12 PARTICLE NATURE OF MATTER

ATOMS AS MATTER

OBJECTIVES

At the end of this topic, students should be able to:

- formulate simple hypothesis and test them before they can draw conclusions based on specific information;
- explain how molecules of a substance move relative to other molecules of the same substance;
- describe the atomic structure of matter;
- state the constituents of the atom;
- state the size of the molecules of a substance in the form of a solid, liquid or gas.

Matter is the material substance that makes up the physical universe.

It is defined as anything that has mass and occupies space.

Matter consists of very tiny particles called atoms. Atoms are always in motion. Democritus suggested that if any piece of a substance were continuously divided, the result would be an atom, a tiny particle of the substance which cannot be divided again.

An atom is the smallest particle of an element that can take part in chemical reaction.

The idea of an atom was unpopular during the time of Democritus. Great philosophers of his days like Plato and Aristotle opposed the atomic idea of matter. The reasons for rejecting the existence of atoms are:

- there is no direct evidence to prove the existence of atoms;
- we cannot see the atoms.

John Dalton, the 19^{th} century chemist revitalized the atomic theory of matter. Now scientists can confidently describe the behaviour of matter in terms of atoms. It was only in 1827, that Robert Brown observed the first evidence for the existence of atoms.

Evidences of the existence of atoms

Many evidences exist which support the idea that matter consists of atoms. For better understanding, we divide these proofs into **direct evidences and indirect evidences**.

1. Indirect evidences for the existence of atoms

1. **A cube of sugar consists of tiny particles:** If enough pressure is exerted on a cube of sugar, it breaks up into smaller particles.
2. **We can crush a piece of chalk into tiny particles or powder**.
3. **Spreading oil drop on water forms a thin layer of oil film:** The spreading of oil dropped into an oil film suggests that oil drop consists of tiny particles. The spreading stops when one molecule thick of the oil rest on the water surface.
4. **Diffusion of gas and liquid molecules:** When a bottle of perfume is opened at one end of a room, the odour quickly fills the entire room. The perfume odour spreads because it consists of molecules which spread to other parts of the room by diffusion. In the same way, a drop of ink placed at one end of a liquid spreads quickly to other parts of the liquid by diffusion, until the whole liquid is uniformly coloured. *The rapid diffusion of the gas and liquid suggests that molecules are in constant motion*.
5. **Dissolving solids in liquids:** Sugar cube, when left undisturbed in water will dissolve and spread to other parts of water. The spreading of sugar molecules can be explained by assuming that the particles of sugar split from the cube and spread to other parts of the water.
6. **Evaporation of liquids:** A small quantity of water left exposed in a tray will disappear after some time. We say that the liquid has evaporated. Evaporation of a liquid is explained by assuming that it consists of tiny particles which escape from the surface of the liquid.
7. **Mixing two liquids to give a combined volume which is less than the original volumes, added together.**

When mixed, it does not result in two litres of the new mixture. This provides good evidence in support of particle nature of matter. If a litre of water is mixed with a litre of alcohol, the volume of the mixture is less than two litres.

This observation is explained by assuming that gap exists between molecules of a substance. When water is mixed with alcohol, water molecules fill the existing gap between alcohol molecules such that the combined volume is less than the original volumes added together.

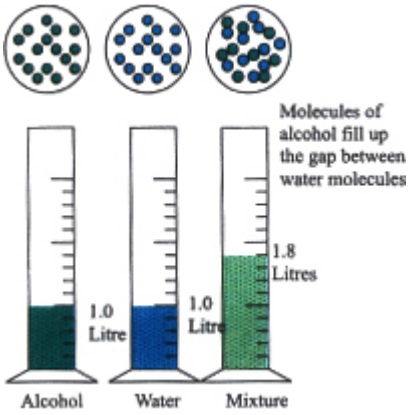


Figure 12.1 A litre of water and a litre of alcohol

2. Direct evidences for the existence of atoms

Molecules are so tiny that it is impossible to see them with an unaided eye. The invention of electron microscope, field-ion microscope and X-rays gives, strong direct evidence in support of atoms.

Figure 12.2 X-ray diffraction pattern of palladium metal

(a) ***X-ray diffraction:*** X-rays reveal the arrangement of atoms in crystals. A beam of X-rays passing through a crystal unto a photographic film reveals that ***atoms are arranged in regular pattern and gap exists between them.*** Figure 12.3b shows X-ray diffraction pattern from palladium crystal, the dots represent atoms.

