EG3029 Chemical Thermodynamics

Tutorial III

Problem 1:
A Carnot engine receives 250 kJ s^{-1} of heat from a heat-source reservoir at 525°C and rejects heat to a heat-sink reservoir at 50°C. What are the power developed and the heat rejected? *(148.78 kW; 101.22 kW)*

Problem 2:
An ideal gas at 2,500 kPa is throttled adiabatically to 150 kPa at the rate of 20 mol s^{-1}. Determine the rate of entropy generation and the loss rate of exergy if the surrounding temperature is T_0 = 300 K. *(0.468 kJ s^{-1} K^{-1}; 140.344 kW)*

Problem 3:
One kilogram of water (V_1 = 1,003 cm^3 kg^{-1}) in a piston/cylinder device at 25°C and 1 bar is compressed in a mechanically reversible, isothermal process to 1,500 bar. Determine Q, W, ΔU, ΔH, and ΔS given that β = 250x10^{-6} K^{-1} and κ = 45x10^{-6} bar^{-1}. A satisfactory assumption is that V is at its arithmetic average value. As a *PVT* equation of state use: *(-10.84 kJ kg^{-1}; 4.91 kJ kg^{-1}; -5.93 kJ kg^{-1}; 134.6 kJ kg^{-1}; -0.03636 kJ kg^{-1} K^{-1})*

$$\frac{dV}{V} = \beta dT - \kappa dP$$

Problem 4:
Assuming S = S(P,V) and taking into consideration that

$$\left(\frac{\partial S}{\partial T}\right)_V = \frac{C_V}{T} \quad \text{and} \quad \left(\frac{\partial S}{\partial T}\right)_P = \frac{C_P}{T},$$

prove that

$$dS = \frac{C_V}{T}\left(\frac{\partial T}{\partial P}\right)_V dP + \frac{C_P}{T}\left(\frac{\partial T}{\partial V}\right)_P dV$$