Chapter: States of Matter

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What is matter?

- **Matter** is anything that takes up space and has mass.
- Matter doesn't have to be visible—even air is matter.

Everything in this photo is matter.

1

States of Matter

- All matter is made up of tiny particles, such as atoms, molecules, or ions.
- Each particle attracts other particles.
- These particles also are constantly moving.
- The motion of the particles and the strength of attraction between the particles determine a material's state of matter.

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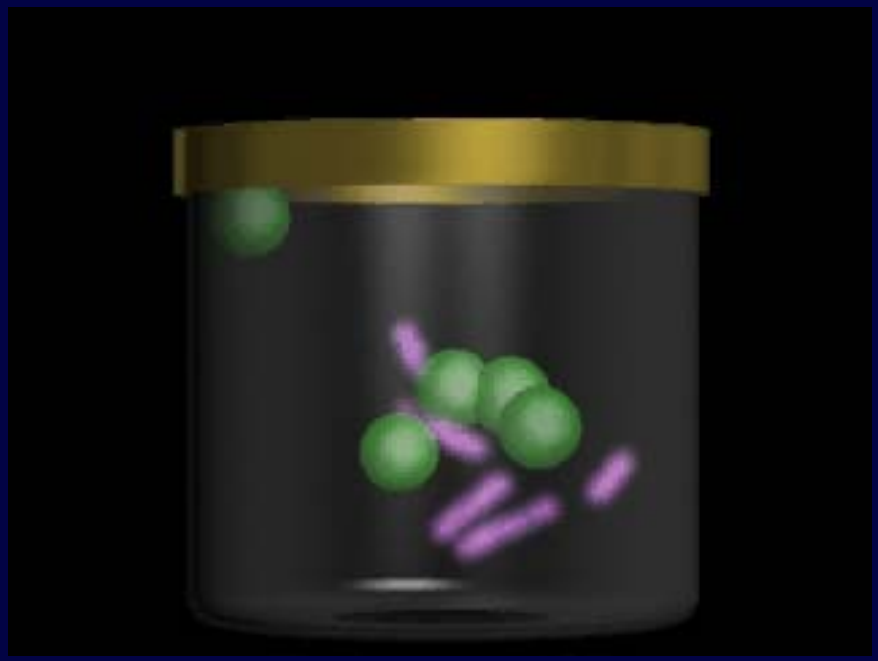
States of Matter

- There are three familiar states of matter—solid, liquid, and gas.
- A fourth state of matter known as plasma occurs at extremely high temperatures. Plasma is found in stars, lightning, and neon lights.



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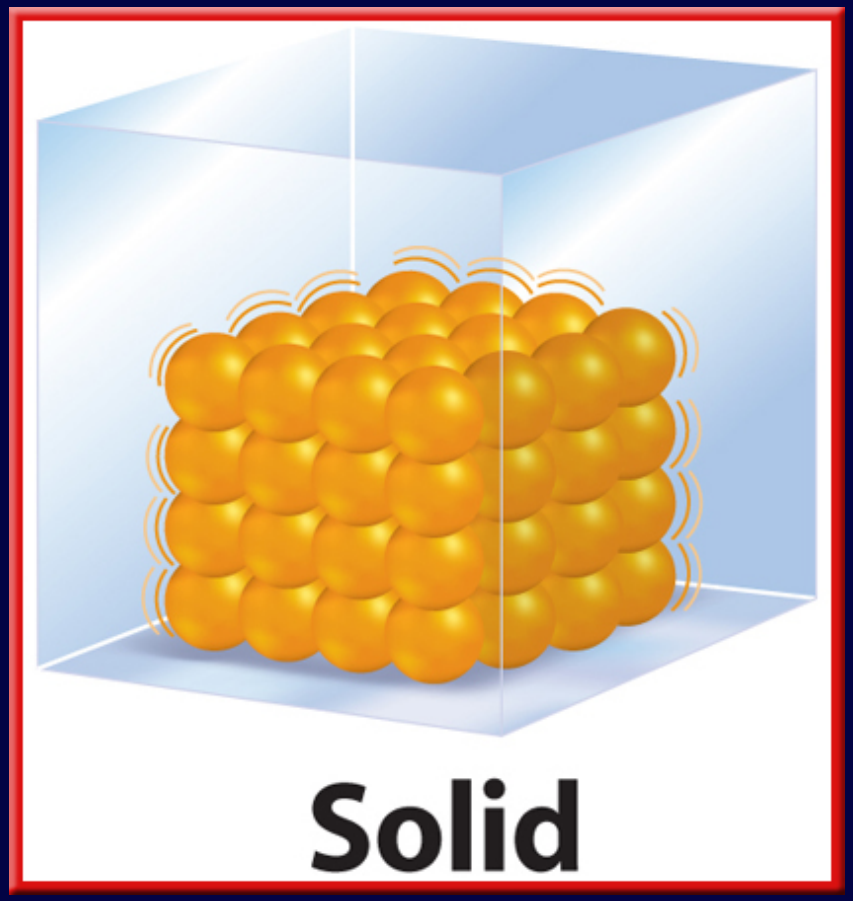
Solids

- A **solid** is matter with a definite shape and volume.
- A solid does not take the shape of a container in which it is placed. This is because the particles of a solid are packed closely together.



