

1. Which of the following statements is true about liquids?

(A) Liquids are incompressible.

(B) Liquids have a fixed shape and volume.

(C) Liquids can be compressed to a large extent.

(D) Liquids do not have a fixed shape but have a fixed volume.

2. Which of the following is NOT an example of a liquid?

(A) Tea (B) Milk

(C) Brick (D) Water

3. In which state of matter do particles move freely and rapidly, but do not have a fixed volume or shape?

(A) Gas (B) Solid

(C) Liquid (D) Plasma

4. Which of the following is TRUE about gases?

(A) Gases are not compressible.

(B) Gases do not expand on heating.

(C) Gases have high interparticle attraction.

(D) Gases have very large interparticle spaces.

5. How is plasma formed?

(A) By compressing a liquid

(B) By applying high pressure to solids

(C) By cooling a gas to absolute zero

(D) By heating a gas to high temperatures

6. Where is plasma naturally found?

(A) In bricks

(B) In metallic pots

(C) Inside solid ice

(D) In the sun and stars

7. What is the Bose-Einstein Condensate (BEC)?

(A) A type of solid

(B) A high-temperature plasma

(C) A state where atoms vibrate rapidly

(D) A gaseous superfluid formed near absolute zero

8. What happens to atoms in the Bose-Einstein Condensate?

(A) They expand significantly.

(B) They move freely and quickly.

(C) They become ions and electrons.

(D) They collapse into the lowest quantum state.

MARK YOUR ANSWERS WITH PEN ONLY. Time Taken ☐ Minutes

1 Ⓐ Ⓑ Ⓒ Ⓓ	2 Ⓐ Ⓑ Ⓒ Ⓓ	3 Ⓐ Ⓑ Ⓒ Ⓓ	4 Ⓐ Ⓑ Ⓒ Ⓓ	5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ	7 Ⓐ Ⓑ Ⓒ Ⓓ	8 Ⓐ Ⓑ Ⓒ Ⓓ	9 Ⓐ Ⓑ Ⓒ Ⓓ	10 Ⓐ Ⓑ Ⓒ Ⓓ

Concept 3

Interconversion of matter, into different states :

The phenomenon of change of matter, from one state to another state and back to original state, by altering the conditions of temperature and pressure, is called **interconversion of matter**.

Altering the temperature of matter

1. **Interconversion of matter, on heating:** A block of ice at 0°C, placed in a beaker and heated. It changes to liquid water. Heat the water till it boils. It slowly gets converted to vapour (gas). From this observation, it is clear that the solids convert into liquids and liquids in turn convert to gas, on heating.

Knowledge Box

Heating increases the kinetic energy of particles, breaking bonds and causing matter to change states.

Melting: The process of changing a solid substance into liquid by heating is called **melting**. For example, when ice (solid) changes into water (liquid), it is called melting of ice. A solid substance can be melted only by applying heat. The melting of a substances takes place at a fixed temperature.

MELTING OF ICE

Melting point: The temperature at which a solid substance melts and changes into a liquid is called **melting point** of the substance.

Melting points of some solid substances:

Solids	Melting point
Ice (H_2O)	0°C
Sodium chloride ($NaCl$)	800°C
Iron	1535°C

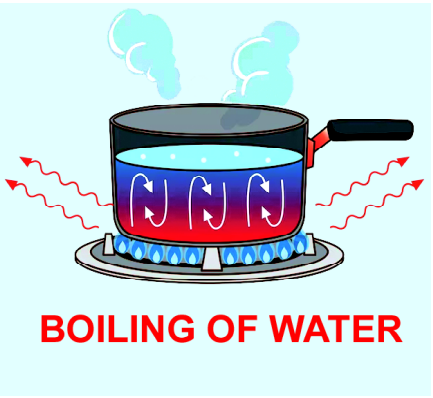
Evaporation:

The gaseous state of a liquid is also called its vapour state. Most of the liquids keep on changing into vapours slowly even at room temperature. The changing of a liquid into vapours (or) gas is called **evaporation**. The evaporation of a liquid can take place at all temperatures.

Evaporation is a surface phenomenon because it occurs only on the surface of a liquid. During evaporation the molecules with higher kinetic energy escape into the air from the upper most layer of the liquid, making it surface phenomenon.

Boiling: When a liquid is heated continuously, then its temperature goes on rising and its evaporation (changing into vapours) takes place faster and faster. At a certain temperature, the liquid changes into vapours (a gas) very rapidly and we say that the liquid has started boiling. The rapid changing of a liquid into vapours (or) gas on heating is called **boiling.** The boiling of a liquid takes place at a fixed temperature.

Boiling is a bulk phenomenon because entire liquid is involved in the process. When a liquid reaches its boiling point, the particles throughout the liquid gain energy and turn into gas.


BOILING OF WATER

Boiling point: The temperature at which a liquid boils and changes into vapours (or gas) very rapidly is called **boiling point** of the liquid for example, water boils at a temperature of 100°C to form a gas is called steam, so the boiling point of water is 100°C.

Boiling points of some liquids:

Liquid	Boiling point
Water	100°C
Chloroform	62°C
Sulphuric acid	280°C

NOTE: *Melting point and boiling point of a substances depends on a number of factors including : inter molecular forces, pressure, molecular size, molecular shape ….etc.*

Sublimation: A few substances change directly from solid to gas on heating without coming into liquid state. This process is called **sublimation** and such substances are called sublimates.

For example: Iodine, Ammonium chloride, camphor and Naphthalene are sublimable substances.

2. **Interconversion of matter by cooling:** Collect some water vapour (gas) and cool it. We will notice that, it becomes liquid water. On cooling further, the liquid water gets converted to ice (solid). A reverse process of heating is taking place on cooling. That is, a gas is converted to liquid and liquid is converted to solid, by cooling.

