Homework 1 for Physics 1320 January 22, 2022
Due Friday, January 28th.

1. If the temperature is 70 degrees F, how many moles of oxygen are contained in a cubic meter at sea level? How many moles of oxygen are contained in a cubic meter at the death zone (elevation 26,000 feet)? Use Laplace's law, and assume that air is 20% oxygen.

2. How sensitive is Laplace's law to temperature? Assuming the temperature is 60 degrees Fahrenheit, find the atmospheric pressure at the top of the Sandias assuming that the pressure at sea level is 1 atm. Compare this with the same result assuming 70 degrees F. What is the percent change in pressure, $\Delta P/P \times 100$? What is the percent change in pressure as compared to the percent change in temperature $(\Delta P/P) \,/\, (\Delta T/T)$ (Don't forget to convert Fahrenheit to Kelvin)

3. Suppose that in the Magdeburg hemisphere demonstration we replace the hollow sphere with a hollow cube, with a volume of 1 cubic foot. The cube is bisected into two equal halves and the seams are sealed with grease. When the cube is evacuated, what is the maximum force (in lbs) needed to pull the cube apart (at sea level)? Does it matter how the cube is bisected?

4.

When the temperature of a gas is reduced you will begin to notice departures from the ideal gas law. These departures are often characterized by the Van der Waals equation of state

$$\left(P + \frac{a}{\bar{V}^2}\right)\left(\bar{V} - b\right) = RT$$

where $\bar{V} = \frac{V}{n}$ is the volume per mole, and a and b are the "Van der Waals constants".

Table of Van der Waals constants

	$a\ (\mathrm{Nm^4})$	$b\ (\mathrm{m^3})$
He	3.46×10^{-3}	2.38×10^{-5}
H_2	2.47×10^{-2}	2.65×10^{-5}
N_2	1.37×10^{-1}	3.87×10^{-5}
O_2	1.38×10^{-1}	3.18×10^{-5}

Use the computer (i.e. DESMOS - the online graphing calculator) to make a graph of P (in Pa) vs V (in cubic meters) for a mole of diatomic oxygen at 154.6 K. Take your range in volume to go from 0 to 6×10^{-4} m^3, and take your range in pressure to go from 0 to 6×10^6 Pa

5. 10 moles of ideal gas initially at 10 atm and 250 K is expanded isothermally and reversibly to a final pressure of 2 atm. Calculate W, ΔU, and Q in Joules.

6. The same gas in problem 5, starting in the same initial state, is expanded isothermally against a constant external pressure of 2 atm, to a final pressure of 2 atm. Calculate W, ΔU, and Q in Joules for this irreversible process.

7. The same fluid in problem 6, starting in the same initial state, is expanded isothermally to a final pressure of 2 atm. The process is carried out in 4 stages. First the gas is expanded against a constant pressure of 8 atm, to 8 atm. Then the gas is expanded against a constant pressure of 6 atm, to 6 atm. Then the gas is expanded against a constant pressure of 4 atm, to 4 atm. Finally, the gas is expanded against a constant pressure of 2 atm, to 2 atm. Calculate W, ΔU, and Q in Joules for the 4-step process. How do your answers compare to those you obtained for problems 5 and 6 above?