1. Given the equation of state for a gas

$$pV_m = RT + \frac{bp}{T^2}$$

where R and b are constant. Show that

(a). $\left(\frac{\partial V_m}{\partial T}\right)_p = \frac{R}{p} - \frac{2b}{T^3}$ (10%)

(b). $\left(\frac{\partial V_m}{\partial p}\right)_T = -\frac{RT}{p^2}$ (10%)

(c). dV_m is an exact differential. (10%)

2. A typical 500 megawatt coal-fired power plant burns about 200 tons of bituminous coal per hour (50 kg-s^{-1}) with a heating value of 12,500 btu-lb^{-1} (28,700 kJ. kg^{-1}). The high-temperature boiler operates at 538 °C while the heat exchanger cools the condensed steam to about 50 °C. Calculate the theoretical (maximum)efficiency of the process and compare with the efficiency that is actually achieved. (20%)

3. Ethylene gas is to be continuously compressed from an initial state of 1 bar and 20 °C to a final pressure of 18 bar in an adiabatic compressor. If compression is 70% efficient compared with an isentropic process, what will be the work requirement and what will be the final temperature of the ethylene? Assume the ethylene behaves as an ideal gas with C_p=44 J/mol-K. (25%)

4. For a binary mixture at T=298 K, the activity coefficient for component 1 is :

$$\ln \gamma_1 = x_2^{\,2}(2 - 3x_2)$$

(a). What is the activity coefficient γ_2 at $x_2 = 0.3$?

(b). What is the molar Gibbs free energy change on mixing (ΔG/RT) for this mixture at $x_2 = 0.3$? (25%)

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