Name:____________________

Gas Unit – Activity: Modeling Gas Behavior

PART 1

Background Information - Please Read:

The combined gas law or ideal gas law can be arrived at from trying to find a mathematical relationship between the properties of volume, temperature, and pressure for a gas. It is important to realize that many scientific models arrive at physical insight by simplifying the behaviors observed in the real world. As such, there are often limits to their applicability.

Today we will examine some real data to figure out under what conditions the ideal gas law best models real gas behavior (and under which conditions it does not).

Below is a table with some P,T,V data for molecular hydrogen, H_2, gas. For each data point find the volume that the ideal gas law would yield and compare it to that of the actual volume of the gas. The data is all for 1 mole of gas.

Temperature (K)	Pressure (bar)	Volume (L) (real →measured)	Volume (L) (ideal →calculated)	Difference (measured minus ideal)	% Difference (Difference divided by Real Volume)
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

1. Referring to the data table, under what conditions does the Ideal Gas equation best model the real gas behavior? (BE ABLE TO EXPLAIN YOUR ANSWER)

A. high pressure
B. low pressure
C. high temperature
D. low temperature

Explanation: Clearly as the pressure increases the percentage error starts to get very very bad. For P = 1atm the IG is less than 0.1% error at every temperature. It is also sometimes better at low T and sometime better at high T. The really trend is clearly that as P increases the error increases

2. From the molecular perspective what is changing as the pressure is increased (at constant) temperature.

A. The molecules get closer together.
B. The space between the molecules does not change, but the molecules are moving faster.
C. The measured pressure increases.
D. The measured volume decreases.
E. A, C and D are all an acceptable answer for this question.

3. What does the ideal gas law predict for the volume in the limit that the pressure goes to infinity? Does this make physical sense?

It goes to ZERO! It is impossible for something that takes up space and has volume to no longer take up space and have volume.

PART 2 *THE HARD SPHERE MODEL*

The volume of the molecules can't go to zero. Only the "volume between the molecules" can go to zero, in which case one would be describing a condensed phase. Explain the reality is that gases do take up space, and they can be described with a new model. This is done by replacing the volume (which represents ideally the volume in space in which the gas can move, which is approximated at the volume of the container) in the ideal gas equation by the volume minus a constant. The constant is essentially the volume occupied by the gas particles. This would give an equation like the following:

$$P(V-nb) = nRT$$ where b is a constant with units of L mol^{-1}.

If we re-arrange this equation to solve for the volume we find

$$V = nRT/P + nb$$

That is: $V = V_{IG} + nb$ OR $V - V_{IG} = nb$

So if this model were to work we would expect that the real volume and the ideal volume would always be different by a constant. The constant is unique to the gas because it is dependent on the size of the gas particle.

 Name:______________________

1. Look back in the data table at the difference between the measured volume and the calculated volume. Is this difference a consistent value for the majority of the data points?

Yes.

2. If so, what value do you think you would get for the constant b for the data that is given?

Looking at the data $b = 0.015\ L\ mol^{-1}$ (or 0.016.....)