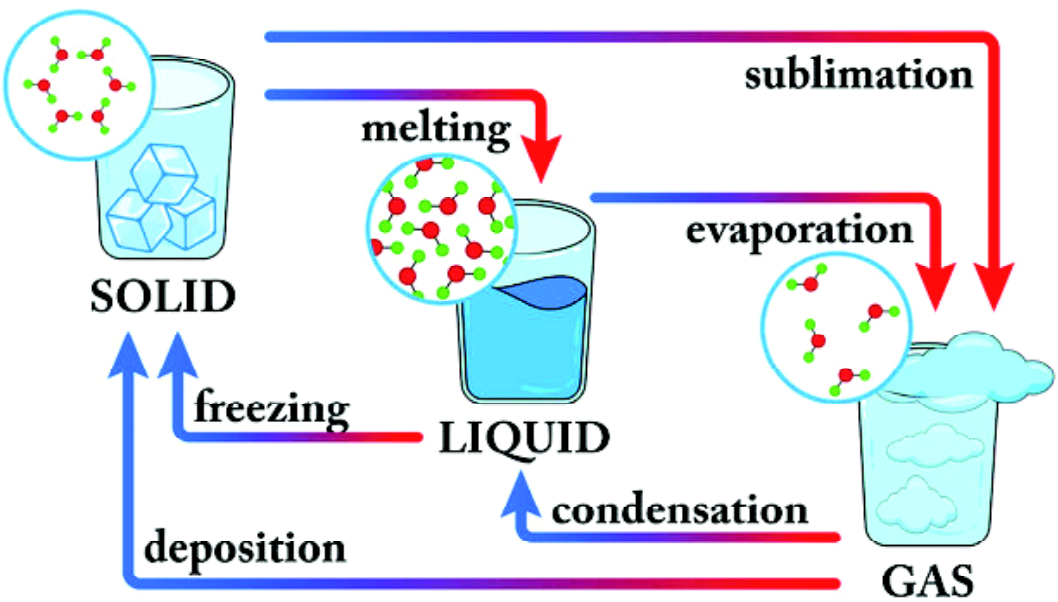
Condensation: We have just seen when water is heated, it changes into steam (or) water vapour. The reverse of this is also true. That is, if we cool the steam, it changes back into water (liquid state). The process of changing a gas (or) vapours into a liquid by cooling is called **condensation.**


CONDENSATION OF VAPOUR

For example, the mirror in the bathroom during a shower becomes foggy because warmer water vapour in the air hits the cooler surface of the mirror.

Freezing: We have seen that when ice is heated, it melts to form water. The reverse of this is also true. That is, when a liquid is cooled, it changes into solid. For example, when water is cooled, its freezes to form ice. The process of changing of state from liquid to solid by cooling, is also called **freezing** (or) **solidification.**


FREEZING INTO ICE



CLASSROOM DISCUSSION QUESTIONS CDQ 03

1. **Which of the following substances undergoes sublimation?**
   (A) Water
   (B) Sodium chloride
   (C) Iodine
   (D) Iron
2. **At what temperature does water boil to form steam?**
   (A) 0°C
   (B) 62°C
   (C) 100°C
   (D) 280°C
3. **What is the temperature at which a solid substance changes into a liquid called?**
   (A) Boiling point
   (B) Freezing point
   (C) Melting point
   (D) Evaporation point
4. **Which process involves changing a gas into a liquid by cooling?**
   (A) Condensation
   (B) Sublimation
   (C) Evaporation
   (D) Freezing
5. **What phenomenon causes a mirror to become foggy during a shower?**
   (A) Sublimation
   (B) Melting
   (C) Boiling
   (D) Condensation
6. **Which of the following substances undergoes freezing to form its solid state?**
   (A) Water
   (B) Chloroform
   (C) Sulphuric acid
   (D) Ammonium chloride
7. **What is the term for the rapid changing of a liquid into vapours (or gas) on heating?**
   (A) Sublimation
   (B) Evaporation
   (C) Melting
   (D) Boiling
8. **Which process involves changing a liquid into a solid by cooling?**
   (A) Boiling
   (B) Freezing
   (C) Melting
   (D) Evaporation

MARK YOUR ANSWERS WITH PEN ONLY. Time Taken ☐ Minutes

1 Ⓐ Ⓑ Ⓒ Ⓓ	2 Ⓐ Ⓑ Ⓒ Ⓓ	3 Ⓐ Ⓑ Ⓒ Ⓓ	4 Ⓐ Ⓑ Ⓒ Ⓓ	5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ	7 Ⓐ Ⓑ Ⓒ Ⓓ	8 Ⓐ Ⓑ Ⓒ Ⓓ	9 Ⓐ Ⓑ Ⓒ Ⓓ	10 Ⓐ Ⓑ Ⓒ Ⓓ

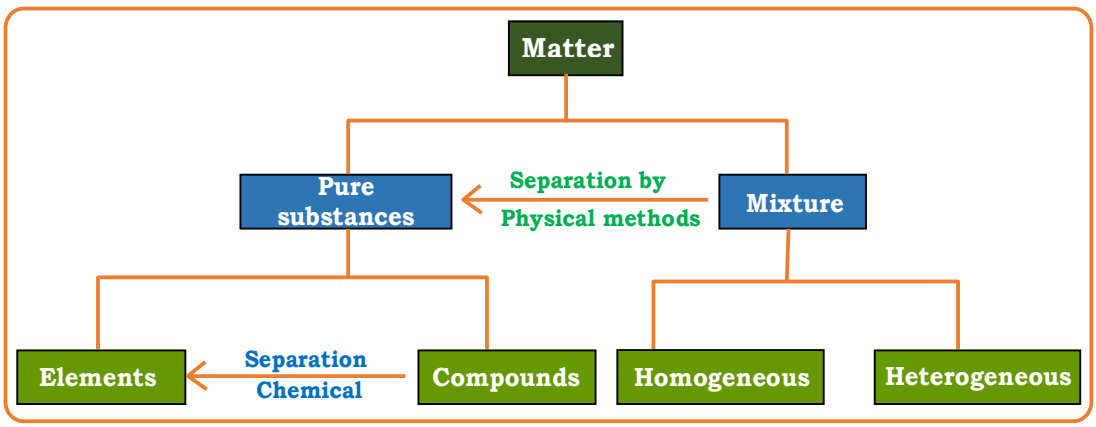
Concept 4

Classification of Matter based on chemical composition

When we talk about matter, usually we talk about a substance, which possesses distinct properties and has a definite composition. For example, sugar (sucrose), table salt (sodium chloride), water, gasoline, etc. All substances do not have the same composition but yet can be identified by their unique properties.

