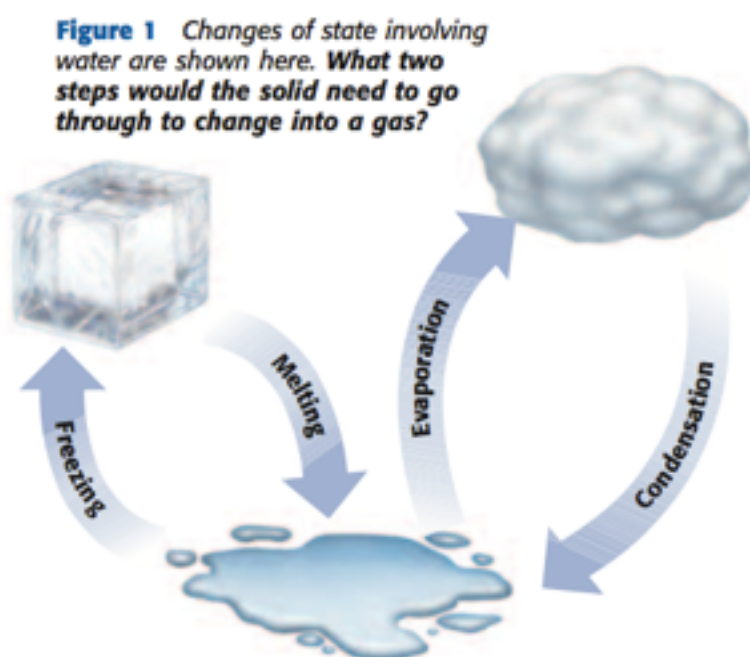


## Energy and Changes of State

A change of state is the change of a substance from one physical form to another. All changes of state are physical changes rather than chemical changes. In a physical change, the identity of a substance does not change.

The particles of a substance move differently depending on the state of the substance. The particles also have different amounts of energy when the substance is in different states. For example, particles in liquid water have more energy than particles in ice. To change a substance from one state to another, you must add or remove energy.



### Melting: Solid to Liquid

One change of state that happens when you add energy to a substance is melting. Melting is the change of state from a solid to a liquid. This change of state is what happens when ice melts.

#### Melting Point

As the temperature of a solid increases, the particles of the solid move faster. When a certain temperature is reached, the solid will melt. The temperature at which a substance changes from a solid to a liquid is the *melting point*, or melting temperature, of the substance. Melting point is a physical property that is characteristic of the material.

Melting points and other physical properties reflect the chemical composition of the material and can be used to classify substances.

## Adding Energy

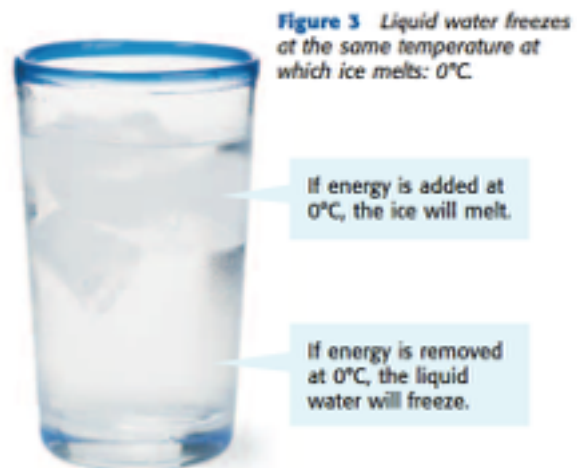
For a solid to melt, particles must absorb energy to overcome some of their attractions to each other. The particles acquire enough energy to slide past one another so that the material, which has melted and become a liquid, can flow.

## Freezing: Liquid to Solid

The change of state from a liquid to a solid is called *freezing*. For a liquid to freeze, the attractions between a liquid's particles must overcome the motion of the particles. Then, the particles will become closely locked in position.

## Removing Energy

The temperature at which a liquid changes into a solid is the liquid's *freezing point*. Freezing is the reverse process of melting. Thus, freezing and melting happen at the same temperature.



## Evaporation: Liquid to Gas

One way to make evaporation happen is to iron a shirt by using a steam iron. Steam comes up from the iron as the wrinkles disappear. This steam forms when the liquid water in the iron becomes hot and changes to gas.

## Evaporation and Boiling

Evaporation is the change of state from a liquid to a gas. Evaporation can happen at the surface of a liquid. For example, when you sweat, your body is cooled through evaporation. Your sweat is mostly water. Water absorbs energy from your skin as the water evaporates. You feel cooler because your body transfers energy to the water.

## Effects of Pressure on Boiling Point

Earlier, you learned that water boils at  $100^{\circ}\text{C}$ . In fact, this is true only at sea level. The reason is that atmospheric pressure varies depending on where you are in relation to sea level. Atmospheric pressure is caused by the weight of the gases that make up the atmosphere.

Atmospheric pressure is lower at higher elevations. The higher you go above sea level, the fewer air particles there are above you. So, the atmospheric pressure is lower. Think about boiling water at the top of a mountain. The boiling point would be lower than  $100^{\circ}\text{C}$ , because water boils more easily if the atmospheric pressure is lower.

## Condensation: Gas to Liquid

Condensation is the change of state from a gas to a liquid. Condensation and evaporation are the reverse of each other. The *condensation point* of a substance is the temperature at which the gas becomes a liquid. The condensation point is the same temperature as the boiling point at a given pressure.

For a gas to become a liquid, large numbers of particles must clump together. Particles clump together when the attraction between them overcomes their motion keeping them apart. For this to happen, energy must be removed from the gas to slow the movement of the particles.

## Sublimation: Solid to Gas

Sublimation is the change of state in which a solid changes directly to a gas.

For a solid to change directly to a gas, the particles of the substance must go from being very tightly packed to being spread far apart. So, the attractions between the particles must be completely overcome. The substance must gain energy for the particles to overcome their attractions.



# Temperature and Changes of State

When most substances lose or gain energy, one of two things happens to the substance: its temperature changes or its state changes. When temperature changes, the speed of the particles also changes. But when a substance is undergoing a change of state, its temperature does not change until the change of state is complete. For example, continued heating of a liquid at its boiling point will change the liquid entirely into vapor instead of raising its temperature. Only after all of the liquid is turned into gas will the temperature rise.

## Changing the State of Water

