Intermediate Thermodynamics
Assignment 7 — Maxwell Relations

Instructions

ξ is a parameter related to your student ID, with ξ_1 corresponding to the last digit, ξ_2 to the last two digits, ξ_3 to the last three digits, etc. For instance, if your ID is 199225962, then $\xi_1 = 2$, $\xi_2 = 62$, $\xi_3 = 962$, $\xi_4 = 5962$, etc. Keep a copy of the assignment — the assignment will not be handed back to you. You must be capable of remembering the solutions you hand in.

Question #1

Starting from the $T\mathrm{d}s$ equations, prove the following two Maxwell relations:

$$\left(\frac{\partial T}{\partial v}\right)_s = -\left(\frac{\partial P}{\partial s}\right)_v \quad \text{and} \quad \left(\frac{\partial T}{\partial P}\right)_s = \left(\frac{\partial v}{\partial s}\right)_P$$

Question #2

Starting from $\psi \equiv h - Ts$, $\phi \equiv e - Ts$ and the $T\mathrm{d}s$ equations, prove the following two Maxwell relations:

$$\left(\frac{\partial s}{\partial v}\right)_T = \left(\frac{\partial P}{\partial T}\right)_v \quad \text{and} \quad \left(\frac{\partial s}{\partial P}\right)_T = -\left(\frac{\partial v}{\partial T}\right)_P$$

Question #3

If the PvT behavior of a gas is given by the Berthelot equation of state, show that the change in enthalpy of the gas during an isothermal process from state 1 to state 2 can be written as:

$$\bar{h}_2 - \bar{h}_1 = \frac{3a}{T}\left(\frac{1}{\bar{v}_1} - \frac{1}{\bar{v}_2}\right) + \bar{R}T\left(\frac{\bar{v}_2}{\bar{v}_2 - b} - \frac{\bar{v}_1}{\bar{v}_1 - b}\right)$$

Question #4

Nitrogen ($T_\mathrm{c} = 126.2$ K, $P_\mathrm{c} = 3.4$ MPa) expands isothermally from 125°C and 8.5 MPa to 3.5 MPa. Determine the change in internal energy, enthalpy, and entropy of the gas, assuming that the nitrogen obeys the Van der Waals' equation of state. Compare your results with the values obtained assuming ideal-gas behavior.

Due on Wednesday May 22nd at 16:30. Do Problems #2, #3, and #4 only.