Matter is classified into two broad categories, namely, pure substances and mixtures.

Pure substances are further divided into two categories as elements and compounds. Similarly, mixtures are also classified into two types, homogeneous mixtures and heterogeneous mixtures. Mixtures can be separated into pure substances by physical methods.



Pure substances

A pure chemical substance is any matter that has a fixed chemical composition and characteristic properties. For example, Oxygen is a pure chemical substance that is a colourless, odourless gas. The substances containing particles of only one kind are **pure substances**.

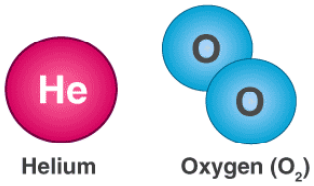
Example **:** Iron, silver, oxygen, carbon dioxide, sodium chloride etc.

Pure substances are further divided into elements and compounds.

A pure substance can be either an element or a compound. First of all, the elements are the building blocks of our nature.

I. Elements:

An element is a substance that consists of only one type or kind of atom. An element is a pure substance as it cannot be broken down or transformed into a new substance even by using some physical or chemical means.



Helium Oxygen (O_2)

In order to call it as an element, its properties must be unique, no two elements are alike.

Elements carry the names and symbols.

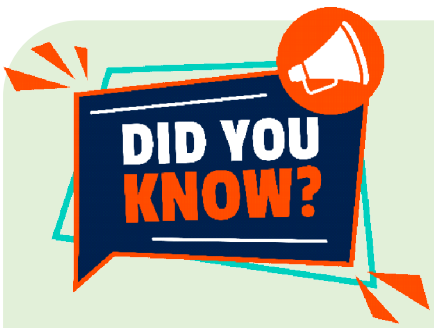
Example: Oxygen (O_2): A gas we breathe; essential for life.

Gold (Au): A shiny metal used in jewellery.

Carbon (C): Found in coal, diamonds, and even in our body!

Few things to know about the elements

- Ancient man was exposed to several pure elements that occur in nature, including carbon, gold, and copper, but people did not recognize these substances as elements.
- There are 118 known elements at this time.
- The same elements occur everywhere in the universe.
- Names of the elements are given by its inventor(s).
- Sometimes, they are named after the place like an element Berkelium (Bk) after its discovery in Berkeley (University of California, Berkeley).
- Sometimes, their names are based on planet, like element Mercury (Hg) named after the planet mercury.
- Sometimes, the name is given to honour the great scientist, like Curium (Cm) after Madame Curie who contributed to radioactivity research.
- Many elements occur naturally, but some are man-made or synthetic.



Curium is named after Mary Curie, the first women to win a Noble prize and the only person to win it in two different sciences (Physics and Chemistry).

Characteristics of elements

i) Nature: An element is pure and homogeneous substance.

Example: Iron (Fe) contains only iron atoms.

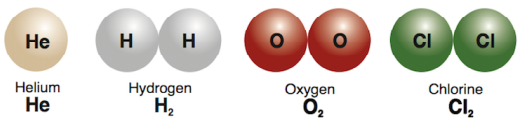
ii) Melting and boiling points: It has characteristic melting and boiling points.

Example: Gold (Au) always melts at 1064°C, no matter where you find it.

iii) Separation of components: An element cannot be broken-down into simpler substances, by any physical (or) chemical means.

Example: Oxygen gas (O_2) can't be split into anything simpler unless through nuclear reactions.

iv) Nature of atoms: An element is made up of same kind of atoms. Different elements are made up of different kinds of atoms.



v) Chemical reaction: An element may chemically react with other elements to from compounds.

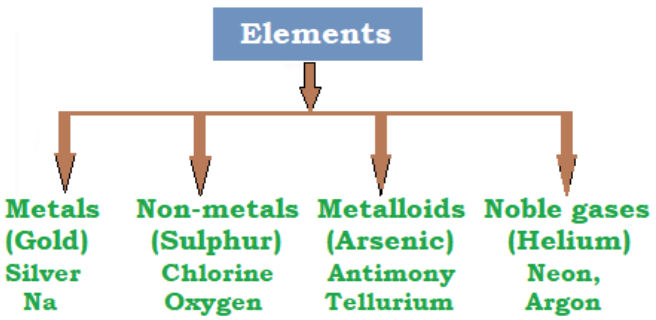
Example: Hydrogen (H) reacts with oxygen (O_2) to form water (H_2O).

Iron (Fe) reacts with oxygen and water to form rust (iron oxide, Fe_2O_3).

Classification of elements

There are more than 118 elements known today, out of these, 92 elements are naturally occurring elements and remaining are artificially synthesised (man-made). On the basis of their general characteristics, they are broadly divided into four groups.

