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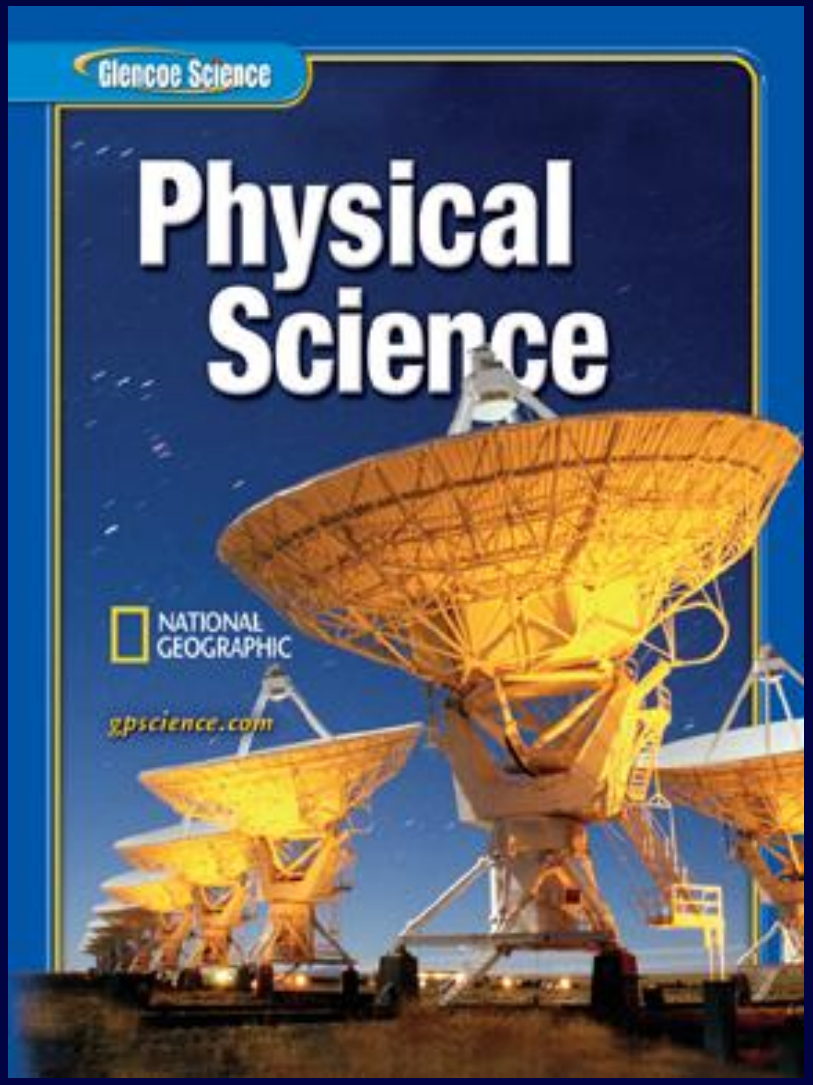
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16

Unit 4: The Nature of Matter

Chapter 16: Solids, Liquids, and Gases

16.1

Kinetic Theory

- kinetic theory is an explanation of how particles in matter behave.

16.1

Kinetic Theory

- All matter is composed of small particles (atoms, molecules)
- These particles are in constant, random motion.

16.1

Thermal Energy and the Kinetic Theory

- Thermal energy- The total energy of a material's particles
- High Temp = High Thermal energy → particles move faster
- Low Temp = Low Thermal Energy→ particles move slowly

16.1

Average Kinetic Energy

- In science, temperature means the average kinetic energy of particles in the substance, or how fast the particles are moving.

- On average, molecules of frozen water at 0°C will move slower than molecules of water at 100°C.

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Average Kinetic Energy

- Water molecules at 0°C have lower average kinetic energy than the molecules at 100°C.

- Molecules will have kinetic energy at all temperatures, including absolute zero.

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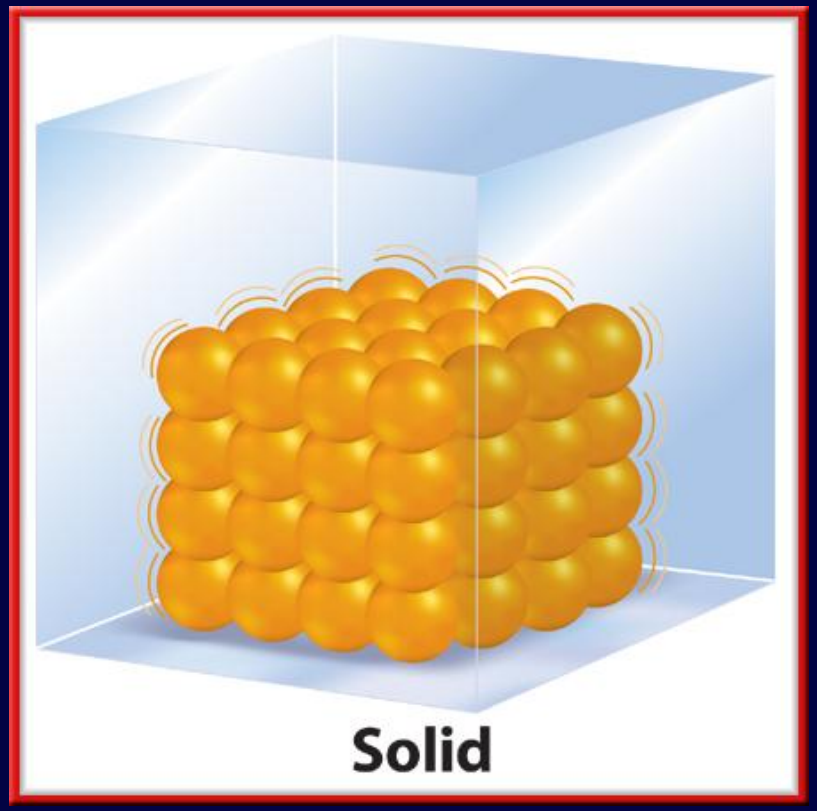
Solid State

- The particles closely packed together.

