NTI Day 3 Lesson
Content Standard: Properties of Matter
States of Matter and Phase Changes
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States of Matter

Matter comes in different "**states**" or forms. It can be a **solid**, **liquid** or **gas**.

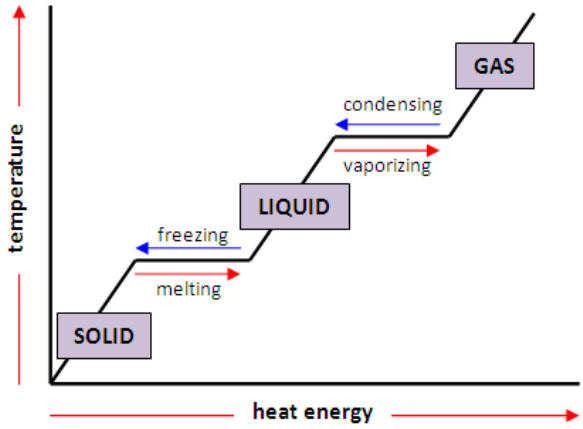
Matter can be found in three main states—solid, liquid, and gas—and can move among these states. For instance, solid water can be melted to form liquid water at 32 °F or 0 °C, and liquid water can be evaporated to form water vapor at 100 °C or 212 °F.

- A solid will hold its shape. A solid is measured in mass (weight). Units used to measure mass include pounds, ounces, grams, or kilograms.
- Liquid takes the shape of its container, but liquid does not expand to fill the entire container. Liquids are measured by volume. Some units used to measure volume are gallons, quarts, pints, cups, mililiters, and liters.
- Gas floats and does not have any particular shape of its own. But if it is placed in a container, it will fill the container and take on the container's shape. A gas is measured by volume. The most common unit for measuring gas is the liter.

When matter loses or gains heat, it can be transformed from one phase to another. This transformation is called a **phase change** or **change of state**. The different types of phase change are:

Melting	heat is gained and solids are transformed into liquids
Freezing	heat is lost and liquids are transformed into solids
Sublimation	heat is gained and solids are transformed into gases without first becoming liquids
Deposition	heat is lost and gases are transformed into solids without first becoming liquids
Vaporization	heat is gained and liquids are transformed into gases
Evaporation	vaporization that takes place at the surface of a liquid
Condensation	heat is lost and gases are transformed into liquids

When heat is added to a substance, the energy of the substance increases. When heat is removed from a substance, the energy of the substance decreases. The following diagram shows the relationship between heat and energy for each state of matter.



Phase Change

Matter can be found in three main states—solid, liquid, and gas—and can move among these states. For instance, solid water can be melted to form liquid water, and liquid water can be evaporated to form water vapor.

When matter is transformed from one phase to another, it is said to undergo a **phase change** or **change of state**.

The different types of phase change are:

Melting	transformation of a solid into a liquid
Freezing	transformation of a liquid into a solid
Sublimation	transformation of a solid into a gas without first becoming a liquid
Deposition	transformation of a gas into a solid without first becoming a liquid
Vaporization	transformation of a liquid into a gas
Evaporation	vaporization that takes place at the surface of a liquid
Condensation	transformation of a gas into a liquid

Phase Changes are Physical Changes

Phase changes are *physical* changes because only the physical properties of the matter change. The mass, chemical composition, and chemical properties of the matter do not change when the substance changes state.

A few of the physical properties which can change with a change of state are **density**, **viscosity**, and **appearance**.

The atoms or molecules in a gas have the same mass as when they are in solid or liquid form, but they are much further apart. This results in a lower density. In fact, the density of a gas is always lower than the same material in liquid or solid form.

Usually, liquids are less dense than the same substance as a solid. Water is a notable exception to this rule.

The ability of liquids to flow is described as their **viscosity**. Liquids experience a change in viscosity when they become a solid or a gas because the particles become either too close together or too far apart to have the ability to flow.

Phase Changes and Heat

Atoms or molecules in a solid are oriented close together in a regular arrangement. For the particles in a solid to overcome the attractive forces that are holding them in this arrangement, heat must be added to the solid.

Atoms or molecules in a liquid are able to move around one another, but are still close together. Heat must also be added to allow the molecules to break away from one another and become a gas.

Heat must be gained or lost for matter to change phases.

Atoms or molecules in liquids are typically farther apart and are arranged more randomly than those in solids. For the particles in a liquid to become more ordered, heat must be removed from the liquid.

Since particles in gas form are arranged in a way that is even less orderly than in liquids, heat must also be added when gas is formed, either through boiling or sublimation. To form liquids from gases (condensation) or solids from gases (deposition), heat energy must be removed from the gas.

States of Matter & Physical Changes

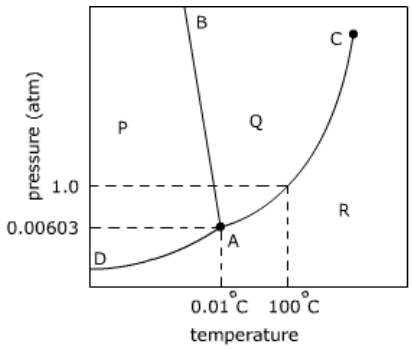
Definition of Phase

Phase is defined as a chemically and physically uniform quantity of matter that can be separated mechanically from a non-homogeneous mixture.

