



Federal University Oye-Ekiti, Ekiti State
Faculty of Science, Department of Physics
2018/2019 Academic Session
PHY 103: General Physics III

Lecture 1: Molecular Treatment of Properties of Matter

Lecturer: Ehiabhili John C.

CONTENT

Matter, states of matter, kinetic molecular theory of matter, change of state/phase, properties of matter

MATTER

Matter is anything made up of atoms, which has mass and occupies space. All matter takes up space. The amount of space taken up, or occupied, by an object is known as the object's *volume*. Everything in the universe that you can see is made up of some type of matter which includes: human being, chairs, water, paper, glowing gas etc.

Mass and Weight

The term *mass* and *weight* are often used as though they mean the same thing, but they don't. Mass (kg) is a measure of the amount of matter in an object. It is a quantity that measures the inertia of an object. In other words, it measures how an object resists change in motion. This is different from weight as weight (N or kgm/s^2) is a measure of the gravitational force exerted on an object. Mass is always constant for an object no matter where the object is located in the universe but weight varies depending on where the object is in relation to the Earth (or any large body in the universe).

STATES OF MATTER

The states of matter are the physical forms in which a substance can exist. It is important to note that matter can exist in three (3) different states, which are: **solid, liquid and gas**. Another state is **plasma** observed mostly in fluorescent lamps and the sun. **Why does matter exist in different states?** This is a question that can be answered if we look at the Kinetic Molecular Theory (KMT) of matter. This theory does not only explain why matter exists in different phases/states; it also describes how matter can change from one state/phase to the other, the microscopic properties of matter (which are atoms and their molecules) and how

constituents of matter interact. This interaction results to their properties that can be seen like temperature, pressure, volume, etc.

STATEMENT OF THE KINETIC MOLECULAR THEORY (KMT) OF MATTER

KMT of matter is a theory that treats samples of matter as a large number of small particles called atoms and molecules, which are in constant motion. The statement reads:

- Matter is made up of particles that are in a constant motion.
- All the particles have kinetic energy, which is dependent on temperature of the sample of matter they make up. This temperature determines if the matter is a liquid, solid or gas.
- Temperature of a substance is a measure of the **average** kinetic energy of that substance i.e. temperature of a matter can be determined by measuring the average kinetic energy of the constantly moving particles of that matter.
- Changing the average kinetic energy of the particles may result to change in state/phase.
- Spaces exist between particles of matter
- There are intermolecular forces of attraction between atoms/molecules of matter and these become stronger as the particles move closer together.

Having the KMT of matter in mind, let's now look at the three (3) different states of matter and how each state differ from the other as shown in table 1 below. Figure 1 shows the pictorial diagram of how the particles of matter are arranged in different states.

Table 1: Different states of matter, how and why each state differ from the other

| S/N | SOLID | LIQUID | GAS |
|-----|---|--|---|
| 1 | Object assumes a definite shape and volume e.g. ice, spoon, plate Reason: molecules are closely packed and locked into place by strong intermolecular bonds | Definite volume without a definite shape but assumes the shape of its container Reason: molecules of a liquid can slip past one another. Also, there exists weak intermolecular bond between the molecules | No definite shape and volume. They fill up the container. Reason: molecules move past one another. Intermolecular bond is very weak |

| | | | |
|---|--|---|---|
| 2 | They do not flow easily Reason: constituent particles cannot slide/move past one another | Flows smoothly Reason: particles can slide past one another | Flows easily Reason: particles can move past one another |
| 3 | Cannot be compressed easily Reason: the free space between particles is little | Not easily compressible Reason: Little space between particles, though more than solids | Compressible Reason: plenty of free space between particles |

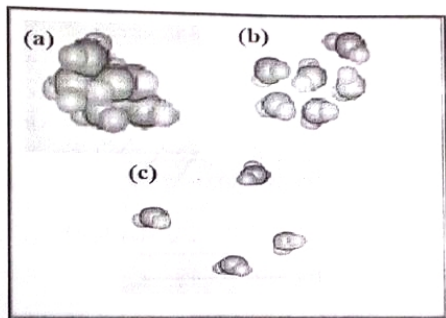


Figure 1: (a) molecules of a solid closely packed together, (b) Molecules of a liquid also packed close to each other but not as close as in solid, (c) as molecules are far apart with very weak intermolecular forces holding them.

CHANGE OF STATE/PHASE

A *change of state* is the change of a substance from one physical form to another. All changes of state are physical changes. Matter can change from one state to the other once its temperature is changed. This temperature change results to change in the average kinetic energy of its particles as stated earlier. A good illustration can be given with water (H_2O) as shown in figure 2. Water in its solid form (ice) has its molecules held together by strong intermolecular forces. When heat is applied to it (**melting**), the temperature of the water increases and the molecules gains more kinetic energy to overcome the forces holding them close together through **melting** thereby forming liquid. Here, the molecules are able to slide

past each other making the liquid to flow. Further heating results to a change of phase from liquid to gas called **evaporation** or **boiling**.

The gas can be changed back to liquid when allowed to cool (**condensation**). This cooling reduces the temperature and kinetic energy of the molecules. Further temperature reduction (**freezing**) gives rise to solid. Solid can change directly to gas through **sublimation** and gas can be changed directly to solid through **re-sublimation/deposition**.

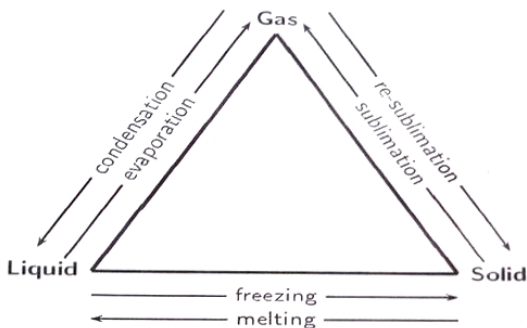


Figure 2: How change of state occur using water as an instance.

EVIDENCE OF PARTICLE NATURE OF MATTER

Brownian motion: This is evidence that matter is made up of atoms and particles that are in constant vibration. When a pollen grain is suspended in a liquid, it moves erratically from one place to the other. According to Albert Einstein, erratic movement of the pollen grain is caused by invisible molecules in the liquid that also moves erratically.

PROPERTIES OF MATTER

Generally, matter can be described by their physical and chemical properties.

Physical properties of matter can be measured or detected without altering the chemical composition of the matter. Example: water (H_2O), which is a matter can **freeze**. When it freezes, it remains H_2O . Other physical properties of matter includes: volume, colour, mass, density, elasticity, viscosity and ability to flow (for liquid and gas). Lecture 2 covers the elastic property of matter (elasticity).

Chemical properties describe matter based on its ability to change into new matter that has different properties. Example: when wood is burned, ash and smoke are created which have very different properties than those of the original piece of wood. Other chemical properties of matter include: reactivity, flammability etc.

Problems

1. Do objects with large masses always have large weights? Explain
2. The volume of a gas can change, but the volume of a solid cannot. Explain why this is true.
3. After taking a shower, you notice that small droplets of water cover the mirror. Explain how this happens. Be sure to describe where the water comes from and the changes it goes through.
4. Classify each of the following as a physical or chemical property:
 - i. Iron and oxygen form rust
 - ii. Iron is more dense than aluminium
 - iii. Magnesium burns brightly when ignited
 - iv. Oil and water do not mix
 - v. Mercury melts at -37°C