PHYSICS

PARTICULATE NATURE OF MATTER

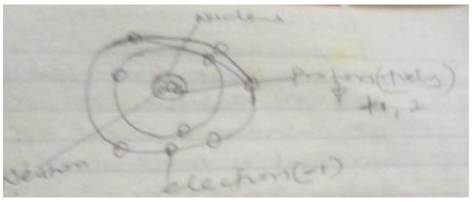
The matter is anything that has mass and occupies space. All matter is acted upon by a force called gravity. Matter exists in three different states; solid, liquid, and gas.

Atoms and molecules

The matter is made up of some particles called atoms or molecules.

A molecule is the smallest particle of a substance that can have a separate existence and still retain the properties of that substance.

An atom is the smallest indivisible particle of an element that takes part in a chemical reaction. The two parts of the atom are protons and neutrons which makes up the nucleus of an atom. The nucleus is located at the center of an atom. The nucleus is a heavy portion of the atom.



The protons have a positive charge; neutrons have no charge. The second part of the atom is the electron. They are very light and are negatively charged.

DETERMINATION OF MOLECULAR SIZE

Lord Raleigh in 1980 first estimated the approximate size of a molecule. He argued that when a drop of oil is placed on top of a water surface. The oil will spread out on top of the water until the thickness of the film of oil was one molecule thick. The thickness of the oil film will be calculated thus:

Let the diameter of oil film = d(cm)

Vol of oil drop = v $(cm)^3$

Area of oil film = $\pi(_2)^2$ Cm^2

:. The thickness of the film = ______

MOTION OF MOLECULES

Brownian motion

It was first observed by Robert Brown, a botanist in 1827. He observed a direct effect of the movement of molecules. Brownian motion can be observed in the laboratory by looking at some smoke. Brownian motion is the rapid, constant, and irregular motion of tiny particles. Importance of Brownian motion

- It gives evidence for the existence of the tiny particles of matter called molecules.
- It gives evidence that these molecules are in a constant state of random motion.

DIFFUSION

It is the tendency of molecules to migrate and fill an empty space due to their random thermal motions e.g: movement of blue copper sulfate in water, the spread of the rotten egg, smell of hydrogen sulfide gas when released in one end of the laboratory. Diffusion takes place in gases and liquids. Its rate depends on the density of the gas and its temperature. Light gases at high temperature faster than heavy gas at low temperature.

States of matter

Solids: The molecules are closely packed; they are held rigidly together by intermolecular forces of cohesion. Solids have definite shapes and volumes and it does not flow but can vibrate about their fixed position. When a solid is heated, the molecules acquire more energy and vibrate faster and farther away from their average position at a certain temperature known as the melting point. The molecules have acquired more kinetic energy and broken into molecular forces binding them together when these the molecular structure collapses and it liquid.

Liquids: The molecules are free to move about because the intermolecular force binding them are weaker than those in solids. The molecules of liquids are closely packed but can move about randomly. It has no definite shape but has a fixed volume. It assumes the shapes of its container. Liquids can flow, when a liquid is heated, molecules gain enough energy to overcome the intermolecular force and then escape from the liquid in the process of evaporation and turns to gas.

Gases: The cohesive forces binding the molecules are negligible. The molecules are very free to move about in all directions, restricted only by the walls of the container. Gases have no definite shape and occupy the whole volume of its container. Gases are easily more compressed than liquids and solids, this is because the molecules are relatively far apart.

CRYSTAL STRUCTURE OF MATTER

Solids are divided into two classes. They are:

Crystalline and

Non-crystalline or **amorphous solid**.

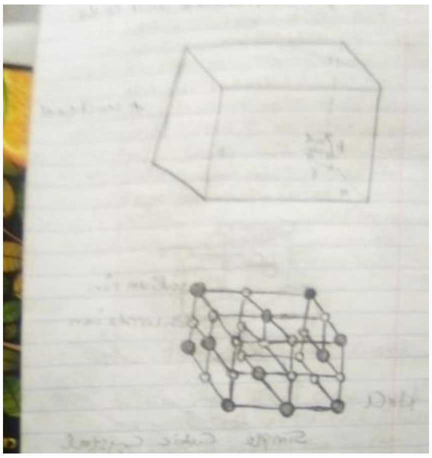
The difference between the two is the arrangement of the atoms or molecules in the solid.