(b) ***Micrograph from electron microscope and field-ion microscope reveal that matter consists of atoms.*** Looking at a crystal through an electron microscope, we can see atoms arranged in regular pattern. Figure 11.3a shows the atoms on the tip of a fine tungsten needle magnified a million times.

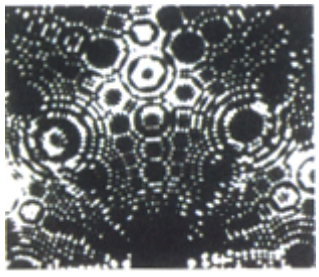


Figure 12.3 Electron microscope photograph of the tip of tungsten needle showing the arrangement of atoms.

The size of an atom

An atom is a very small particle. *The smallest known atom is the hydrogen atom*. Hydrogen atom is so small that if a million hydrogen atoms are placed side by side, they will stretch only 0.0001m. This is the reason an atom is invisible to the normal eye. The diameter of an atom is about 10^{-10}m.

The atomic structure

An atom consists of three basic particles the **proton,** the **neutron** and the **electron.** The proton is positively charged, the electron carries a negative charge while the neutron has no charge. The nucleus is at the centre of the atom and contains two particles, the proton and the

neutron. The nucleus therefore, is positively charged.

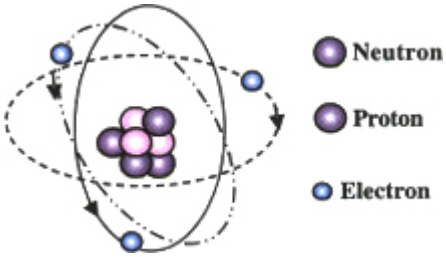


Figure 12.4 An atomic structure

The negatively charged electrons orbit the nucleus at a great speed. As they move round the nucleus, they trace a path called orbits or shells. Each shell can contain up to a certain number of electrons. The first or K-shell can hold a maximum of two electrons, the second or L-shell can hold up to eight electrons.

The atom is almost an empty space. The nucleus occupies a very small part of the atom; the diameter of the nucleus is about 10^{-15} m. ***The whole mass of an atom is concentrated at the nucleus.***

A normal atom is electrical neutral because the total number of protons balances the total number of electrons.

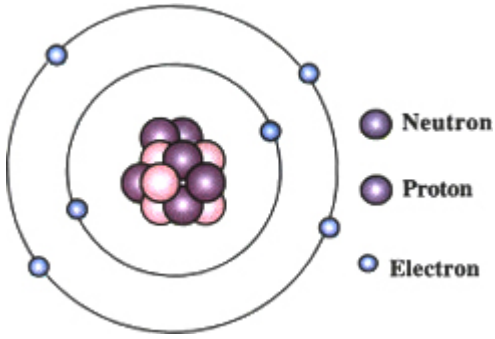


Figure 12.5 Structure of carbon-12 atom

Pure substances

Every substance consists of matter. Two types of pure substances are **element** and **compound**.

Element

An element is a substance which cannot be split into simpler substances.

An element therefore contains only one kind of atom. Examples of elements are copper, iron, aluminium, hydrogen, oxygen, etc. **An element cannot be split to get a new substance.** An atom can exist separately by itself in some elements; examples are copper, helium, iron, etc. **In some elements, atoms pair up to form group of atoms called molecules.** Examples of elements where atoms pair up to form molecules are oxygen, chlorine, hydrogen and other gases.

A molecule is the smallest particle of a substance, which can

stay separately by itself and still retain all the properties of the substance.

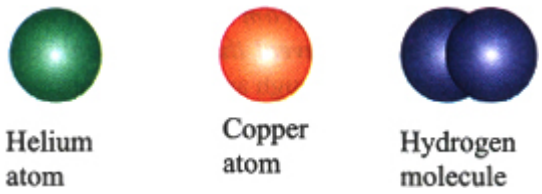


Figure 12.6a Elements

Some of these properties are density, colour, electrical conductivity, etc.

Compound

A compound is a pure substance which contains two or more elements combined chemically.

