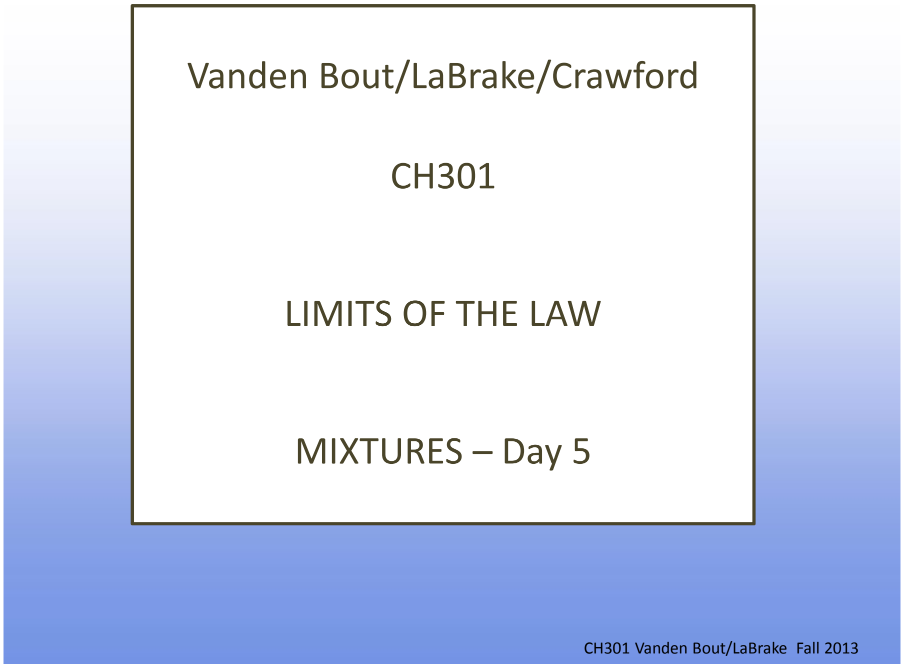
Unit1Day5-VandenBout

Tuesday, September 10, 2013
3:15 PM



Vanden Bout/LaBrake/Crawford

CH301

LIMITS OF THE LAW

MIXTURES – Day 5

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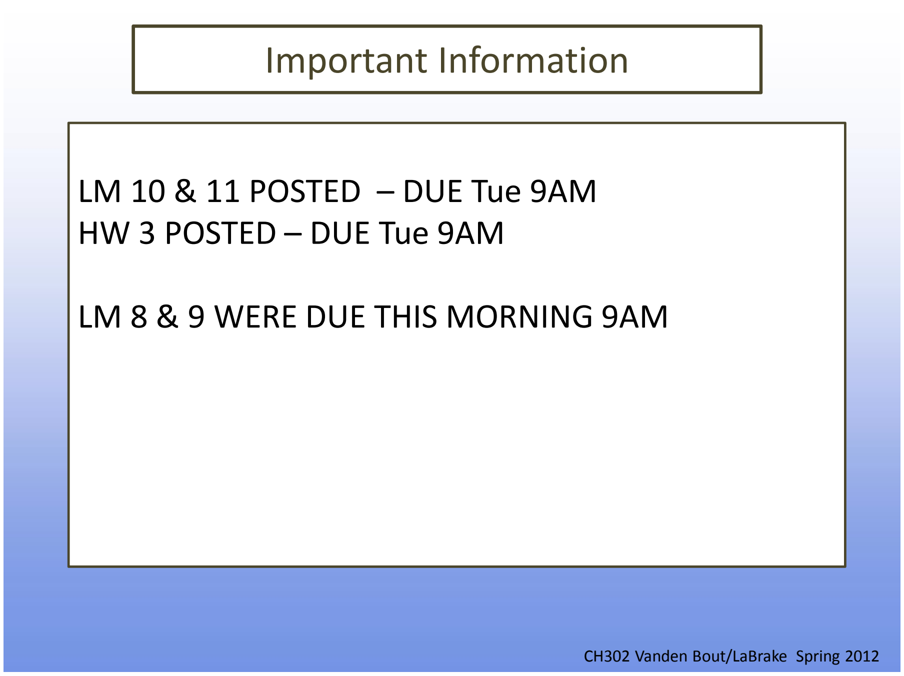

