Gases III

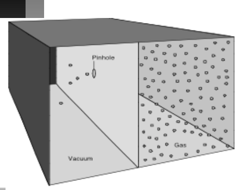
Dr. Ron Rusay

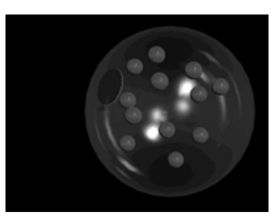
Diffusion and Effusion

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:

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

QUESTION

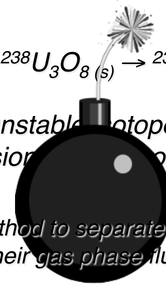
If ammonia gas is released into a tube at the same time that hydrogen chloride gas is released at the opposite end of the tube as illustrated below, the gases will react when they come in contact. This will occur:

A) In the middle of the tube.
B) Closer to the ammonia.
C) Closer to the hydrogen chloride
D) Never. The gases are too light and will never come in contact.

Applying Gas Behavior
Preparation & Separation of ^{235}U

0.7200 % 99.2745 %

- $^{235}U_3O_{8\,(s)} + {}^{238}U_3O_{8\,(s)} \rightarrow {}^{235}UF_{6\,(g)} + {}^{238}UF_{6\,(g)}$
- *^{235}U is the unstable isotope that is used in nuclear fission. Which isotope is the most abundant?*



Design a method to separate the isomers using their gas phase fluorides.

Be very careful.

Applying Gas Behavior
Preparation of UF_6

- $^{235}UF_{6\,(g)} + {}^{238}UF_{6\,(g)}$
- *0.7200 % 99.2745 %*

Milled uranium ore U_3O_8, "yellowcake", is dissolved in nitric acid, yielding a solution of uranyl nitrate $UO_2(NO_3)_2$, which is then treated with ammonia to produce ammonium diuranate $(NH_4)_2U_2O_7$. Reduction with hydrogen gas gives UO_2, which is converted with hydrofluoric acid (HF) to uranium tetrafluoride, UF_4. Oxidation with fluorine gas yields UF_6.

Applying Gas Behavior
Separation of ^{235}U

- $^{235}UF_{6\,(g)} + {}^{238}UF_{6\,(g)}$
- *0.7200 % 99.2745 %*

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

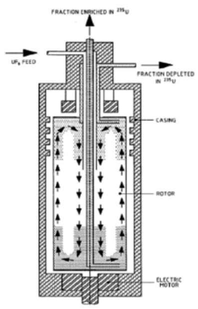
$$^{235}UF_{6\,(g)} / {}^{238}UF_{6\,(g)} = (352)^{1/2} / (349)^{1/2}$$

$$= 1.00429$$

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

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

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

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

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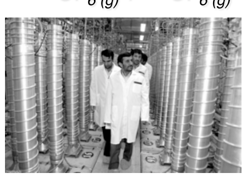
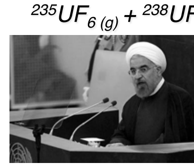


February 2008
*AP) — **Iran** starts using new **centrifuges** that can enrich ^{235}U @ 2x the previous speed. The United Nations **nuclear** watchdog agency confirmed that **Iran** was using 10 of the new IR-2 **centrifuges.***

February 2012
Iranian news reported the use of new, fourth -generation centrifuges and the production of its first domestically engineered uranium fuel rods.

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

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



September 2013
Iranian president, Hassan Rouhani, in a U.N. speech said Iran would never give up the right to enrich uranium, but would swiftly resolve its nuclear standoff with the West.

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

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

July 2014
Iran's supreme leader, Ayatollah Ali Khamenei, says that Iran ultimately needs 190,000 nuclear centrifuges. Britain, China, France, Russia, United States and Germany want to limit Iran to 10,000.

