SHOW ALL CALCULATIONS

\[ R = 0.082057 \text{ L atm mol}^{-1} \text{ K}^{-1} = 8.31451 \text{ J mol}^{-1} \text{ K}^{-1} \]

1. Calculate the change in entropy when 150g of (a) water at 0°C, (b) ice at 0°C is added to 320 g of water at 90°C in an insulated container. (Problem 4.6, 25 points)

2. Calculate the minimum work needed to freeze 150 g of water originally at 0°C standing in a room at 30°C. What would be the minimum time required in a refrigerator operating ideally at 250W. (Exercise 4.21, 20 points)

3. The standard molar entropy of NH\(_3\) (g) is 192.4 J K\(^{-1}\) mol\(^{-1}\) at 298 K, and its heat capacity is given with the coefficients given in Table 2.16 (p 948).
   \[ C_p = a + bT + \frac{c}{T^2} \]
   Calculate the standard molar entropy at (a) 150°C and (b) 600°C. (Problem 4.3, 25 points)

4. The fugacity coefficient of a certain gas at 250.0 K and 55 bar is \( \gamma = 0.652 \). Calculate the difference of its chemical potential from that of a perfect gas in the same state. (Exercise 5.6, 15 points)

5. At 300 K the standard enthalpy of combustion of sucrose is -5630 kJ mol\(^{-1}\) and the standard Gibbs function of the reaction is -5748 kJ mol\(^{-1}\). Estimate the additional non-expansion work that may be obtained by raising the temperature to blood temperature, 37°C. (Problem 5.3, 15 points)

6. Instead of assuming that the volume of a condensed phase is constant when pressure is applied, assume only that the compressibility is constant. Show that when the pressure is changed isothermally by \( \Delta p \), \( G \) changes to
   \[ G' = G + V_m \Delta p \left( 1 - \frac{\kappa T \Delta p}{2} \right) \]
   assess the error in assuming that a solid is incompressible by applying this expression to the compression of copper when \( \Delta p = 500 \text{ atm} \). (For copper at 25°C, \( \kappa T \approx 0.8 \times 10^{-6} \text{ atm}^{-1} \) and \( \rho = 8.93 \text{ g cm}^{-3} \), Problem 5.14, 20 points)