Important Information

LM 10 & 11 POSTED – DUE Tue 9AM
HW 3 POSTED – DUE Tue 9AM

LM 8 & 9 WERE DUE THIS MORNING 9AM

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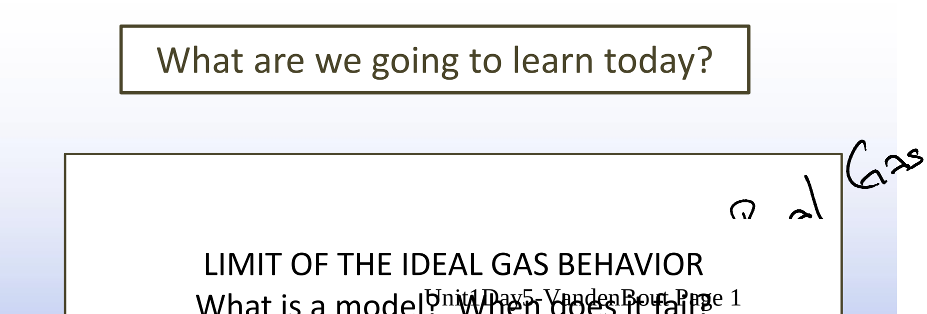
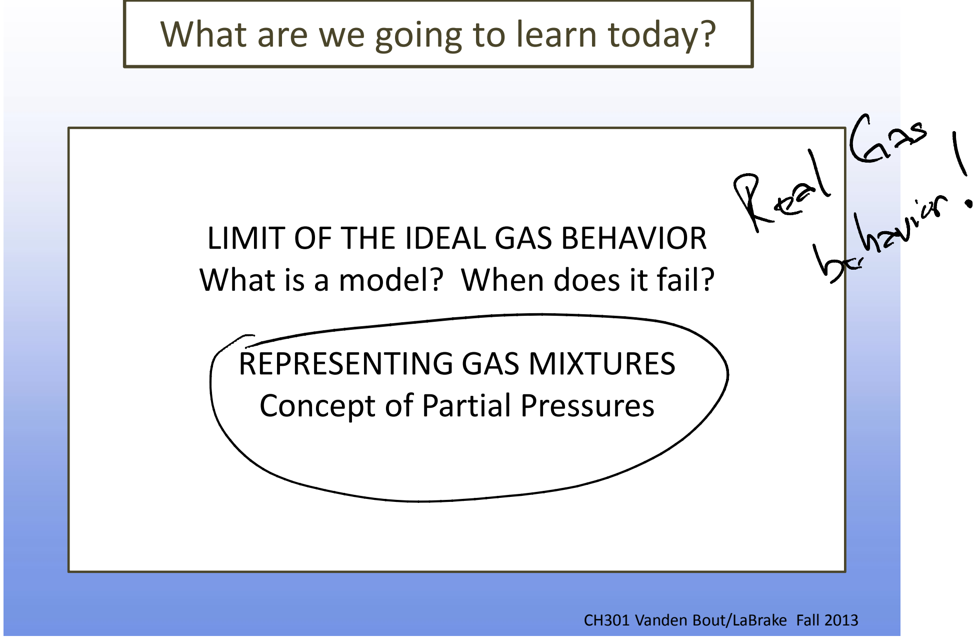


What are we going to learn today?

Real Gas !

LIMIT OF THE IDEAL GAS BEHAVIOR
What is a model? When does it fail?