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Particles in Motion

- The particles that make up all types of matter are in constant motion.
- Although you can’t see them, a solid’s particles are vibrating in place.
- These particles do not have enough energy to move out of their fixed positions.

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Crystalline Solids

- In some solids, the particles are arranged in a repeating, three-dimensional pattern called a crystal.
- These solids are called crystalline solids.

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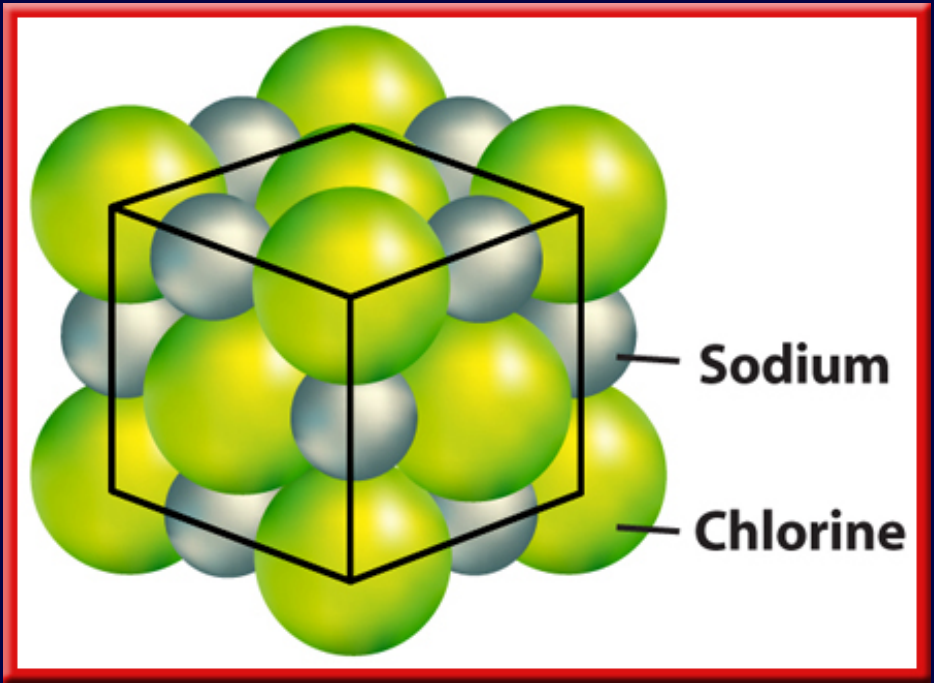
Crystalline Solids

- The particles in a crystal of sodium chloride (NaCl) are arranged in an orderly pattern.



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Amorphous Solids

- Some solids come together without forming crystal structures. Instead, the particles are found in a random arrangement.
- These solids are called amorphous (uh MOR fuhs) solids.
- Rubber, plastic, and glass are examples of amorphous solids.

1

Liquids

- A **liquid** is matter that has a definite volume but no definite shape.
- Liquid takes the shape of the container.
- The volume of a liquid, however, is the same no matter what the shape of the container.

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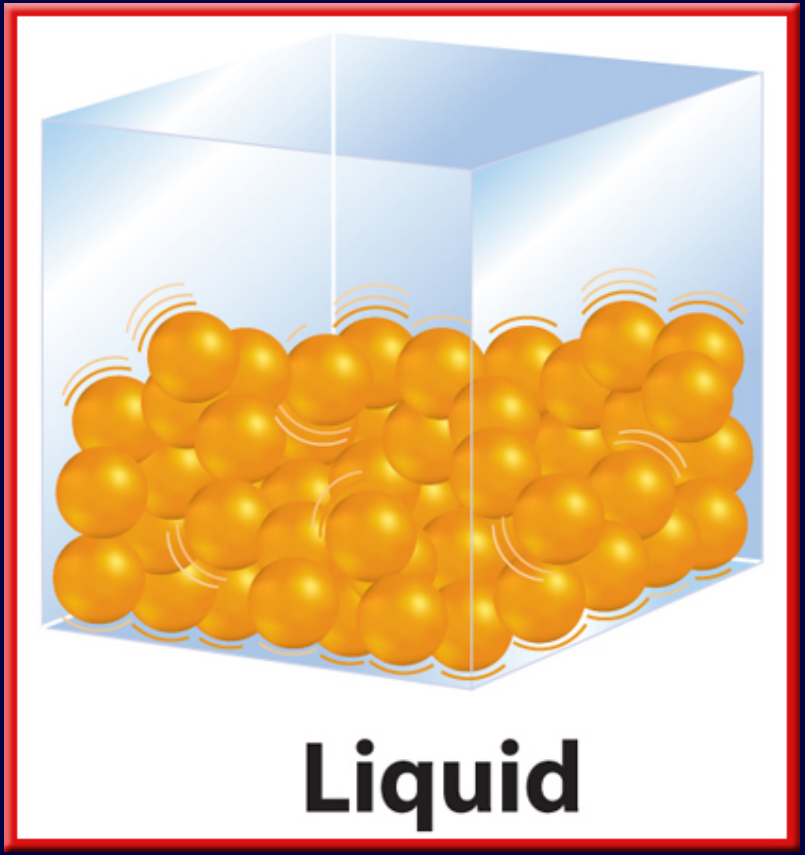
Free to Move

