Ideal Gas Law

- An equation of state for a gas.
- "state" is the condition of the gas at a given time.
  - $PV = nRT$
- [Consider] If the moles remain constant and conditions change then:
  - $P_1V_1/T_1 = P_2V_2/T_2$

QUESTION

If a person exhaled 125 mL of CO_2 gas at 37.0°C and 0.950 atm of pressure, what would this volume be at a colder temperature of 10.0°C and 0.900 atm of pressure?

A) 3.12 mL
B) 0.130 L
C) 0.120 L
D) 22.4 L

Ideal Gas Law

- $PV = nRT$
- R = proportionality constant = 0.08206 L atm K^{-1} mol^{-1}
- P = pressure in atm
- V = volume in liters
- n = moles
- T = temperature in Kelvins
- Holds closely at P < 1 atm

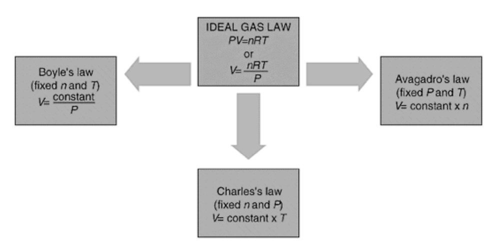
Standard Temperature and Pressure

- "STP"
- For 1 mole of a gas at STP:
- P = **1 atmosphere**
- T = **0°C**
- The molar volume of an ideal gas is **22.42 liters** at STP

QUESTION

If a 10.0 L sample of a gas at 25°C suddenly had its volume doubled, without changing its temperature what would happen to its pressure? What could be done to keep the pressure constant without changing the temperature?

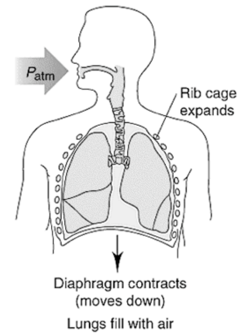
A) The pressure would double; nothing else could be done to prevent this.
B) The pressure would double; the moles of gas could be doubled.
C) The pressure would decrease by a factor of two; the moles of gas could be halved.
D) The pressure would decrease by a factor of two; the moles could be doubled.

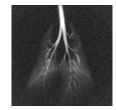


QUESTION

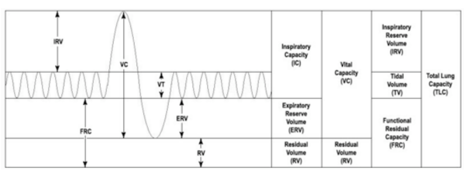
A typical total capacity for human lungs is approximately 5,800 mL. At a temperature of 37°C (average body temperature) and pressure of 0.98 atm, how many moles of air do we carry inside our lungs when inflated? (R = 0.08206 L atm/ K mol)

A) 1.9 mol
B) 0.22 mol
C) 230 mol
D) 2.20 mol
E) 0 mol: Moles can harm a person's lungs.





Do you have enough oxygen to climb Mt. Everest?
http://www.chemcollective.org/applets/everest.php



An average pair of human lungs actually contains only about 3.5 L of air after inhalation and about 3.0 L after exhalation. Assuming that air in your lungs is at 37°C and 1.0 atm

a) *How many moles of O_2* are actually *in a typical breath?*.
b) *What is the mass of O_2 in a typical breath?*.
c) *How much of the O_2 is essential biochemically?*

QUESTION

The primary source of exhaled CO_2 is from the combustion of glucose, $C_6H_{12}O_6$ (molar mass = 180. g/mol.). The balanced equation is shown here:

$$C_6H_{12}O_6\,(aq) + 6\,O_2\,(g) \rightarrow 6\,CO_2\,(g) + 6\,H_2O\,(l)$$

If you oxidized 5.42 grams of $C_6H_{12}O_6$ while tying your boots to climb Mt. Everest, how many liters of O_2 @ STP conditions did you use?

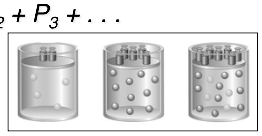
A) 0.737 L
B) 0.672 L
C) 4.05 L
D) 22.4 L

Dalton's Law of Partial Pressures

- *For a mixture of gases, the total pressure is the sum of the pressures of each gas in the mixture.*

$$P_{Total} = P_1 + P_2 + P_3 + \ldots$$

$$P_{Total} \propto n_{Total}$$



$$n_{Total} = n_1 + n_2 + n_3 + \ldots$$

Dalton's Law of Partial Pressures

- *For a mixture of gases, the partial gas pressure and total pressure equal the mole fraction of each gas in the mixture.*

$$P_1 / P_{Total} = n_1 / n_{Total}$$

QUESTION

If the mole fraction of O_2 in our atmosphere at standard conditions is approximately 0.209, what is the partial pressure of the oxygen in every breath you take?