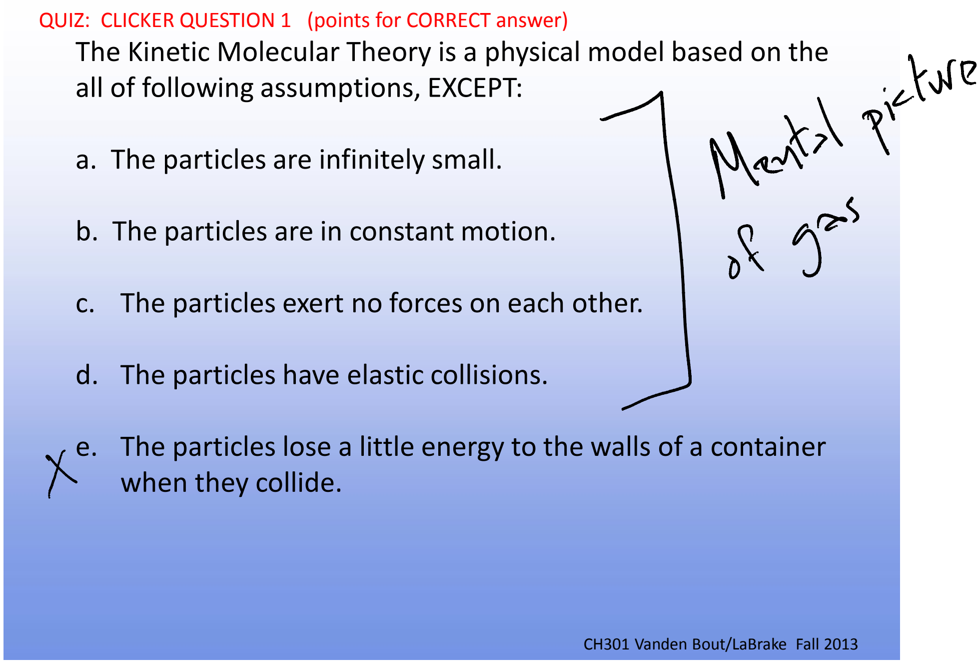


What are we going to learn today?

LIMIT OF THE IDEAL GAS BEHAVIOR
What is a model? When does it fail?

Real Gas behavior!

REPRESENTING GAS MIXTURES
Concept of Partial Pressures



QUIZ: CLICKER QUESTION 1 (points for CORRECT answer)

The Kinetic Molecular Theory is a physical model based on the all of following assumptions, EXCEPT:

a. The particles are infinitely small.

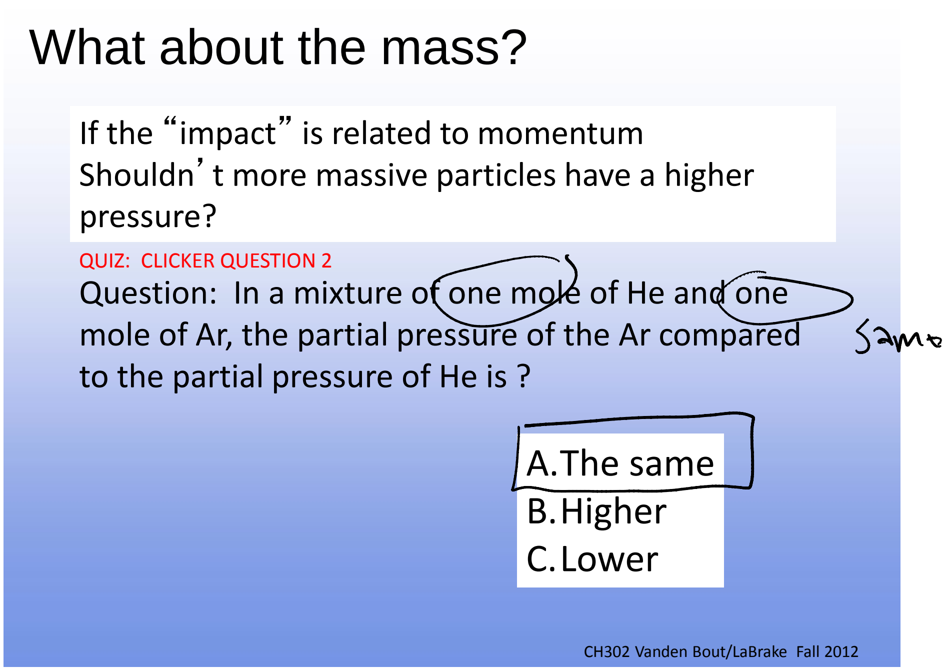
b. The particles are in constant motion.

c. The particles exert no forces on each other.

d. The particles have elastic collisions.

Mental picture of gas

[✓ e.] The particles lose a little energy to the walls of a container when they collide.



What about the mass?

If the "impact" is related to momentum
Shouldn't more massive particles have a higher pressure?

QUIZ: CLICKER QUESTION 2

Question: In a mixture of one mole of He and one mole of Ar, the partial pressure of the Ar compared to the partial pressure of He is ?

