Q4001 Thermodynamics of Materials **September, 2019**
Homework 5

1. The Helmholtz function of a certain gas is

$$A = -\frac{n^2 a}{V} - nRT\ln(V - nb) + J(T)$$

where J is a function of T only. Derive an expression for the pressure of the gas.

2. The Gibbs function of a gas is given by

$$G = nRT\ln\left(\frac{P}{P_0}\right) - nBP$$

where B is a function of T. Find the expression for:

   (a) the equation of state
   (b) the entropy
   (c) the Helmholtz function

3. Read the article by J. Pellicer et al. "Thermodynamics of Rubber Elasticity".

4. With the information from Pellicer's paper:

   (a) Write an expression for conformation work for a elastic system at constant volume.
   (b) What is the relation between the constant k in this paper and the Young's modulus of the elastic material?
   (c) Derive equations 2, 3, 6, 7, 9 and 10.
   (d) Reproduce Figures 2, 3, 4 and 5. Please, use anything but Excel.
   (e) Why is it that rubberlike elasticity is an entropic effect?

5. Demonstrate the following thermodynamic relations:

   (a) $C_P = C_V + \dfrac{\alpha^2 TV}{\kappa_T}$

   (b) $\kappa_T - \kappa_S = \dfrac{\alpha^2 \overline{V} T}{\overline{C}_P}$ where $\kappa_S = -\dfrac{1}{\overline{V}}\left(\dfrac{\partial \overline{V}}{\partial P}\right)_S$

   (c) $\dfrac{\kappa_T}{\kappa_S} = \dfrac{\overline{C}_P}{\overline{C}_V}$

   (d) $\left(\dfrac{\partial H}{\partial V}\right)_S = -\dfrac{C_P}{\kappa_T C_V}$

   (e) $\left(\dfrac{\partial C_P}{\partial P}\right)_T = -TV\left(\alpha^2 + \dfrac{d\alpha}{dT}\right)$

Due date: Tuesday, september 17th.