1. Metals 2. Non-metals 3. Metalloids 4. Inert gases



CLASSROOM DISCUSSION QUESTIONS CDQ 04

1. What is a pure substance?

(A) A mixture of elements and compounds

(B) A substance that contains different kinds of atoms

(C) A substance that can be separated by physical methods

(D) A substance with a fixed chemical composition and distinct properties

2. What defines an element?

(A) A mixture of various atoms

(B) A substance made of one type of atom

(C) A compound made from two or more different elements

(D) A substance that can be broken down into simpler substances

3. How many known elements are there currently?

(A) 92 (B) 100

(C) 118 (D) 150

4. Which of the following elements was named after a planet?

(A) Berkelium (Bk)

(B) Mercury (Hg)

(C) Curium (Cm)

(D) Oxygen (O)

5. Which of the following is an example of an element?

(A) Oxygen (O)

(B) Water (H_2O)

(C) Carbon dioxide (CO_2)

(D) Sodium chloride (NaCl)

6. Which of the following is an example of a compound?

(A) Iron (Fe)

(B) Gold (Au)

(C) Oxygen (O)

(D) Sodium chloride (NaCl)

7. What is the nature of an element?

(A) It is impure and heterogeneous

(B) It is impure and homogeneous

(C) It is pure and homogeneous

(D) It is pure and hetergeneous

MARK YOUR ANSWERS WITH PEN ONLY. Time Taken ☐ Minutes

1 Ⓐ Ⓑ Ⓒ Ⓓ	2 Ⓐ Ⓑ Ⓒ Ⓓ	3 Ⓐ Ⓑ Ⓒ Ⓓ	4 Ⓐ Ⓑ Ⓒ Ⓓ	5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ	7 Ⓐ Ⓑ Ⓒ Ⓓ	8 Ⓐ Ⓑ Ⓒ Ⓓ	9 Ⓐ Ⓑ Ⓒ Ⓓ	10 Ⓐ Ⓑ Ⓒ Ⓓ

Concept 5

Metals :

Metallic elements in general exhibit the following characteristics:

- **State:** All metals are solids at room temperature (except mercury, which is liquid).
- **Conductivity:** Metals are excellent conductors of heat and electricity.
- **Malleability:** Metals can be hammered into thin sheets.
- **Ductility:** Metals can be drawn into wires.
- **Appearance:** Metals are lustrous (shiny) when freshly cut or polished.
- **Strength:** Metals possess high tensile strength, making them strong and resistant to breaking under tension.
- **Hardness:** Most metals are hard, though exceptions like alkali metals (e.g., sodium, potassium) are relatively soft.
- **Density:** Metals generally have high densities.
- **Sonority:** Metals are sonorous, meaning they produce a ringing sound when struck.

Fun Facts

Single gram of Gold can be stretched into wire of almost two kilometres long.

Exceptions

- Mercury is a liquid metal at normal or room temperature and Gallium becomes liquid at above 30°C temperature.
- Zinc metal is not malleable and ductile at room temperature.
- Some metals like Sodium and Potassium are soft metals, even they can be cut with a knife.

Examples: Iron (Fe), Gold (Au), Copper (Cu), Aluminium (Al), Silver (Ag), etc.

Non-Metals :

Non-metals in general exhibit the following characteristic properties:

- **Hardness:** Non-metals are generally not hard.
- **Appearance:** Non-metals typically have dull surfaces and do not shine.
- **State:** Most non-metals are either soft solids or gases at room temperature.
- **Malleability:** Non-metals are not malleable (cannot be hammered into sheets).

- **Ductility:** Non-metals are not ductile (cannot be drawn into wires).
- **Brittleness:** Non-metals are brittle and break into pieces when hammered, much like glass.
- **Conductivity:** Non-metals are poor conductors of heat and electricity.
- **Sonority:** Non-metals are not sonorous and do not produce a ringing sound when struck.

Exceptions

- **Diamond** a form of carbon, is the hardest naturally occurring material.
- **Graphite** a form of carbon, has a lustre and is a good conductor of heat and electricity.
- **Iodine,** which has a lustrous appearance.
- **Bromine** is a liquid non - metal.

Examples: Carbon (C), Oxygen (O), Sulphur (S), Hydrogen (H), Nitrogen (N), etc.

Metalloids :

Metalloids exhibit the following properties that lie in between that of metals and non-metals.

Examples: Boron (B), Silicon (Si), Germanium (Ge), Arsenic (Ar), Antimony (Sb), Tellurium (Te) and Polonium (Po).

Inert gases :

The gaseous elements which do not combine with other elements and even themselves and exist as individual atoms are called inert gases.

Examples: Helium(He), Neon(Ne), Argon (Ar), Krypton(Kr), Xenon(Xe), Radon(Rn) (Radio active element).

Inert gases are also called noble gases, aerogens, rare gases, zero group elements.

Atom:

The smallest particle of an element that retains the properties of the element is called the **atom** of the element.

An element is made up of only one kind of atoms. All atoms of an element are identical (there are exceptions to this, about which you will read in higher classes), but atoms of one element are different from the atoms of any other element.

For example, all atoms of oxygen are identical. Similarly, all atoms of nitrogen are identical. But atoms of oxygen are different from the atoms of nitrogen.

CLASSROOM DISCUSSION QUESTIONS CDQ 05

1. **Which of the following is a liquid metal at room temperature?**
   (A) Zinc
   (B) Gallium
   (C) Sodium
   (D) Mercury
2. **Metals are good conductors of electricity because they have:**
   (A) High density
   (B) Free protons
   (C) Free electrons
   (D) High malleability
3. **Which of the following is a liquid non-metal?**
   (A) Iodine
   (B) Carbon
   (C) Sulphur
   (D) Bromine
4. **The hardest naturally occurring material is:**
   (A) Silicon
   (B) Sulphur
   (C) Graphite
   (D) Diamond
5. **Which of the following is a metalloid?**
   (A) Gold
   (B) Argon
   (C) Silicon
   (D) Aluminium
6. **The properties of metalloids are:**
   (A) Same as metals
   (B) Same as non-metals
   (C) A mix of metals and non-metals
   (D) None of the above
7. **Which of the following is an inert gas?**
   (A) Neon
   (B) Oxygen
   (C) Nitrogen
   (D) Hydrogen
8. **The smallest particle of an element that retains its properties is called:**
   (A) Ion
   (B) Atom
   (C) Molecule
   (D) Compound

