Phys 119A HW#8

Due: Friday, Dec. 3 at the beginning of class.

READING: SCHROEDER: CHAPTER 5.3 (skip "the van der Waals Model"), 5.5, 5.6
CARTER: CHAPTER 9, 10.1, 10.4

BOOK PROBLEMS:

SCHROEDER: 5.29, 5.30, 5.31, 5.32, 5.41, 5.76, 5.81, 5.82, 5.84

CARTER: 9.8, 10.2

ADDITIONAL PROBLEM:

The natural variables describing the energy of a rubber band are entropy, length of the rubber band (L) and number of molecules. Thus:

$$dU = TdS + \gamma dL + \mu dN$$

a) The variable γ is the tension on the rubber band. Write an expression for γ in terms of partial derivatives.
b) Write down the analog to the Gibbs-Duhem equation for the rubber band.
c) Prove that $\left.\frac{\partial S}{\partial T}\right|_{L,N}$ must be positive for a rubber band in stable equilibrium.
d) Create a thermodynamic potential for the rubber band that is a natural function of T,L and N.
e) Based on the total differential of the potential derived in part d, you can express the derivative $\left.\frac{\partial \gamma}{\partial T}\right|_{L,N}$ in terms of a different derivative. Write the equality.
f) For typical rubber, tension will increase with temperature at constant length. This is a consequence of the equation of state for rubber (if you are interested, work through Schroeder problem 3.34 for a microscopic explanation of this). This sets the sign of the partial derivative you identified in part e. Using this knowledge, your result from part c and the cyclic rule, what can you say about the sign of the quantity $\left.\frac{\partial T}{\partial L}\right|_{S,N}$?
g) Now do the experiment. Take a rubber band and place it between your lips. Rapidly stretch it. (If done quickly, there is no chance for heat to flow and the process should approximately correspond to constant entropy conditions.) You should be able to sense the change in temperature. Does it agree with your prediction from part f?