Same

- [✓ A.The same]
- B.Higher
- C.Lower

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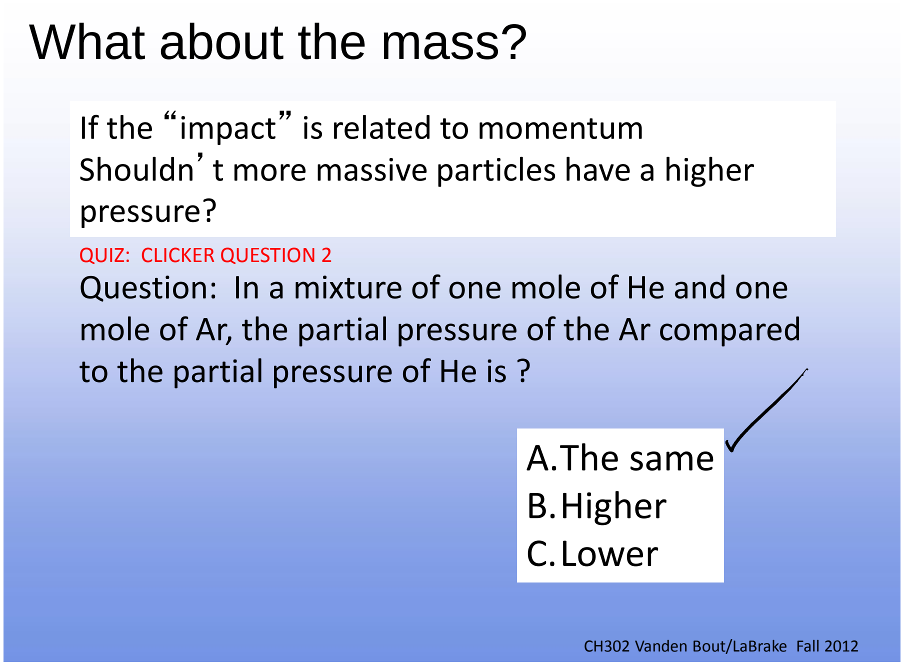

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Engaging in practice matters…

Illusion of Understanding

- Watching isn't the same as doing

Maximize Learning Opportunities

- test your understanding
- make mistakes
- receive coaching

What did we learn last time?

Ideal Gas is amazing – empirically derived and also theoretically derived.

→ physical model

$PV = nRT$

We now know how to relate rms velocity to both temperature and mass

We can apply our knowledge of velocities to diffusion and effusion of gases

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

J

kg mol⁻¹

molar mass

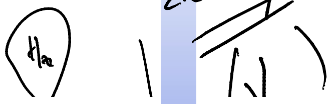
Finally, there is a distribution of velocities. This will have huge implications for future understanding of chemistry!

MASS DENSITY FOR GASES

THINK BACK TO BALLOONS
SAME T & P

same except density.

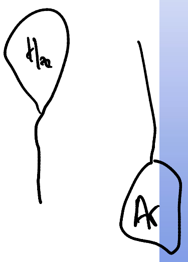
DIFFERENT DENSITIES WERE DUE TO THE *DIFFERENT* MASSES OF THE GAS "PARTICLES"



WHAT ABOUT MIXTURES?

DIFFERENT DENSITIES WERE DUE TO THE *DIFFERENT* MASSES OF THE GAS "PARTICLES"

WHAT ABOUT MIXTURES?

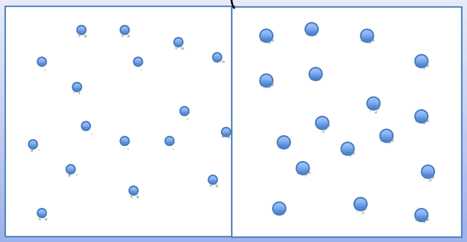


(V_{rms})

How to describe a mixture

wall

Two containers of equal volume separated by a wall



n_{He}= mole He
T = 300K
P = 1 bar

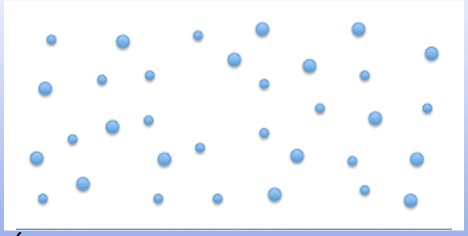
n_{Ar} = mole Ar
T = 300K
P = 1 bar

Same V,P, T therefore $n_{He} = n_{Ar}$

Mixtures

Remove the wall. Total pressure is still 1 bar

Unchanged!