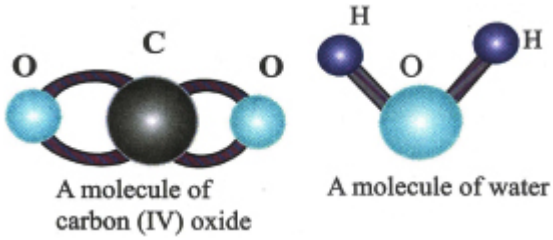


Figure 12.6b Compounds containing two or more kinds of atoms

A compound has two or more atoms of different elements held together by strong chemical bonds. We can split up a compound into two or more simpler substances.

The size of a molecule

A molecule consists of atoms. Atoms are very small particles; therefore, a molecule should also be small. How big is a molecule? We can obtain a rough estimate of the size of a molecule by performing an oil drop experiment outlined below.

a. Fill a clean basin with clean water. Lightly sprinkle the water with a small lycopodium powder.
b. Use a fine wire loop to form a fine drop of olive oil of diameter 0.5mm.
c. Dip the loop with the oil drop in water. The oil drop spreads to form an oil patch. The spreading of the oil stops when only one molecule thickness of the oil rests on the water surface.
d. Use your metre rule to estimate the largest diameter of the oil patch formed. We can estimate the diameter of the oil molecule by calculating the thickness of the oil patch. Suppose the diameter of the oil drop is **d** metres and the diameter of the oil patch formed is **D** metres. *The same volume of the oil drop spreads to form the oil patch;* therefore:

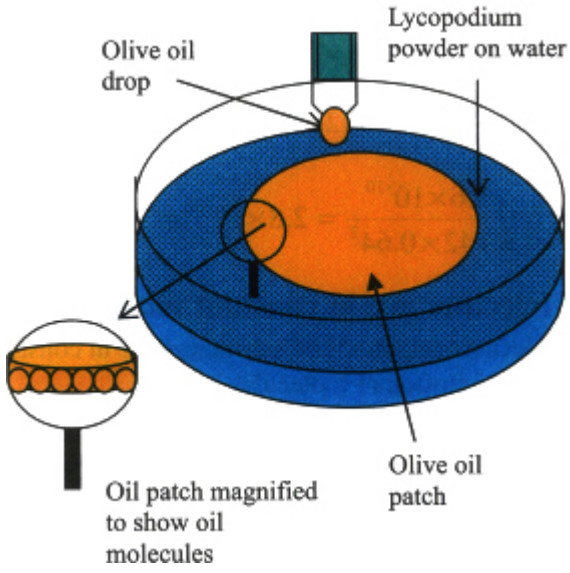


Figure 12.7 Estimation of the size of a molecule

	With Radius (r)	With Diameter (d)
Volume of oil drop	$= \frac{4}{3}\pi r^3$	$= \frac{4}{3}\pi\left(\frac{d}{2}\right)^3$
Volume of oil patch	$= \pi R^2 t$	$= \pi\left(\frac{D}{2}\right)^2 t$

$$\frac{4}{3}\pi\left(\frac{d}{2}\right)^3 = \pi\left(\frac{D}{2}\right)^2 t \text{ Or } \frac{4}{3}\pi r^3 = \pi R^2 t$$

$$\therefore t = \frac{2d^3}{3D^2} \quad or \quad t = \frac{4r^3}{3R^2}$$

The result from the experiment above shows that the size of oil molecule is about 2 Ã— 10^{-9}m. Olive oil has large molecules, the molecular size is even less than this value for some substances.

Worked example

A student placed a drop of olive oil of volume 3.6Ã—$10^{-10}$$m^3$ on the surface of still water and the drop spreads to form an oil film of radius 0.64m. Calculate the size of the oil molecule.

Solution

Volume of oil drop = Volume of oil film.

3.6Ã—$10^{-10}$$m^3$ = Ï€R^2h

3.6x$10^{-10}$$m^3$ = 3.142 Ã— $(0.64)^2$h

$$h = \frac{3.6\times10^{-10}}{3.142\times0.64^2} = 2.8\times10^{-10}m$$

Molecules are in constant motion

Molecules and atoms of substances are in constant motion. Discussed below are some proofs of constant motion of molecules.

a. Dissolving of solids in liquids

When a sugar cube dissolves in water, the molecules spread to other parts of water proving that the sugar molecules are moving.