- Have a fixed shape and volume
- Particles still vibrate



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Liquid State

- What happens to a solid when thermal energy or heat is added to it?
- The particles vibrate faster until they have enough energy to overcome the attractive forces→ liquid
- Have fixed volume … not fixed shape!

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Liquid State

- **melting point** - Temp at which a solid begins to liquefy.
- **A.K.A. - Heat of fusion**

16.1

Liquid Flow

- Particles in a liquid have more kinetic energy than particles in a solid.

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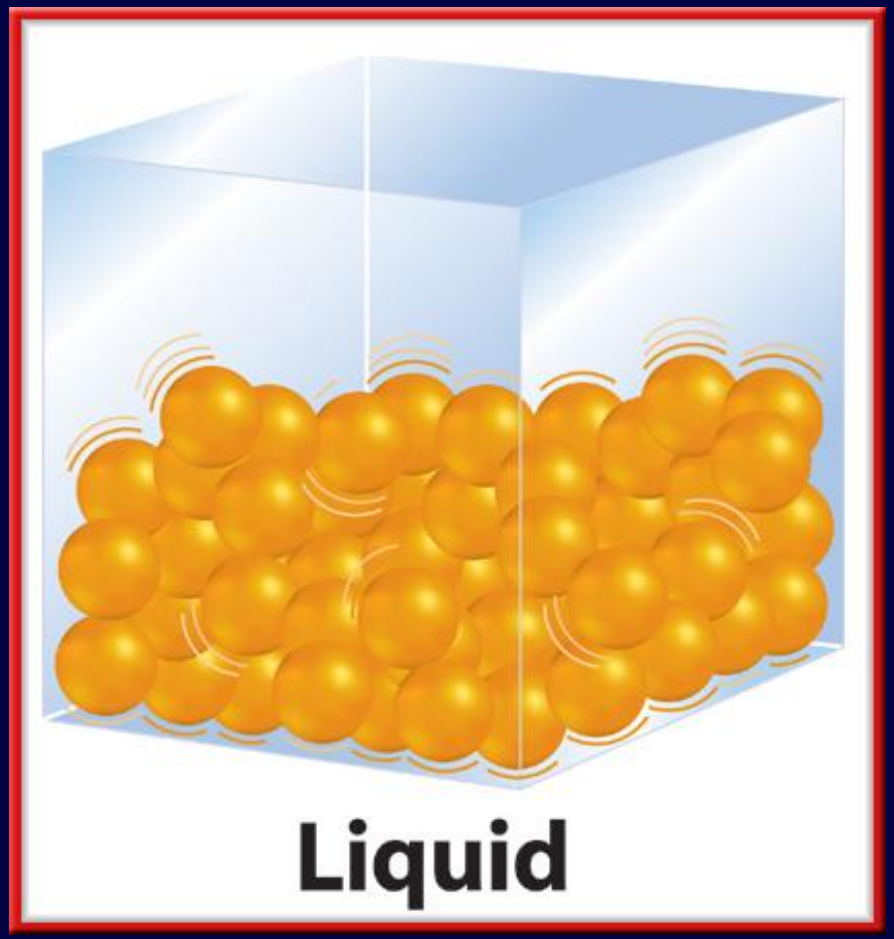
Liquid Flow

- This extra kinetic energy allows particles to partially overcome the attractions to other particles.



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Liquid Flow

- Thus, the particles can slide past each other, allowing liquids to flow and take the shape of their container.

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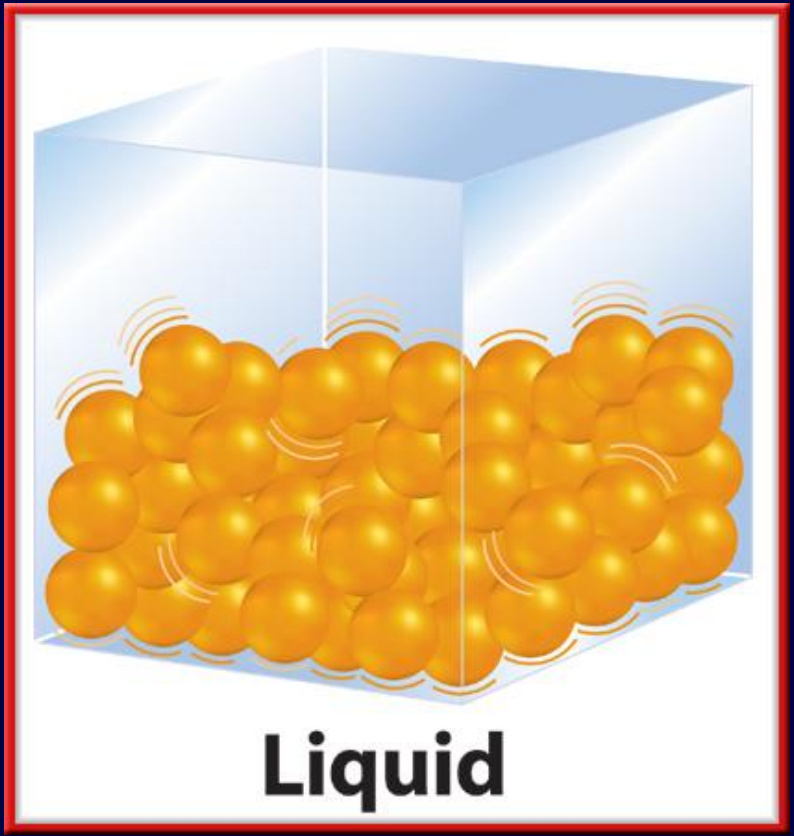
Liquid Flow

- However, the particles in a liquid have not completely overcome the attractive forces between them
- This causes the particles to cling together, giving liquids a definite volume.



