

What's going on here?

Substances can exist in three different states—*solid*, *liquid*, or *gas*. Regardless of whether the substance is a solid, liquid, or gas, the atoms, ions, or molecules that make up the substance are attracted to each other. The attractions between these particles is what holds the substance together.

Turn up the heat

In a solid, the atoms, ions, or molecules of the substance are held very close together. They vibrate but do not move past each other. This is what gives solids their definite size and shape.

When heat energy is added to a solid, the motion of the particles increases. The particles are still attracted to each other but their extra movement starts to compete with their attraction. If enough heat is added, the motion of the particles begins to overcome the attraction and the particles move more freely. They begin to slide past each other as the substance begins to change its state from a solid to a liquid. This process is called *melting*. The particles in a liquid are only slightly further apart than in a solid. Their attractions hold them together enough so they don't just fly apart and become a gas.

When heat energy is added to a liquid, the motion of the particles increases again. If enough heat is added, the motion of the particles can completely overcome the attractions between them. When this happens, the particles of the liquid go into the air as a gas. This process is called *evaporation*. As a gas, particles are completely free to move, and their attractions have almost no effect on them.

Cool it

These processes work in reverse also. But instead of adding heat, the substance is cooled by removing heat. When a gas is cooled, the motion of the particles slows down. If the particles slow down enough, their attraction for each other causes them to come together and change from a gas to a liquid. This process is called *condensation*.

If the liquid is cooled even more, the particles slow down even more. The attractions between the particles cause them to arrange themselves in more fixed and orderly positions to become a solid. This process is called *freezing*.

It is the combination of the attraction the particles of a substance have for each other and how much energy they have that determines whether a substance is a solid, liquid, or gas.

What's going on here? *(continued)*

1. If heat energy is added to a solid like ice, it will begin to melt. What happens to the water molecules in an ice cube as it melts to become liquid water?

2. If heat energy is added to a liquid like water, it will begin to evaporate. What happens to the water molecules in a drop of liquid water as it evaporates to become the gas water vapor?

3. If a gas like water vapor is cooled enough, it will begin to condense. What happens to the water molecules in water vapor as they condense to become tiny drops of liquid water?

4. If liquid water is cooled enough, it will begin to freeze. What happens to the water molecules in water as they freeze to become ice?

Cool factoid

When we think of changes of state, we usually think of a substance changing between solid, liquid, and gas. But the common gas, carbon dioxide, is different. When carbon dioxide gas is cooled enough, it doesn't change into a liquid like most gases, it just changes directly to a solid. But this doesn't happen until the temperature reaches $-78\text{ }^{\circ}\text{C}$ or $-108\text{ }^{\circ}\text{F}$. That's pretty cold! It works the other way too. When solid carbon dioxide (dry ice) is warmed, it skips the liquid state and changes right to a gas! But don't be fooled. When dry ice makes all that cool special-effects "smoke", that's not carbon dioxide you are seeing. The dry ice cools the air enough so that the smoke you see is really condensed water vapor. The carbon dioxide gas is invisible.