Read with a partner, while partner A reads a paragraph you need to highlight and annotate then switch roles. Discuss the important concepts from each paragraph.

Temperature

You don't need a science book to tell you that the word *hot* means higher temperatures or the word *cold* means lower temperatures. When scientists think about high and low temperatures, however, they do not think about "hot" and "cold." Instead, they think about particles of matter in motion.

Recall that all matter is made up of tiny particles. These particles are always moving even if the matter they make up is stationary. Recall that the energy of motion is called kinetic energy. So all particles of matter have kinetic energy. The faster particles move, the more kinetic energy they have. Temperature is a measure of the average kinetic energy of the individual particles in matter.

In Figure 1, the hot cocoa has a higher temperature than the cold chocolate milk. The cocoa's particles are moving faster, so they have greater average kinetic energy. If the milk is heated, its particles will move faster, so their kinetic energy will increase. The temperature of the milk will rise.

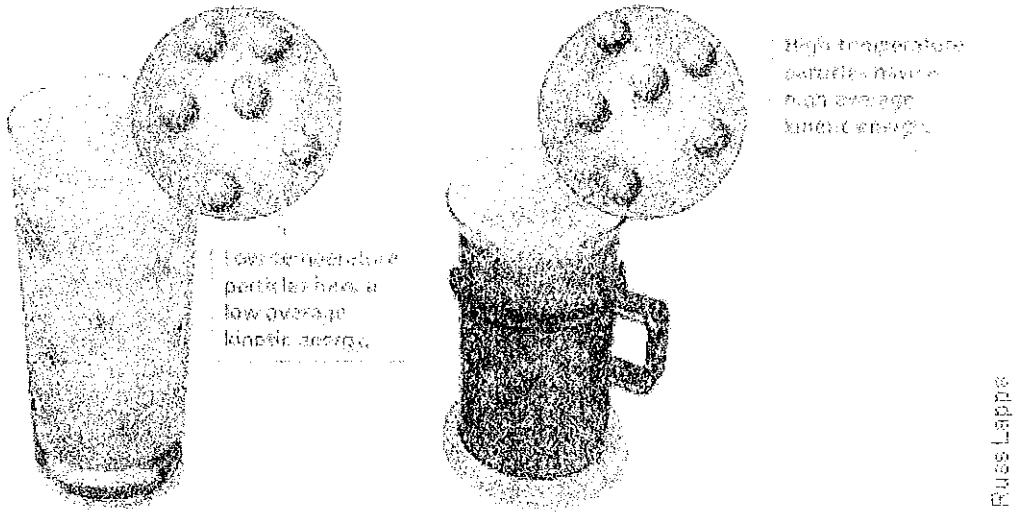


FIGURE 1- Temperature The particles of hot cocoa move faster than those of cold chocolate milk. Applying Concepts *Which drink has particles with greater average kinetic energy?*

Thermal Energy and Heat

Different objects at the same temperature can have different energies. To understand this, you need to know about thermal energy and about heat. You may be used to thinking about thermal energy as heat, but they are not the same thing. Temperature, thermal energy, and heat are closely related, but they are all different.

Thermal Energy

You may recall that the total energy of all of the particles in an object is called thermal energy, or sometimes internal energy. The thermal energy of an object depends on the number of particles in the object, the temperature of the object, and the arrangement of the object's particles. You will learn about how the arrangement of particles affects thermal energy in Section 3.

The more particles an object has at a given temperature, the more thermal energy it has. For example, a 1-liter pot of hot cocoa at 75°C has more thermal energy than a 0.2-liter mug of hot cocoa at 75°C because the pot contains more cocoa particles. On the other hand, the higher the temperature of an object, the more thermal energy the object has. Therefore, if two 1-liter pots of hot cocoa have different temperatures, the pot with the higher temperature has more thermal energy. In Section 3, you will learn about how thermal energies differ for solids, liquids, and gases.

Heat

Thermal energy that is transferred from matter at a higher temperature to matter at a lower temperature is called **heat**. The scientific definition of heat is different from its everyday use. In a conversation, you might say that an object contains heat. However, objects contain thermal energy, not heat. Only when thermal energy is transferred is it called heat. **Heat is thermal energy moving from a warmer object to a cooler object.** For example, when you hold an ice cube in your hand, as shown in Figure 4, the ice cube melts because thermal energy is transferred from your hand to the ice cube.
Recall that work also involves the transfer of energy. Since work and heat are both energy transfers, they are both measured in the same unit—joules.

