

Additional Teacher Background

Chapter 2, Lesson 3, p. 101

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 the rate of condensation is 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 was 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.