1. A weight of 10 kg is placed upon a large block of melting ice so that the weight bears upon an area of 1 cm^2. To prevent penetration by weight, how much the temperature of the ice must be lowered, assuming that no heat is conducted through the weight? Latent heat of fusion of ice = 333 kJ/kg. Ice floats on water with 11/12 of its volume submerged. Density of water ρ_w = 1000 kg/m^3. (20%)

2. Consider a box at constant volume and in thermal equilibrium with its surroundings. Inside the box are two A-B liquid solutions of different composition, separated by an internal partition that is thermally conductive and impermeable to component B. The dividing wall has the property that its displacement (δV) and the flow of component A through it are coupled by the following relation: $\delta V = K \delta n_A$.
   (a) Draw a picture of this system, indicating constant parameters. What is the relevant equilibrium extremum principle to apply for such a system? (5%) (b) What are the constraints on this system? (5%) (c) Determine the equilibrium criterion for A in terms of its chemical potential and the pressure on each side of the box. (10%)

3. The equation of state for a van der Waal gas is $\left(P + \dfrac{a}{V^2} \right)(V - b) = RT$ and its molar internal energy is given by $U = cT - \dfrac{a}{V}$, where a, b, and c are constants. Calculate the molar heat capacities C_V and C_P. (20%)

4. Answer CORRECT or NOT CORRECT in the following short questions. If your answer is NOT CORRECT, you have to state your reason(s). If your answer is CORRECT, you have to point out which thermodynamic principle(s) you have followed. No credit will be given without reason(s).
   (a) The only way to transfer heat from high temperature to low temperature is by an irreversible process. (4%)
   (b) If the thermal expansion is negative, the constant pressure heat capacity is smaller than the constant volume heat capacity. (4%)
   (c) Enthalpy is a conserved quantity. (4%)
   (d) In an adiabatic expansion of a material the temperature always goes down. (4%)
   (e) The entropy of a system can decrease. (4%)

5. Shown below is a hypothetical phase diagram for a single-component closed system. Answer the following questions about this diagram:

(a) Apply the phase rule to each of the marked locations 1, 2, and 3, and determine whether those points on the diagram correctly mark stable equilibria.(5%)

(b) Is the molar volume change of transformation $\Delta V_{\alpha \to gas}$ for the transformation of solid α to the gas phase positive or negative?(5%)

(c) For the fixed pressure P', draw a qualitative plot of the Gibbs free energy of this material for each phase as a function of temperature over the range shown.(10%)