The three basic and most common phases are the **solid**, **liquid,** and **gas** phases.

Other phases include crystalline phase, colloidal phase, glass phase, amorphous phase and plasma.

Phase diagram
A phase diagram is a convenient way of representing the phases of a substance as a function of temperature and pressure. Given below is the phase diagram of water.

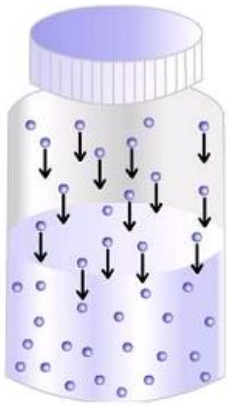


Region P shows the region where water remains solid (ice). In region Q, water exists in the liquid phase. Water exists in the gas phase in region R. The curves, DA, AC and AB represent the points at which two phases coexist. For example, all along the line DA, ice and gas will be in equilibrium. All along AC, liquid water and water vapor will remain in equilibrium. Similarly, at all points lying on AB, ice and liquid water will be in equilibrium.

Triple point
This is a point where the three phases of the substance coexist. In this phase diagram, ice, liquid water and vapor coexist at point A. This point is called the triple point. The triple point of water occurs at 0.00603 atm and 0.01°C.

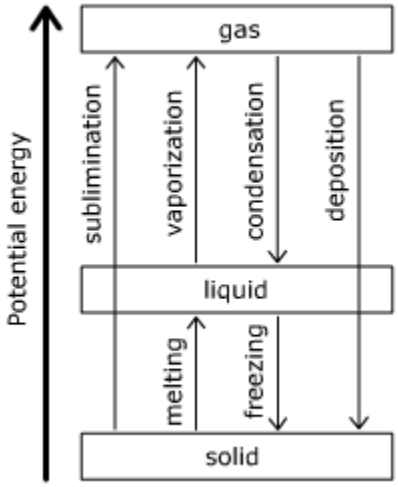
Boiling point
This is the temperature at which the vapor pressure of a liquid equals the atmospheric pressure. For water, this temperature corresponds to 100°C.

Vapor pressure
This is the pressure exerted by a vapor held in equilibrium with its solid or liquid state when placed in a closed container.



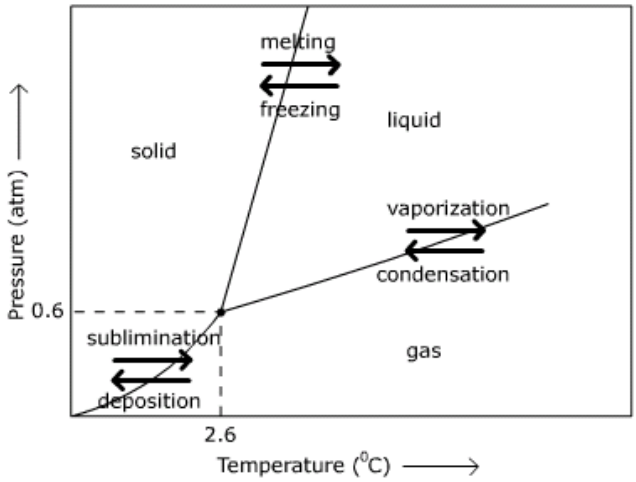
Critical temperature
This is the temperature above which any substance will and can exist only in gaseous state.

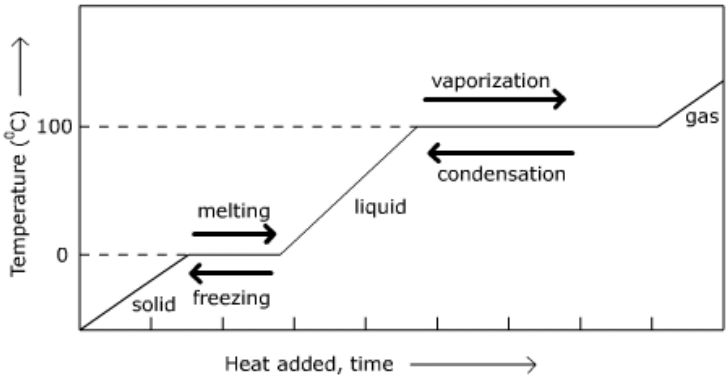
Sublimation
Some solids, such as iodine and dry ice, vaporize without passing through the liquid state at normal atmospheric pressure. The conversion of a solid directly into a gas is called sublimation. The reverse transformation is called **deposition**. Given below is a schematic representation of melting, freezing, sublimation, vaporization, condensation, and deposition.



Critical pressure
This is the minimum pressure required for the liquefaction of a gas.

Phase diagrams and Heating curves – a comparison





This heating curve helps one make correlations between phase diagrams and heating curves. The processes of vaporization, condensation, melting, and freezing are clearly mentioned. These processes take place along the flat portions (plateaus) of the graph indicating that the heat supplied is used to produce a phase change and not to raise the temperature of the sample. That is, during a phase change, though the amount of heat energy changes, the temperature does not change.

Raoult's Law
According to Raoult's Law, the extent to which a nonvolatile solute lowers the vapor pressure is proportional to its concentration. Therefore, the addition of solute particles will change the melting and boiling points of the solution, resulting in a change in their phase diagrams.