Physics 7b
Fall 2008
Midterm 1
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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. math fact: $\ln(e^x)=x$

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

Name____

SID____

Sect. # or day and time __________________________

Name of GSI (if known)_______________________________

1._____

2._____

3._____

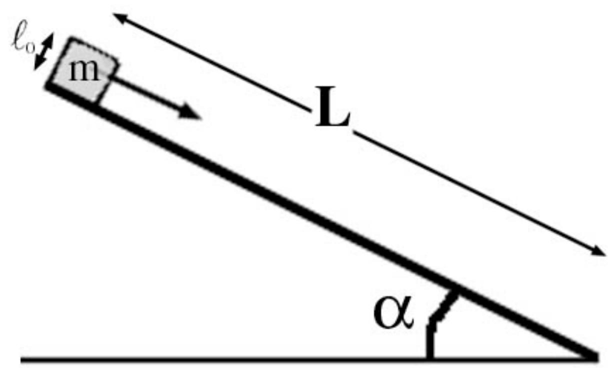
4._____

5._____

Total______

1. A heat engine operating between $400^{\circ}C$ and an ice water reservoir, has an efficiency that is 65% of the Carnot value. The ice water reservoir has some big chunks of ice floating on the water. If the engine operates a (frictionless) machine that lifts a 1200-kg mass up to the top of a 75-m high tower, what mass of ice will be melted in the water.

2. A solid cube of mass m and side length ℓ_0 is placed at the top of a ramp with tilt angle α. When the block is released it slides slowly down. Assume all fictional heating goes into the block, not the ramp. The material of the block has specific heat c and volume expansion coefficient γ. Find the mass density, ρ, of the block after it has slid a distance L down the ramp.



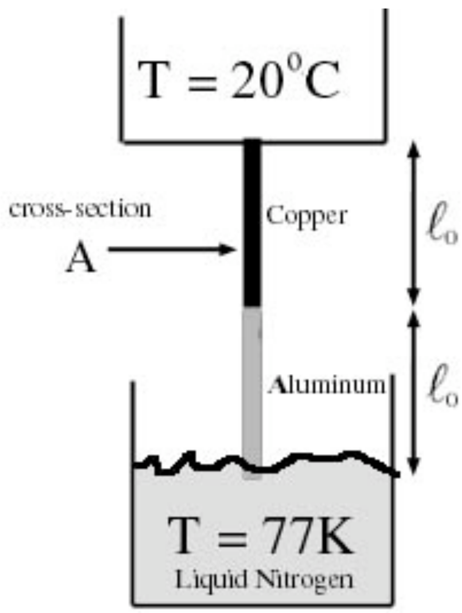
3. A 1.0-mol. sample of an ideal monatomic gas, originally at a pressure of 1.0-atm, undergoes a three step process:

   (1) It is expanded adiabatically from T_1=588K to T_2=389K
   (2) It is compressed at constant pressure until the temperature reaches T_3.
   (3) It then returns to its original pressure and temperature by a constant volume process.

(a) Plot these processes on a PV diagram.

(b) Calculate the change in internal energy, *ΔE*, the work done by the gas, *W*, and the heat *Q* added to the gas, for each process.

4. A copper rod and an aluminum rod, both of length $\ell = 50$-cm and cross sectional area A=0.5-cm^2 are joined together, end to end. One end of the rod is held at room temperature (20°C), while the other end dips into a container of liquid nitrogen, T=77 K. Compute the evaporation rate of the liquid nitrogen in liquid liters per second, due to the heat flow down the rods. (Latent heat of evaporation of liquid nitrogen is 5.6x10^3 J/mol, density is 800 kg/m^3, M_W=28, k_{cu}=401 W/m·K, k_{Al}=235 W/m·K).



5. Sound of wavelength λ cannot propagate in a gas if the mean free path, ℓ, is comparable to or greater than λ. Assuming that the density of the Earth's atmosphere varies with altitude y, as $\rho = \rho_0 e^{\frac{-mgy}{kT}}$ (here m is the weight of a molecule, and ρ_0 is the density at sea level) <u>estimate</u> the altitude where sound with λ= 0.2-m will no longer propagate. Assume that the air temperature is constant ~0°C.