- The particles in a liquid move more freely than the particles in a solid.
- The particles in a liquid have enough energy to move out of their fixed positions but not enough energy to move far apart.



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Viscosity

- Some liquids flow more easily than others.
- A liquid's resistance to flow is known as the liquid's **viscosity**.
- The slower a liquid flows, the higher its viscosity is.
- For many liquids, viscosity increases as the liquid becomes colder.

1

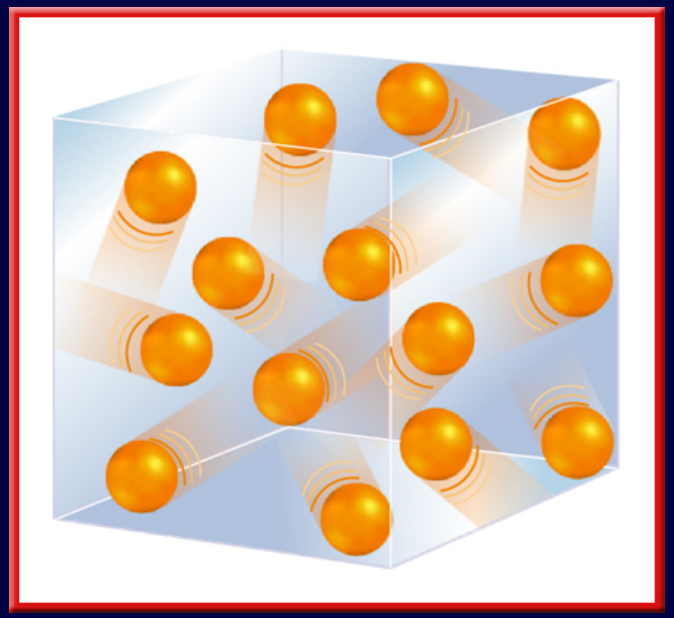
Surface Tension

- The uneven forces acting on the particles on the surface of a liquid are called **surface tension**.
- Surface tension causes the liquid to act as if a thin film were stretched across its surface.

1

Gases

- **Gas** is matter that does not have a definite shape or volume.
- The particles in gas are much farther apart than those in a liquid or solid.
- Gas particles move at high speeds in all directions.



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Vapor

- Matter that exists in the gas state but is generally a liquid or solid at room temperature is called vapor.
- Water, for example, is a liquid at room temperature. Thus, water vapor is the term for the gas state of water.

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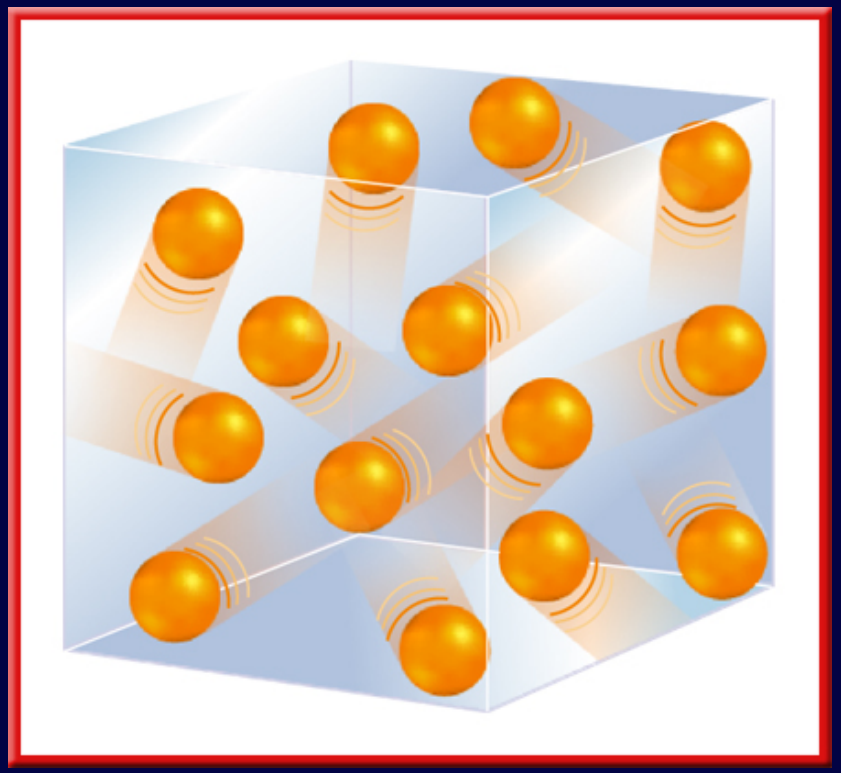
Question 1

What state of matter is shown in this illustration?



