Atoms and molecules are in motion

We warm things up and cool things down all the time, but we usually don’t think much about what’s really happening. If you put a room-temperature metal spoon into a hot liquid like soup or hot chocolate, the metal gets hotter. But what actually has to happen for the hot liquid to make the metal hotter?

By now you know that substances are made of atoms and molecules. These atoms and molecules are always in motion. You also know that when atoms and molecules are heated, they move faster and when they are cooled, they move slower. But how do the atoms and molecules actually get heated and cooled? In our example of heating a metal spoon in a hot liquid, what is the process that transfers energy from the water to the spoon?

Moving atoms and molecules have energy

Energy can be transferred to make things warmer

In our example of a spoon in hot liquid, the molecules of hot liquid are moving quickly so they have a lot of kinetic energy. When the room-temperature spoon is placed in the liquid, the fast-moving molecules in the liquid contact the slower-moving atoms in the spoon. The fast-moving molecules hit the slower-moving atoms and speed them up. In this way, the fast-moving molecules transfer some of their kinetic energy to the slower atoms so that these slower atoms now have more kinetic energy. This process of transferring energy by direct contact is called conduction.

Changing from a liquid to a gas—Evaporation

You see evidence of evaporation all the time. Evaporation causes wet clothes to dry and the water in puddles to “disappear”. But the water doesn’t actually disappear. It changes state from a liquid to a gas.

The molecules in a liquid evaporate when they have enough energy to overcome the attractions of the molecules around them. The molecules of a liquid are moving and bumping into each other all the time, transferring energy between one another. Some molecules will have more energy than others. If their motion is energetic enough, these molecules can completely overcome the attractions of the molecules around them. When this happens, the molecules go into the air as a gas. This process is called evaporation.
Heating increases the rate of evaporation

You’ve probably noticed that higher temperatures seem to make evaporation happen faster. Wet clothes and puddles seem to dry more quickly when they are heated by the sun or in some other way.

You can test whether heat affects the rate of evaporation by placing a drop of water on two paper towels. If one paper is heated and the other remains at room temperature, the water that is heated will evaporate faster.

![Room Temperature vs. Hot](image)

When a liquid is heated, the motion of its molecules increases. The number of molecules that are moving fast enough to overcome the attractions of other molecules increases. Therefore, when water is heated, more molecules are able to break away from the liquid and the rate of evaporation increases.

Different liquids have different rates of evaporation

It makes sense that different liquids have different rates of evaporation. Different liquids are made of different molecules. These molecules have their own characteristic strength of attraction to one another. These molecules require a different amount of energy to increase their motion enough to overcome the attractions to change from a liquid to a gas.

Liquids will evaporate over a wide range of temperatures

Even at room temperature, or lower, liquids will evaporate. You can test this by wetting a paper towel and hanging it up indoors at room temperature. Evaporation at room temperature might seem strange since the molecules of a liquid need to have a certain amount of energy to evaporate. Where do they get the energy if the liquid is not warmed? But remember that the temperature of a substance is the average kinetic energy of its atoms or molecules. Even cold water, for instance, has a small percentage of molecules with much more kinetic energy than the others. With all the random bumping of a billion trillion molecules, there are always a few molecules which gain enough energy to evaporate. The rate of evaporation will be slow but it will happen.
Changing from a gas to a liquid—Condensation

If you have seen water form on the outside of a cold cup, you have seen an example of condensation. Water molecules from the air contact the cold cup and transfer some of their energy to the cup. These molecules slow down enough that their attractions can overcome their motion and hold them together as a liquid. This process is called condensation.

Cooling increases the rate of condensation

You can test to see if cooling water vapor increases the rate of condensation by making two similar samples of water vapor and cooling one more than the other. In the illustration, two samples of water vapor are trapped inside the cups. Ice is placed on one top cup but not the other.

In a few minutes, there are water drops on the inside top of both cups but more water can be seen on the inside of the top cup with the ice. This shows that cooling water vapor increases the rate of condensation. When a gas is cooled, the motion of its molecules decreases. The number of molecules moving slow enough for their attractions to hold them together increases. More molecules join together to form a liquid and the rate of condensation increases.

Prediction: