Science Online

Topic: States of Matter

Visit earth.msscience.com for Web links to information about the four states of matter.

Activity Search for information on a family of elements called the halogens. Use the information you find to write a "Wanted Poster" on one halogen. Include items such as physical description, distinguishing characteristics, and known associates.

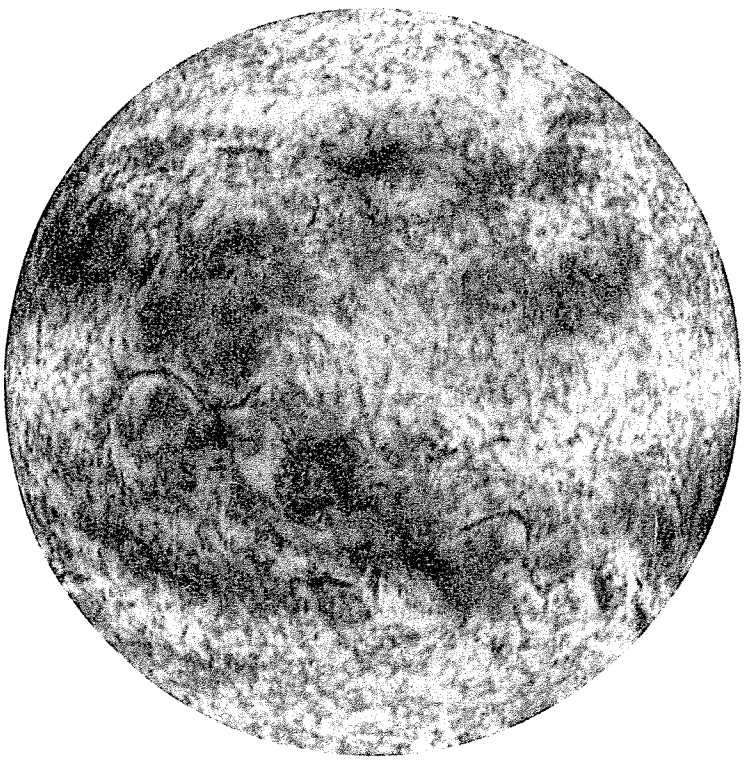
Liquids Particles in a liquid are attracted to each other, but are not in fixed positions as they are in the solid shown in **Figure 15.** This is because liquid particles have more energy than solid particles. This energy allows them to move around and change positions with each other.

When you eat breakfast, you might have several liquids at the table such as syrup, juice, and milk. These are substances in the liquid state, even though one flows more freely than the others at room temperature. The particles in a liquid can change positions to fit the shape of the container they are held in. You can pour any liquid into any container, and it will flow until it matches the shape of its new container.

Gases The particles that make up gases have enough energy to overcome any attractions between them. This allows them to move freely and independently. Unlike liquids and solids, gases spread out and fill the container in which they are placed. Air fresheners work in a similar way. If an air freshener is placed in a corner, it isn't long before the particles from the air freshener have spread throughout the room. Look at the hot-air balloon shown in **Figure 15C.** The particles in the balloon are evenly spaced throughout the balloon. The balloon floats in the sky, because the hot air inside the balloon is less dense than the colder air around it.

Reading Check *How do air fresheners work?*

Figure 14 The Sun is an example of a plasma.



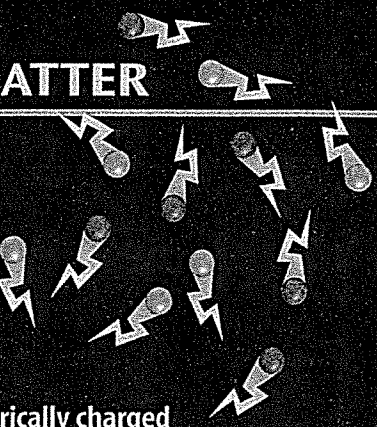
Plasma Although it is probably unfamiliar to most people, plasma is the most common state of matter in the universe. This state is associated with high temperatures. Can you name something that is in the plasma state? Stars like the Sun, shown in **Figure 14,** are composed of matter in the plasma state. Plasma also exists in Jupiter's magnetic field. On Earth, plasma is found in lightning bolts, as shown in **Figure 15D.** Plasma is composed of ions and electrons. It forms when high temperatures cause some of the electrons normally found in an atom's electron cloud to escape and move outside of the electron cloud.

