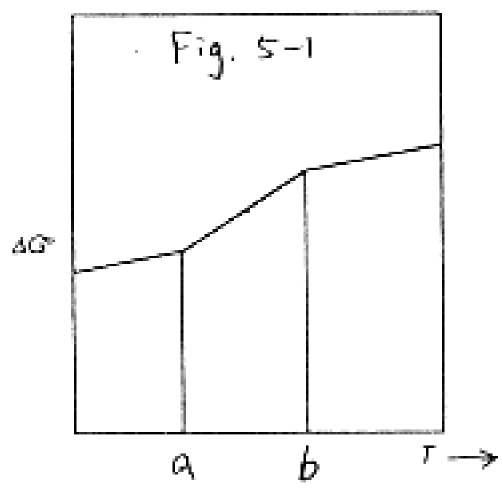
1. (12 points) Two identical bodies have constant and equal heat capacities ($C_1=C_2=8$ J/K). In addition a reversible work source is available. The initial temperatures of the two bodies are 0°C and 100°C. (a) What is the maximum work that can be delivered to the reversible work source, leaving the two bodies in thermal equilibrium? (b) What is the corresponding equilibrium temperature? (c) Is this the minimum or maximum attainable equilibrium temperature? Why?

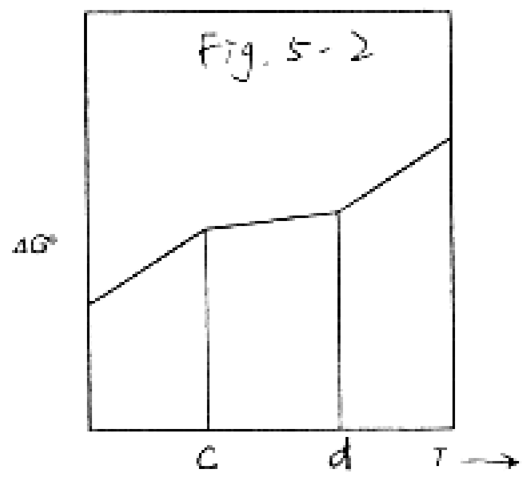
2. (15 points) An adiabatic container contains 2 moles of liquid aluminum at 700°C. When X moles of Cr_2O_3, which is initially at 298K, is added to the liquid aluminum (with which it reacts to form Cr and Al_2O_3), the temperature of the resulting mixture of Cr_2O_3, Al_2O_3, and Cr is raised to 1600K. How do you calculate the "X"? And list all thermodynamic data required for the calculation. It is known that the melting point of Al is 660°C(=933K). Cr_2O_3, Al_2O_3, and Cr are in solid states from 298K to 1600K.

3. (10 points) One mole of monatomic ideal gas is initially at temperature of 2000K and pressure of 1 MPa. The gas is cooled while the volume changes quasistatically in a process conducted so that PV^3=constant. The final temperature is 500K. Determine the change in entropy of the gas.