MARK YOUR ANSWERS WITH PEN ONLY. Time Taken ☐ Minutes

1 Ⓐ Ⓑ Ⓒ Ⓓ	2 Ⓐ Ⓑ Ⓒ Ⓓ	3 Ⓐ Ⓑ Ⓒ Ⓓ	4 Ⓐ Ⓑ Ⓒ Ⓓ	5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ	7 Ⓐ Ⓑ Ⓒ Ⓓ	8 Ⓐ Ⓑ Ⓒ Ⓓ	9 Ⓐ Ⓑ Ⓒ Ⓓ	10 Ⓐ Ⓑ Ⓒ Ⓓ

Concept 6

Molecule:

An atom can sometimes exist alone and sometimes in groups. A group of atoms is called a **molecule**. A molecule can always exist by itself. A molecule may contain similar or dissimilar atoms.

Example:

Molecules of elements	
Molecules with similar atoms	
Molecule	**Formula**
Oxygen	O_2
Hydrogen	H_2
Chlorine	Cl_2

Molecules of Compounds	
Molecules with different atoms	
Molecule	**Formula**
Water	H_2O
Sodium chloride	$NaCl$
Calcium oxide	CaO

Atoms of most elements can exist alone, e.g. iron, gold, aluminium or silver. But in certain gaseous elements, such as hydrogen, nitrogen, oxygen, chlorine or iodine, atoms cannot exist alone. They can exist only in pairs. A molecule of these elements contains two similar atoms. Some molecules even contain three similar atoms. For example, ozone gas has its molecules with three atoms of oxygen (O_3).

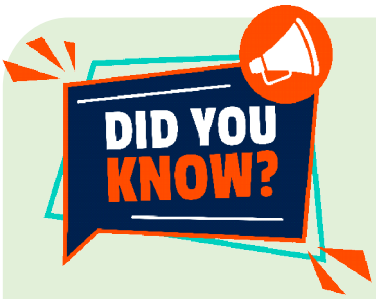
We can therefore define a molecule as:

A **molecule** is the smallest particle of an element or a compound that can exist by itself.

The molecule of an element contains one or more atoms of the same kind. The molecule of a compound contains two or more atoms of different kinds.

From the above discussions, we can conclude the following facts.

- The smallest particle of compound is known as its **molecule**.
- The molecules of compounds can be broken down into the elements from which they are made.



Ozone (O_3) is a molecule made up of three oxygen atoms. It forms a layer of atmosphere that protects us from harmful ultraviolet (UV) radiation from the sun.

- A molecule is the smallest particles of an element or a compound, which shows all the properties of that substance (element or compound).
- Symbol represents one atom of an element. On the other hand, molecular formula represent one molecule of an element or a compound.

II. Compounds:

A compound is the substance formed by the chemical union of two or more elements in a definite ratio, which is fixed by the nature. We cannot change this ratio, no matter who does it.

For example, water is made up of one part oxygen and two parts hydrogen. This ratio is fixed by the nature and we cannot alter this. When the compound is formed, altogether a new substance is formed and the properties of which are quite different from its reacting elements. Like elements, compounds also carry names and symbols that you come across in a later chapter.

For understanding what a compound is, consider the facts given below:

1. There are only 26 letters in the English alphabet. Different combinations of these letters make a large number of words.
2. Only ten numerals from 0 to 9 make innumerable numbers.
3. A variety in music is obtained by using different combinations of only a few basic musical notes.

Similarly, compounds are formed by the combination of elements. For example, one atom of carbon combines with two atoms of oxygen to form the molecule of a compound, carbon dioxide. Thus the molecule is the smallest particle of the compound. It has dissimilar atoms.

There are millions of different compounds around you. Probably everything you can see is one type of compound or another. When elements join and become compounds, the new compounds formed have few or none of the physical or chemical properties of the original elements. They have a new life of their own.

Fun Facts

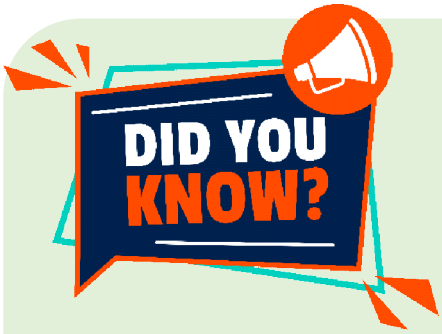
Carbon is known as "building block of life" because it can form millions of compounds.

For example:

Element **sodium** (Na) alone is soft and silvery shiny metal and that can easily cut with knife. It is a very reactive metal. Its melting point is 97.6°C and it reacts violently with water.

Element **chlorine** consists of chlorine molecules (Cl_2). Chlorine is a non-metal yellowish green gas. It is highly toxic and it was used as a warfare agent during world war-I. Its boiling point is –34°C.

But when sodium and chlorine (Cl) combine, they form a non-reactive substance called **sodium chloride** (table salt, NaCl). It is a brittle, colourless crystalline hard solid having a melting point of 800°C. It does not react with water as sodium does and not toxic to humans as chlorine but an essential component of all living organisms.



About 80% of all medicines involve chlorine in their production, including common drugs like paracetamol and antiseptics.

Thus, a compound is a substance, composed of two or more elements, chemically combined in a definite proportion.

Compound	Formula
Salt	NaCl; Sodium Chloride
Baking powder	$NaHCO_3$; Sodium bicarbonate
Vinegar	$C_2H_4O_2$; Acetic acid
Sugar	$C_{12}H_{22}O_{11}$; Sucrose
Chalk	$CaCO_3$; Calcium carbonate
Bleaching powder	$Ca(OCl)_2$ Calcium hypochlorite
Gobar gas	CH_4; Methane
Battery acid	H_2SO_4; Sulphuric acid
Quick lime	CaO; Calcium oxide
Sand	SiO_2; Silicon dioxide

Impure substances or Mixtures :

When two or more substances (either elements or compounds) combine in any proportion then the resultant substance so obtained is called a **mixture**. We study about these mixtures in further classes.

