Physics 132-2 Test 1

I pledge that I have neither given nor received unauthorized assistance during the completion of this work.

Signature ________________________________

Questions (6 for 7 pts. apiece) Answer in complete, well-written sentences WITHIN the spaces provided.

1. We claim that matter consists of atoms and molecules. What evidence can you cite to support that claim?

2. In lab, we used the relationship between pressure P and temperature T to extract absolute zero. The value for this class for absolute zero is $-318 \pm 8°$. The average for all my classes since 2005 is $-309 \pm 39°$. Is the value for this class consistent with the all-class average? Is the value for this class consistent with the expected value of $-273°$? Be quantitative in your answer.

3. In the calorimetry lab we initially measured the specific heat c with units of $J/kg-K$. We later converted that to the molar specific heat C with units of $J/mole-K$. How did you make that conversion? Explain.

4. You have shown in lab that our model of an ideal gas requires that $PV = \frac{2}{3}N\langle E_{kin}\rangle$. You also went from that equation to $\langle E_{kin}\rangle = \frac{3}{2}k_BT$. What experimental law did you use? Show the steps to go from the first equation to the second.

DO NOT WRITE BELOW THIS LINE.

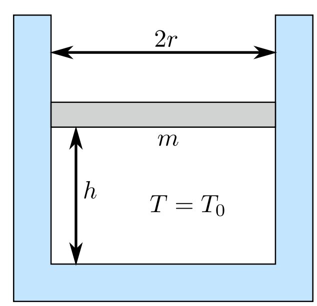
5. What is irreversibility?

6. The molecular masses and temperatures of three ideal, monatomic gases are (a) m_0 and $2T_0$, (b) $2m_0$ and T_0, (c) $6m_0$ and $6T_0$. Rank the gases according to the rms speeds of their molecules, greatest first. Show your reasoning.

Problems (3). Clearly show all reasoning for full credit. Use a separate sheet to show your work.

1. 14 pts. Calculate the multiplicity of an Einstein solid with $N = 1$ and $E_{int} = 5\epsilon$ by directly listing and counting the microstates. Check your work by using the appropriate equation.

2. 20 pts. The circular, lead piston shown in the figure has mass m, radius r and floats on N molecules of compressed air at a temperature of T_0. What is the piston height h in terms of m, r, N, T_0 and any other constants? Start from the forces acting on the piston. Atmospheric pressure is P_0.



3. 24 pts. A room with a volume $V_0 = 100\ m^3$ is filled with an ideal diatomic gas (air) at a temperature $T_0 = 283\ K$ and pressure $P_0 = 1.0 \times 10^5\ N/m^2$. The air in the room is heated to a new temperature $T_1 = 297\ K$ with the pressure remaining at P_0 since the room is not airtight.

    1. What is the initial internal energy of the air in the room?

    2. What is the change in the internal energy of the air in the room? Does this result make sense? Explain. Notice the room is not airtight so air can move freely in and out of it.

Physics 132 Equations

$$\vec{F} = m\vec{a} = \frac{d\vec{p}}{dt} \quad KE = \frac{1}{2}mv^2 \quad ME_0 = ME_1 \quad PE_g = mgh \quad \vec{p} = m\vec{v} \quad \vec{p}_0 = \vec{p}_1 \quad W = \int \vec{F}\cdot d\vec{s} \rightarrow P\Delta V$$

$$Q = C\Delta T = cm\Delta T = nC_v\Delta T \quad Q_{f,v} = mL_{f,v} \quad \Delta E_{int} = Q+W \quad \vec{I} = \int \vec{F}dt = \langle\vec{F}\rangle\Delta t = \Delta\vec{p}$$

$$P = \frac{|\vec{F}|}{A} \quad PV = Nk_BT = nRT \quad \langle KE\rangle = \langle E_{kin}\rangle = \frac{1}{2}m\overline{v^2} \quad \langle E_{kin}\rangle = \frac{3}{2}k_BT$$

$$E_{int} = N\langle E_{kin}\rangle = \frac{3}{2}Nk_BT \quad v_{rms} = \sqrt{\langle v^2\rangle} \quad C_V = \frac{f}{2}N_Ak_B \quad E_f = \frac{k_BT}{2} \quad E_{int} = \frac{f}{2}Nk_BT$$

$$f \equiv \#\text{ of degrees of freedom} \quad E_{atom} = (n_x+n_y+n_z)\epsilon \quad E = \sum_{i=1}^{3N} n_i\epsilon = q\epsilon \quad \Omega(N,q) = \frac{(q+3N-1)!}{q!(3N-1)!}$$

$$q = \frac{E}{\epsilon} \quad S = k_B\ln\Omega \quad \langle x\rangle = \frac{1}{N}\sum_i x_i \quad \sigma = \sqrt{\frac{\sum_i (x_i - \langle x\rangle)^2}{N-1}}$$

$$A = \pi r^2 \quad A = 4\pi r^2 \quad V = Ah \quad V = \frac{4}{3}\pi r^3 \quad \frac{d}{dx}x^n = nx^{n-1} \quad \frac{d}{dx}(u\cdot v) = u\frac{dv}{dx}+v\frac{du}{dx} \quad \frac{d}{dx}\ln x = \frac{1}{x}$$

$$\frac{df(x)}{dx} = \lim_{\Delta x\to 0}\frac{f(x+\Delta x)-f(x)}{\Delta x} \quad \int_a^b f(x)dx = \lim_{\Delta x\to 0}\sum_{n=1}^{N} f(x)\Delta x \quad \frac{d}{dy}f(x) = \frac{df}{dx}\frac{dx}{dy}$$

Physics 132 Constants

$T_{boiling}$ (N_2)	$77\ K$	$T_{freezing}$ (N_2)	$63\ K$
$T_{boiling}$ (water)	$373\ K$ or $100°$C	$T_{freezing}$ (water)	$273\ K$ or $0°$C
L_v(water)	$2.26\times10^6\ J/kg$	L_f (water)	$3.33\times10^5\ J/kg$
L_v(N_2)	$2.01\times10^5\ J/kg$	c (copper)	$3.87\times10^2\ J/kg -°$ C
c (water)	$4.19\times10^3\ J/kg-K$	c (steam)	$0.69\ J/kg-K$
c (iron)	$4.5\times10^2\ J/kg-k$	c (aluminum)	$9.0\times10^2\ J/kg-K$
ρ (water)	$1.0\times10^3 kg/m^3$	P_{atm}	$1.01\times10^5\ N/m^2$
k_B	$1.38\times10^{-23}\ J/K$	proton/neutron mass	$1.67\times10^{-27}\ kg$
R	$8.31 J/K-mole$	g	$9.8\ m/s^2$
$0\ K$	$-273°$ C	$1\ u$	$1.67\times10^{-27}\ kg$
Gravitation constant	$6.67\times10^{-11}\ N-m^2/kg^2$	Earth's radius	$6.37\times10^6\ m$
e electronic charge	$1.6\times10^{-19}\ C$	$k_e = 1/4\pi\epsilon_0$	$8.99\times10^9\ N-m^2/C^2$