A) 1.00 atm
B) 4.78 atm
C) 159 torr
D) 3640 mmHg

Applying the Ideal Gas Law

- $PV = nRT$
- n = g of gas/ MM_{gas} [MM_{gas} =g/mol]
- PV = (g of gas/ MM_{gas})RT
- MM_{gas} = g of gas(RT)/PV
- MM_{gas} = g of gas/V (RT/P)
- MM_{gas} = density of gas (RT/P)

QUESTION

Under STP conditions what is the density of O_2 gas?

A) Not enough information is given to solve this.
B) 1.31 g/L
C) 1.43 g/L
D) 0.999 g/L

QUESTION

Which sequence represents the gases in order of increasing density at STP?

A) Fluorine < Carbon monoxide < Chlorine < Argon

B) Carbon monoxide < Fluorine < Argon < Chlorine

C) Argon < Carbon monoxide < Chlorine < Fluorine

D) Fluorine < Chlorine < Carbon monoxide < Argon

Applying the Ideal Gas Law

The density of an unknown atmospheric gas pollutant was experimentally determined to be 1.964 g/ L @ 0 ºC and 760 torr.

- *What is the molar mass of the gas?*
- *What might the gas be?*

Applying the Ideal Gas Law

1.964 g/ L @ 0 ºC and 760 torr.
R = 0.08206 L atm K^{-1} mol^{-1}
ºC → K
torr → atm

MM_{gas} = density of gas (RT/P)
MM_{gas} = 1.964 g/ L x 0.08206 L atm K^{-1} mol^{-1} x 273K/ 760 torr x 760 torr/ 1atm

MM_{gas} = 44.0 g/mol

QUESTION

Freon-12 had been widely used as a refrigerant in air conditioning systems. However, it has been shown to be related to destroying Earth's important ozone layer. What is the molar mass of Freon-12 if 9.27 grams was collected **by water displacement**, in a 2.00 liter volume at 30.0°C and 764 mmHg. Water's vapor pressure at this temperature is approximately 31.8 mmHg.

A) 120. g/mol
B) 12.0 g/mol
C) 115 g/mol
D) 92.7 g/mol

QUESTION

The aroma of fresh raspberries can be attributed, at least in part, to 3-(para-hydroxyphenyl)-2-butanone. What is the molar mass of this pleasant smelling compound if at 1.00 atmosphere of pressure and 25.0°C, 0.0820 grams has a volume of 12.2 mL?

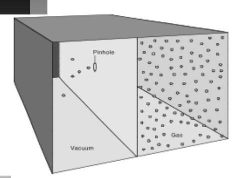
A) 13.8 g/mol
B) 164 g/mol
C) 40.9 g/mol
D) 224 g/mol

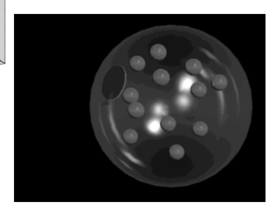
Diffusion and Effusion

Diffusion: describes the mixing of gases. The rate of diffusion is the rate of gas mixing.

Effusion: describes the passage of gas into an evacuated chamber.

Effusion





Effusion and Diffusion

Effusion:

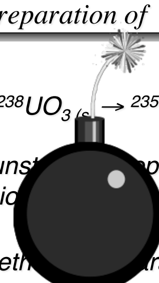
$$\frac{\text{Rate of effusion for gas 1}}{\text{Rate of effusion for gas 2}} = \frac{\sqrt{M_2}}{\sqrt{M_1}}$$

Diffusion:

$$\frac{\text{Distance traveled by gas 1}}{\text{Distance traveled by gas 2}} = \frac{\sqrt{M_2}}{\sqrt{M_1}}$$

Applying Gas Behavior

Preparation of ^{235}U

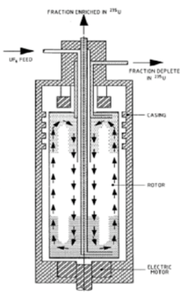


- $^{235}UO_{3\,(s)} + {}^{238}UO_{3\,(s}$ → $^{235}UF_{6\,(g)} + {}^{238}UF_{6\,(g)}$
- *^{235}U is the uns... ...pe that is used in nuclear fissio... ...otope is the most abundant?*
- *Design a meth... ...rate the isomers.*
- *Be very careful*

Applying Gas Behavior
Centrification of $^{235}U/^{238}U$

- $^{235}UF_{6\,(g)} + {}^{238}UF_{6\,(g)}$

U-238, moves toward the outside of the cylinder and U-235, collects closer to the center. The stream that is slightly enriched in U-235 is withdrawn and fed into the next higher stage, while the slightly depleted stream is recycled back into the next lower stage.