NATIONAL GEOGRAPHIC

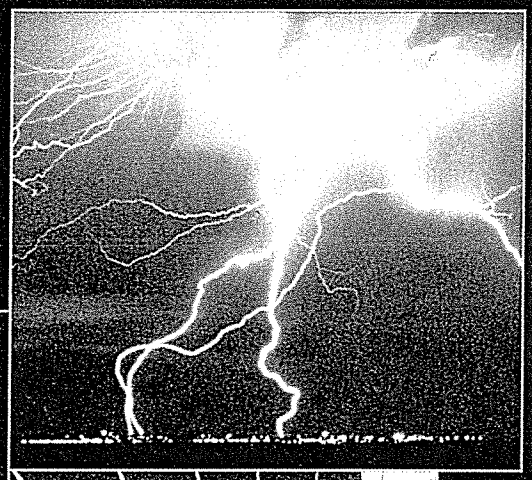
VISUALIZING STATES OF MATTER

Figure 15

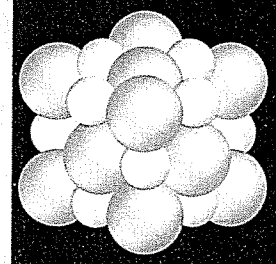
Matter on Earth exists naturally in four different states—solid, liquid, gas, and plasma—as shown here. The state of a sample of matter depends upon the amount of energy its atoms or molecules possess. The more energy that matter contains, the more freely its atoms or molecules move, because they are able to overcome the attractive forces that tend to hold them together.

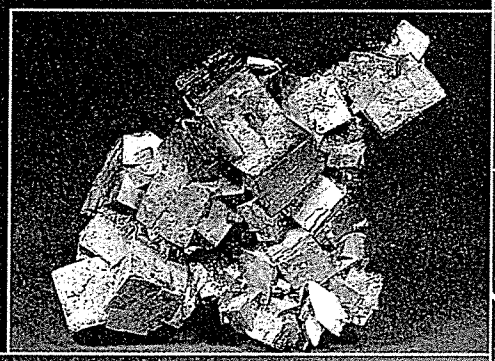


D PLASMA Electrically charged particles in lightning are free moving.



A SOLID In a solid such as galena, the tightly packed atoms or molecules lack the energy to move out of position.





B LIQUID The atoms or molecules in a liquid such as water have enough energy to overcome some attractive forces and move over and around one another.

C GAS In air and other gases, atoms or molecules have sufficient energy to separate from each other completely and move in all directions.

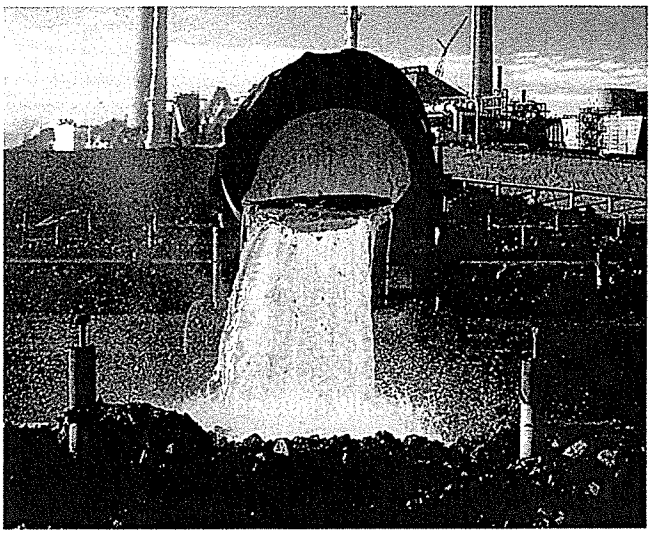


Figure 16 A solid metal can be changed to a liquid by adding thermal energy to its molecules. **Describe** *what is happening to the molecules during this change.*

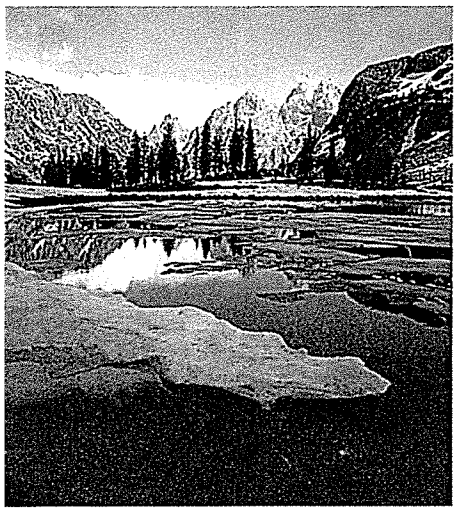
Changing the State of Matter

Matter is changed from a liquid to a solid at its freezing point and from a liquid to a gas at its boiling point. You may know the freezing and boiling points of water. Water begins to change from a liquid to a solid at its freezing point of 0°C. It boils at 100°C. Water is the only substance that occurs naturally on Earth as a solid, liquid, and gas. Other substances don't naturally occur in these three states on Earth because of the limited temperature range Earth experiences. For example, temperatures on Earth do not get cold enough for solid carbon dioxide to exist naturally. However, it can be manufactured.