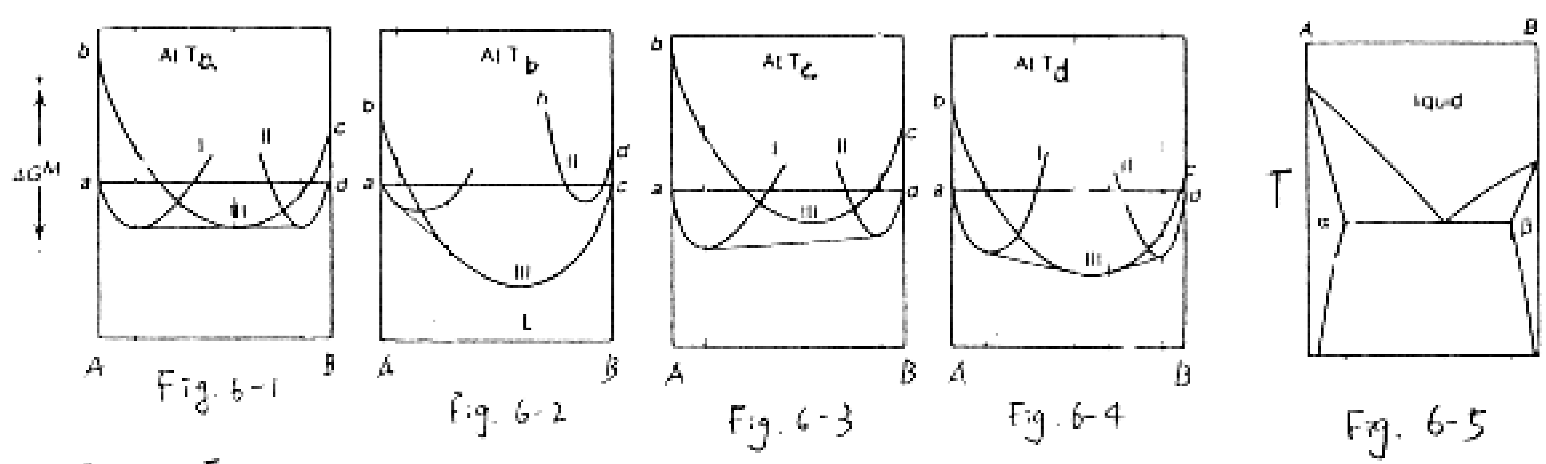
4. (13 points) (a) Derive the relation $\left(\frac{\partial P}{\partial T}\right)_S = \frac{C_p}{TV\alpha}$, where $\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P$. (b) Ice is originally at −3°C and 1 atm. The pressure is increased adiabatically until the ice reaches the melting point. How can the temperature and pressure of this melting point be calculated? What thermodynamic data do you need for the calculation?

5. (15 pt) Figures 5-1 and 5-2 show the effect of melting of the metal A and metal oxide AO_2 on the Ellingham line the oxidation of the metal A. Can you identify what the melting points (for A and AO_2) a,b,c,d ~~representing~~ are on both figures? Also explain reasons supporting your answer.





6. (15 pt) Figures 6-1 to 6-4 represent the molar Gibbs free energies of mixing of the system A-B at four different temperature Ta, Tb, Tc, Td. Figure 6-5 given is the corresponding phase diagram. (1) Please redraw a phase diagram on your answer sheet and sketch the isothermal lines representing Ta, Tb, Tc, Td. (2) Draw the corresponding activities of A and B as a function of composition at temperature Tb and Td.



Curve I : α phase ; Curve II : β phase ; curve III : Liquid phase

7. (10 pt) For the reaction

$P_4 = 2P_2$, $\Delta G^\circ = 225{,}400 + 7.90\ T \ln T - 209.4\ T$ J

(1) What is the temperature when $X(P_4)=X(P_2)=0.5$ at a total pressure of 1 atm?

(2) Use Le Chatelier's principle to predict that if the temperature is increased to 2000K, in order to keep $X(P_4)=X(P_2)=0.5$, the total pressure need to be increased or decreased?

(3) Determine the total pressure in (2), i.e. when T= 2000 K, and $X(P_4)=X(P_2)=0.5$

8. (10 pt) If there is a binary solution A-B, both component A and component B obey Henry's law when the solution is dilute (≤0.10). If $P_A^\circ=0.03$ atm and $P_A=0.04X_A$ (in Henrian solution A-B) at 298K. If $P_B^\circ=0.02$ atm and $P_B=0.03X_B$ (in Henrian solution A-B) at 298K. Calculate the partial pressure of A and B when the composition of solution are (a) $X_A=0.09$ $X_B=0.91$ (b) $X_B=0.9$ $X_A=0.1$ (c) When $X_A=X_B=0.5$, which of the following can be the total vapor pressure, explain why? 0.01atm, 0.02atm, 0.024atm, 0.03atm, 0.04atm