A. gas
B. liquid
C. plasma
D. solid

1

Answer

The answer is A. Particles in a gas are much farther apart than those in a liquid or solid.

1

Question 2

Some solids are composed of particles that fall into a pattern; they have a repeating, three-dimensional shape. What do you call these kinds of solids?

Answer

The answer is crystalline solids. A common example of a crystalline solid is table salt.

1

Question 3

Which is composed of particles that have enough energy to move past each other but not enough to break away from each other?

A. ice cube
B. lemonade
C. oxygen
D. water vapor

1

Answer

The answer is B. Lemonade is a liquid. Particles in a liquid stay close together although they are free to move past each other.

2

Thermal Energy and Heat Energy

- Simply stated, energy is the ability to do work or cause change.
- The energy of motion is called kinetic energy.

2

Thermal Energy and Heat Energy

- The total kinetic energy of all the particles in a sample of matter is called **thermal energy**.
- Thermal energy, an extensive property, depends on the number of particles in a substance as well as the amount of energy each particle has.

2

Temperature

- Not all of the particles in a sample of matter have the same amount of energy.
- The average kinetic energy of the individual particles is the **temperature**, an intensive property of the substance.
- Temperature is different from thermal energy because thermal energy is a total and temperature is an average.

2

Heat

- The movement of thermal energy from a substance at a higher temperature to one at a lower temperature is called **heat**.

- When a substance is heated, it gains thermal energy. Therefore, its particles move faster and its temperature rises.

2

Specific Heat

- The specific heat of a substance is the amount of heat required to raise the temperature of 1 g of a substance 1°C.
- Substances that have a low specific heat, heat up and cool down quickly.

2

Specific Heat

- A substance with a high specific heat, heats up and cools down slowly because a much larger quantity of heat is required to cause its temperature to rise of fall by the same amount.

2

Changes Between the Solid and Liquid States

- Matter can change from one state to another when thermal energy is absorbed or released.
- This change is known as change of state.

2

Melting

- The change from the solid state to the liquid state is called **melting**.

- The temperature at which a substance changes from a solid to a liquid is called the melting point.
- The melting point of water is 0°C.

2

Melting

- Amorphous solids, such as rubber and glass, don’t melt in the same way as crystalline solids.
- Because they don’t have crystal structures to break down, these solids get softer and softer as they are heated.

2

Freezing

- The change from the liquid state to the solid state is called **freezing**.
- The temperature at which a substance changes from the liquid state to the solid state is called the freezing point.

2

Freezing

- During freezing, the temperature of a substance remains constant while the particles in the liquid form a crystalline solid.
- Energy is released during freezing.
- After all of the liquid has become a solid, the temperature begins to decrease again.

2

Changes Between the Liquid and Gas States—Vaporization

- The change from a liquid to a gas is known as vaporization (vay puh ruh ZAY shun).
- The temperature of the substance does not change during vaporization. However, the substance absorbs thermal energy.

2

Changes Between the Liquid and Gas States—Vaporization

- Two forms of vaporization exist.
- Vaporization that takes place below the surface of a liquid is called boiling.
- The temperature at which a liquid boils is called the boiling point.

2

Changes Between the Liquid and Gas States—Vaporization

- Vaporization that takes place at the surface of a liquid is called evaporation.
- Evaporation, which occurs at temperatures below the boiling point, explains how puddles dry up.

2

Location of Molecules

- It takes more than speed for water molecules to escape the liquid state.
- During evaporation, these faster molecules also must be near the surface, heading in the right direction, and they must avoid hitting other water molecules as they leave.

2

Condensation

- As a gas cools, its particles slow down.
- When particles move slowly enough for their attractions to bring them together, droplets of liquid form.
- This process, which is the opposite of vaporization, is called **condensation**.

2

Condensation

- In the same way, water vapor in the atmosphere condenses to form the liquid water droplets in clouds.
- When the droplets become large enough, the can fall to the ground as rain.

2

Changes Between the Solid and Gas States

- Some substances can change from the solid state to the gas state without ever becoming a liquid.
- During this process, known as sublimation, the surface particles of the solid gain enough energy to become a gas.
- One example of a substance that undergoes sublimation is dry ice.

