

# Temperature, Thermal Energy, and Heat

For starters, temperature and heat are not the same thing. Temperature is a measure of the average kinetic energy of the particles in a sample of matter. By using the word average, we mean that some of the particles are moving faster than the average speed and some are moving slower than the average speed. As the speed of the particles increase so too does the temperature increase and vice versa.

So if we have two containers of water of equal mass, but the first container has a temperature of 30 degrees Celsius while the second container has a temperature of 50 degrees Celsius, the speed of the particles in the second container is higher than in the first container, and therefore have a greater average kinetic energy.

Thermal energy is the total energy of the particles in a sample of matter, including both their kinetic and potential energy. The kinetic energy is based on the motion of the particles while the potential energy is based on the forces that act within or between the particles. Thermal energy is also based on the mass of the sample. The more mass a sample has means it will have more thermal energy.

Suppose you have a glass of water at a temperature of 50 degrees Celsius. The temperature of the water in your swimming pool is also 50 degrees Celsius. Since there is a larger mass of water in the swimming pool we say the swimming pool has more thermal energy. Since energy is defined as the ability or capacity to do work or cause change, the water in the swimming pool can do more work than the water in the glass. For example, if we're trying to melt ice, the water in the swimming pool, with its larger mass and greater

thermal energy could melt a larger amount of ice than could a glass of water. Just like the units for work, the units for thermal energy are measured in joules.

Thermal energy also depends on what type of a substance your sample is made out of. If I had a twenty gram sample of copper at room temperature and a twenty gram sample of water at room temperature they would have different amounts of thermal energy since they are two different substances.

When we are talking about heat, we're referring to thermal energy that flows from something with a higher temperature to something with a lower temperature. So if you are holding an ice cube in your hand, your hand feels cold not because the ice cube puts cold into your hand, but because heat (thermal energy) flows out of your hand and into the ice cube. Since the amount of thermal energy in your hand has decreased it causes the speed of the particles in your hand to slow down, decreasing the temperature.

To measure changes in thermal energy scientists usually use some type of a calorimeter. Remember that a calorimeter is a type of insulated container used to study the transfer of thermal energy. A type of calorimeter called a bomb calorimeter is used to determine the thermal energy in foods. These units of food energy are called calories. A calorie is the amount of food energy needed to raise one gram of water one degree Celsius. One thousand of these small calories (small c) is equal to a kilocalorie (large C). It is these large calories that are used to represent the energy content of foods.