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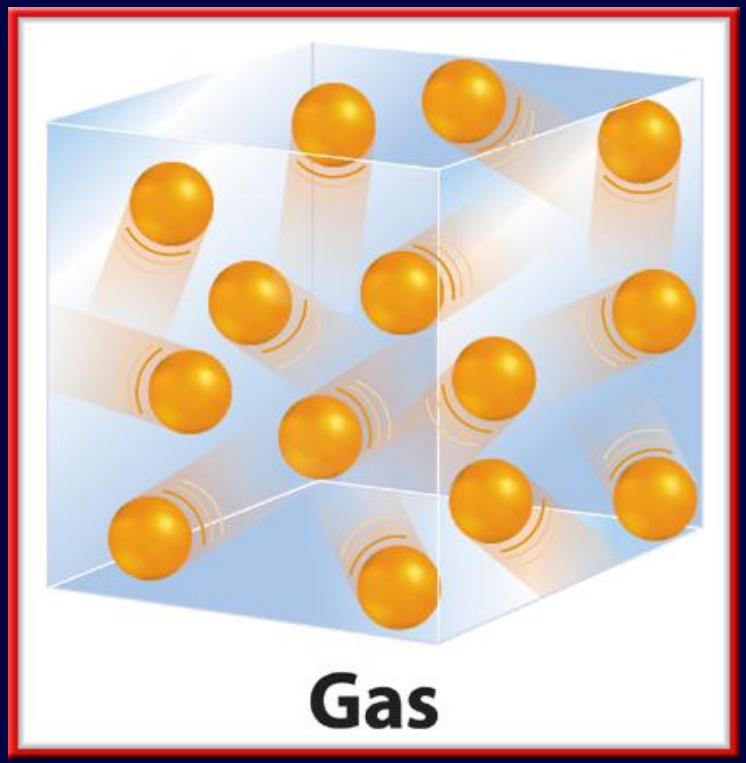
Gas State

- Gas particles have enough kinetic energy to overcome the attractions between them.
- Do not have a fixed volume or shape.
- Therefore, they can spread far apart or contract to fill the container that they are in.



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Gas State

- Some particles are moving faster and have more kinetic energy than others. The particles that are moving fast enough can escape the attractive forces of other particles and enter the gas state.

Click image to view movie

16.1

Gas State

- Vaporization- particles are moving fast enough to escape the attractive forces
- evaporation and boiling.

16.1

Gas State

- **Boiling point** - Temperature at which the liquid starts to boil.
- **A.K.A. - Heat of vaporization**

Click image to view movie

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Gas State

- Pressure of the vapor in the liquid is equal to the external pressure acting on the surface of the liquid.

16.1

Gases Fill Their Container

- **Diffusion** - Spreading of particles throughout a given volume until they are uniformly distributed.

16.1

Thermal Expansion

- The kinetic theory also explains other characteristics of matter in the world around you.
- Have you noticed the seams in a concrete driveway or sidewalk?
- These separation lines are called expansion joints.

16.1

Thermal Expansion

- When concrete absorbs heat, it expands. Then when it cols, it contracts.

- If expansion joints are not used, the concrete will crack when the temperature changes.

16.1

Expansion of Matter

- Particles move faster and separate as the temperature rises. This separation of particles results in an expansion of the entire object, known as thermal expansion.

- **Thermal expansion** –Increase or decrease in the size of a substance when the temperature increased or decreased.

16.1

Expansion of Matter

Increase Temp → Increased particle movement→ Increase in sizes

Decrease Temp→ Decrease particle movement→ Decrease in size

Examples: Solid?

Liquid?

Gas?

16.1

Expansion in Liquids

- A common example of expansion in liquids occurs in thermometers.

- The addition of energy causes the particles of the liquid in the thermometer to move faster.

16.1

Expansion in Gases

- Hot-air balloons are able to rise due to thermal expansion of air.

- The air in the balloon is heated, causing the distance between the particles in the air to increase.

16.1

Expansion in Gases

- As the hot-air balloon expands, and becomes less dense causing the balloon to rise

16.1

Question 1

What are the three assumptions of the kinetic theory?

16.1

Answer

The three assumptions are that all mater is composed of small particles, these particles are in constant random motion, and these particles are colliding with each other and with the walls of their containers.

16.1

Question 2

What is the difference between thermal energy and temperature?

16.1

Answer

Thermal energy is the total amount of kinetic and potential energy of a materials' particles; temperature is a measure of the average kinetic energy of a material's particles.

16.1

Question 3

The temperature at which a solid begins to liquefy is called its _____.

A. boiling point
B. heat of fusion
C. heat of vaporization
D. melting point

16.1

Answer

The answer is D. The heat of fusion is the amount of energy required; melting point is a temperature.

16.2

How do ships float?

- Despite their weight ships are able to float.

16.2

How do ships float?

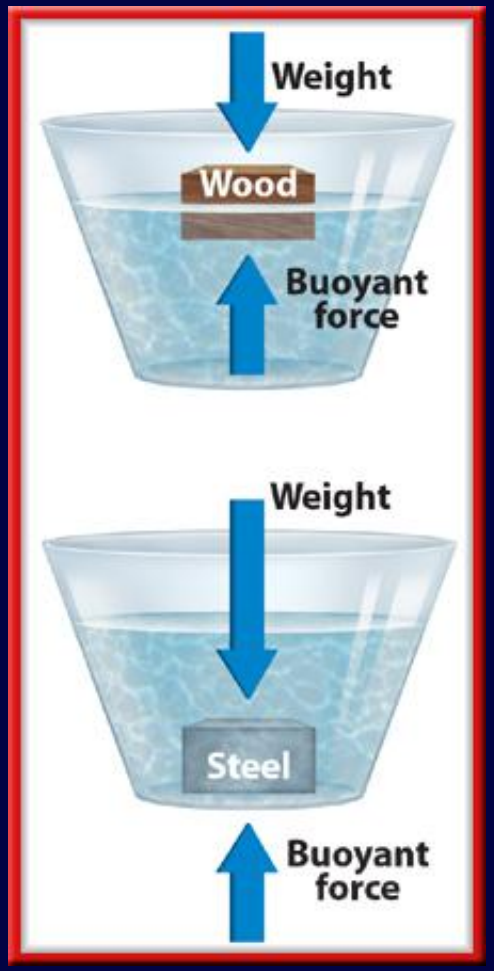
- **Buoyancy** is the ability of a fluid—a liquid or a gas—to exert an upward force on an object immersed in it.