Crystal

A Crystal is a piece of solid matter in which the atoms, molecules, or ions are arranged in a highly regular repeating pattern or lattice. Crystals are the small particles make up a crystalline substance. The particles in crystals are arranged in a regular three- dimensional framework or pattern called crystal lattice which repeats over and over again in all directions.

Structure of simple crystals.

Simple crystals composed of a huge number of simple basic units or building blocks called unit cells.

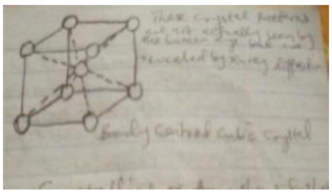


Here the atoms or molecules, are placed at the corners of imaginary cubes stacked side by side, up and down like building blocks. Such is the structure of NaCl. There are other types of crystals:

i. Face centered cubic   ii. Body centered cubic.

In the face centered cubic Crystal, the unit cell has the identical particles at each of the corners plus another in the center of each face. E.g of such Crystal are those of much common metalss like copper, Silver, Al, Pb, etc.

In the body centered cubic Crystal, the unit cell has identical particles at each corner plus one in the center of the cell. Each atom has eight immediate neighbors. E.g of such crystals are iron, chromium, salt etc.



Non- crystalline or amorphous substance

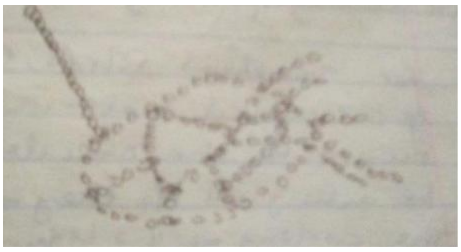
Non-crystalline substances lack the regular arrangement of atoms.

CHARACTERISTICS OF CRYSTALS.

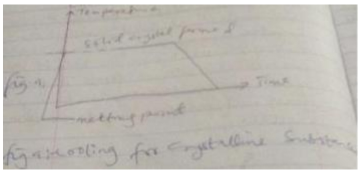
They are said to be amorphous or without form.

They are more like liquids than solids e.gs are glass and plastics.

They do not form crystals.



Substances that form amorphous solids usually consist of long chainlike molecules that are intertwined in the liquid state like long strands of earthworms. They behave oddly when they are cooled. Crystalline solids solidify at a constant temperature.



For amorphous solids, crystallization of the melted material never occurs because the molecules cannot be untangled before they're frozen. The cooling of the liquid continues until the substance no longer has the ability to move at which point we call it a solid. It is a liquid not a solid. Amorphous substances soften gradually when heated, unlike a crystalline substance like ice cube which will suddenly melt. It is why you can heat glass tubing in a flame to soften and bend it.

FLUIDS AT REST AND IN MOTION.

SURFACE TENSION.

The molecules of liquids and gases are free to move than those of solid, both liquids and gases are able to flow, for this reason, they are grouped together as fluids. They have no rigid shape and respond to forces much differently than solids.

Surface tension is the force acting along the surface of a liquid causing the liquid to behave like a stretched elastic skin.

APPLICATIONS AND EFFECTS OF SURFACE TENSION.

A razor blade with density y greater than that of water, if placed gently on the surface of the the water, will rest there as if it were being supported by this elastic skin.

It is due to surface tension that insects can walk on water.

The high surface tension of pure water prevents it from penetrating easily between the fabric of materials being washed.

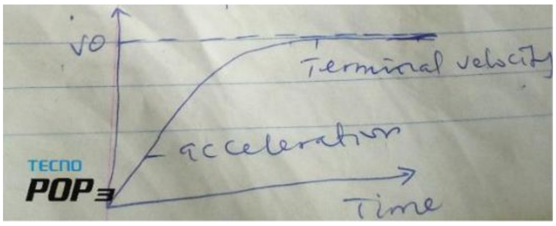
IV. Waterproof materials used for umbrellas, raincoats are treated with oil-based substances that repel water molecules.

NOTE: *The force of attraction between the molecules of the same substance is called cohesion while the force of attraction between molecules of different substances is called adhesion.*

VISCOSITY

Viscosity is the internal friction between layers of a liquid or gas in motion. Viscosity is considered as friction in fluids. The more the viscosity of the liquid, the more the opposition to the movement of the stone and hence the slower it's motion.

TERMINAL VELOCITY (or speed).



When a stone falls through a viscous liquid, it is subject to three forces: its weight (W) acting downwards, the up thrust(U) of the liquid on the stone acting upwards, and the viscous force(V) opposing its motion. The viscous force acts opposite to the motion of the stone ie upwards.

