Gases

Dr. Ron Rusay

Gases

- *Uniformly fill any container.*
- *Exert pressure on its surroundings.*
- *Mix completely with other gases*



Gases:
Pressure, Mass, Volume, Temperature

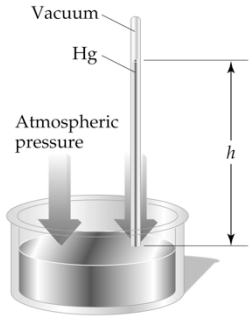
Pressure

- *is equal to force/unit area*
- *SI units = Newton/meter^2 = 1 Pascal (Pa)*
- *1 standard atmosphere = 101,325 Pa*
- *1 standard atmosphere = 1 atm = 760 mm Hg = 760 torr*

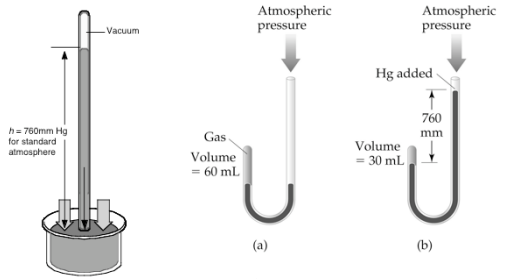
QUESTION

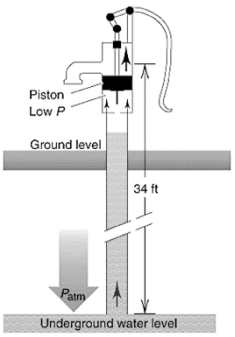
Four bicycle tires are inflated to the following pressures. Which one has the highest pressure? Tire A 3.42 atm; Tire B 48 lbs/sq in; Tire C 305 kPa; Tire D 1520 mmHg. (Recall; 1.00 atm = 760 mmHg = 14.7 lb/sq in = 101.3 kPa)

A. Tire A
B. Tire B
C. Tire C
D. Tire D



Toricellian Barometer





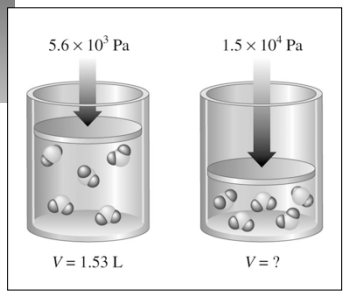
Pressure & Volume
*Boyle's Law**

P-V Relationships

*Boyle's Law**

- *Pressure × Volume = Constant (T = constant)*
  - $P_1V_1 = P_2V_2$ *(T = constant)*
  - $V \propto 1/P$ *(T = constant)*
- *(*Holds precisely only at very low pressures.)*

QUESTION

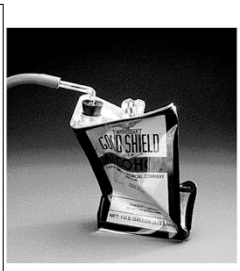


A) 4.0 L
B) 0.57 L
C) 5.7 L
D) 0.4 L

An empty one gallon can is hooked to a vacuum pump.

What do you expect to happen?

Explain why the can collapsed.



Pressure vs. Volume

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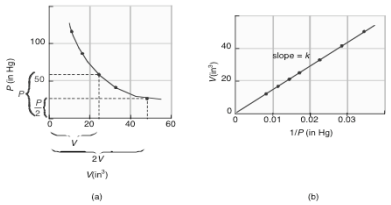
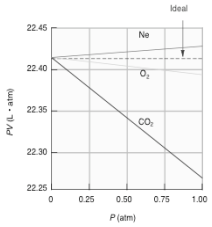


Ideal Gases

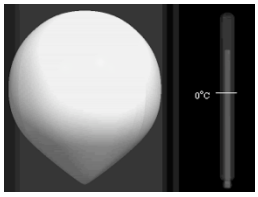
Real vs. "Ideal"

Definition: A gas that strictly obeys Boyle's Law is called an ideal gas.



Temperature & Volume

Temperature & Volume



Charles's Law

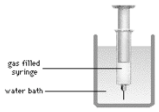
ð *The volume of a gas is directly proportional to temperature, and extrapolates to zero at zero Kelvin.*

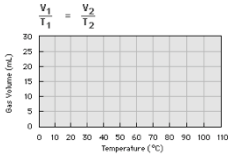
ð $V = \alpha T$ (P = constant)

α = a proportionality constant

Temperature and Volume

(@ constant P)



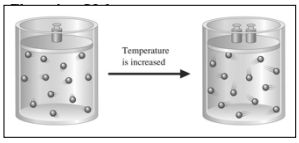


Charles's Law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad (P = \text{constant})$$

Pressure vs. Temperature

constant V)



The Meaning of Temperature

$$(\text{KE})_{\text{avg}} = \frac{3}{2}RT$$

- *Kelvin temperature is an index of the random motions of gas particles (higher T means greater motion.)*

QUESTION

Kinetic molecular theory helps explain the definition of temperature based on molecular motion. Which statement describes an important aspect of this connection?

