Physics 7b
Fall 2006
Midterm 1
R. Packard

Work all problems. Introduce and clearly define algebraic symbols to represent all physical quantities. Do not perform numerical work until you have a final algebraic answer within a box. Check the dimensions of your answer before inserting numbers. Work the easiest parts first, and the next hardest, etc. If you do not understand the question ask the proctor for assistance. All problems are weighted equally.

$k_B=1.38\times10^{-23}$ J/K, $N_A=6.02\times10^{23}$, latent heat of fusion of water 3.3×10^{5} J/kg, specific heat of ice, 2100J/kgC^o, specific heat of liquid water 4186J/kgC^o, $\sigma=5.6\times10^{-8}$ W/m^{2}K^4

When considering gas processes you may assume the gas follows the ideal gas law.

Name____

SID____

Sect. # or day and time ___________________________

TA name (if known)_______________________________

1._____

2._____

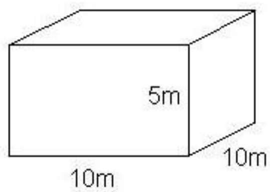
3._____

4._____

5._____

Total______

Problems 1,2, and 3 all are based on the same "house" described in problem 1.



1. Consider a house with a square "footprint" (i.e. base) 10m on each side and height 5m. Air is ~80% N_2 with a molecular weight M_W=28g/mole

a. (5pts) Estimate how many air molecules fill the interior space of the house when the inside temperature is 20°C. Tell what assumptions you made for the estimate.

b. (5pts) The walls of the house have a linear expansion coefficient $\alpha=1\text{x}10^{-5}/^{o}\text{C}$. If the temperature of the walls changes by 10°C, what is the fractional change in the interior volume?

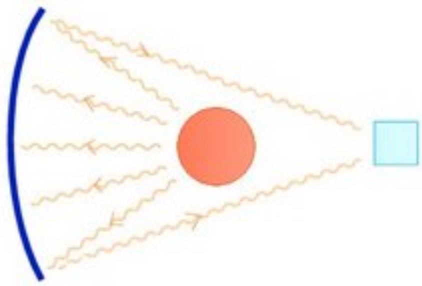
c. (5pts) Assuming that the house is not air tight, what is the fractional change in the number density of molecules (i.e. number per unit volume) corresponding to this 10°C temperature rise.?

2. a. (5pts) When the inhabitants of the house go away on vacation they turn off the heat. When they return they turn it back on. How many kWhrs of energy does it take to raise the temperature of the air in the house by $15^{o}C$? Ignore heat losses during the warm up time. Express your answer in terms of a numeric factor times the symbol N, which will stand for the answer in problem 1a above.

b. (5pts) If the house heater output is 5kW, how long does it take to raise the temperature by those $15^{o}C$? Again, use the symbol N to stand for the answer in problem 1a.

3. (15pts) This house requires 5kW of heat on a winter day when it is 13^{o}C outside and 21^{o}C inside. In the summer this house is cooled by an air conditioner (a refrigerator unit which cools the inside, pumping the heat to the outside) which operates at 75% of the Carnot coefficient of performance for a refrigerator. When it is 37^{o} outside, how much does it cost to cool the house for one month if the inside temperature remains at 21^{o}C inside and if the cost of electricity is \$0.14/kWhr. Assume the inside and outside temperatures remain constant.

4. (15pts) A metal ball of radius 1m is heated to a temperature of 800°C. The ball is placed near a curved mirror so that 20% of the emitted thermal radiation falls onto a small box containing 5kg of ice at -10°C. Assuming the ball's emissivity is ε=0.6 and the absorptivity of the box is 1, how long does it take to melt the ice and raise the water within to +20°C?



5. (15pts) (Prob. 20-39 from homework) What is the total change in entropy when 2.5 kg of water at $0^{o}C$ is frozen to ice at $0^{o}C$ by being in contact with 450 kg of ice at $-15^{o}C$?