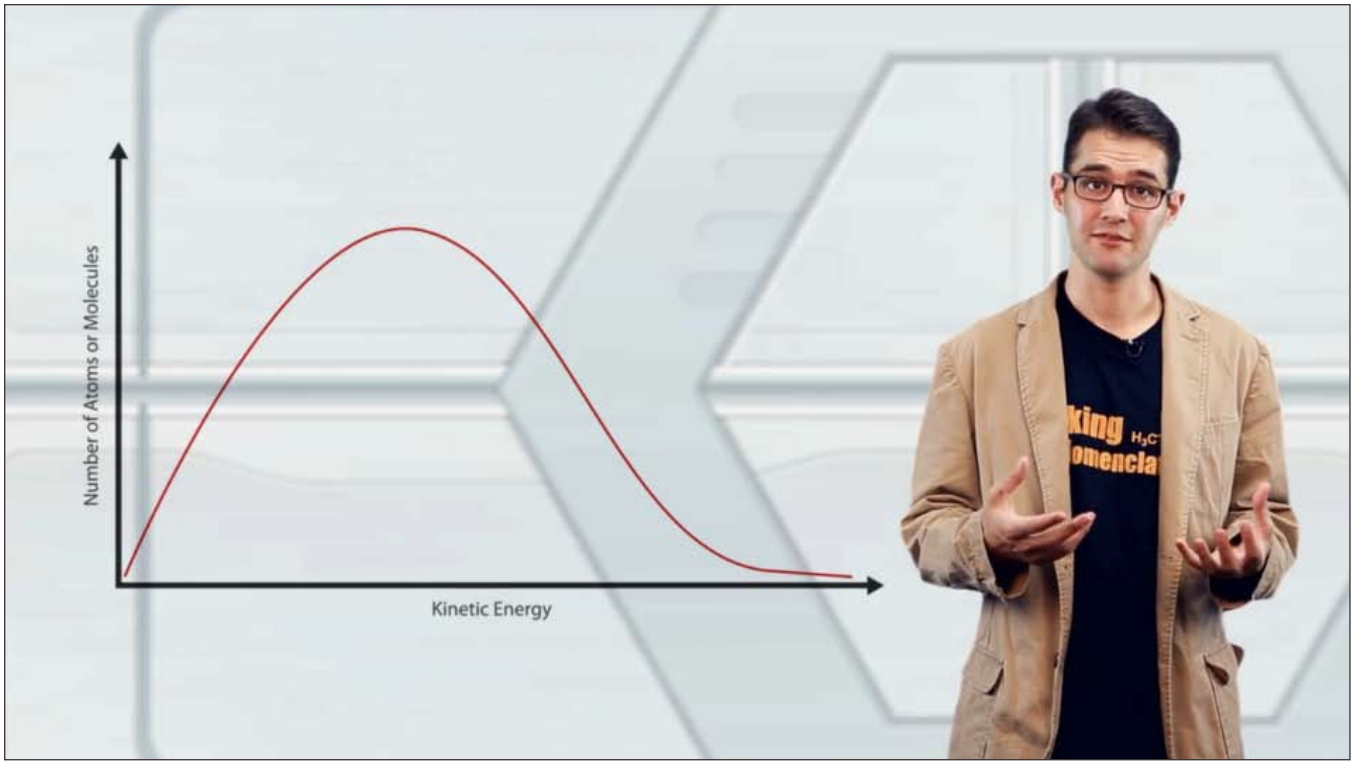
Temperature & Energy | A Video



This video explores evaporation and the definition of temperature. It can be used as a supplement to an investigation, or may stand on its own to introduce a lesson or extend student learning.

highschoolenergy.acs.org/how-do-we-use-energy/temperature-energy.html

Video Transcript

Chris
Ah, the humble thermometer. Whether we want to know if our holiday turkey is cooked or if we need concrete proof that we're too sick to attend school, a thermometer is the exact scientific tool we need. But what, exactly, does a thermometer measure?

In other words, what is temperature, really?

Brittny
Whether it's solid, liquid, or gas, all matter is made up of atoms and molecules. These particles are constantly in motion. They collide with each other and with the walls of anything they are contained in. We quantify the motions of the particles by their kinetic energies.

In chemistry, we define the temperature of a substance as the average kinetic energy of all the atoms or molecules of that substance.

Not all of the particles of a substance have the same kinetic energy. At any given time, the kinetic energy of the particles can be represented by a distribution. Some atoms or molecules have a lot of kinetic energy and move very fast. Other atoms or molecules have a little kinetic energy and move very slowly. It is the *average* kinetic energy of the particles that thermometers measure and we record as the temperature.

One process that illustrates varying kinetic energies particularly well is evaporation. As you probably know, evaporation is a phase change where particles of a substance move from the liquid phase into the gas phase.

But have you ever wondered how a puddle of water can evaporate at room temperature? Keep that in mind—we'll come back to that question in a bit.

Chris
When we think about a phase change from liquid to gas, we often think about adding thermal energy to a liquid by heating it up. When we do, the molecules of the liquid move faster and spread slightly farther apart, until they acquire enough energy to overcome the attractions they have for other molecules of the liquid and enter the gas phase.

Think about this: If someone asked you to turn a beaker full of water into water vapor, what would you do?

Being the brilliant young scientist that you are, you might put it on a hot plate and crank up the heat. Now you can kick back and relax until the hot plate transfers enough energy to get all the water molecules to transition from the liquid phase to the gas phase. In less science-y terms, you would boil the water.

Boiling is a special example of a liquid-to-gas phase change that occurs at a specific temperature called the boiling point, where the vapor pressure of the substance is equal to one atmosphere pressure. Boiling is usually carried out using a continuous input of energy from an external source (like a hot plate) to keep the temperature constant.

The obvious conclusion is this: If you continuously add thermal energy from a hot plate you can cause a phase change from liquid to gas.

But how can a puddle of water evaporate at room temperature?

When water evaporates at room temperature, some fast-moving, highly energetic molecules have enough energy to overcome the attractions that individual molecules have for one another and enter the gas phase. As these high-energy molecules leave the liquid phase, the average energy of the remaining liquid molecules is lowered, and their temperature decreases. This liquid is at a lower energy than its surroundings, so it absorbs energy from those surroundings. The cycle continues as the puddle slowly disappears.

Boiling is a faster process because the surroundings (the hot plate) heat the liquid to a higher temperature where more molecules have high energy, so vaporization is faster. The hot plate is hotter than the liquid, so thermal energy transfer is fast enough to keep the liquid temperature constant at the boiling temperature.

Evaporation can take place at any temperature because some of the molecules in a liquid—the ones at the higher end of the distribution—will always have enough energy to enter the gas phase.

Chris
To sum up, temperature represents the average kinetic energy of the particles of substance. But it's the spread of kinetic energies among the individual particles that explains why puddles dry up.