2

Question 1

The total kinetic energy of all the particles in a substance is known as _____?

A. freezing
B. heat
C. temperature
D. thermal energy

2

Answer

The answer is D. When you heat a substance, you increase its thermal energy.

2

Question 2

The amount of heat required to raise the temperature of 1 g of a substance by 1° C is known as _____?

A. freezing
B. heat
C. specific heat
D. temperature

2

Answer

The answer is C. Different substances have different specific heats.

2

Question 3

The average kinetic energy of the individual particles in a particular substance is referred to as _____?

2

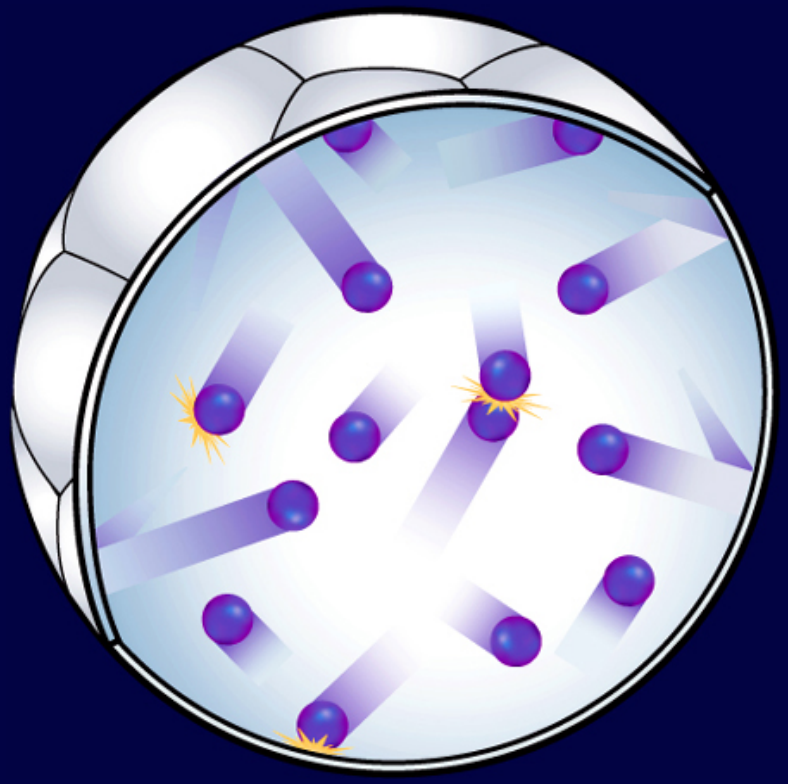
Answer

The average kinetic energy of the particles in a substance is its temperature. Since different particles have different amounts of energy in any substance, temperature will be an average measurement.

3

Pressure

- The firmness of a ball is the result of the motion of the air particles in the ball.
- As each particle collides with the inside walls, it exerts a force, pushing the surface of the ball outward.



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Pressure

- A force is a push or a pull.
- **Pressure** is equal to the force exerted on a surface divided by the total area over which the force is exerted.

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

3

Pressure

- When force is measured in newtons (N) and area is measured in square meters (m^2), pressure is measured in newtons per square meter (N/m^2).
- This unit of pressure is called a pascal (Pa).
- A more useful unit when discussing atmospheric pressure is the kilopascal (kPa), which is 1,000 pascals.

3

Force and Area

- Pressure depends on the quantity of force exerted and the area over which the force is exerted.
- As the force increases over a given area, pressure increases.
- If the force decreases, the pressure will decrease.
- If the area changes, the same amount of force can result in different pressure.

3

Atmospheric Pressure

- The pressure of air also is known as atmospheric pressure.
- Atmospheric pressure is 101.3 kPa at sea level.
- This means that air exerts a force of about 101,000 N on every square meter it touches. This is approximately equal to the weight of a large truck.

3

Atmospheric Pressure

- You often take advantage of air pressure without even realizing it.
- Air pressure enables you to drink from a straw.
- When you first suck on a straw, you remove the air from it.

3

Atmospheric Pressure

- Air pressure pushes down on the liquid in your glass then forces liquid up into the straw.