- If the buoyant force is less than the object's weight, the object will sink.

16.2

Archimedes' Principle

- **Archimedes' Principle** buoyant force on an object is equal to the weight of the fluid displaced by the object.



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Density

- An object will float if its density is less than the density of the fluid it is placed in.

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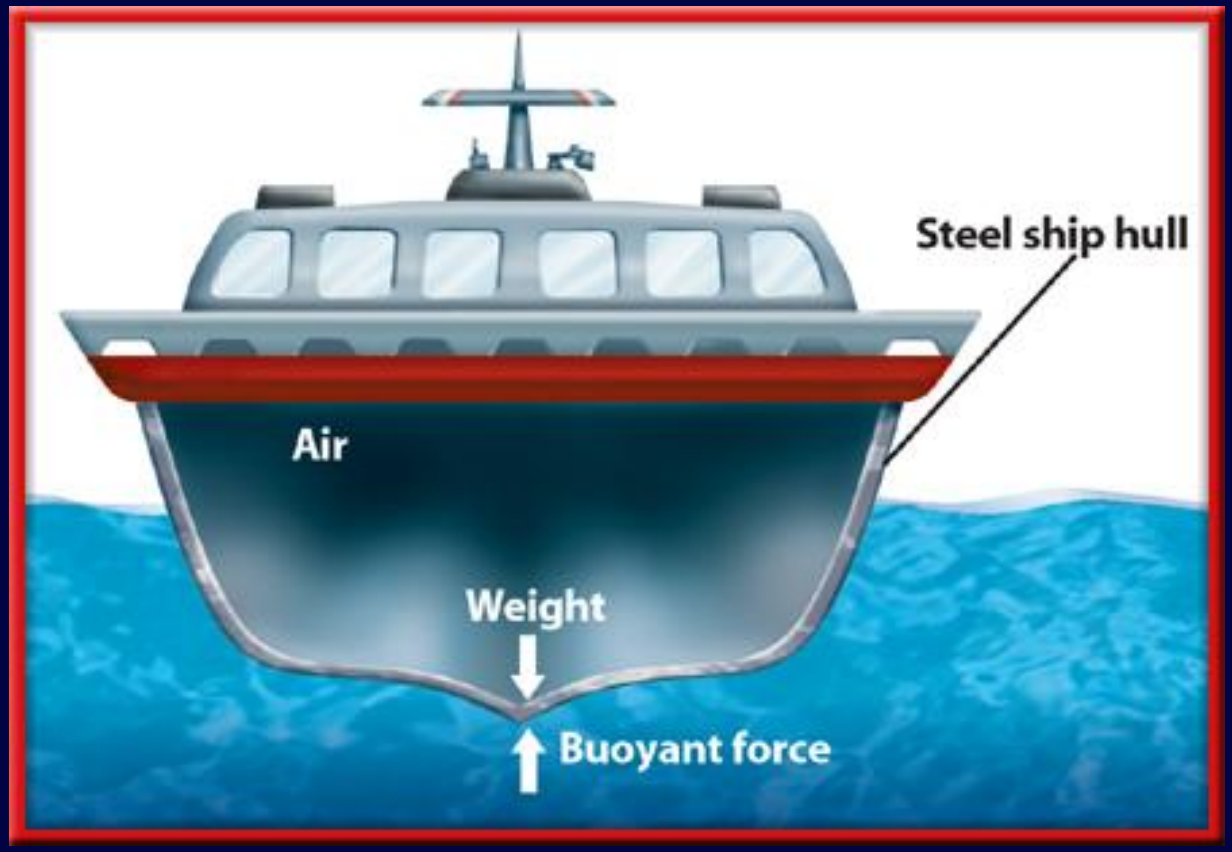
Density



16.2

Pascal's Principle

- **Pressure** is force exerted per unit area.

- **Pascal's Principle-** pressure applied to a fluid is transmitted throughout the fluid.
- Examples:

16.2

Pascal's Principle

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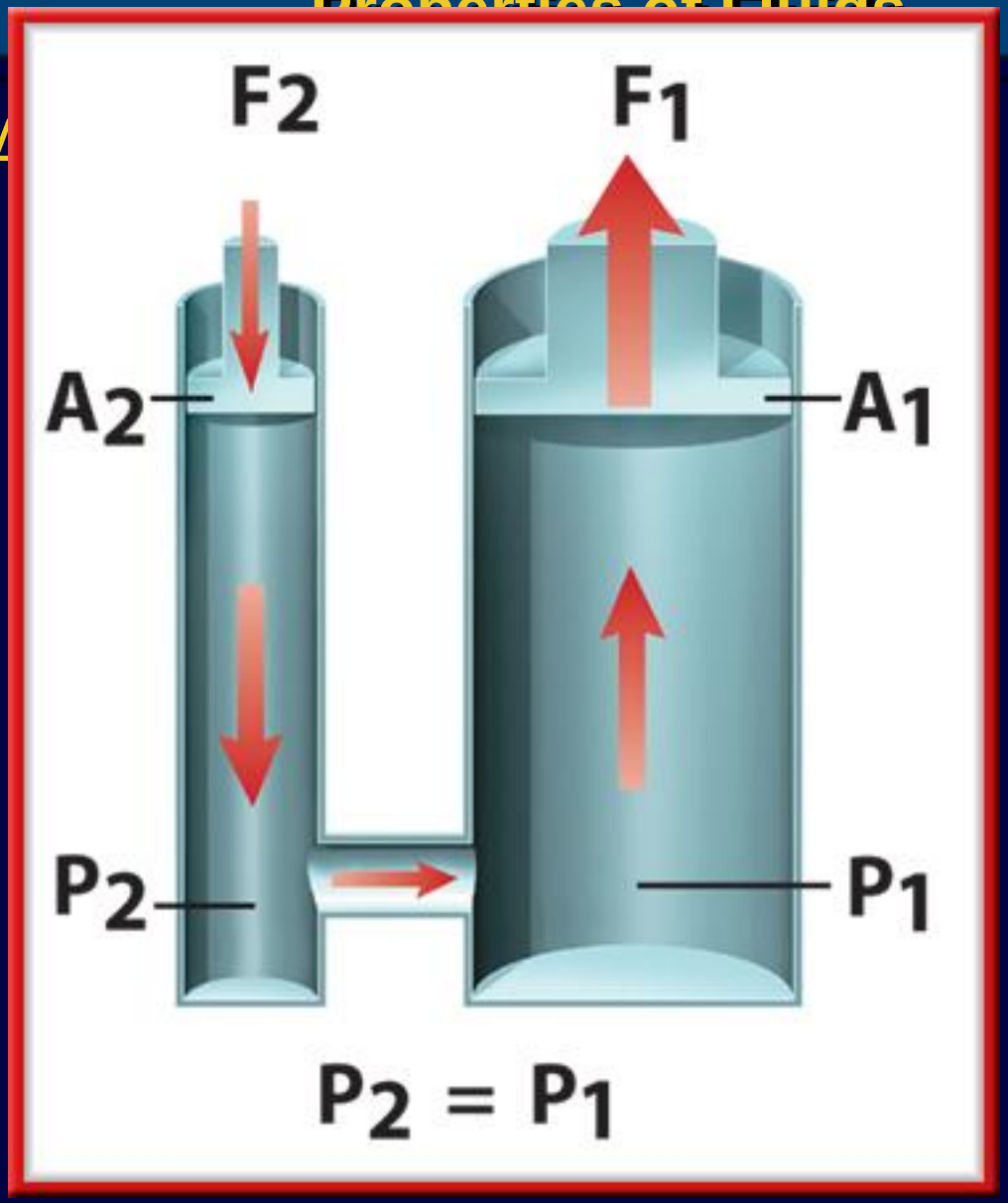

16.2

Bernoulli's Principle

- Bernoulli's principle- as the velocity of a fluid increases, the pressure exerted by the fluid decreases.
- Examples

16.2

Bernoulli's Principle

- The velocity of the air you blew over the top surface of the paper is greater than that of the quiet air below it.

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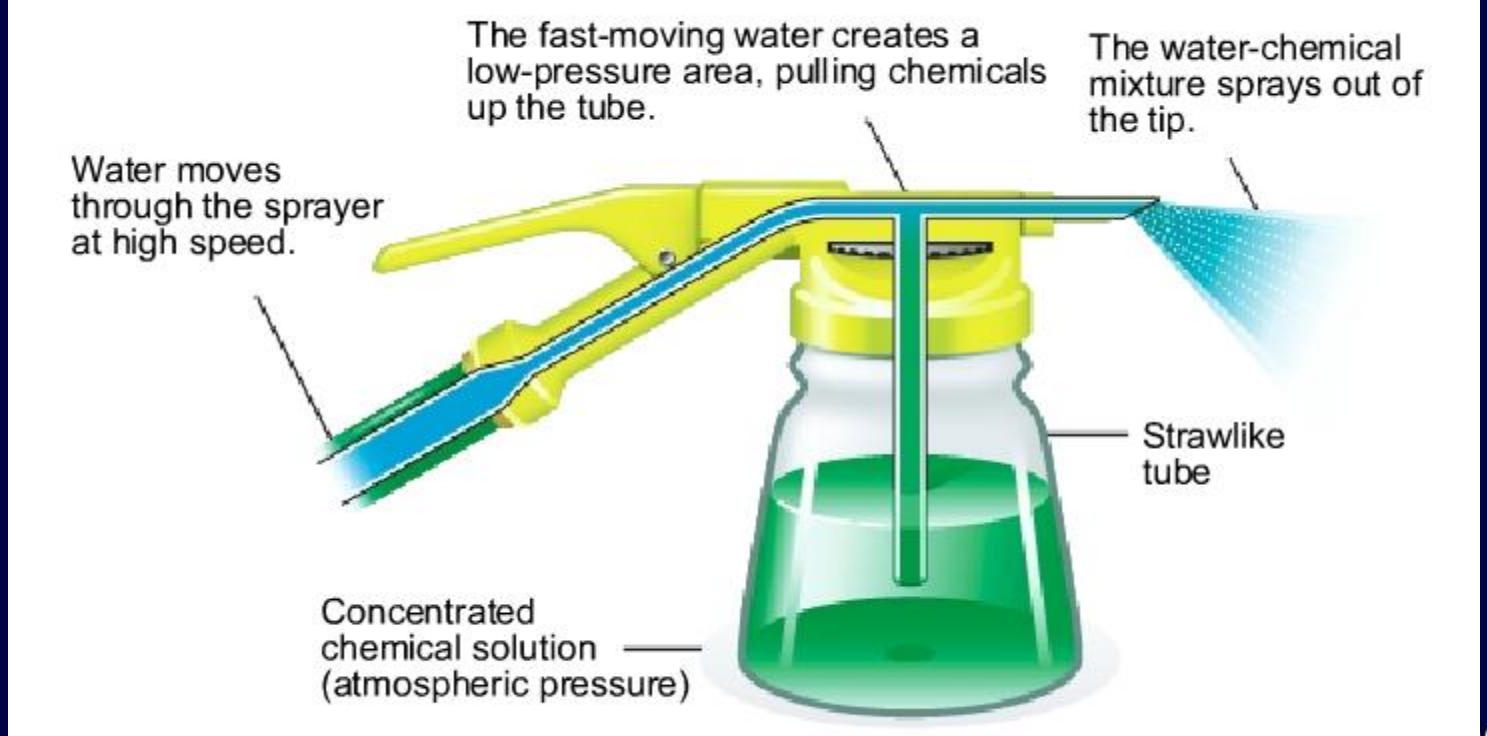
Bernoulli's Principle

Bernoulli's principle was used in designing the hose-end sprayer.



