07

Matter and Its States

Matter is anything which has mass and occupies space. It exists in five states, *viz*, solid, liquid, gas, plasma and Bose-Einstein condensate. Out of which the former three are commonly seen.

States of Matter

The five states of matter are discussed below

1. Solids

- They have definite volume and definite shape.
- They are incompressible and have strongest intermolecular interactions.
- They are highly dense as compared to liquid and gas. e.g., wood, stone, iron, etc.

2. Liquids

- They have definite volume, but no definite shape. They take the shape of the vessel in which they are kept.
- They can flow, hence considered as fluids, e.g., milk, water, mercury, etc.

3. Gases

- They have neither definite volume nor definite shape. They take the shape and volume of the container in which they are filled.
- They are highly compressible.
- They can flow so considered as fluids, e.g. air, oxygen and nitrogen.

4. Plasma

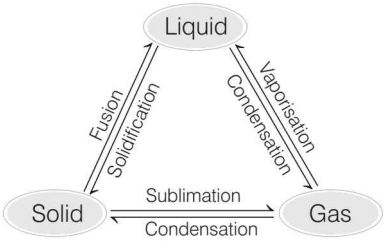
- The fourth state of matter is called plasma. This state contains ionised gas with super energetic and super excited particles e.g. sun, stars etc.

5. Bose-Einstein Condensate

- In 1924-25, Satyendra Nath Bose and Albert Einstein gave the information about Bose-Einstein condensate.
- It is a state of matter in which a gas of extremely low pressure cooled upto temperature which is very close to absolute zero (-273.15°C).
- It is called the fifth state of matter.

Interconversion of States of Matter

The states of matter are interconvertible. They can be interchanged by changing temperature or pressure as



Interconversion of the three states of matter

Various terms related to interconversion of states of matter are

(i) **Fusion** The process of melting, i.e., change of solid state into liquid state is also known as fusion.

(ii) **Melting Point** The temperature at which a solid starts to melt to become a liquid at the atmospheric pressure is called its melting point.

(iii) **Sublimation** It is the process used for those solids which convert directly into vapours on heating without converting into liquid phase and the vapours upon cooling give back the solid. Such solids are called **sublimates**.

It is used to separate a sublimate (substance undergoing sublimation like camphor, naphthalene, ammonium chloride, etc.) from non-sublimate.

(iv) **Vaporisation** The process in which a liquid substance changes into a gas rapidly on heating is called vaporisation. The same phenomenon is called **evaporation**, when heating is categorised to be done below the boiling point of the liquid.

(v) **Boiling Point** The temperature at which a liquid starts boiling at the atmospheric pressure is known as its boiling point. Boiling point of water at normal pressure is 100°C.

(vi) **Condensation** It is the process in which gas changes into the liquid state or liquid changes to solid state or gas directly converts into solid state. i.e., **Solidification.**

Particles of Matter

Matter has mainly two kinds of particles

Atoms

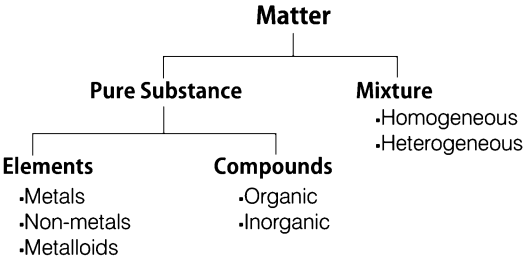
- The word atom has been derived from Greek word *atomos* meaning *indivisible*.
- An atom is the smallest particle of an element that may or may not exist independently and retain all its chemical properties, i.e. takes part in chemical reactions.
- Atoms of different elements have different masses and chemical properties.

Molecules

- A molecule is a group of two or more atoms that are chemically bonded together.
- It can be defined as the smallest particle of an element or a compound that is capable of independent existence and shows all the properties of that substance. However, it does not take part in a chemical reaction.

Chemical Classification of Matter

On the basis of chemical composition, matter can be classified as



Pure Substances

A substance is said to be pure, if all the constituent particles of that substance are the same in their chemical nature. e.g. all the elements and compounds are pure substances.

(i) Elements

- They contain only single type of atoms. Elements combine to give molecules.
- Examples of elements are sulphur, phosphorus, oxygen etc.
- Elements known at present are 118. Out of which 94 are natural. Elements which are liquid at room temperature are mercury (Hg) and bromine (Br).
- Elements which become liquid at a temperature slightly above the room temperature (303 K) are gallium (Ga) and caesium (Cs).

