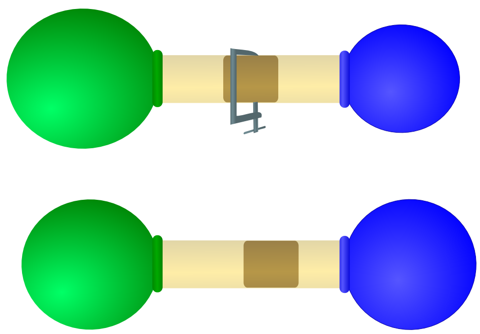
# The Zeroth Law of Thermodynamics

**Skills to Develop**

- Define the Zeroth Law of Thermodynamics

## Equilibria Again

We discussed equilibrium reactions before, especially in the stoichiometry section. We mentioned chemical equilibria, between reactants and products. We also mentioned solubility equilibria in the precipitation section. Now let's introduce some other types of equilibrium. Suppose we put a partially-filled balloon on each end of a tube with a piston. Initially the piston is clamped in place. If we remove the clamp so the piston can move, it will move until the pressure on each side is equal. At this point, the balloons will probably also be the same size (unless they are different size balloons), because pressure determines the size of the balloons. The changes the volume on each side until the pressures are equal, and then the system reaches mechanical equilibrium, because the piston won't move any more. Pressure is the property that tells us whether systems will be at mechanical equilibrium; if we clamp the piston and put on a new balloon, if it's at the same pressure as the other balloons then the piston won't move when the clamp is removed.



A balloon and piston system.

*Top: initial position. Bottom: after reaching mechanical equilibrium.*

Now we can introduce **energy** can flow in and out; maybe they have metal walls, or some other wall that conducts heat). We set them in contact, so they are touching each other. Maybe we can observe some sort of change in the systems, like that the pressure inside one increases and the other decreases. This might mean that one was hotter and the other colder, so the pressure inside changed as they approached the same temperature once they were touching. If no change happens when they touch, we could say that they were in thermal equilibrium. (If we leave them in contact long enough, they will reach thermal equilibrium, but that is different from being in thermal equilibrium when they first touch.) If we have a system A, and we find that it is in thermal equilibrium with another system B, and also with another system C, then we know without doing the experiment that B and C are also in thermal equilibrium with each other. That statement is the **Zeroth Law of Thermodynamics**. The property that tells us if 2 systems are already at thermal equilibrium is the **temperature**. This is a familiar word, but technically this concept of thermal equilibrium is how it is defined: the Zeroth Law introduces the concept and property of temperature.

We measure temperature using a **thermometer**. In science we use 2 scales to measure temperature, the Celsius or centigrade scale, on which water freezes at 0 °C and boils at 100 °C; and the Kelvin scale, on which water freezes at 273.15 K and boils at 373.15 K. The Celsius scale is probably what you are used to from regular life (although I am used to the Fahrenheit scale), and it is convenient because it focuses on water, which is very important for our lives. The Kelvin scale is good for science and thermodynamics especially, because 0 K is the lowest possible temperature.

## Contributors and Attributions

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