3.2 States of Matter (6.2.2)

Explore this Phenomena

Observe the clothes that have been put out on a clothesline to dry. Record your observations and questions in the chart below.

TABLE 3.2:

Observations	Questions

Draw a model to explain why clothes dry while out on a clothesline.

Standard 6.2.2

Develop a model to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating).

TABLE 3.3:

In this section, focus on cause and effect. Events have causes. Look for relationships that explain why things are happening. Notice how adding and removing energy causes phase changes and how that affects density.

States of Matter

There are three major states in which any given type of matter can exist. The three states are solid, liquid, and gas.

Solids are defined by the following characteristics:

- definite shape (rigid)
- definite volume
- particles vibrate around fixed axes

Liquids have the following characteristics:

- no definite shape (takes the shape of its container)
- has definite volume
- particles are free to move over each other, but are still attracted to each other

Gases have the following characteristics:

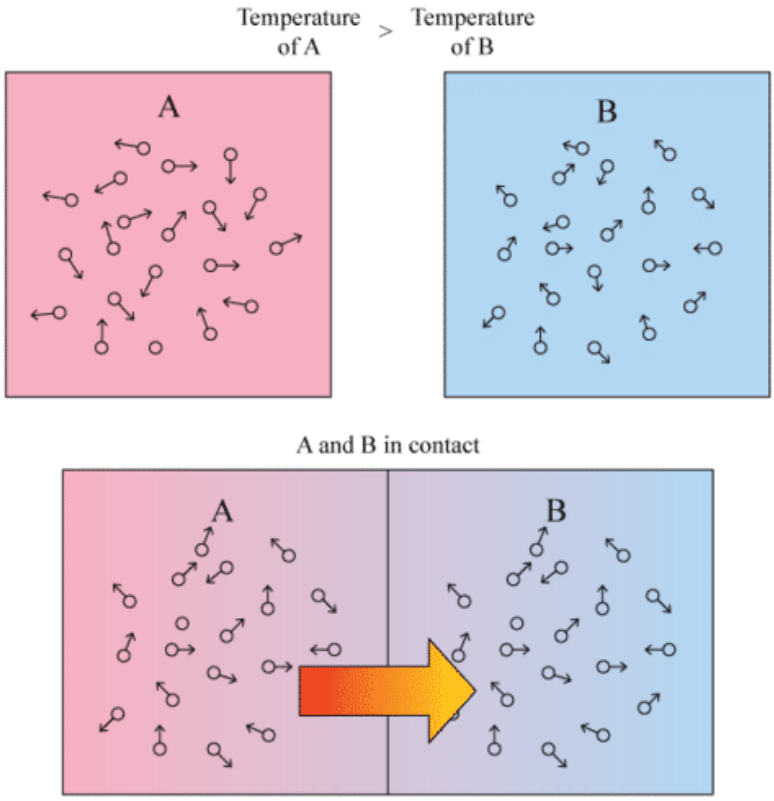
- no definite shape (takes the shape of its container)
- no definite volume

- particles move in random motion with little or no attraction to each other

How tightly atoms and molecules are packed together is referred to as density. Solids are more dense than liquids. Liquids are more dense than gases.

What Is Heat?

Heat is the transfer of thermal energy between substances . Thermal energy is the energy causing the particles of matter to move. Temperature is the average measure of that energy. Thermal energy always moves from matter with greater thermal energy to matter with less thermal energy, so it moves from warmer to cooler substances. You can see this in the figure below .



Faster-moving particles of the warmer substance bump into and transfer some of their energy to slower-moving particles of the cooler substance. Thermal energy is transferred in this way until both substances have the same thermal energy and temperature .

As thermal energy is transferred, materials expand as temperature increases. The density of a substance is temperature dependent and usually decreases as temperature increases. Density is an important physical property of matter. It reflects how closely packed and the arrangement of particle in matter. For instance, a golf ball and a table tennis ball are about the same size. However, the golf ball is much heavier than the table tennis ball. Now imagine a similar size ball made out of lead. That would be very heavy indeed! What are we comparing? By comparing the mass of an object relative to its size, we are studying a property called density. Matter with less density will rise and matter with greater density will sink.