$\overset{\checkmark}{P}V = \overset{\checkmark}{n}RT$. What is n now?
n is the total number of moles of all the gases

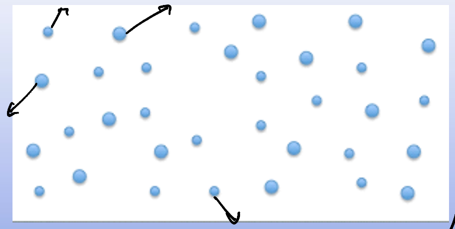
$n=n_{He} + n_{Ar} = 2 \times n_{He}$ ← total gas

$\underset{TOTAL}{PV} = \underset{TOTAL}{n}RT$

Partial Pressure

Total pressure is still 1 bar

P_{He} P_{Ar}



Ar? He?

Where does the pressure come from?
We can think of dividing it up into the
Pressure from the He and the pressure from the Ar

Mixtures

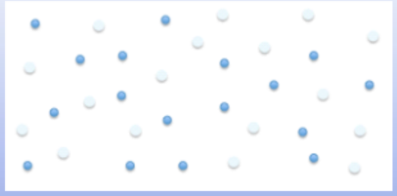
Half the particles are Ar so half the pressure should be from Ar

$P_{Ar}V = n_{ar}RT$

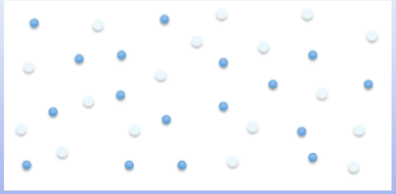
$P_{Ar} = n_{Ar}RT/V$
n_{Ar} is half the number of total moles
So P_{Ar} is half the total pressure

Mixtures

The same is true for He



$PV = n_{He}RT$



$P_{He}V$ = '' \

$P_{He} = n_{He}RT/V$

n_{He} is half the number of total moles

So P_{He} is half the total pressure

Partial Pressure

This is what we call "partial pressure"

In a mixture, the partial pressure of gas "i"

$$\underset{\text{generic}}{P_i} = n_iRT/V$$

Dalton's Law

The sum of all partial pressure must be the total pressure

$$P_{\text{Total}} = \overset{\text{sum over all gases}}{\sum_{i=o}^{n}} P_i$$

$$P_{\text{Total}} = \sum_{i=o}^{n} P_i = P_1 + P_2 + \ldots = \underset{P_1}{\frac{n_1RT}{V}} + \underset{P_2}{\frac{n_2RT}{V}} + \ldots = \frac{\overbrace{(n_1 + n_2 + \ldots)}^{n_{\text{TOTAL}}}RT}{V} = \frac{nRT}{V}$$

Mole Fraction Percentage

What fraction of the particles are gas "i"?

$$P_i = X_i P_{TOTAL} \qquad \left(X_i = \boxed{\frac{n_i}{n_{TOTAL}}} \right)$$

how much fraction is gas i.

$$P_i = \frac{n_i}{\cancel{n_{TOTAL}}} \left(\frac{\cancel{n_{TOTAL}} RT}{V} \right) = \frac{n_i RT}{V}$$