Terminal velocity is termed constant velocity.

$V=W-U$

Raindrops whose motion is opposed by the viscosity of air attains a terminal velocity before it reaches the ground. Likewise, any object released from an airplane attains a terminal velocity before hitting the ground.

SIMILARITIES BETWEEN VISCOSITY AND FRICTION.

- Both forces oppose relative motion between surfaces.
- Both depends on the nature of the materials in contact.

DIFFERENCES BETWEEN VISCOSITY AND FRICTION.

- Friction does not depend on areas of surfaces in contact, viscosity depends on areas of surfaces in contact.
- Friction is independent on normal reaction, viscosity is not.
- Friction occurs in solids, viscosity takes place in liquids and gases (fluids).
- Friction does not depend on the relative velocities between two layers, viscosity depends on the relative velocity between layers.

APPLICATIONS OF VISCOSITY.

- Oils, grease, and air as used as lubricants because of their viscosity. Engine oils are used in lubricating engines and other machines so as to keep metal surfaces from rubbing against each other.
- The viscosity of oil and greases decrease with temperature, hence their lubricating effects are lowered at high temperatures. Water is not used as a lubricant because it has a low viscosity.
- It is because of the viscosity of the air that the bob of a swinging pendulum comes to rest more quickly with a cord attached to the string than without a cord. The wider the area of the cord, the greater the viscous force opposing the pendulum's motion, and hence the quicker the pendulum comes to rest.

UNITS USED IN INDUSTRIES.

Units used in industries and business sometimes differ from those used in the laboratory, because in these areas quantities involved are large for example power measured in watts in the laboratory may be measured in horsepower in industry. In oil industries, the barrel is used as a unit of measurement. Hectare is a unit for measuring the area of land.

MEASUREMENT

Length is measured using:

I. Metre rule.
II. Large distances such as the length or width of a football field can be measured with steel tapes.
III. Calipers are used to measure length on solid objects that are in a cylindrical form.
IV. Ben calipers are used to measure small lengths, the thickness of a meter rule, the internal and external diameter of the tube, the diameter of a rod.

Micrometer screw gauge is used to measure smaller lengths like the diameter of a wire, the diameter of a small ball e.g (a pendulum bob), or the thickness of a piece of paper.

Measurement of volume:

Rectangular block: We can obtain the volume of a rectangular block by measuring its length (l), breadth (b), and height (h). The volume is given by V= l×b×h

Irregular solid: Volume of irregular solid is obtained by immersing it completely in a measuring cylinder containing a liquid in which the solid is insoluble.

A sphere: We measure the diameter with a micrometer screw gauge and obtain the volume by :

$V = 4/3\pi r^3$

Where r=d/2

Cylindrical wire: We measure the length of the wire using a meter rule and the diameter of the wire using a micrometer screw gauge. We measure the diameter at different points of the wire and calculate the mean diameter.

Volume= πr^2or (2)= 4 ^{2}

Liquids: The volume of a liquid can be measured with a measuring cylinder, a pipette, or a burette.

DIMENSIONS OF PHYSICAL QUANTITIES.

Dimension usually denotes the physical nature of a quantity. Any quantity which can be measured in units of length is said to have the dimensions of length (L). Any quantity which can be measured in units of time is said to have a dimension of time (T) and any quantity which can be measured in the unit of mass is said to have a dimension of mass (M). The symbols that are used to specify the length, mass, and time are [L], [M], [T], respectively. They are usually enclosed in brackets. The dimension of the volume is written as(V) are written as:

V= [Length]/[Time] =[L]/[T] or V =[L][T^{-1}]

Dimension for area, A= length × breadth =[L] × [L] =[L^2] For volume, V = [L] × [L] × [L] = [L^3]

Examples:

Deduce the dimensions of:

Force.

Pressure.

SOLUTION

a. Force = mass × acceleration

=mass ×acceleration/time

Since dimension of velocity = LT^{-1}

Dimensions of force = $M \times LT^{-1}/T$ =[M] [LT^{-2}]

b. Pressure =force/area = [MLT^{-2}]/[L^2]

[M] [$L^{-2}T^{-2}$]

APPLICATIONS OF DIMENSION.

In finding the true relationship between physical quantities, where the correct mathematical relation or formulas cannot be easily obtained.

Helps in determining the appropriate unit of a physical quantity.