Mixtures are like salads-different ingredients come together, but each keeps its unique.

CLASSROOM DISCUSSION QUESTIONS CDQ 06

1. The smallest particle of a compound that can exist by itself is known as:

(A) Atom

(B) Molecule

(C) Electron

(D) None of these

2. What happens to the properties of elements when they form a compound?

(A) They partially change.

(B) They remain unchanged.

(C) They combine with other properties.

(D) They become completely different from the original elements.

3. What is the fixed ratio of hydrogen to oxygen in water (H_2O)?

(A) 1 : 2

(B) 2 : 1

(C) 1 : 1

(D) 3 : 1

4. Sodium (Na) and Chlorine (Cl_2) combine to form:

(A) Chlorine oxide (ClO_2)

(B) Sodium chloride ($NaCl$)

(C) Sodium hydroxide ($NaOH$)

(D) Sodium carbonate (Na_2CO_3)

5. Chlorine gas used in :

(A) Treatment of drinking water

(B) Drug industry

(C) Production of paper

(D) All of these

6. What happens to the properties of the substances in a mixture?

(A) They remain the same.

(B) They change completely.

(C) They vanish after combining.

(D) They combine to form new properties.

7. The appearance of sodium metal is :

(A) Soft and silvery white

(B) Hard and silvery white

(C) Hard and golden yellow

(D) None of these

MARK YOUR ANSWERS WITH PEN ONLY. Time Taken ☐ Minutes

1 Ⓐ Ⓑ Ⓒ Ⓓ	2 Ⓐ Ⓑ Ⓒ Ⓓ	3 Ⓐ Ⓑ Ⓒ Ⓓ	4 Ⓐ Ⓑ Ⓒ Ⓓ	5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ	7 Ⓐ Ⓑ Ⓒ Ⓓ	8 Ⓐ Ⓑ Ⓒ Ⓓ	9 Ⓐ Ⓑ Ⓒ Ⓓ	10 Ⓐ Ⓑ Ⓒ Ⓓ

C.D.F. (Concepts, Definitions and Formulae)

1. Anything which occupies space and has mass is called **matter.**
2. The matter around us exist in three states. They are solids, liquids and gases.
3. Molecules attract each other with a force. This force is called **intermolecular force.** There is also some space between the molecules this is called **intermolecular space.**
4. The fourth states of matter is **Plasma**. Plasma is ionized gas.
5. The collapse of the atoms into a single quantum state is known as **Bose-Condensation** (or) **Bose-Einstein condensate** is fifth state of matter.
6. The process by which a solid changes to liquids by absorbing heat, is called **melting**.
7. The temperature at which a solid substance melts and changes into a liquid is called **melting point** of the substance.
8. The process by which a liquid changes to gas (vapour) by absorbing Heat, is called **boiling** (or) **vaporisation**.
9. The temperature at which a liquid boils and changes into vapours (or gas) very rapidly is called **boiling point** of the liquid.
10. The process by which a gas converted to a liquid, by giving out heat is called **liquefaction** (or) **condensation.**
11. The process by which a liquid is converted to solid, is known as **solidification** (or) **freezing.**
12. The constant temperature at which a liquid changes to a solid, is known as **freezing point**.
13. The changing of a liquid into vapours (or gas) is called **evaporation**. The evaporation of a liquid can take place at all temperatures.
14. Metals are hard, lustrous, malleable, ductile, sonorous and good conductors of heat and electricity. Examples: Fe, Cu, A*l*, Ca, Mg etc.
15. Non- metals have low melting point and boiling points non lustrous, non malleable, non ductile, non sonorous, brittle and poor conductors of heat and electricity. Examples: C, N, P, O, S etc.
16. Metalloids exhibit the properties that lie in between that of metals and non metals. Examples: B, Si, Ge, As, Sb, Te, Po etc.
17. Inert gases are also called noble gases, aerogens, rare gases, zero group elements. Examples: Helium (He), Neon (Ne), Argon (Ar), Krypton (Kr), Xenon (Xe), Radon (Rn).
18. The smallest particle of an element that retains the properties of the element is called an **atom** of the element.
19. An atom can sometimes exist alone and sometimes in groups. A group of atoms is called a **molecule**.
20. When two atoms of hydrogen combine with one atom of oxygen, a molecule of water is formed. Water is not an element, it is a **compound**.

Advanced Worksheet

LEVEL 1

Single Correct Answer Type (S.C.A.T.)

1. **Physical classification of matter is based on differences of certain physical properties of the following :**
   (A) Mass
   (B) Rigidity
   (C) Arrangement
   (D) All

2. **The molecular force of interactions in a gas depends upon the :**
   (A) Density
   (B) Rigidity
   (C) Mass
   (D) Temperature

3. **Which of the following is a sublimable substance?**
   (A) Sulphuric acid
   (B) Ammonium chloride
   (C) Table salt
   (D) Water

4. **Symbol for Nitrogen is :**
   (A) Ni (B) Ng
   (C) N (D) Nt

5. **Bromine is a :**
   (A) Liquid (B) Solid
   (C) Gas (D) Plasma

6. **Highly reactive metal is :**
   (A) Iron
   (B) Silver
   (C) Sodium
   (D) Gold

7. **Which one of the following is a compound?**
   (A) Hydrogen
   (B) Nitrogen
   (C) Air
   (D) Carbon dioxide

8. **The boiling point of a substance is the temperature at which it changes from :**
   (A) Solid to liquid
   (B) Liquid to solid
   (C) Liquid to gas
   (D) Gas to solid

