PHYSICS 4B **QUIZ 2** SPRING QUARTER 2018
PROF. HIRSCH **3 Problems** APRIL 23

Information (may or may not be needed):
At STP=0°C, 1atm, ideal gas occupies 22.4L; 1atm=1.013x10^{5}Pa; 1L=10^{-3}m^3;
R=8.314J/(K mol)=0.082 L atm/(K mol); 1u=1.66x10^{-27}kg; k=1.38x10^{-23}J/K
Avogadro's number: N_A=6.02x10^{23}

Problem 1 (10 pts)
On a given day, temperature is 0°C, pressure is 1atm, and relative humidity is 75%. The saturated vapor pressure of water at 0°C is 6.1x10^{2}Pa. The molecular weight of water is 18. For the following questions, answers accurate to 1% are good. Assume all gases are ideal gases.
You put 10g of ice in a container that has volume 1.5L, put a lid on it that seals it, and wait a while.
(a) Assuming air has molecular weight 29, how much air (in g) is there in the container?
(b) What is the relative humidity in the air in the container?
Now you heat up the container and everything inside it to 100°C, and wait a while.
(c) What is the total pressure inside the container, in atm?
(d) How much liquid water (in g) is there in the container?

Problem 2 (10 pts (a, b, c) + 3 pts extra credit (d))
In an ideal gas with molecules of molecular weight 20u, the rms speed of the molecules is 600m/s.
(a) What is the temperature, in K?
Hint: the average kinetic energy of a molecule is (3/2)kT.
(b) If there are 1,000 molecules with speed between 600m/s and 605m/s, how many are there with speed between 1200m/s and 1210m/s?
(c) For every 1,000 molecules with velocity in the x direction v_x btween 599m/s and 601m/s, how many have v_x between -1m/s and 1m/s?
(d) Assume there is 1 mol of this gas in a rectangular container, and the total force exerted on one of the walls of the container by the gas is 9,000N. Estimate the average time between 2 subsequent collisions of a given molecule with this wall. Assume the mean free path is much larger than the dimensions of this container.

Problem 3 (10 pts)
The Young modulus of concrete is E=20x10^{9}N/m^2. That means that to change the length of a concrete block by a fraction x requires a force per unit area xE.
The density of concrete at 10°C is 2,300 kg/m^3. The coefficient of linear thermal expansion of concrete is 12x10^{-6} °C^{-1}.
(a) What is the density of concrete at 50°C, in kg/m^3?
(b) If you lay concrete blocks of length 3m and cross-sectional area 0.5m^2 next to each other at temperature 10°C, what will be the force per unit area on the blocks when the temperature is 50°C?
(c) If you want the force per unit area on the blocks not to exceed 3x10^{6}N/m^2 when the temperature varies between 10°C and 50°C, and you lay the blocks when the temperature is 10°C, what minimum space (in mm) should you leave between the blocks?