

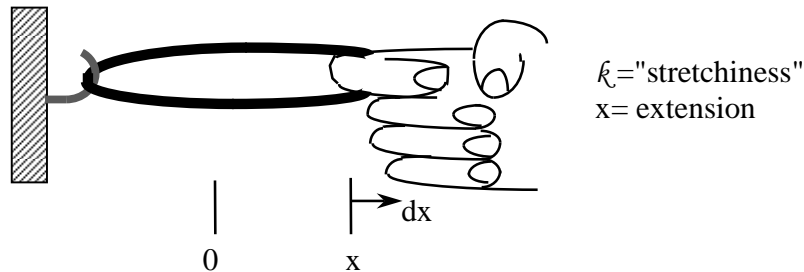
## Handin Homework 10 : Foundations of Thermodynamics

1. In an isothermal expansion of an ideal gas  $\Delta U=0$ . The value is **not** zero for a real gas. Using the Van der Waal's equation of state, find  $\Delta U$  for an isothermal expansion from  $V_1$  to  $V_2$ .

Hints: Van der Waal's:  $P = \frac{nRT}{(V-nb)} - a \frac{n^2}{V^2}$  and remember  $\left(\frac{\partial U}{\partial V}\right)_T = -P + T \left(\frac{\partial P}{\partial T}\right)_V$

2. The work for the system in stretching a rubber band is  $w_{\text{net}} = -F dx$ , where  $F$  is the restoring force,  $F = -\kappa x$ . At constant temperature and pressure,  $\Delta G = w_{\text{net}}$ , where  $w_{\text{net}}$  is the non-PV work. Therefore, the total change in Gibbs energy for a process involving stretching a rubber band is:

$$dG = -S dT + V dP - F dx.$$



(a). Under what conditions is  $\Delta G$  be a good spontaneity criterion ( i.e. when what is held constant)?

(b). For an initial state with a stretched rubber band,  $x > 0$ , find the direction for spontaneous change, either  $dx > 0$  or  $dx < 0$ , at constant temperature and pressure.

(c). Define a new state function:  $R \equiv G + F x$ . What are the independent variables for  $R$ ?

3. Given that  $dU = TdS - PdV$  and for an ideal gas  $dS = \frac{C_v}{T} dT + \frac{nR}{V} dV$  show that  $dU = C_v dT$  for any process for an ideal gas. (At first it doesn't look like  $dU=TdS-PdV$  will give just  $C_v dT$ , does it?)