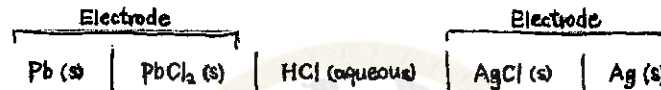


1. Briefly answer the following short questions: (25%)
 - (a) How would you experimentally determine the change in the entropy of a substance at its melting point?
 - (b) Can the activity of a substance be greater than one? Explain.
 - (c) State the most general form of the Gibbs-Duhem equation and explain why it is useful.
 - (d) What are the shortcomings of the regular solution model?
 - (e) What is the difference between a quasistatic and a reversible process?

2. The EMF of the cell represented in the accompanying diagram is 0.490 V at 25 °C and the temperature coefficient is -1.84×10^{-4} V/°C. All the components are presented as pure solids in contact with an HCl electrolyte. (15%)
 - (a) Write the half-cell and overall cell reactions.
 - (b) Calculate the Gibbs free energy change and the entropy change for this reaction at 25 °C. (Faraday constant = 96480 Coul)



3. For a given binary system at constant T and P, the liquid molar volume of the solution (cm³/mole) is given by: $V = 100x_A + 80x_B + 2.5x_Ax_B$ (20%)
 - (a) Compute the partial molar volumes of A and B and plot them, together with the molar volume of the solution, as a function of the composition of the solution.
 - (b) Compute the volume of mixing as a function of composition.

 4. An Fe-Mn solid solution containing 0.001 mole fraction Mn is in equilibrium with a FeO-MnO solid solution and a gaseous atmosphere containing oxygen at 1000K. (15%)
 - (a) How many degrees of freedom does the equilibrium have?
 - (b) What is the composition of the equilibrium oxide solution, and what is the oxygen pressure in the gas phase? Assume that both solid solutions are ideal.
- Data: For Fe: $Fe_{(s)} + 0.5 O_{2(g)} = FeO_{(s)}$; ΔG° (Joules) = $-259600 + 62.55 T$
 For Mn: $Mn_{(s)} + 0.5 O_{2(g)} = MnO_{(s)}$; ΔG° (Joules) = $-384700 + 72.8 T$
5. Answer the following questions for the Ga-Se system. The phase diagram is attached. (25%)
 - (a) Draw schematic plots of the molar Gibbs energy at (i) 730°C, (ii) 915°C, (iii) 1005°C.
 - (b) Draw schematic plots of the activity of Ga as a function of composition at 915°C.
 - (c) Draw an equilibrium cooling curve for a liquid initially of composition 60wt% Se at 1100°C which is cooled to room temperature. For each portion of the curve indicate the phase present.
 - (d) What is the lowest temperature that a crystal of β -Ga₂Se₃ could be grown from the melt? What is the composition of the liquid that you would use?

