Change of State

Picture an ice cream cone on a hot summer day. The ice cream quickly starts to drip onto your hand. You're not surprised. You know that ice cream melts if it's not kept cold. But why does the ice cream melt?

Particles of a substance at a warmer temperature have more thermal energy than particles of that same substance at a cooler temperature. You may recall that <u>thermal energy always flows as heat from a warmer substance to a cooler substance</u>. So, when you take ice cream outside on a hot summer day, it absorbs thermal energy from the air and your hand. The added energy changes the ice cream from a solid to a liquid.

<u>Changes Between Solid and Liquid</u>

How does the physical state of a substance relate to its thermal energy? Particles of a liquid have more thermal energy than particles of the same substance in solid form. As a gas, the particles of this same substance have even more thermal energy. A substance changes state when its thermal energy increases or decreases sufficiently. A change from solid to liquid involves an increase in thermal energy. As you can guess, a change from liquid to solid is just the opposite: It involves a decrease in thermal energy.

Melting

The change in state from a solid to a liquid is called **melting.** In most pure substances, melting occurs at a specific temperature, called the melting point. Because melting point is a characteristic property of a substance, chemists often compare melting points when trying to identify an unknown material. The melting point of pure water, for example, is 0°C.
What happens to the particles of a substance as it melts? Think of an ice cube taken from the freezer. The energy to melt the ice comes mostly from the air in the room. At first, the added thermal energy makes the water molecules vibrate faster, raising their temperature. **At its melting point, the particles of a solid substance are vibrating so fast that they break free from their fixed positions.**

Freezing

The change of state from liquid to solid is called **freezing.** It is just the reverse of melting. **At its freezing temperature, the particles of a liquid are moving so slowly that they begin to form regular patterns.**

When you put liquid water into a freezer, for example, the water loses energy to the cold air in the freezer. The water molecules move more and more slowly as they lose energy. Over time, the water becomes solid ice. When water begins to freeze, its temperature remains at 0°C until freezing is complete. The freezing point of water, 0°C, is the same as its melting point.

Changes Between Liquid and Gas

Have you ever wondered how clouds form, or why rain falls from clouds? And why do puddles dry up after a rain shower? To answer these questions, you need to look at what happens when changes occur between the liquid and gas states.

The change from a liquid to a gas is called vaporization (vay puhr ih ZAY shun). **Vaporization takes place when the particles in a liquid gain enough energy to form a gas.** There are two main types of vaporization—evaporation and boiling.

Evaporation

Vaporization that takes place only on the surface of a liquid is called **evaporation** (ee vap uh RAY shun). A shrinking puddle is an example. Water in the puddle gains energy from the ground, the air, or the sun. The added energy enables some of the water molecules on the surface of the puddle to escape into the air, or evaporate.

Boiling

Another kind of vaporization is called boiling. **Boiling** occurs when a liquid changes to a gas below its surface as well as at the surface. You see the results of this process when the boiling liquid bubbles. The temperature at which a liquid boils is called its boiling point**.** As with melting points, chemists use boiling points to help identify an unknown substance.

Condensation

The opposite of vaporization is called **condensation.** One way you can observe condensation is by breathing onto a mirror. When warm water vapor in your breath reaches the cooler surface of the mirror, the water vapor condenses into liquid droplets. **Condensation occurs when particles in a gas lose enough thermal energy to form a liquid.** For example, clouds typically form when water vapor in the atmosphere condenses into liquid droplets. When the droplets get heavy enough, they fall to the ground as rain.

Changes Between Solid and Gas

Sublimation

If you live where the winters are cold, you may have noticed that snow seems to disappear on a sunny day even when the temperature stays well below freezing. This change is the result of sublimation. **Sublimation** occurs when the surface particles of a solid gain enough energy that they form a gas. **During sublimation, particles of a solid do not pass through the liquid state as they form a gas.**

One example of sublimation occurs with dry ice. Dry ice is the common name for solid carbon dioxide. At ordinary atmospheric pressures, carbon dioxide cannot exist as a liquid. So instead of melting, solid carbon dioxide changes directly into a gas. This property helps keep materials near dry ice cold and dry. For this reason, using dry ice is a way to keep temperature low when a refrigerator is not available. When dry ice becomes a gas, it cools water vapor in the nearby air. The water vapor then condenses into a liquid, forming fog around the dry ice.

Deposition

The opposite of sublimation is deposition (de poh **zi** shun). When particles of a gas lose enough energy to go into the solid state, they are **deposited** and become a solid. **They do not go through the liquid phase.** This process takes place when computer chips are created and when ice crystals grow on cold surfaces without ever forming liquid water first. If you have ever seen ice form on a window during the night, deposition is often the reason.

Look at the following diagram to see how all these processes link together to describe changes in state.