Thermal Energy

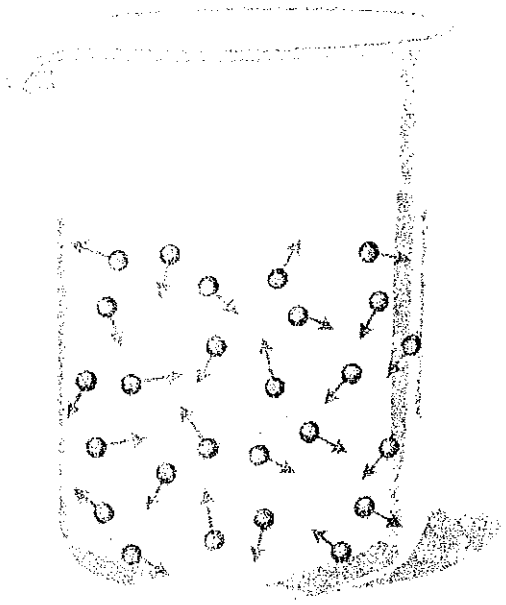
SEE ALSO

255 Atoms
261 Molecules
300 Forms of Energy

All matter is made of particles called atoms and molecules. These particles are in constant motion. They vibrate, rotate, or move from one place to another in a random manner. Some move faster than others. Since these particles are in motion, they have kinetic energy. Kinetic energy is the energy an object or substance has due to its motion.

Word Watch!

The prefix *therm-* means "heat."



Molecules of water have kinetic energy.

Thermal energy is the total amount of kinetic energy contained in all the particles of a substance. The greater the kinetic energy of the particles in the substance, the more thermal energy the substance has. But thermal energy also depends on the number of particles in a substance. The more particles a substance contains, the greater its thermal energy.

SEE ALSO

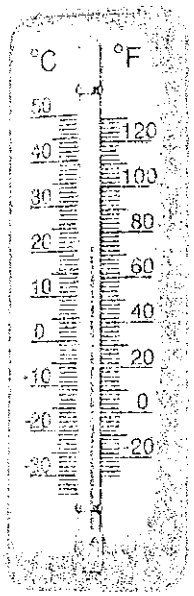
202 Ocean Water
302 Temperature versus Heat

Science Alert!

More thermal energy does not necessarily mean a higher temperature. For example, the ocean, because it is so massive, has far more thermal energy than a pot of boiling water.

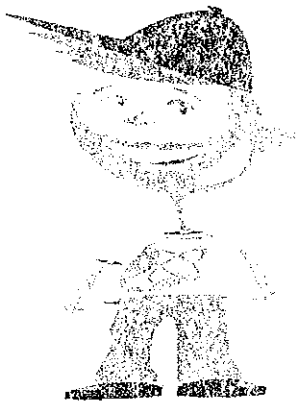
Temperature versus Heat

When you think of temperature, you probably think "hot" or "cold." To scientists, **temperature** is a measure of the *average* kinetic energy of the particles in a substance. The more kinetic energy the particles have, the higher the temperature of the substance. Unlike thermal energy, however, temperature is not affected by the number of particles the substance contains.



A thermometer is a device used to measure temperature.

Two common units of temperature are degrees Celsius (°C) and degrees Fahrenheit (°F).



See Also
070 Taking Temperature Readings

Did You Know?

An object may feel hot or cold, but you can't tell its temperature just by touching it. That's because your skin can only detect *differences* in temperature, not temperature itself. For example, if your hands are very cold, even a cool object will feel warm.

So if thermal energy is the total kinetic energy of the particles of a substance, and temperature is the average kinetic energy of the particles, what is heat? **Heat** is the transfer of thermal energy between substances that are at different temperatures. The energy is always transferred from the warmer substance (the one with the higher temperature) to the cooler substance (the one with the lower temperature). The term *heat* is also commonly used in place of the term *thermal energy*.

See Also
303 Equalization of Temperatures
304 Methods of Heat Transfer

Hot Chocolate Confusion

Read the passages provided then respond to the real-world scenario below:

It was another cloudy, cold day in Michigan. Isabella and Meghan were huddled close drinking hot chocolate, trying to get warm. They knew about the law of conservation of energy, and thought the energy in the hot chocolate would transfer into their bodies to warm them from the inside. Isabella had one of Starbuck's new "trenta"-sized 31oz. cups, while Meghan had a "short"-sized 8oz. cup. The ladies weren't worried because the hot chocolate in both cups was the same ***temperature***, so they were sure they would receive the same amount of ***thermal energy*** by the time they were finished, and the ***heat*** would make them both warm again. Were Isabella and Meghan correct in their thinking? Will they both receive the same amount of warmth (heat) from the hot chocolate each purchased? **(Provide the correct response to this question. Define the scientific principles of temperature, heat, and thermal energy, and completely explain the concepts involved).**

Response needs to be well-written and typed to include the following:

Correct response to the questions _____/5
Definitions of the scientific principles _____/3
Use of definitions to explain the scientific thinking ____/2

Total: ____/10