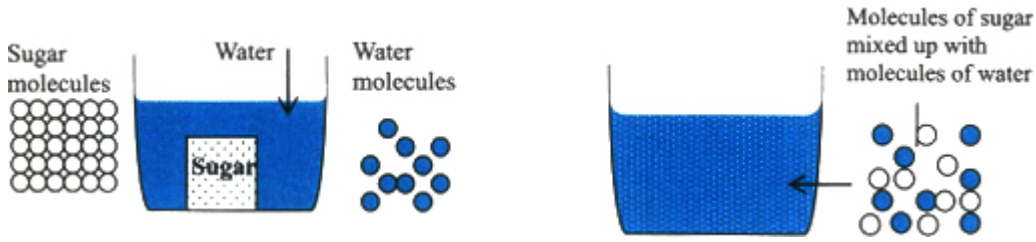


Figure 12.8 Spreading of sugar molecules is an evidence of constant motion of molecules

b. Diffusion of gas molecules

Diffusion is an evidence that the molecules of a gas are moving. Diffusion is the spreading of gas molecules to occupy any available space. Figure 13.9 shows a gas jar containing air placed over another gas jar of chlorine. After some time, both gases spread or diffuse through the jars. The spreading of the chlorine gas to the upper jar can be explained by assuming that chlorine gas consists of molecules, which are moving fast. The rate of diffusion depends on the **temperature** and **density** of the gas. The rate of diffusion is lower for gases with high density.

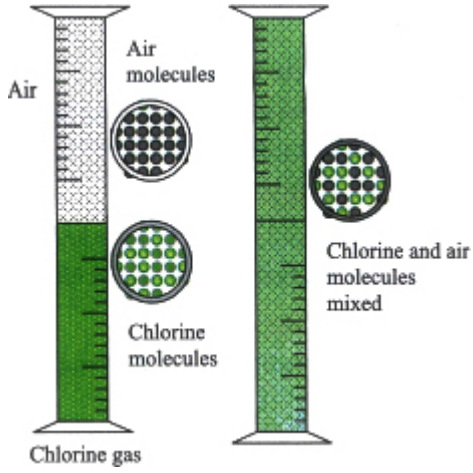


Figure 12.9 Diffusion of air and chlorine gas evidence of constant motion of molecules

c. The Brownian motion

One of the convincing evidences of molecular motion is the Brownian motion. In 1827, Robert Brown viewed the particles of pollen grains floating on water, he noticed that they were in constant rapid motion, and changed direction at random as if they have life. Experiments by

other scientists show that the particles move faster in warm liquid. For the same conditions, small particles move faster than large ones.

The continuous random motion of the pollen grains floating on water is due to water molecules hitting the pollen grains in all direction. Many molecules are hitting and pushing the grain from every direction. **The grain moves in the direction of the resultant push.** The direction of the resultant push on the grain changes at random making it to move erratically.

Brownian motion in a gas

Figure 13.11 is the apparatus for observing Brownian motion in the laboratory.

a. Trap some smoke particles from a smouldering paper in a smoke cell.

b. Use a glass rod to focus light on the smoke particles to illuminate it.

c. Observe the movement of the smoke particles with a microscope as in Figure 12:11.

The smoke particles are seen as specs of light constantly moving and changing direction as shown in Figure 12.10. *The random motion of the smoke particles is due to the push they receive from air molecules from all directions*.

Figure 12.10 Erratic motion of the molecules

Direct evidence of molecular motion

Direct photograph of big molecules are blurred. This is a clear evidence for motion of molecules because pictures taken of fast moving objects are blurred. See Figure 12.2.

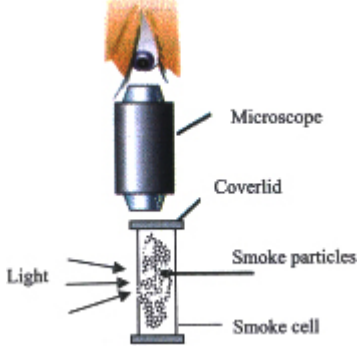


Figure 12.11 Viewing Brownian motion of smoke particles in air

Space between molecules

Space exists between atoms and molecules of substances. The

following evidences suggest that atoms and molecules are spaced out in a substance.

a. Contraction of substances

When you cool solids, liquids and gases, they contract. This is a good reason to believe that space exists between of molecules the same substance.

b. Compression of gases

Compression of gases into smaller volume means that there are spaces among the gas molecules.

c. Mixing two liquids to get a total volume which is less than the original volumes of the two liquids.