16.3

Fluid Flow

- **Viscosity-** The resistance to flow by a fluid is called.

16.2

Fluid Flow

- flowing particles are pulling the other particles, causing them to flow
- High viscosity= Low Flow, Thick
- Low viscosity= High flow, Thin

16.2

Question 1

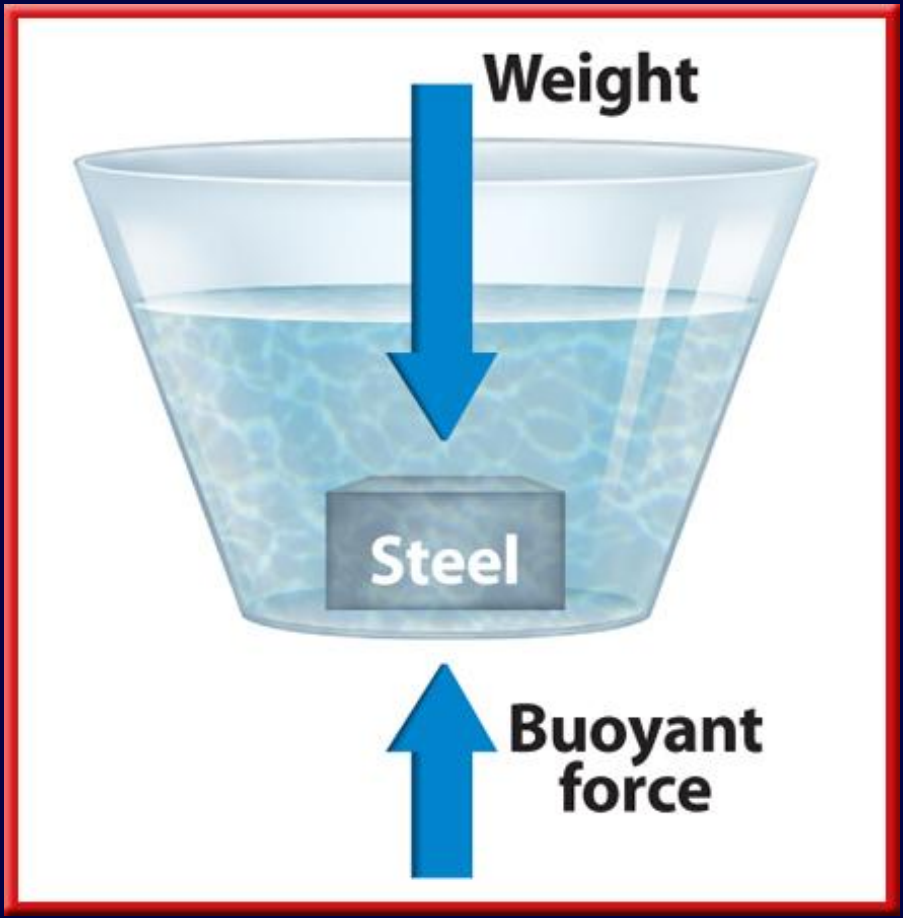
If the buoyant force on an object in a fluid is less than the object's weight, the object will _____.

A. be propelled forward
B. expand
C. float
D. sink

16.2

Answer

The answer is D. Buoyancy is the ability of a fluid to exert an upward force on an object immersed in it.



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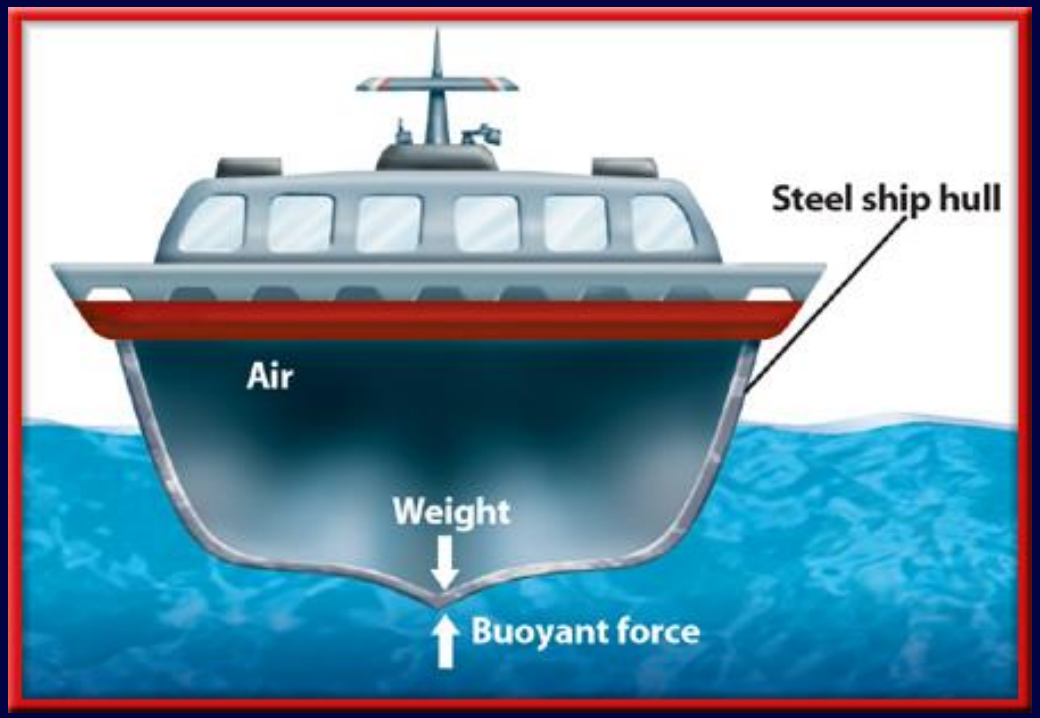
Question 2

Why can a steel ship float in water if a steel block with the same mass sinks?