3

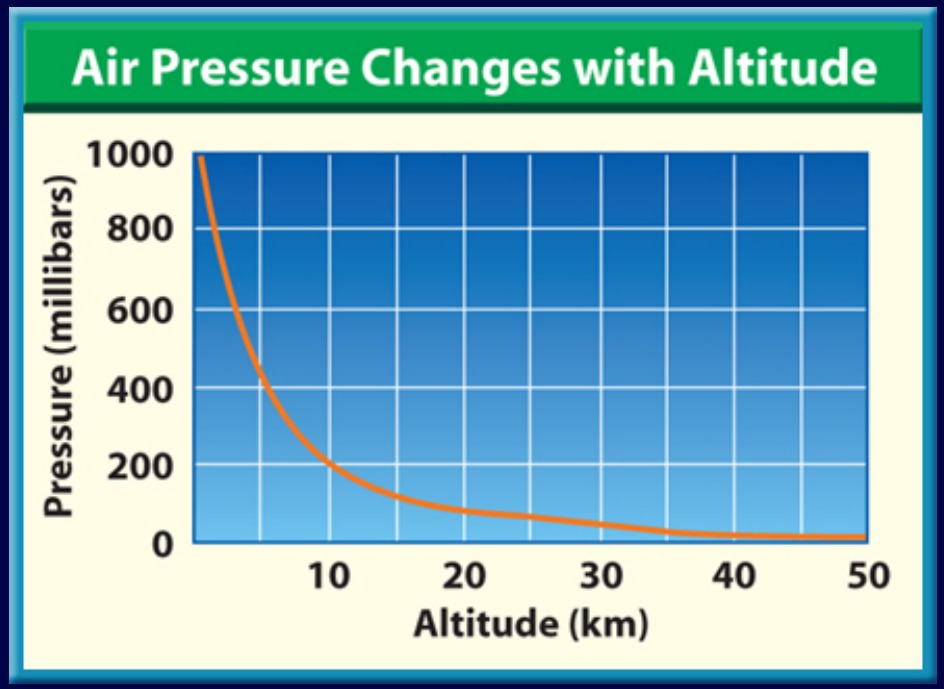
Balanced Pressure

- If air is so forceful, why don't you feel it?
- The reason is that the pressure exerted outward by the fluids in your body balances the pressure exerted by the atmosphere on the surface of your body.

3

Variations in Atmospheric Pressure

- Atmospheric pressure changes with altitude.
- As altitude increases atmospheric pressure decreases.



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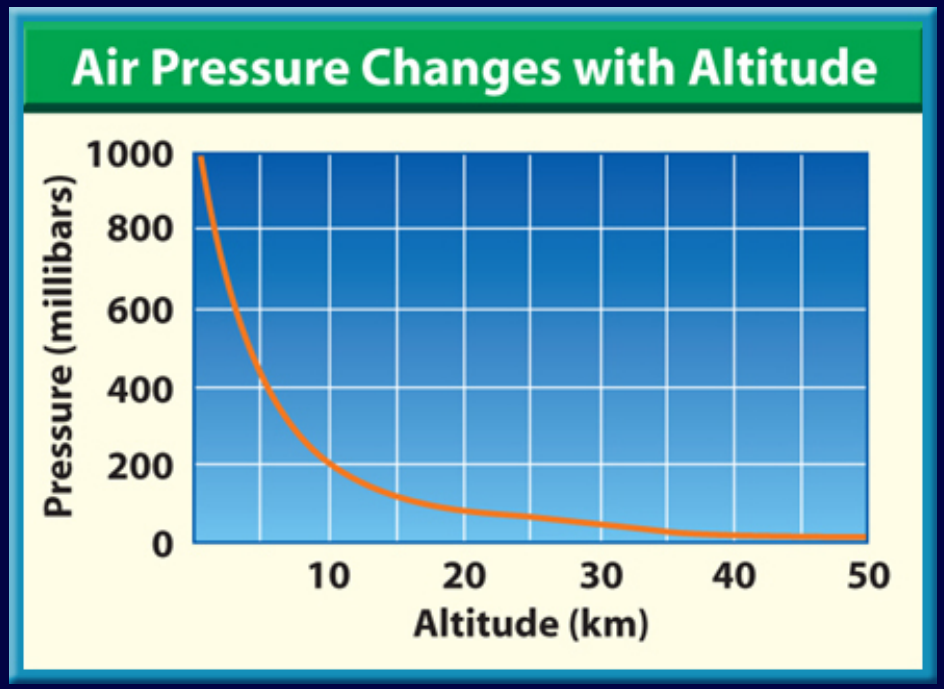
Variations in Atmospheric Pressure

- This is because fewer air particles are found in a given volume.
- Fewer particles have fewer collisions, and therefore exert less pressure.



3

Variations in Atmospheric Pressure

- Notice how the balloon expands as it is carried up the mountain.
- The reason is that atmospheric pressure decreases with altitude.