The molecules of one liquid fill up the gap between the molecules of the other liquid.

d. Photographs from X-ray diffraction and electron microscope

Direct photographs from X-ray diffraction and electron microscope reveal that atoms are far from each other. It also reveals that these atoms are regularly arranged to form crystals. See figures 13.2 and 13.3.

Summary

- Matter is any thing that has mass and occupies space.
- Matter consists of tiny particles called atoms. Atoms are always in motion.
- An atom is the smallest particle of an element that can take part in chemical reaction.
- X-ray diffraction shows that atoms are arranged in regular pattern and that empty space exists between the atoms.
- An atom is a very small particle. The diameter of an atom is approximately 10^{-10}m.
- An atom consists of three basic particles; the proton, the neutron and the electron.
- The atom is mostly an empty space. The nucleus occupies a very small part of the atom; the diameter of the nucleus is about 10^{-15}m.
- An element is a substance that cannot be split up into simpler substances. An element therefore contains only one kind of atom.
- In some element, atoms pair up to form group of atoms called molecules. A molecule is the smallest particle of a substance which can stay separately by itself and retain all the properties of the substance.

- A compound is a pure substance which contains two or more elements combined chemically. A compound has two or more atoms of different elements held together by strong chemical bonds.
- Molecules and atoms of substances are in constant motion.

Practice questions 12a

1. What is matter? Give **three** evidences that suggest the existence of atoms.
2. State three evidences for saying that the atoms of matter are in constant motion.
3. (a) Draw a labelled diagram of the apparatus used to view the incessant motion of smoke particles.
   (b) Describe the motion of the smoke particles as seen through the microscope.
   (c) Use a sketch to explain the reason for the random motion of the smoke particles.
4. (a) Describe an experiment to determine the size of a molecule of olive oil.
   (b) What assumptions were made in order to estimate the size of olive oil?
   (c) In an experiment to measure the size of a molecule 0.5 mm diameter of a liquid spreads on water to form a patch of diameter 95 cm. Calculate the size of the liquid molecule.
5. Describe one evidence each for solid, liquid and gas that suggest that a space exist between atoms of a substance.

KINETIC THEORY OF MATTER

OBJECTIVES

At the end of this topic, students should be able to:

- state the kinetic theory of matter;
- use molecular theory of matter to explain the three states of matter;
- describe the structure of simple crystals;
- give two examples of crystals;
- distinguish between crystalline substances and amorphous substances.

The kinetic theory is a scientific model, which helps us to understand the behaviour of matter using the properties of molecules. It is based on the following assumptions:

1. Matter consists of small particles called atoms (molecules).
2. Atoms and molecules are constantly in motion; hence, they have kinetic energy.

3. Atoms and molecules of a substance are separated from each other by distances greater than their diameters.
4. Atoms and molecules of a substance attract each other with a force which decreases fast as their distance apart increases.
5. When atoms or molecules of a substance collide with each other, they rebound without losing energy or momentum.
6. When a substance is heated, the velocity and kinetic energy of the atoms or molecules increases. The average kinetic energy of the molecules is proportional to the absolute temperature of the substance.

State of matter

The three states of matter are **solid, liquid** and **gas.** The differences between these states of matter can be explained using the kinetic theory of matter.

â€¢ Solid state

A solid consists of atoms, which are packed close to each other. These atoms attract each other strongly that they only vibrate about a fixed position as if they are held in that position by springs. The atoms of a solid are arranged in three-dimensional (3D) regular patterns, which are repeated in all directions. This 3D arrangement pattern leads to a three dimensional structure which gives the solid a definite shape and volume.

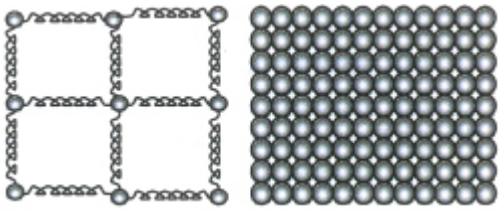


Figure 12.12 Three – dimensional regular pattern of solid, atoms, are tightly packed

â€¢ Liquid state

The molecules of a liquid are far from each other and the forces holding the liquid molecules together are weak compared to that of solid. The weak attractive forces between molecules means that they are free to move. A liquid therefore, flows easily since the molecules are not held in a fixed position. Liquids have definite volume but have no specific shape; it quickly takes the shape of the container.