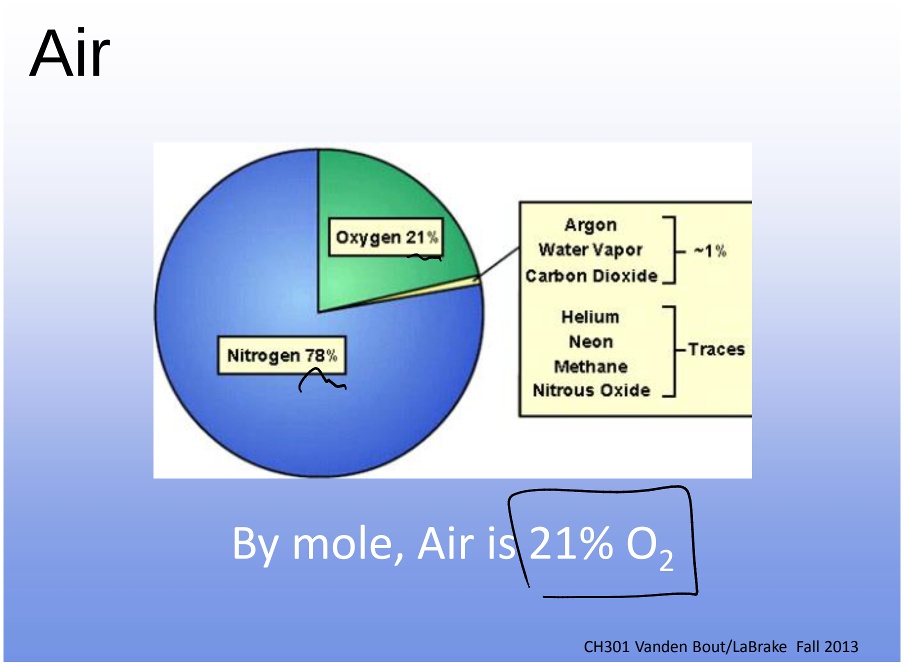
Mole Fraction Percentage

What fraction of the particles are gas "i"?

$$P_i = \frac{n_i RT}{V} = \frac{n}{n} \times \frac{n_i RT}{V} = \frac{n_i}{n} \times \frac{nRT}{V} = \frac{n_i}{n} \times P_{\text{total}} = X_i P_{\text{total}}$$

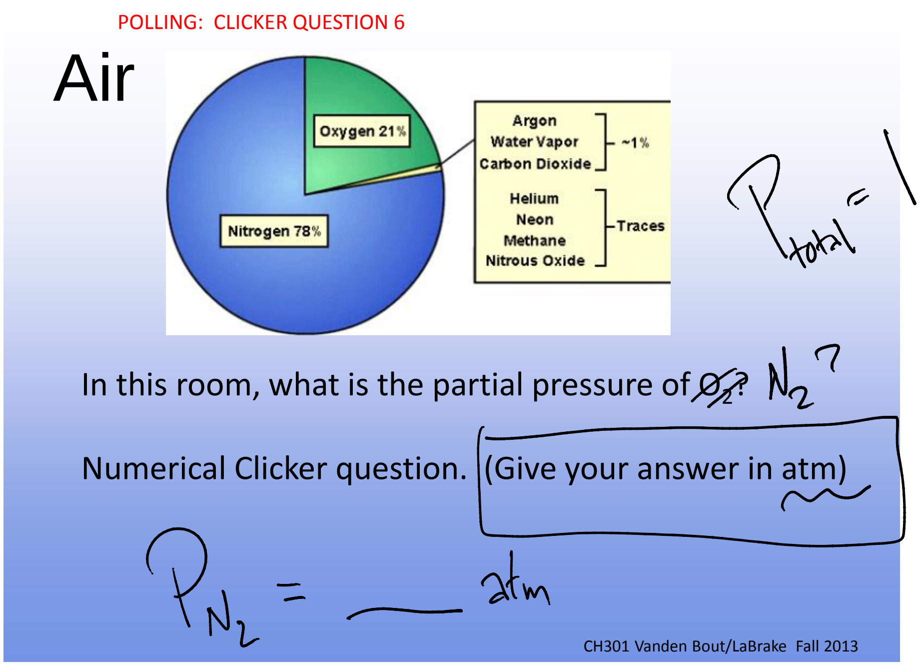
$$X_i = \frac{n_i}{n}$$

Mole fraction X_i is the number of moles i divided by the total number of moles



Air

By mole, Air is $\boxed{21\%\ O_2}$



POLLING: CLICKER QUESTION 6

Air

In this room, what is the partial pressure of ~~O_2~~? N_2?

Numerical Clicker question. (Give your answer in atm)

$P_{N_2} = \_\_\_\_$ atm

$P_{total} = 1$ atm

$$P_i = \boxed{\frac{n_i}{V}} RT$$

Air

Mole fraction of O_2 = 0.21

$P_{02} = X_{O2}P_{total} = (0.21)(1 \text{ atm}) = 0.21 \text{ atm}$

Scientific Model

A description of nature that can predict things about many similar situations

A good model must be able to explain as many characteristics of these observations as possible, but also be as simple as possible

A good model should provide "physical insight"

What happens when a simple model breaks down….?