A) Temperature is inversely related to the kinetic energy of the gas particles.
B) At the same temperature, more massive gas particles will be moving faster than less massive gas particles.
C) As the temperature of a gas sample increases, the average velocity of the gas particles increases.
D) Kinetic energy is directly related to temperature. This is valid for any units of temperature.

Kinetic Molecular Theory

- *1. Volume of individual particles is ≈ zero.*
- *2. Collisions of particles with container walls cause pressure exerted by gas.*
- *3. Particles exert no forces on each other.*
- *4. Average kinetic energy ∝ Kelvin temperature of a gas.*

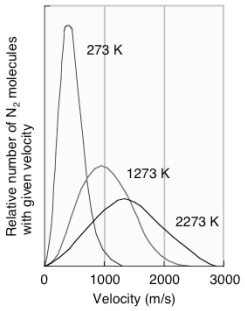
Molecular Motion / Theory

The Meaning of Temperature

Temperature (Kelvin) is an index of the random motions of gas particles (higher T means greater motion.)

$$(KE)_{avg} = \frac{3}{2}RT$$

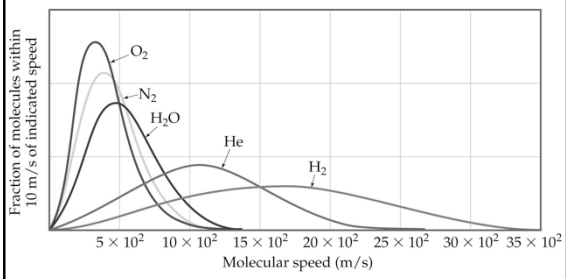
Velocity & Temperature



QUESTION

Why is it critical that the temperature be held constant when applying Boyle's law to changing the pressure of a trapped gas?

A) Gas molecules may expand at higher temperatures; this would change the volume.
B) Changing the temperature causes the gas to behave in non-ideal fashion.
C) Changing the temperature affects the average particle speed, which could affect the pressure.
D) Allowing the temperature to drop below 0°C would cause the trapped gas to no longer follow Boyle's Law.



QUESTION

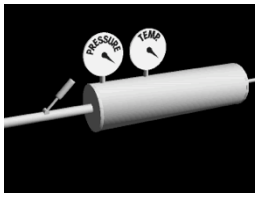
As the temperature of a gas increases, which statement best correlates to information about molecular velocity?

A) The average molecular velocity will increase, but the distribution of molecular velocities will stay the same.
B) The average molecular velocity will stay the same, but the molecular velocity distribution will spread.
C) The average molecular velocity will increase, and the distribution of the molecular velocities will spread.
D) The average molecular velocity will stay the same, and the distribution of the molecular velocities will stay the same.

View Gas Molecules Applet
http://chemconnections.org/Java/molecules/index.html

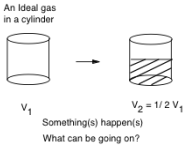
View Molecular Vibrations: IRGasTutor
http://chemistry.beloit.edu/Warming/pages/infrared.html

Changes in Temperature
(ΔPV&T)



Pressure, Volume & Temperature

Applying a Gas Law

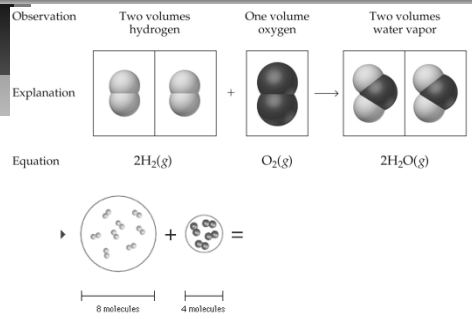


Provide 3 different sets of conditions (Pressure and Temperature) which can account for the volume of the gas decreasing by 1/2.
Cases 1-3 in the handout.

Avogadro's Law

- *For a gas at constant temperature and pressure, the volume is directly proportional to the number of moles of gas (at low pressures).*
- $V = \alpha n$
- α = proportionality constant
- *V = volume of the gas*
- *n = number of moles of gas*

Volume vs. n (moles of a gas)



Volume	22.4 L	22.4 L	22.4 L
Pressure	1 atm	1 atm	1 atm
Temperature	0°C	0°C	0°C
Mass of gas	4.00 g	28.0 g	16.0 g
Number of gas molecules	6.02×10^{23}	6.02×10^{23}	6.02×10^{23}

QUESTION

Each of the balloons hold 1.0 L of different gases. All four are at 25°C and each contains the same number of molecules. Of the following which would also have to be the same for each balloon? (obviously not their color)

A) Their density
B) Their mass
C) Their atomic numbers
D) Their pressure