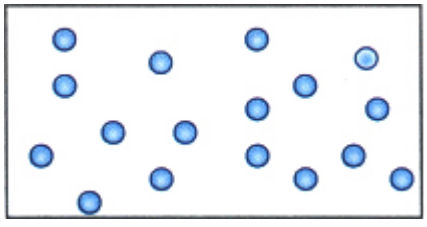


Figure 12.13 Liquid molecules are far from each other, therefore they can flow

â€¢ Gaseous state

The molecules of a gas are so far from each other that the greater part of a gas is an empty space. The force of attraction between gas molecules is very small that it can be neglected. The molecules move in a straight line at high speed, changing their direction when they collide with each other or the walls of the container. The collision of the gas molecules with the walls of the container is responsible for the pressure of the gas. A gas has neither definite volume nor shape; it assumes the volume and shape of the container.

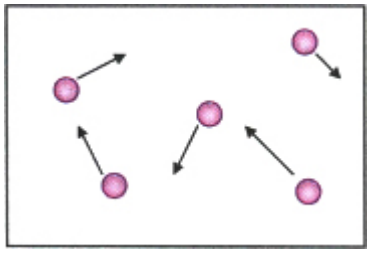


Figure 12.14 Gas molecules are far apart

Change of state

Matter can change from one state to another if given enough heat energy. When a solid is heated, the molecules gain energy to vibrate faster. If sufficient energy is given to the solid, the three dimensional structure of the solid collapses and the molecules become free to move around as a liquid.

Crystalline Materials

A crystal is a material whose atoms are packed closely together in a regular structure. Metals are crystals because their atoms are arranged in an orderly pattern, which repeats the same pattern throughout the solid. This gives the solid its three dimensional geometric shape. The structure of a crystal is formed by repeating a small pattern of the crystal called a **unit cell**.

A unit cell is the smallest part of the crystal which has all the properties of the solids.

The whole crystal is formed by repeating the unit cell in all the directions. The pattern of unit cells to produce the least space between atoms is known as **closely-packed arrangements.** Three such basic unit cells are:

â€¢ body centred cube (BCC) which occupies about 68% of the available space;

â€¢ face centred cube (FCC) which occupies about 74% of the available space;

â€¢ hexagonal closed-packed structure.

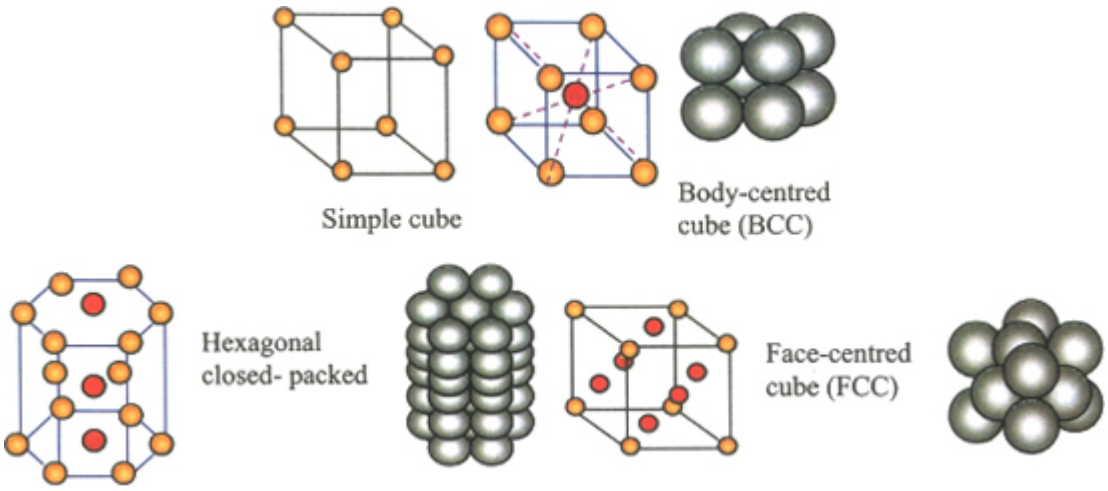


Figure 12.15 Basic unit cells of crystal

Space lattice

The geometrical arrangement of unit cells repeated many times in different directions is a space lattice. There are about fourteen of such arrangements; four of such arrangements are shown in Figure 12.15. The surfaces of crystals called faces are plane and reflect light. They meet each other at angles which determine the property of the crystal.

