# Teacher Background

## Chapter 2, Lesson 3

Exploring evaporation and condensation gives middle school students an opportunity to understand some everyday phenomena on the molecular level.
Some aspects of evaporation and condensation discussed below are probably beyond the scope of what you would present to middle school students.

We include this background here for you as these ideas may come up in other sources you encounter.

***Big idea 1:***
If two atoms or molecules are attracted to each and are "bonded," it takes energy to pull them apart. If two atoms or molecules are attracted to each other and are not yet bonded, energy is released when they come together and bond. In chemistry, this concept is often stated as:

**It takes energy to break bonds.**
**Energy is released when bonds are formed.**

**Note:** In the context of evaporation and condensation of water, the use of the term "bond" refers to the interaction and close association *between* water molecules. It does not refer to the covalent bond which holds the oxygen atom and the hydrogen atoms together *within* the water molecule. The bond breaking and bond making involved in evaporation and condensation deals with the attractions and interactions *between* water molecules.

***Big idea 2:***
Another big idea is that the energy atoms and molecules have based on their motion is called **kinetic energy**. The energy they have based on their attraction to each other is called **potential energy**.

***Big idea 3:***
This is like a combination of Big ideas 1 and 2. When we say that it takes energy to break bonds and energy is released when bonds are formed, it really means energy is *converted* between kinetic and potential energy. For example, it takes a certain amount of kinetic energy to separate two water molecules. When they are separated, the kinetic energy used to separate them is converted to the potential energy of attraction between them. If they come together again, this potential energy is converted back to kinetic energy. Energy is not created or destroyed; it is converted from one form to another.

 

**Evaporation has a cooling effect**
**Condensation has a warming effect**

These ideas can help explain why evaporation has a cooling effect and condensation has a warming effect.

Think about a single water molecule in a sample of water. Assume that the molecule has average kinetic energy. This molecule gets hit by some fast-moving water molecules that transfer some of their kinetic energy to our average water molecule. The water molecule now has above-average kinetic energy. This extra kinetic energy is "used" to break its "bonds" to other water molecules causing it to evaporate. This extra kinetic energy is converted to potential energy of attraction between the water molecule as a gas and the other water molecules in the liquid. The extra kinetic energy is not in the water anymore so the temperature of the water decreases.

Now imagine that same water molecule as a molecule of water vapor with average kinetic energy. As this molecule is attracted to other water molecules its potential energy decreases while its kinetic energy increases. The water molecule now has above-average kinetic energy. It hits other water molecules and transfers this extra kinetic energy to them which enables it to bond to other water molecules. The extra kinetic energy is now in the water so the temperature of the water increases.

 

## Teacher Background

## Chapter 2, Lesson 3

***Dynamic equilibrium***

It is common to see a puddle of water or wet clothes dry up from evaporation. It is also common to see water vapor condense on a cold surface to form liquid water. In both these cases, there is a net change in one direction—either from a liquid to a gas (evaporation) or from a gas to a liquid (condensation).

But under certain conditions, evaporation and condensation balance each other so there is no *net* change in either direction. The classic example is water placed in a closed container at room temperature. Even at room temperature, some fraction of the water molecules at the surface will gain enough energy from other molecules to evaporate and will enter the air inside the container. And some fraction of these water vapor molecules will lose enough energy to molecules at the surface to condense and become part of the liquid water.

At first, there are not many molecules of water vapor so the rate of condensation is slower than the rate of evaporation. But as more molecules evaporate, the concentration of molecules in the vapor increases and more molecules are available to condense to liquid water. Eventually, the air inside the container has enough water vapor molecules that the number losing energy and condensing equals the number gaining energy and evaporating. At this point, the air in the container is saturated and has a 100% relative humidity and evaporation and condensation are in equilibrium. Even though there is no *net* change, evaporation and condensation are still occurring. For this reason, the equilibrium is referred to as a *dynamic* equilibrium.

***Dynamic equilibrium at different temperatures***

Evaporation and condensation achieve a dynamic equilibrium at any temperature. For example, if the room temperature container in the above example is cooled, the rate of evaporation decreases. This means that initially, the rate of condensation will be greater than the rate of evaporation. But as more water vapor molecules condense, there are fewer water vapor molecules in the air and the rate of condensation slows down. Eventually, the rate of condensation and evaporation become equal at the lower temperature with fewer water molecules evaporating and condensing than at room temperature.

 

If the temperature of the container is now increased above room temperature, the rate of evaporation would again be greater than the rate of condensation. But as more water vapor molecules entered the air in the container, the rate of condensation would increase. Eventually, the rate of evaporation and condensation would become equal at the higher temperature with more water molecules evaporating and condensing than at room temperature.

 