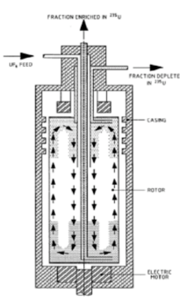
Applying Gas Behavior
Centrification of $^{235}U/^{238}U$

- $^{235}UF_{6\,(g)} + {}^{238}UF_{6\,(g)}$

Applying Gas Behavior
Centrification of $^{235}U/^{238}U$

- $^{235}UF_{6\,(g)} + {}^{238}UF_{6\,(g)}$

February 25, 2008
*AP) — **Iran** starts using new **centrifuges** that can enrich ^{235}U @ 2x the previous speed. The United Nations **nuclear** watchdog agency confirmed that **Iran** was using 10 of the new IR-2 **centrifuges***



Real Gases

Must correct ideal gas behavior when at high pressure (smaller volume) and low temperature (attractive forces become important).

Real Gases

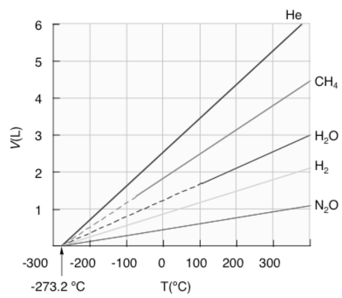
$$[P_{obs} + a(n/V)^2] \square (V - nb) = nRT$$

ϒ corrected pressure → P_{ideal}

ϒ corrected volume → V_{ideal}

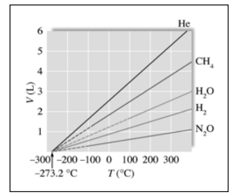
Substance	a (L^2-atm/mol^2)	b (L/mol)
He	0.0341	0.02370
Ne	0.211	0.0171
Ar	1.34	0.0322
Kr	2.32	0.0398
Xe	4.19	0.0510
H_2	0.244	0.0266
N_2	1.39	0.0391
O_2	1.36	0.0318
Cl_2	6.49	0.0562
H_2O	5.46	0.0305
CH_4	2.25	0.0428
CO_2	3.59	0.0427
CCl_4	20.4	0.1383

Real Gases
Volume vs. Temperature @ constant P

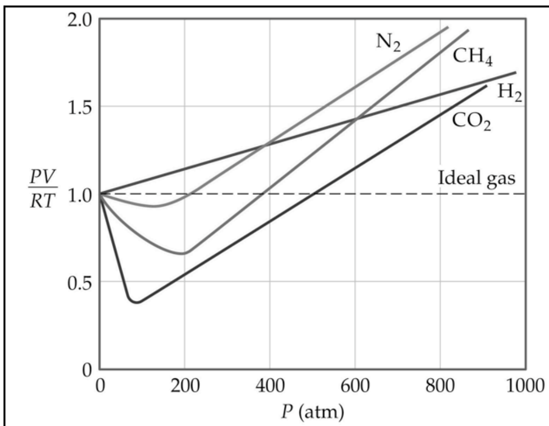


QUESTION

After examining the figure, which statement is accurate, and consistent about the real gases shown at constant pressure?



A) At –273°C all gases occupy nearly the same volume; the different slopes are because of differences in molar masses.
B) At zero Celsius the gases have different volumes because the larger the molecule, the larger the volume.
C) Since the pressure is constant, the only difference in volume that could cause the different slopes is in the attractive forces (Van der Waal's forces).
D) The volumes do not reach zero but if the graph used K instead of °C the volume would reach zero for all the gases.

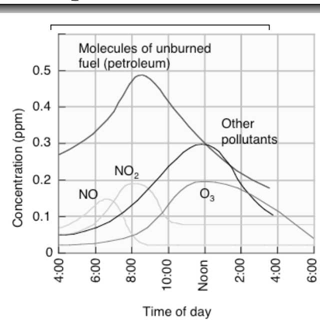


QUESTION

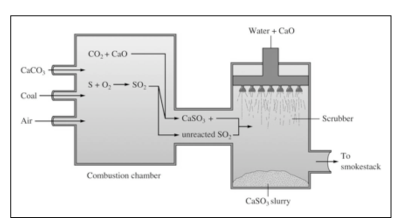
Real gases exhibit their most "ideal" behavior at which relative conditions?

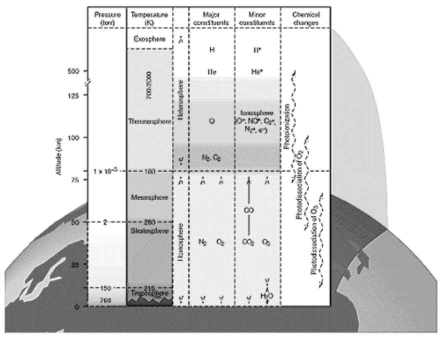
A) Low temperatures and low pressures
B) High temperatures and high pressures
C) High temperatures and low pressures
D) Low temperatures and high pressures

Atmospheric Pollutants



Atmospheric Pollutants





Gases & Airbags

Use of Chemical Reactions and Physical Properties

Airbags

Workshop: Gases II