Please show your work for all calculations, and report answers to the proper number of significant digits to receive full credit. For calculations, circle your final answer. Use a separate piece of paper to answer these questions.

1. When a liquid is compressed (via an increase in pressure), its Gibbs energy increases. This relationship is summarized by one of the equations in Section 3.8 of the textbook.
   (a) Give the equation that relates change in Gibbs energy to a change in pressure.
   (b) Show how this equation can be derived from the equation \( dG = VdP - SdT \) and the total differential of \( G(P, T) \).
   (c) Calculate the molar Gibbs energy change for liquid water as it is compressed from 1 bar to \( 1.000 \times 10^3 \) bar at room temperature. Assume that the molar volume of water is constant.

2. Ethanol and methanol form nearly ideal solutions with each other. At 20.0°C, the vapor pressure of pure ethanol is 5.93 kPa and that of methanol is 11.83 kPa.
   (a) Calculate the mole fractions of methanol and ethanol in a solution obtained by mixing 100.0 g of each.
   (b) Calculate the partial pressures of methanol and ethanol and the total vapor pressure of the solution.
   (c) Calculate the mole fraction of methanol in the vapor phase.

3. The vapor pressure of Hg (l) is 0.133 bar at 260.0°C and 0.533 bar at 330.0°C. Assume that \( \Delta C_P^\circ = 0 \) and that mercury vapor is an ideal gas.
   (a) Calculate the values of \( \Delta_{vap}H^\circ \) and \( S^\circ \) (g) at 25.0°C?
   (b) Use Trouton’s Rule to estimate \( \Delta_{vap}H^\circ \) and the vapor pressure of mercury at 25.0°C. The boiling point of mercury is 630.0 K.

4. Starting from the equation, \( H_m = G_m - T \left( \frac{\partial G_m}{\partial T} \right)_P \), derive the equation, \( C_{P, m} = -T \left( \frac{\partial^2 \mu}{\partial T^2} \right)_P \) where \( \mu \) is chemical potential.

5. A solution of ethanol (EtOH) and chloroform at 45.0°C with \( x_{EtOH} = 0.9900 \) has a vapor pressure of 177.95 torr. At this high dilution of chloroform, the solution can be assumed to be essentially ideally dilute. The vapor pressure of pure ethanol at 45.0°C is 172.76 torr. Determine the Henry’s Law constant for chloroform in ethanol at 45.0°C.