- Elements have the following order of abundance in earth crust : Oxygen > silicon > aluminium > iron > calcium.
- Elements have the following order of abundance in human body : Oxygen > carbon > hydrogen > nitrogen.

(ii) Compounds

- These contain more than one kind of atoms. These cannot be separated into constituent atoms by simple physical methods.
- Their examples are silica (SiO_2), water (H_2O), sugar ($C_{12}H_{22}O_{11}$), salt (NaCl), etc.

Mixtures

- These are obtained by mixing two or more substances in any proportion.
- Mixtures can be **homogeneous,** i.e. have uniform composition throughout (e.g., salt solution, sugar solution, air, true solutions, etc) or **heterogeneous,** i.e. have non-uniform composition (e.g. mixture of salt and sugar, colloidal solutions, etc).

Solutions

- *These are homogeneous mixtures of two or more substances.*
- *A solution also called true solution contain two components : solute (in less quantity) and solvent (in more quantity). Examples of solutions are sugar solution, tincture of iodine (solution of iodine in alcohol), aerated drinks like soda water, air, alloys, etc.*
- *Concentration of solution may be expressed by percentage, mole fraction, parts per million, gram per litre, molarity molality, normality, etc.*

Practice Exercise

1. Which statement is incorrect about matter?
(a) It exist in three states
(b) It has mass
(c) It occupies space
(d) All are true

2. Which of the following has strongest intermolecular attractions?
(a) Solid
(b) Liquid
(c) Gas
(d) Plasma

3. In which of the following states, does the sun exist?
(a) solid (b) gas
(c) plasma (d) BEC

4. Fluids are the substance that can flow over a surface. Identify the substance which is not a fluid.
(a) Milk
(b) Air
(c) Mercury
(d) Wood

5. That type of substance which has indefinite shape and volume is called ..... .It takes the volume and ..... of its container, i.e. it can be compressed to fill in a small container and it ..... to fill a large one.
Choose the correct order to fill up the blanks.
(a) liquid, size, fails (b) gas, expands, size
(c) gas, shape, expands (d) liquid, fail, shape

6. Which of the following states of matter require near absolute zero of temperature?
(a) Solid
(b) Gas
(c) Plasma
(d) Bose-Einstein condensate

7. Pick odd one out on the basis of states of matter.
(a) milk (b) mercury
(c) ice (d) oil

8. which of the following states has gas of extremely low density at a super low temperature?
(a) solid (b) plasma

(c) BEC (d) All of these

9. Choose the correct statement of the following
(a) conversion of solid into vapours without passing through the liquid state is called vapourisation.
(b) conversion of vapours into solid without passing through the liquid state is called sublimation.
(c) conversion of vapours into solid without passing through the liquid state is called condensation.
(d) conversion of solid into liquid is called sublimation.

10. During summer, water kept in an earthen pot becomes cool because of the phenomenon of ..... .Fill in the blanks.
(a) boiling (b) evaporation
(c) freezing (d) condensation

11. Particles of matter may consist of
I. atoms II. molecules
III. gas
(a) Only I
(b) Only II
(c) Both I and II
(d) I, II and III

12. Most abundant element in earth crust is
(a) carbon
(b) aluminium
(c) oxygen
(d) hydrogen

13. An element can be
(a) metal
(b) non-metal
(c) metalloid
(d) All of the above

14. Both elements and compounds are pure substances. They differ in having different
(a) state
(b) colour
(c) constituent particles
(c) All of the above

15. Identify the compound among the following
(a) iron (b) liquid mercury
(c) nitrogen gas (d) water

16. Which of the following is not a pure substance?
(a) Milk (b) Water (c) Iron (d) Silver

17. If powders of table salt (compound) and sugar (compound) are mixed well into each other then what type of substance is formed?
(a) Pure compound
(b) Homogeneous mixture
(c) Heterogeneous mixture
(d) Pure element

18. which of the following sets will not give a homogeneous mixture?
(a) gas-gas (b) liquid-liquid
(c) solid-solid (d) solid-liquid

19. True solutions are always
(a) compounds
(b) homogeneous mixtures
(c) heterogeneous mixtures
(d) None of the above

20. Which of the following does not express the concentration of a solution?
(a) Litre (b) Molarity
(c) Molality (d) Normality

Answers

1	*(a)*	2	*(a)*	3	*(c)*	4	*(d)*	5	*(c)*	6	*(d)*	7	*(c)*	8	*(c)*	9	*(c)*	10	*(b)*
11	*(c)*	12	*(c)*	13	*(d)*	14	*(c)*	15	*(d)*	16	*(a)*	17	*(c)*	18	*(c)*	19	*(b)*	20	*(a)*