GROUP WORK HARD SPHERE MODEL

WORK IN GROUPS

DIVIDE UP THE WORK TO COMPLETE THE DATA TABLE AND THEN DISCUSS YOUR RESULTS

$R = .08314 \text{ L-bar K}^{-1} \text{ mol}^{-1}$

$$\% \text{ diff} = \frac{V_{IG} - V_{RG}}{V_{RG}} \times 100\%$$

POLL: CLICKER QUESTION 2

Under what conditions does the Ideal Gas Equation of State, best model the real gas behavior?

Talk amongst yourselves… then answer:

a)High pressure
b)Low pressure
c)High temperature
d)Low temperature

Under what condition does the Ideal Gas Equation of State, best model the real gas behavior?

Low pressure

WHY??

behavior?

Low pressure

WHY??

From the molecular perspective what is going on?

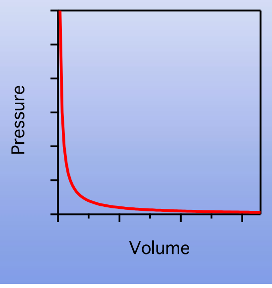
(Low pressure)

From the molecular perspective what is going on?

P increases – V decreases

V = constant/P

As P gets very large,
V goes to zero!



http://ch301.cm.utexas.edu/simulations/gas-laws/GasLawSimulator.swf

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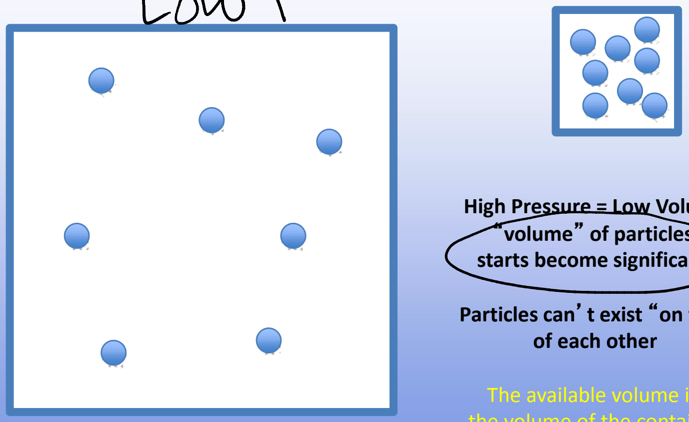
Breakdown of Ideal Gas

LOW P



HIGH P

High Pressure = Low Volume
"volume" of particles starts become significant.

Particles can't exist "on top" of each other

The available volume is
the volume of the container
minus the volume of the particles

Low Pressure = Large Volume
"volume" of particles doesn't matter

P = 1000 atm!   Low P: 1 atm

At high pressure – need to account for volume occupied by the gas particles themselves.

Different sized of particles now matters!

HARD SPHERE MODEL

At high pressure – need to account for volume occupied by the gas particles themselves. Different sized of particles now matters.

$P(\underline{V-nb}) = nRT$

$V= (nRT/P) + nb$

$\boxed{V = V_{IG} + nb}$

–Using this idea what do you think the volume of a mole of H_2 particles is based on the real data you have?

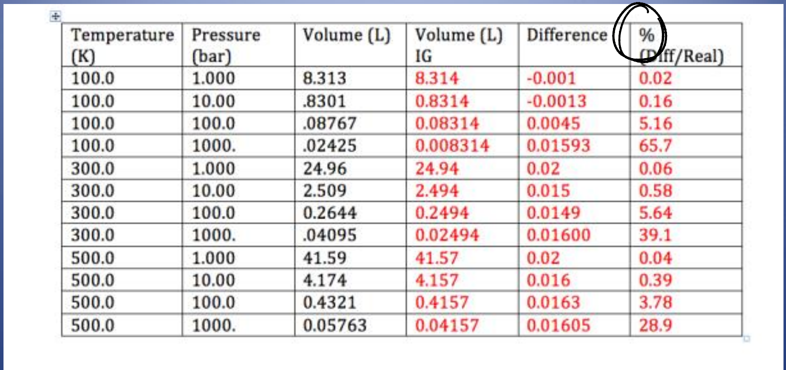
POLLING: CLICKER QUESTION 3

–Using this idea what do you think the volume of a mole of H_2 particles is based on the real data you have?