3

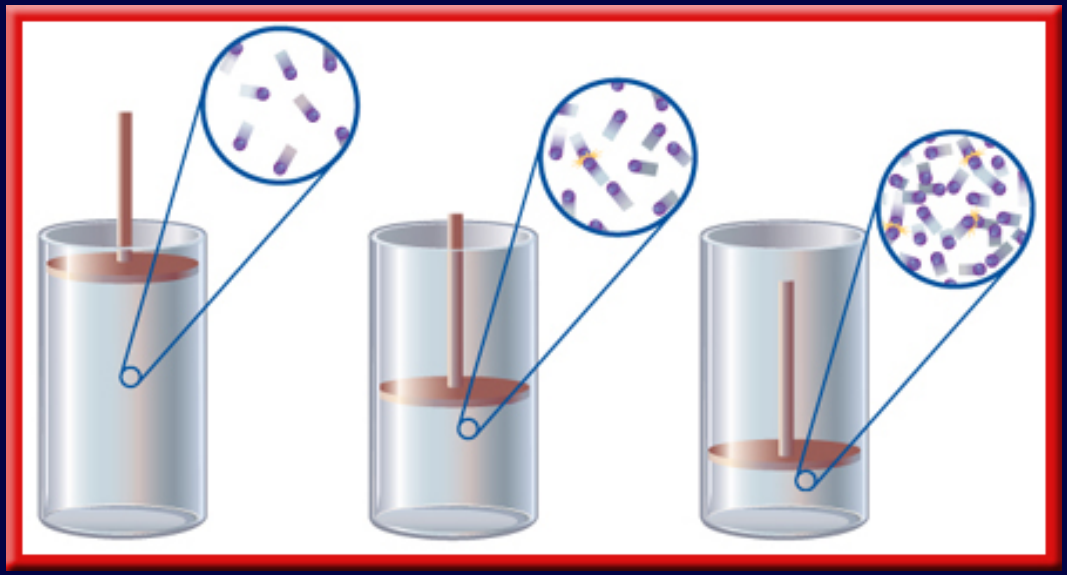
Air Travel

- If you travel to higher altitudes you might feel a popping sensation in your ears.
- As the air pressure drops, the air pressure in your ears becomes greater than the air pressure outside your body.
- The release of some of the air trapped inside your ears is heard as a pop.

3

Changes in Gas Pressure
Pressure and Volume

- As volume decreases, pressure increases.
- As the piston is moved down, the gas particles have less space and collide more often. The pressure increases.



3

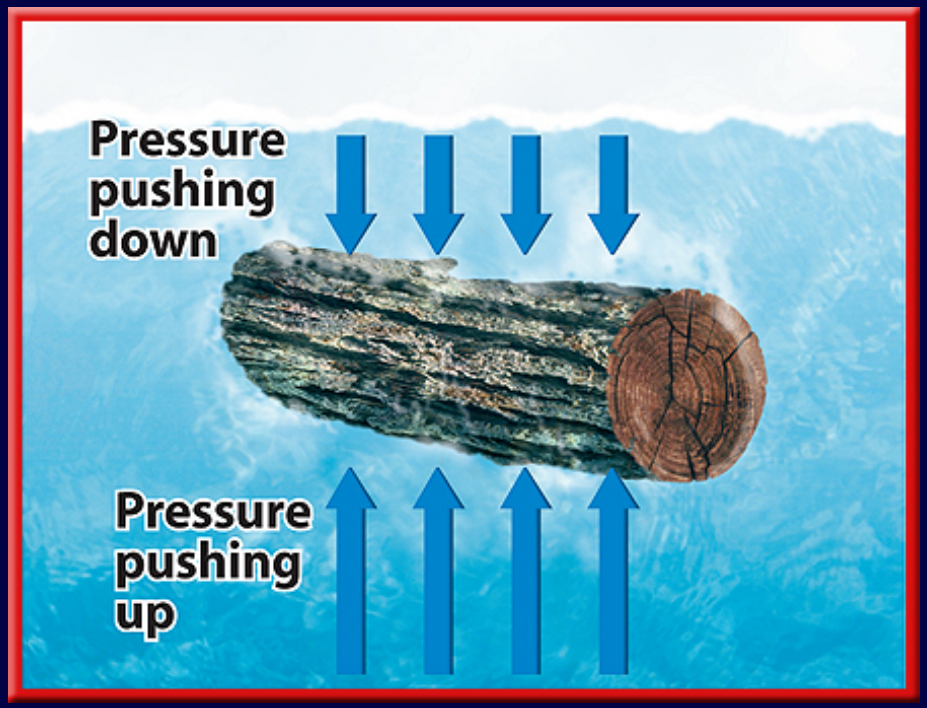
Pressure and Temperature

- When the volume of a confined gas remains the same, the pressure can change as the temperature of the gas changes.
- Even though the volume of this container does not change, the pressure increases as the substance is heated.

3

Float or Sink

- Just as air pressure increases as you walk down a mountain, water pressure increases as you swim deeper in water.



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Float or Sink

- The difference in pressure results in an upward force on an object immersed in a fluid.
- This force is known as the **buoyant force**.
- If the buoyant force is equal to the weight of an object, the object will float.
- If the buoyant force is less than the weight of an object, the object will sink.

3

Archimedes' Principle

- According to **Archimedes'** (ar kuh MEE deez) **principle**, the buoyant force on an object is equal to the weight of the fluid displaced by the object.
- If you place an object in a beaker that already is filled to the brim with water, some water will spill out of the beaker.
- If you weigh the spilled water, you will find the buoyant force on the object.