Growing crystals in the laboratory

Crystals can be grown in the laboratory by forming a saturated solution of copper (II) tetraoxosulphate (VI). Suspend a thread in the solution formed and leave the solution standing undisturbed for many days. Large piece of crystals are formed on the thread. When this is viewed with a hand lens or microscope, smooth regular surfaces of copper (II) tetraoxosulphate (VI) is observed. Figure 13.16 is a photograph of copper (II) tetraoxosulphate (VI) crystal. Other salt solutions that form crystals are solutions of sodium chloride, lead (II) iodide and potassium tetraoxosulphate (VI).

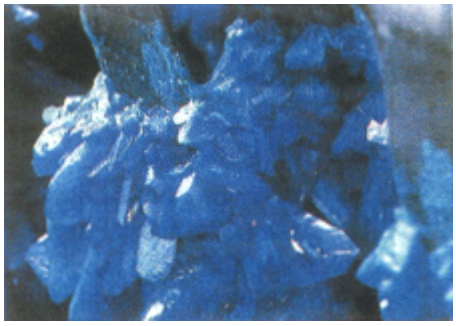
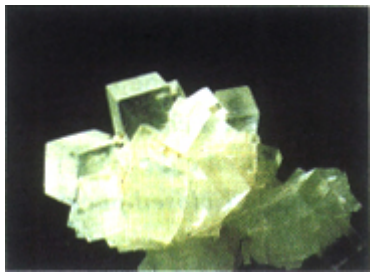


Figure 12.16 Beautiful crystals of copper (II) tetraoxosulphate (VI)

Amorphous solids

The atoms of amorphous solids are not arranged regularly as in crystals. When the amorphous materials are viewed with a powerful microscope, the pattern observed is similar to those of a liquid. Glass and soot are good examples of amorphous solid. X-ray diffraction of a liquid and glass look alike. Glass is a super cooled liquid, which forms a solid before it could shape into a crystal.



Differences between crystalline and amorphous substances

Crystalline	Amorphous
1. Atoms are arranged in regular pattern to form a solid with definite shape.	Atoms are not arranged regularly, therefore, they have no definite shape.
2. They melt and boil at definite temperature.	They do not melt or boil at a definite temperature.

Summary

- **Shape of matter:** A solid has definite shape; liquid has no definite shape. The shape of a liquid depends on the shape of a container and gas has no particular shape.
- **Movement of particles:** Particles of solid vibrate about their fixed positions; particles of liquid are free to flow but their motion is restricted by their closeness and the particles of a gas move fast in a straight lines.
- **Spacing of particles:** Particles of solid are very close to each other; particles of liquid are close and particles of gas are very far from each other.
- **Arrangement of particles:** Particles of solid are regularly arranged; particles of liquid are randomly arranged and the particles of gas are also randomly arranged.
- **Crystals:** Crystals are beautiful solids with regularly arranged atoms and smooth faces and edges.
- **A unit cell** is the smallest part of the crystal which has all the

properties of the solid.

- **Lattice** is the geometrical arrangement of unit cells repeated over and over.

Practice questions 12b

1. State **five** assumptions of atomic theory of matter.
2. What is matter? State the three states of matter.
3. (a) Describe the structure of a solid using the kinetic theory of matter;
   (b) What happens to a solid when it is heated continuously?
4. Compare the three states of matter under the following headings: motion of particles, spacing of particles and arrangement particles.
5. Give a reason why a gas can be compressed and a solid cannot be compressed.
6. Distinguish between crystalline solid and amorphous solid.
7. (i) What is a crystal?
   (ii) Define these terms as applied to crystals: unit cell, space lattice and closed – packed crystals.

Past questions

1. Which of the following statements about matter is **not** correct?
   A. Each molecule of a substance moves to and fro about a fixed position.
   B. Energy is required to break the forces of attraction between molecules.
   C. Molecules of liquids are more closely packed than those of gases.
   D. Molecules of solids move more freely than molecules of liquids.

   WASSCE
2. A tuber of cassava can be processed into powder. This explains the fact that
   A. matter can change spontaneously from one to another.
   B. matter cannot be destroyed.
   C. force is required to change matter from one state to another.
   D. matter consists of tiny particles.

   WASSCE
3. One common characteristics of solids, liquids and gases is that
   A. all the three have fixed volume.
   B. their molecules have the same size.
   C. their molecules are always in motion.
   D. all the three have the same inter molecular forces.