A. 0.040 L mol^{-1}
B. 0.016 L mol^{-1}
C. 0.00012 L mol^{-1}
D. 0.418 L mol^{-1}
E. 22.46 L mol^{-1}

$V_{RG} - V_{IG} = ?$

Hard Sphere Model



Temperature (K)	Pressure (bar)	Volume (L)	Volume (L) IG	Difference	% (Diff/Real)
100.0	1.000	8.313	8.314	-0.001	0.02
100.0	10.00	.8301	0.8314	-0.0013	0.16
100.0	100.0	.08767	0.08314	0.0045	5.16
100.0	1000.	.02425	0.008314	0.01593	65.7
300.0	1.000	24.96	24.94	0.02	0.06
300.0	10.00	2.509	2.494	0.015	0.58
300.0	100.0	0.2644	0.2494	0.0149	5.64
300.0	1000.	.04095	0.02494	0.01600	39.1
500.0	1.000	41.59	41.57	0.02	0.04
500.0	10.00	4.174	4.157	0.016	0.39
500.0	100.0	0.4321	0.4157	0.0163	3.78
500.0	1000.	0.05763	0.04157	0.01605	28.9

At high pressure, the difference is nearly always 0.016 L
Also true at high temperature!

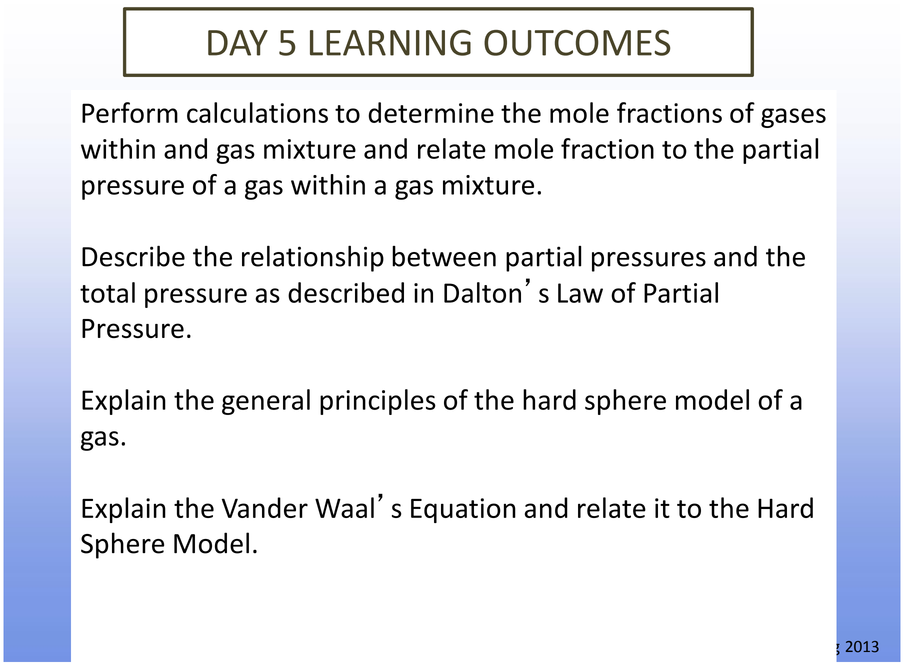
What did we learn today?

Models are not perfect
They let us make predictions– pretty darn good ones in many cases

Ideal Gas Model is very good at low Pressure
Models can be improved adding new correction factors (hard sphere model)

The size of the particles starts to matter at high pressure (and high temperature) as the collisions between the particles become more important.

When ideal gas law holds, we can “imagine” the pressure is coming from individual types of gases



DAY 5 LEARNING OUTCOMES

Perform calculations to determine the mole fractions of gases within and gas mixture and relate mole fraction to the partial pressure of a gas within a gas mixture.

Describe the relationship between partial pressures and the total pressure as described in Dalton's Law of Partial Pressure.

Explain the general principles of the hard sphere model of a gas.

Explain the Vander Waal's Equation and relate it to the Hard Sphere Model.

2013