How do you cool down a glass of room-temperature cola? You probably add ice cubes to it, as in the figure to the right. You might think that the ice cools down the cola, but in fact, it works the other way around. The warm cola heats up the ice. Thermal energy from the warm cola is transferred to the much colder ice, causing it to melt. The cola loses thermal energy in the process, so its temperature falls.

Changes in States of Matter

A change of state occurs whenever matter changes from one state to another, for example a solid changing to a liquid. This change is an effect of energy being transferred from one substance to another. Changes of state are physical changes, meaning they are reversible changes and do not change how molecules are combined. For example, when fog changes to water vapor, it is still water (H_2O) and can change back to liquid water again. Matter may change back and forth between these states.

As energy in a substance is transferred, it causes a change in its state. In the previous example, ice was added to a cola. The energy was transferred from the warmer cola to the cooler ice. This caused the ice to melt and change from a solid to a liquid.

Types of Phase Changes

Melting occurs when particles of a solid absorb enough energy to partly overcome the force of attraction holding them together. This allows them to move out of their fixed positions and slip over one another. The solid becomes a liquid.

The process in which water or any other liquid changes to a solid is called freezing. Freezing occurs when a liquid cools to a point at which its particles no longer have enough energy to overcome the force of attraction between them. Instead, the particles remain in fixed positions, crowded closely together.

When air cools, it can hold less water vapor, so some of the water vapor in the air changed to liquid water. The process in which water vapor—or another gas—changes to a liquid is called condensation. Another common example of condensation is pictured in the figure below.

Evaporation is the process in which a liquid changes to a gas. It occurs when individual liquid particles at the exposed surface of the liquid absorb just enough energy to overcome the force of attraction with other liquid particles. If the surface particles are moving in the right direction, they will pull away from the liquid and move into the air becoming a gas.

FIGURE 3.5

This picture shows the contrail (condensation trail) left behind by a jet. Water vapor in its exhaust gases condensed on dust particles in the air.

Focus Questions:

- Draw a model that shows the motion of particles in a solid, liquid and a gas.
- What is the effect as heat energy is added to a bar of chocolate?
- Ice floats in water. What does this tell us about the ice's density?

Putting It Together

Review your initial explanation from the beginning of this section. Revise your model for why clothes dry while out on a clothesline based on what you have learned about phase changes and particle motion.

3.3 Heat Energy and Particle Motion (6.2.3)

Explore this Phenomena

Above are two different bodies of water that are close in location.Which body of water will freeze first? Explain your reasoning.

Standard 6.2.3

Plan and carry out an investigation to determine the relationship between temperature, the amount of heat transferred, and the change of average particle motion in various types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.

TABLE 3.4:

In this section, focus on the relationship between heat transfer and the average particle motion in matter.

Heat Energy and Particle Motion

When heat flows into an object, its thermal energy increases and so does its temperature. The amount of temperature increase depends on three things: 1) how much heat was added, 2) the size (mass) of the object, and 3) the material of which the object is made.

Thermal energy and temperature are closely related. Both reflect the amount of moving particles of matter as energy. However, temperature is the average measure of that energy, whereas thermal energy is the total energy within a system. Does this mean that matter with a lower temperature has less thermal energy than matter with a higher temperature? Not necessarily. Another factor also affects thermal energy. The other factor is mass.

The soup is boiling hot and has a temperature of 100 °C, whereas the water in the tub is just comfortably warm, with a temperature of about 38 °C. Although the water in the tub has a much lower temperature, it has greater thermal energy. This is because temperature is a measure of the average energy of the particles, rather than a measure of the total energy. The particles of soup have a greater average energy than the the particles of water in the tub; the soup has a higher temperature. However, the mass of the water in the tub is much greater than the mass of the soup in the pot. This means that there are many more particles of water in the tub than particles in the soup. All those moving particles give the water in the tub greater total energy, even though their average energy is less. Therefore, the water in the tub has greater thermal energy than the soup.

Focus Questions

- What factors influence how much the temperature of an object will increase or decrease?
- Look at the pot of soup and the tub of water in the figure above. Which object has greater thermal energy? Explain your reasoning.
- What is the difference between thermal energy and temperature?

Putting It Together

Reread your initial explanation about which body of water will freeze first. Then consider what you have learned about thermal energy and construct an explanation that describes which body of water will freeze first and why.