The attraction between particles of a substance and their rate of movement are factors that determine the state of matter. When thermal energy is added to ice, the rate of movement of its molecules increases. This allows the molecules to move more freely and causes the ice to melt. As **Figure 16** shows, even solid metal can melt when enough thermal energy is added.

Changes in state also occur because of increases or decreases in pressure. For example, decreasing pressure lowers the boiling points of liquids. At high elevations, water boils at a lower temperature because the air pressure has decreased. Also, many solids melt at lower temperatures when pressure is decreased. Intense pressure keeps material in Earth's mantle in a solid or semi-solid state even though the temperature is high. A decrease in pressure can cause some material to melt and form magma. However, extreme changes in pressure usually are required to alter the melting points of solids by only a few degrees.

Figure 17 If ice were more dense than water, lakes would freeze solid from the bottom up. **Infer** *What effect might this have on the fish?*



Changes in Physical Properties

Chemical properties of matter don't change when the matter changes state, but some of its physical properties change. For example, the density of water changes as water changes state. Ice floats in liquid water, as seen in **Figure 17,** because it is less dense than liquid water. This is unique, because most materials are denser in their solid state than in their liquid state.

Reading Check *Why does ice float in water?*

Some physical properties of substances don't change when they change state. For example, water is colorless and transparent in each of its states.

Matter on Mars

Matter in one state often can be changed to another state by adding or removing thermal energy. Changes in thermal energy might explain why Mars appears to have had considerable water on its surface in the past but now has little or no water on its surface. Recent images of Mars reveal that there might still be some groundwater that occasionally reaches the surface, as shown in **Figure 18.** But what could explain the huge water-carved channels that formed long ago? Much of the liquid water on Mars might have changed state as the planet cooled to its current temperature. Scientists believe that some of Mars's liquid water soaked into the ground and froze, forming permafrost. Some of the water might have frozen to form the polar ice caps. Even more of the water might have evaporated into the atmosphere and escaped to space.

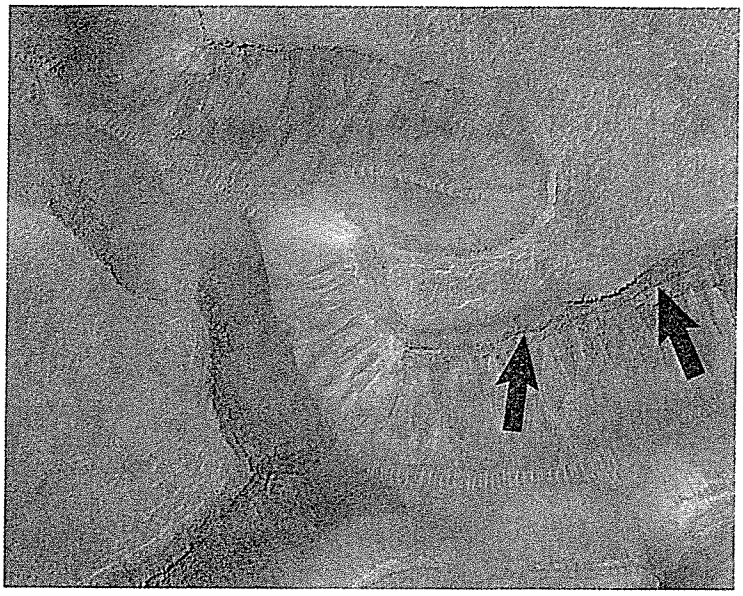


Figure 18 Groundwater might reach the surface of Mars along the edge of this large channel.

SECTION 3 REVIEW

Summary

Physical Properties of Matter

- Density is the mass of an object divided by its volume.

States of Matter

- Solids have a definite shape and volume.
- Liquids take the shape of their containers.
- Gases spread out and fill their containers.
- Plasma occurs at high temperatures and has such high energy that some electrons may escape their electron clouds.

Changing the State of Matter

- Both temperature and pressure can cause changes in the state of matter.

Changes in Physical Properties

- Chemical properties do not change when matter changes state, but physical properties can change.

Self Check

1. **List** the four states of matter in order from lowest to highest particle movement.
2. **Explain** how temperature can bring about changes in the state of matter.
3. **Explain** why an ice cube will melt if compressed, even though the temperature remains the same.
4. **Think Critically** Suppose you blow up a balloon and then place it in a freezer. Later, you find that the balloon has shrunk and has bits of ice in it. Explain.

Applying Skills

5. **Classify** Assign each of the following items to one of the four states of matter and describe their characteristics: groundwater, lightning, lava, snow, textbook, ice cap, notebook, apple juice, eraser, glass, cotton, helium, iron oxide, lake, limestone, and water vapor.
6. **Infer** You have probably noticed that some liquids, such as honey and molasses, flow slowly at room temperature. How does heating affect flow rate?