9. **Metals can be hammered into thin sheets. This property is called :**
   (A) Density
   (B) Malleability
   (C) Ductility
   (D) Strength

10. **The smallest particle of an element or a compound that can exists by itself is :**
    (A) An atom
    (B) A molecule
    (C) An elemen
    (D) A compound

11. In a compound, elements are always present in a ____.

(A) Fixed ratio

(B) Variable ratio

(C) Same ratio

(D) None of these

12. Certain substances exist in the solid state because :

(A) Intermolecular forces are weak

(B) Molecules can slide over one another

(C) Molecules are tightly packed

(D) Molecular motion is very fast

13. The boiling point of H_2SO_4 is :

(A) 10^0C (B) 100^0C

(C) 280^0C (D) 152^0C

14. Which of the following elements is named in the honour of Madam Curie ?

(A) Curium

(B) Berkelium

(C) Mercury

(D) Pluto

15. Metal which becomes liquid at 30^0C Temperature :

(A) Iron

(B) Copper

(C) Galium

(D) Bromine

16. Molecular formula of ozone is :

(A) O_3 (B) O_2

(C) ZnO (D) CaO

17. Plasma is made by heating a __.

(A) Solid (B) Gas

(C) Liquid (D) None

18. Water boils at :

(A) 100^0C (B) 62^0C

(C) 0^0C (D) 200^0C

19. Hydrogen is :

(A) Element

(B) Pure substance

(C) (A) and (B)

(D) Mixture

20. Which of the following carbon form has some metallic properties ?

(A) Graphite

(B) Diamond

(C) Coal

(D) Coke

21. The fixed ratio of oxygen and hydrogen by volume respectively to form water is :

(A) 1 : 2 (B) 2 : 1

(C) 1 : 1 (D) 2 : 3

22. A substance that has no definite shape or volume and can spread to occupy any available space is :

(A) Sugar

(B) Milk

(C) Oxygen

(D) Oil

23. The fifth state of matter is :

(A) Solid

(B) Gas

(C) Liquid

(D) Bose - Einstein condensate

24. The intermolecular forces are minimum in case of :

(A) Solids

(B) Liquids

(C) Gases

(D) None of these

25. The intermolecular forces are maximum in case of :

(A) Copper

(B) Water

(C) Carbon dioxide

(D) Hydrogen

26. Which one of the following is a property of gases?

(A) They have no rigidity

(B) They can diffuse

(C) They have definite mass

(D) All of these

27. Liquids can flow easily, which of the following is not a correct reason for it?

(A) Intermolecular forces are very strong

(B) Molecules are far from each other

(C) Molecules can slide over each other

(D) Molecular motion is very fast

28. Which of the following elements is a non metal?

(A) Mercury

(B) Lead

(C) Zinc

(D) Carbon

29. The melting point of a substance is the temperature at which it changes from :

(A) Gas to solid

(B) Liquid to solid

(C) Solid to liquid

(D) Solid to gas

30. An element is made up of :

(A) Only one kind of atoms

(B) Only two kinds of atoms

(C) Many kinds of atoms

(D) None of these

31. Which one of the following is not a property of gases?

(A) They have a definite volume

(B) They have no definite shape

(C) They have definite mass

(D) They can diffuse

32. Which of the following will diffuse faster than the others?

(A) Water

(B) Petrol

(C) Perfume

(D) Milk

33. Among the following, metalloid is:

(A) Iron
(B) Carbon
(C) Antimony
(D) Sulphur

Multi Correct Answer Type (M.C.A.T.)

34. Calcium carbonate is also known as :

(A) Lime stone
(B) Chalk
(C) Gobar gas
(D) sand

35. Which of the following are pure substances ?

(A) Elements
(B) Compounds
(C) Mixtures
(D) Non-metals

36. Choose the properties of Non-metal.

(A) Hard
(B) Brittle
(C) Sonorous
(D) Bad conductors of Heat & Electricity

37. Plasma is occuring in :

(A) Flames
(B) Lightering
(C) Super Novas
(D) Sun & Stars

38. Inert gases are also known as :

(A) Noble gases
(B) Aerogens
(C) Rare gases
(D) Alkali metal

39. The whole universe is composed of _____ and _____.

(A) Matter
(B) Energy
(C) Soil
(D) Water

40. Choose the correct statement(s).

(A) Gases can be compressed
(B) Solids do not diffuse
(C) Liquids have less rigidity
(D) Solids have least inter-molecular space

41. Every matter occupies _____ and has _____ .

(A) Space
(B) Colour
(C) Mass
(D) Taste

42. Which of the following is/are noble gases?

(A) Hydrogen
(B) Helium
(C) Argon
(D) Oxygen

43. What are the properties of a metal?

(A) Malleable

(B) Ductile

(C) Bad conductor

(D) High density

44. In which of the following states, matter can flow?

(A) Solid

(B) Liquid

(C) Gas

(D) All

45. Which of the following substances are sublimable solids?

(A) Sodium

(B) Iodine

(C) Camphor

(D) Ammonium chloride

Comprehension Passage Type (C.P.T.)

PASSAGE - I

Interconversion of matter involves change of state of matter from one state to another state and back to its original state due to change in temperature and pressure.

46. The constant temperature at which a gas changes into liquid state is called:

(A) Liquefaction point

(B) Freezing point

(C) Boiling point

(D) Melting point

47. The change in state from liquid to solid is known as:

(A) Evaporation

(B) Vaporization

(C) Freezing

(D) Condensation

48. The melting point of ice is :

(A) 100°C (B) 0°C

(C) 10^0C (D) –100°C

PASSAGE - II

Atoms and Molecues in the gas lose all electrons and forms ions and electrons to co-exist. The plasma is produced in Sun and Stars because of very high temperature. The Sun & Stars glow because of the presence of plasma in them. Plasma has very 'low' density, for example the solar wind which averages on 10 particles per cubic cm.