16.2

Answer

The reason the steel ship can float is because its mass takes up a larger volume, so its density is less than that of the steel block, and less than the density of water.

16.2

Question 3

According to Pascal's principle, _____ applied to a fluid is transmitted throughout the fluid.

A. density
B. pressure
C. temperature
D. volume

16.2

Answer

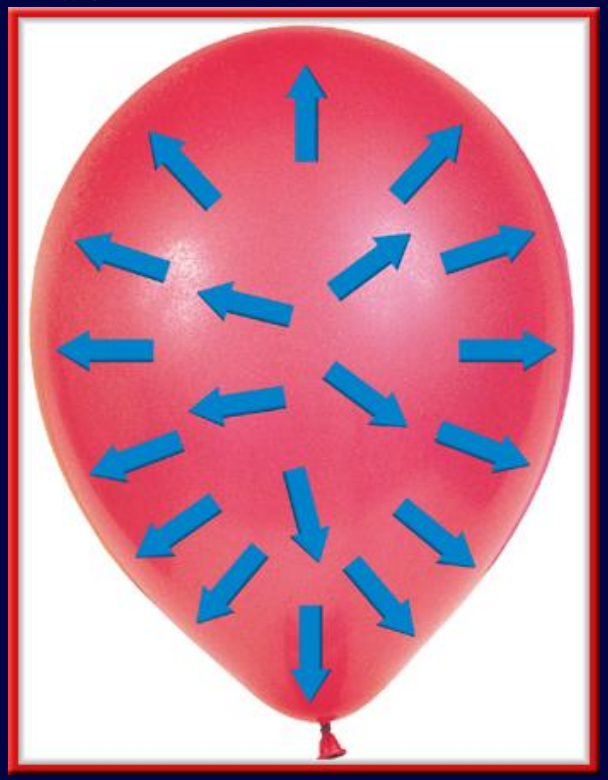
The answer is B. Pressure is a force exerted per unit area. Pressure applied to a fluid is transmitted throughout the fluid

16.3

Pressure

- **Pressure** is the amount of force exerted per unit of area, or
- $P = F/A$.

- They remain inflated because of collisions the air particles have with the walls of their container.



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Pressure

- **Pascal** Unit of Pressure (Pa)

- 1 Pascal = 1 Newton per square meter or
  - 1 N/m^2

16.3

Pressure

- At sea level, atmospheric pressure is 101.3 kPa.

- At Earth's surface, the atmosphere exerts a force of about 101,300 N on every square meter—about the weight of a large truck.

16.3

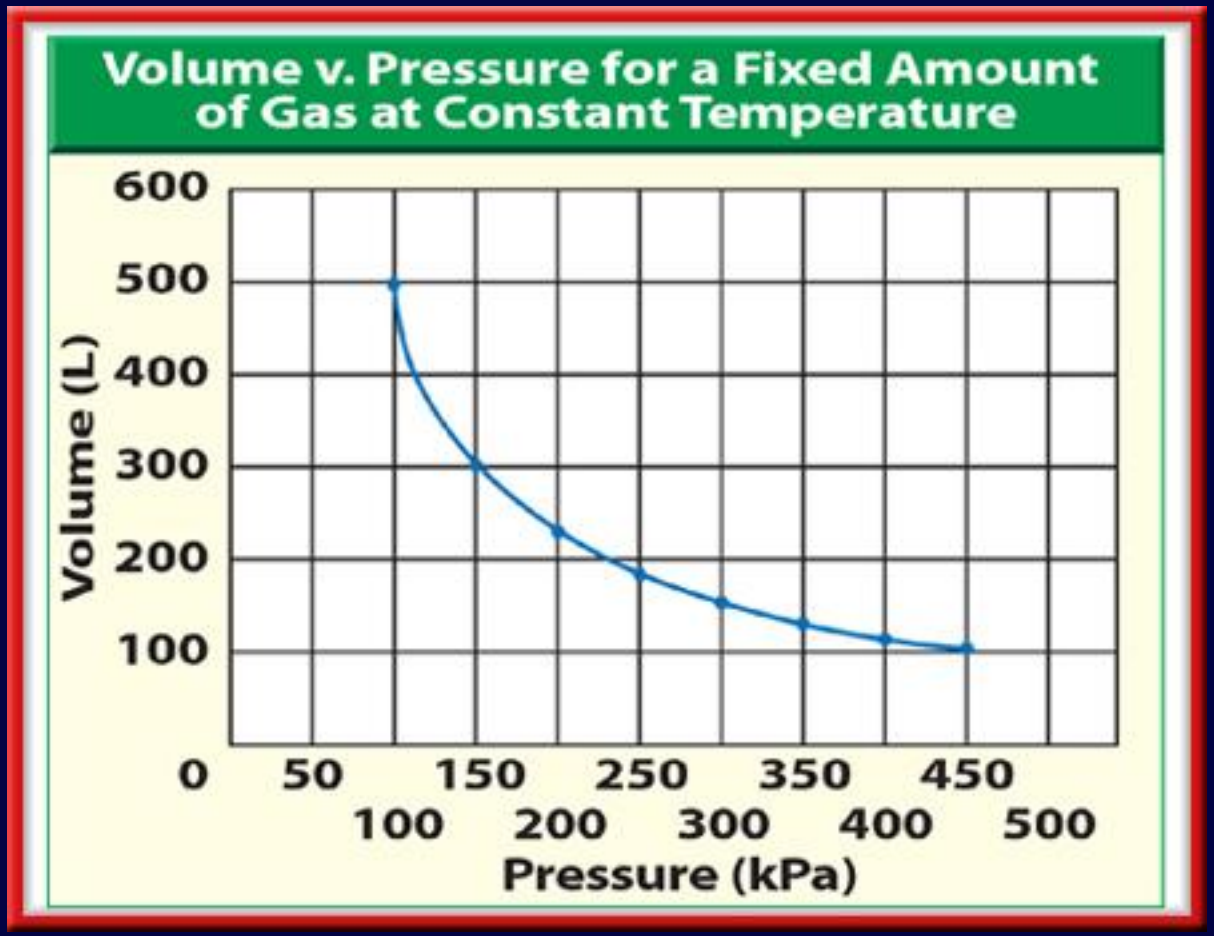
Boyle's Law

- Boyle's law-
  - Decrease size of container→ Increases Pressure
  - Increase size of container→ Decrease Pressure

Temperature must remain constant

16.3

Boyle's Law



16.3

Boyle's Law in Action

- $P_1V_1 = P_2V_2$.