WASSCE

4. Atoms of solids having crystalline structures are arranged in regular patterns called
   A. energy levels.
   B. atomic structure.
   C. lattices.
   D. orbits.

WASSCE

5. An atom is electrically neutral because it contains equal number of
   A. protons and photons.
   B. neutrons and electrons.
   C. protons and electrons.
   D. electrons and photons.

WASSCE

6. The following are the states of matter:
   I Liquid II Solid III Gas.
   In which of these states do their atoms vibrate about fixed mean positions?
   A. I only
   B. II only
   C. III only
   D. I, II and III.

WASSCE

7. An evidence of particle nature of matter is the
   A. orbital motion.
   B. Brownian motion
   C. rotational motion.
   D. oscillatory motion.
   E. translational motion.

WAEC

8. The odour of a leaking gas is perceived at a distance from the source. This is made possible by the process of
   A. sublimation.
   B. diffusion.
   C. osmosis.
   D. evaporation.
   E. capillarity.

WAEC

9. Which of the following statements about kinetic theory of matter is **not** correct?
   A. The molecules of matter are always in constant motion.
   B. When a body is heated, the average kinetic energy of its

molecules decreases.

C. Molecules of a liquid move more freely than those of a solid.
D. Matter is made up of very tiny particles called molecules.
E. The molecules of gas move more freely than those of a liquid.

WAEC

10. When sugar at the bottom of a glass of water gradually dissolves, the water level does not change appreciably. Which of the following statements best explains this?
    A. Water is suitable solvent for sugar.
    B. The sugar and water have become single solution.
    C. The volume of sugar molecules does not change when the sugar dissolves.
    D. The sugar molecules are smaller than water molecules.
    E. Water molecules are separated by large spaces between them.

WAEC

11. Which statement is **NOT** correct about molecules?
    A. The number of molecules in a unit volume of a solid is greater than that in a unit volume of a liquid or gas.
    B. Molecules are made up of atoms.
    C. The force of attraction between two molecules of a solid is greater than that between two molecules of a liquid or gas.
    D. Molecules of gases are in regular motion.
    E. Molecules of a solid vibrate about their mean positions.

NECO

12. A few grains of table salt were put in a cup of cold water kept at constant temperature and left undisturbed. Eventually, all the water tasted salty. This action is due to
    A. convection
    B. osmosis
    C. capillarity
    D. diffusion
    E. conductivity.

JAMB

13. Which of the following are true in the structure of atoms?
    A. The atoms of different elements differ only in the number of protons and electrons.
    B. The number of protons equals the number of electrons.
    C. Atoms are constructed according to the plan of our solar system.
    D. All of the above.
    E. A and C only.

JAMB

14. Which of the following are true of atoms?

A. Atoms are indestructible.
B. All atoms of a pure substance or element are identical.
C. Atoms of different substances have different weights.
D. All of the above.
E. A and B only.

JAMB

15. Which of the following statements describes an atom accurately?
I Atoms of all elements are identical.
II An atom contains a nucleus and a number of electrons.
III Due to the electrons in the atom, an atom is negatively charged.
IV Electrons in the atom move in circular orbits round the nucleus.
A. I and II only
B. II and III only
C. III and IV only
D. II and IV only
E. I, II and III only.

JAMB

16. The rate of diffusion of gases increases with increase(s) in
I. Density II temperature III mass Which is/are correct?
A. I only.
B. II only.
C. I and II only.
D. II and III only.
E. I, II, III.

NECO

17. In which of the following are crystalline structures observable?
I Gas II Liquid III Solid
A. I only.
B. II only.
C. III only.
D. I and III only.
E. II and III only.

NECO

18. The molecular structure of a liquid is such that
A. the molecules have unlimited freedom of movement.
B. molecular movement is restricted to vibration only.
C. intermolecular collisions take place.
D. all molecules move with the same speed.

WASSCE

19. Which of the following concepts is not an evidence of the particle nature of matter?
A. Diffusion.

B. Brownian motion.
C. Diffraction.
D. Crystallization.

WASSCE

20. (a) Define matter.
(b) List any **four** properties of matter based on its interaction either with itself or energy.

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21. Explain diffusion.
(b) State **one** factor that can affect the rate of diffusion.

WASSCE

22. State any three properties of matter which are common to all substances.