PHYSICS 7B – Fall 2010
Midterm 1, R. Ramesh
Monday, September 27, 2010

Use the convention that ΔE=Q-W on this exam.

Problem 1 (20 points)

Consider a gas being blown along at a velocity $\mathbf{u} = u\hat{z}$, so that its velocity distribution is given by

$$F(\mathbf{v}) = \frac{1}{Z} e^{-m(\mathbf{v}-\mathbf{u})^2/2kT}.$$

Note that this is a probability distribution for the vector quantity **v**, not the scalar speed v=|**v**|, and has units of $[\text{velocity}]^{-3}$.

a) Find $\langle \mathbf{v} \rangle$, $\langle v^2 \rangle$ and v_{rms}.

b) Find the peak velocity where F(**v**) is maximized.

Problem 2 (15 points)

One hundred grams of ice at 0°C is dropped into 200g of water at 49°C. The system is thermlly isolated. After a period of time, the ice has entirely melted, leaving 300g of water at 6°C. Assume the specific heat of water is constant and equal to $1 JK^{-1}kg^{-1}$.

a) Calculate the latent heat of fusion for water.

b) Calculate ΔS for the entire system.

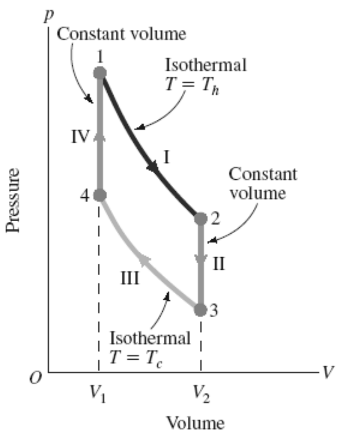
Problem 3 (25 points)

For the thermodynamic cycle on the right with an ideal diatomic gas as the working material,

a) Calculate W and Q for each of the four sides of the PV diagram.

b) Sketch T vs. S for this process. You need not indicate specific values of T or S on your plot, but label the points 1-4 corresponding to those on the P-V diagram.

c) Compare the efficiency of this engine with the efficiency of a Carnot engine for T_H=400 K, T_C=300 K, V_1=1 L, and V_2=5 L.



Problem 4 (15 points)

Using what you know about heat conduction, derive equations for the effective thermal conductivity of two materials with the same area and thickness but different thermal conductivities k_1 and k_2 when

a) The materials have are arranged in series (heat flows through one then through the other).

b) The materials conduct heat in parallel (heat flows through both simultaneously).

Problem 5 (25 points)

Use a combination of heat engines and heat pumps to prove that no engine can be more efficient than a Carnot engine when operating between a given maximum and minimum temperature.