3

Density

- **Density** is mass divided by volume.
- An object will float in a fluid that is more dense than itself and sink in a fluid that is less dense than itself.
- If an object has the same density, the object will neither sink nor float but instead stay at the same level in the fluid.

3

Pascal's Principle

- When a force is applied to a confined fluid, an increase in pressure is transmitted equally to all parts of the fluid.
- This relationship is known as **Pascal's principle**.

3

Hydraulic Systems

- You witness Pascal's principle when a car is lifted up to have its oil changed or if you re in a dentist's chair as it is raised or lowered.
- These devices, known as hydraulic (hi DRAW lihk) systems, use Pascal's principle to increase force.

Click image to view movie.

3

Hydraulic Systems

- Hydraulic systems enable people to lift heavy objects using relatively small forces.

$$\text{pressure} = \frac{\text{force}}{\text{area}} \quad \text{or} \quad \text{force} = \text{pressure x area}$$

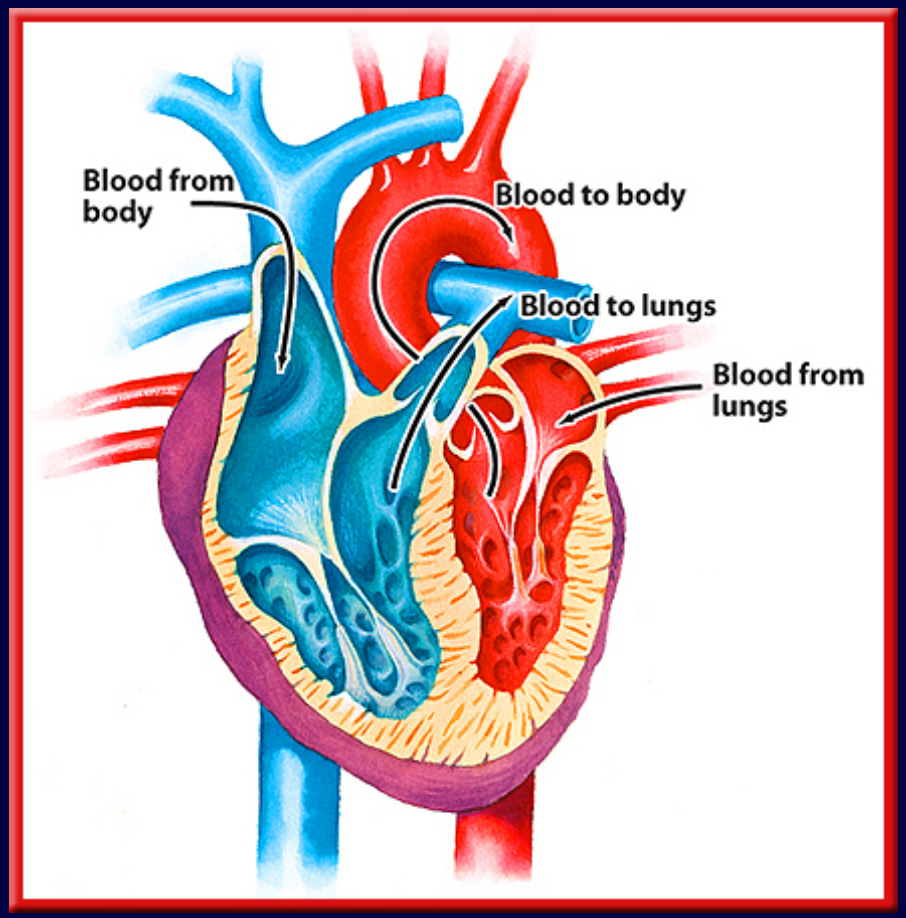
3

Force Pumps

- If an otherwise closed container has a hole in it, any fluid in the container will be pushed out the opening when you squeeze it.
- This arrangement is known as a force pump.

3

Force Pumps



- Your heart has two force pumps.
- One pump pushes blood to the lungs, where it picks up oxygen.
- The other force pump pushes the oxygen-rich blood to the rest of your body.

3

Question 1

You can’t drink juice through a straw while standing on the moon. Why not?

Answer

Juice rises in a straw when you suck on it only because air pressure is pushing down on the juice in the glass. On the moon there is no atmosphere and therefore no air pressure.

3

Question 2

Pressure is equal to the force exerted on an area divided by the total area. That means that if you decrease the area, the force _____.

A. decreases
B. increases
C. stays the same
D. turns around

3

Answer

The correct answer is B. Decreased area equals increased force.

3

Question 3

Describe what is happening to the balloon in this figure?

3

Answer

The balloon is expanding as the hiker carries it up the mountain. The reason is because atmospheric pressure decreases with altitude. With less pressure on the balloon, the gas particles within the balloon are free to expand.

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