To get full credit: Show your work and EXPLAIN answers not based on calculation.

Revised September 2, 2018

Exercise A. Repeat Problems 3 and 4 of Homework #1 using the van der Waals equation, using the van der Waals coefficients in Table 1.6.

Problem 1. Assuming the van der Waals equation is accurate, what is the percent error in the ideal gas law for each of the conditions of Problems 3 and 4 of Homework #1?

Problem 2 Consider sealed glass container is filled with pure N_2 and connected to a pressure gauge. At 300 K, the gauge reads 105 Torr, and the ideal gas law applies.

Use logic (not math) to estimate the reading of the gauge (to the nearest Torr) if the gas is cooled to 4.2 K (the boiling point of He).

Exercise B. Consider question 5 on Homework #1. If the atmosphere is 0.04 mole % carbon dioxide and 21 mole % oxygen, calculate the total mass of CO_2 and O_2 in the atmosphere, in kg.

Problem 3. Consider the mass of CO_2 produced in question 6 on Homework #1. How much would the partial pressure of CO_2 in the atmosphere increase from the addition of this mass?

Problem 4. Sketch P vs. molar volume for a gas with $P(\overline{V}-b) = RT$

Exercise C. What is $\langle v^2 \rangle^{1/2}$ and average translational kinetic energy of O_2 molecules at 293 K? Helium atoms?

Problem 5. What is the temperature at which the speed of the O_2 molecules doubles? The speed of the Helium atoms?

Exercise D. Assume you have a balloon that you have blown up and tied off and left to sit out at room temperature in your home. Approximately what is the pressure of the air inside the balloon?

Problem 6. You heat the air inside the balloon to 37 °C (without heating the room air); what is the pressure of the air inside the balloon? Explain!

Exercise E. The vibrational frequency of Na_2 (g) corresponds to $\tilde{\nu}$ =159 cm^{-1} while that of N_2 (g) corresponds $\tilde{\nu}$ = 2358 cm^{-1}. Compute the temperature at which k_BT equals $hc\tilde{\nu}$ for both molecules. Watch your units!

Problem 7. Which has the higher heat capacity at room temperature: Na_2 (g) or N_2 (g)? Explain!

Additional Questions (not graded)

A mixture H_2 and Ar are placed in a container which is being maintained at constant temperature. The total pressure is 1.5 bar. A second pressure gauge is used that places a platinum film between its sensor and the gas. The platinum film is permeable to H_2 but not Ar. The pressure on the second gauge reads 0.5 bar. What is the partial pressure of H_2?

The average distance a molecule or atom travels between collisions with another molecule is called the mean free path, $\lambda = (1.414\ \pi N d^2)^{-1}$, where N is the number density of the gas and d is the diameter of the molecule (0.3 nm for O_2). What is the number density, average distance between collisions, and time interval between collisions for an O_2 molecule at room temperature and 1 bar of pressure? 10^{-6} torr?

Problems 1.26 and 1.27 of the 9th Edition of Atkins and de Paula.