- P- pressure in container
- V- volume in container

16.3

The Pressure-Temperature Relationship

- Temp vs. Pressure

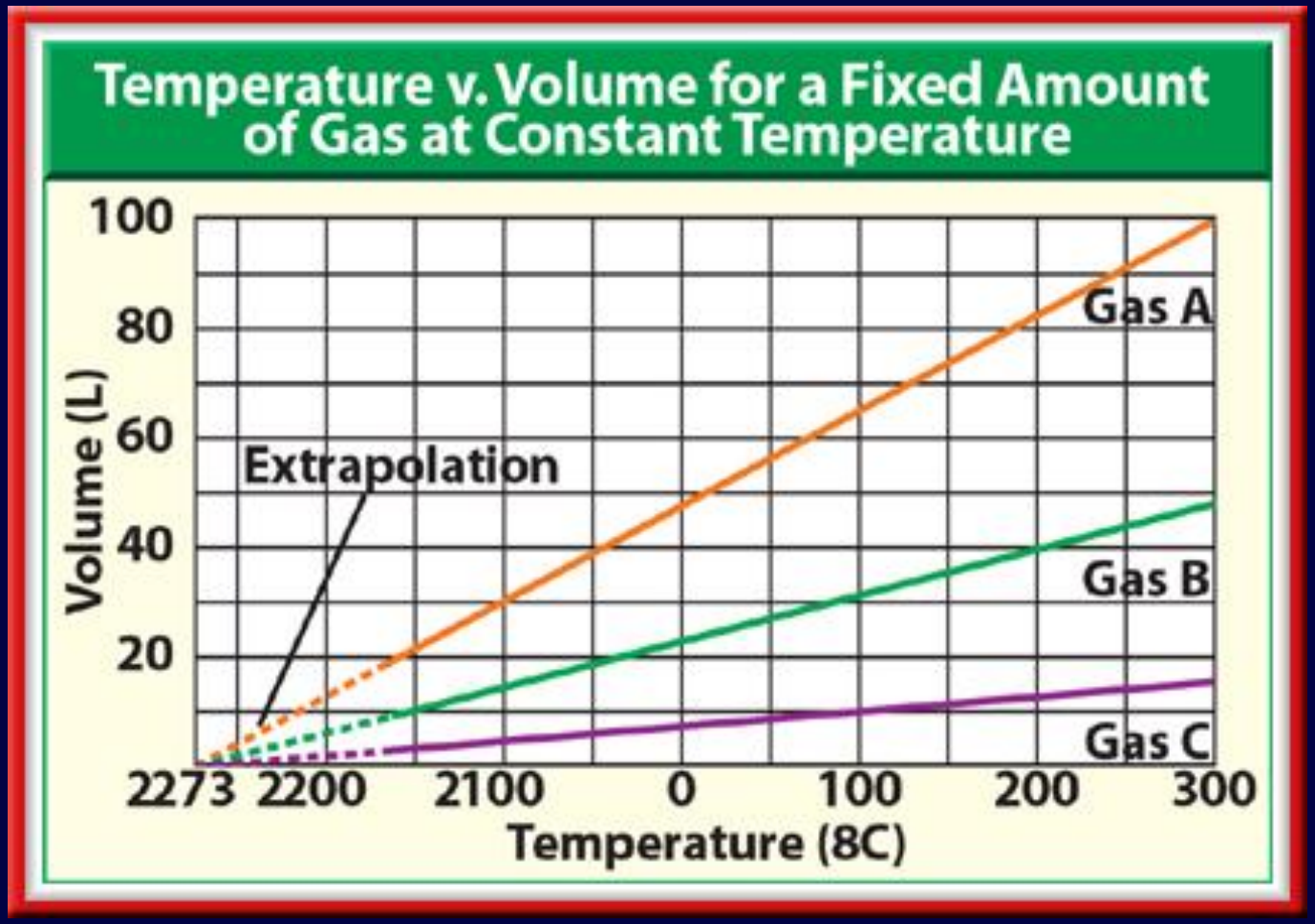
16.3

Charles's Law

- Charles's law- Volume of a gas increases with increasing temperature, as long as pressure does not change

16.3

Charles's Law



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Using Charles's Law

- $V_1/T_1 = V_2/T_2$

V- Volume of gas

T- Temperature of gas

- The pressure must be the same
- Temperature in Kelvin (add 273 to C°)

16.3

Question 1

Compare Boyle's law to Charles' law.

16.3

Answer

Boyle's law relates the pressure of a gas to its volume at constant temperature. As volume increases, the pressure decreases; the reverse is also true. Charles' law relates the volume of a gas to its temperature at a constant pressure. As the temperature of a gas increases, its volume also increases.

16.3

Question 2

What would be the resulting volume of a 3.0-L balloon at 25.0º C that was placed in a container of ice water at 4.0º C, if pressure is constant?

A. 2.8 L
B. 3.0 L
C. 4.8 L
D. 5.0 L

16.3

Answer

The answer is A. Use the formula that relates volume to temperature given in Kelvin, $V_1/T_1 = V_2/T_2$. In this case, $V_1 = 3.0$ L, $T_1 = 25.0^\circ$ C + 273 = 298º K, $T_2 = 4.0^\circ$ C + 273 = 277º K. Solving for V_2 gives 2.8 L.

16.3

Question 3

The SI unit of pressure is the _____, which is N/m^2

A. coulomb
B. tesla
C. Watt
D. pascal

16.3

Answer

The answer is D. The SI unit of pressure is the Pascal; pressures are often given in kilopascals.

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