Inter particle collisions are unlikely-hence these plasmas are termed as collision less.

49. Solar wind which averages on ___ particles per cubic cm.

(A) 10 (B) 20

(C) 5 (D) 0

50. Plasma is produced in Sun and Stars because of very high :

(A) Temperature

(B) Pressure

(C) Volume

(D) Electrons

51. Atoms and molecules in the gas lose all electrons and form ____to co-exist in plasma state.

(A) Only ions

(B) Only electrons

(C) Ions & electrons

(D) None

Matrix Matching Type (M.M.T.)

SET - I

Column - I

52. Ice

53. Dew

54. Hails

55. Steam

Column - II

(A) Solid form of water

(B) Liquid form of water

(C) Gaseous form of water

(D) Formed when water is cooled

SET - II

Column - I

56. Gobar gas

57. Battery acid

58. Sucrose

59. Sand

Column - II

(A) Silicon dioxide

(B) Sugar

(C) Sulphuric acid

(D) Methane

Integer Type Questions (I.T.Q.)

60. _____ states of matter exist in the universe.

61. Elements are classified into _____ types.

Analytical Approach Type (A.A.T.)

62. The decreasing order of densities of solids, liquids and gases for a given mass is:

(A) Solids > Gases > Liquids

(B) Gases > Solids > Liquids

(C) Liquids > Gases > Solids

(D) Solids > Liquids > Gases

63. Which of the following is not an example of vaporization?

(A) Dry air gains water vapour as it moves over the ocean

(B) Water droplets form on a mirror

(C) Wet pavement dries after a rain

(D) Bubbles form as water boils

64. When ice melts, its particles :

(A) Come close together and lose energy

(B) Gain energy and begin to move

(C) Lose energy and begin to move

(D) All of these

65. When a liquid is heated, its particles :

(A) Vibrate faster

(B) Slow down and form patterns

(C) Release energy to the surroundings

(D) Converts into solid

Figure Based Questions (F.B.Q.)

66. A student poured an equal amount of water into 4 containers as shown below. What result does this experiment show?

(A) Water has definite volume.

(B) Water has no definite shape.

(C) Water has definite mass.

(D) Water has no definite volume.

Statement Type (S.T.)

(A) Both statements are correct

(B) Both statements are incorrect

(C) Statement I is correct statement II is incorrect

(D) Statement I is incorrect Statement II is correct

67. Statement - I: Solids can not be compressed.

Statement - II: This is due to compact arrangement of molecules.

68. Statement - I: An element cannot be broken down into simple substance, by any physical or chemical means.

Statement - II: The substance containing particles of only one kind is called "pure substance".

69. Statement - I: The inter molecular spaces are very small and so intermolecular forces of attraction are negligible in gases.

Statement - II: Gases have a definite mass but no definite shape.

Assertion Reason Type : (A.R.T.)

70. Assertion (A): Some sugar can be added to a glassful of water without causing an overflow.

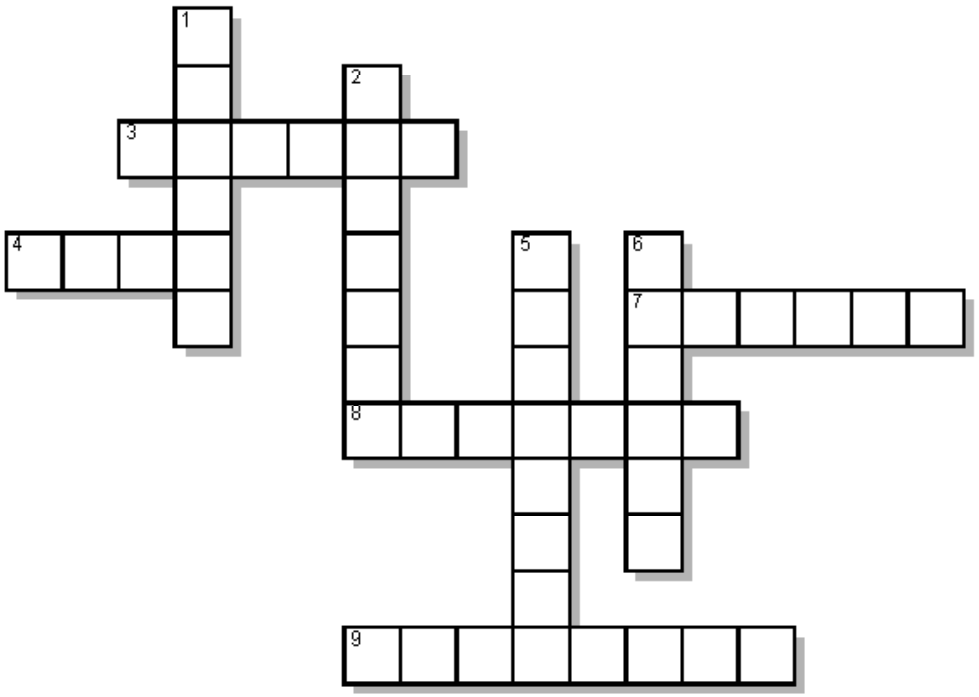
Reason (R): Liquids have spaces present between the molecules.

(A) A and R are true and R explains A

(B) A and R are true but R does not explain A

(C) Only A is true

(D) Only R is true



***Across*: (→)**

3. Any thing that occupies space and has mass.
4. The smallest particle of an element that retains the properties of the element.
7. An example for the sublimable substances.
8. Inter molecular attractions are least in _____ state.
9. The process of conversion of liquid into solid.

***Down*: (↓)**

1. The state of matter which contains ionized gas particles and electrons.
2. The process of conversion of solid into liquid.
5. The smallest particle of an element or a compound that can exist individually.
6. The state of matter which has fixed volume but no fixed shape.

NOTES