Real Gases

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

Real Gases

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

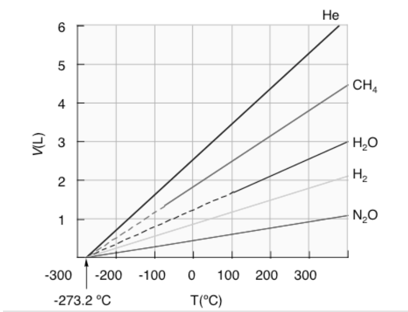
ϒ corrected pressure → P_{ideal}

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

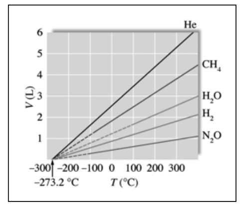
Real Gases

Volume vs. Temperature @ constant P

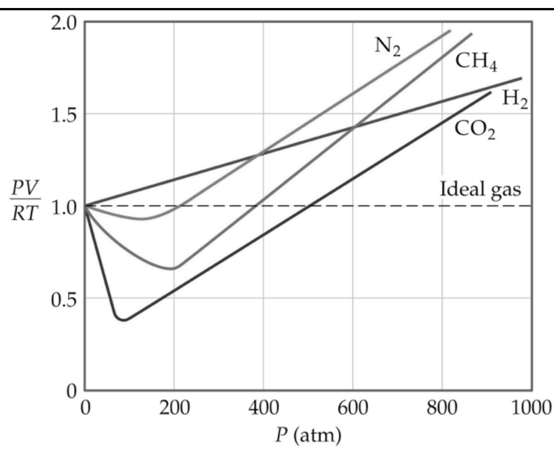


QUESTION

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?

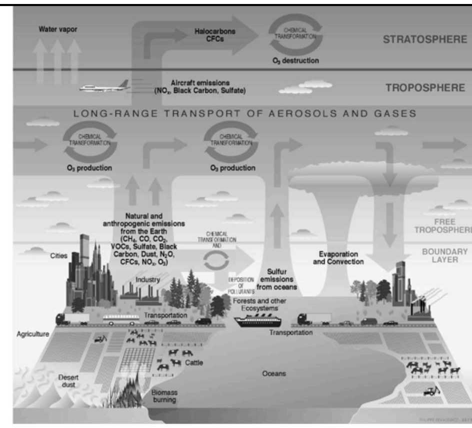
A) Low temperatures and low pressures
B) High temperatures and high pressures
C) High temperatures and low pressures
D) Low temperatures and high pressures

Atmospheric Pollutants

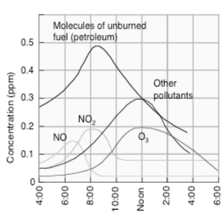
Atmospheric Composition Near Sea Level (Dry Air)*

Component	Mole Fraction
N_2	0.78084
O_2	0.20948
Ar	0.00934
CO_2	0.000345
Ne	0.00001818
He	0.00000524
CH_4	0.00000168
Kr	0.00000114
H_2	0.0000005
NO	0.0000005
Xe	0.000000087

*The atmosphere contains various amounts of water vapor depending on conditions.



Atmospheric Pollutants



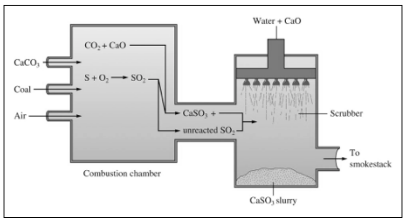
QUESTION

What time of day is it in LA?

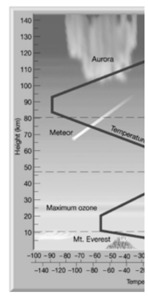
A) 8:00AM B) 4:00PM

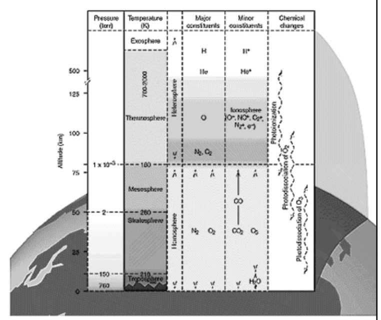
Atmospheric Pollutants

Acid Rain Protection



Air Composition / Altitude





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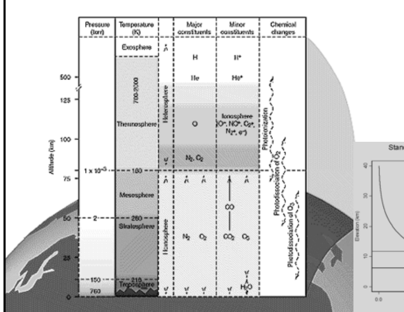

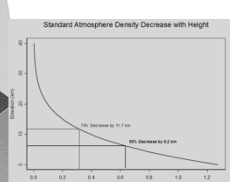

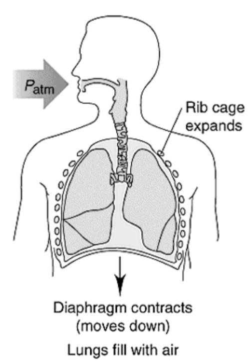

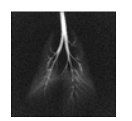

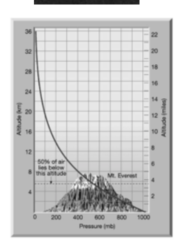

Do you have enough oxygen to climb Mt. Everest?

http://chemconnections.org/chemwiki/everest/everest.htm

Gases & Airbags

Use of Chemical Reactions and Physical Properties

Workshop: Gases II