

MME2009 Metallurgical Thermodynamics

Problem Set III

- 1- Calculate the entropy of 1 mole of Cu_2S at 800 C and the entropy change when Cu_2S is cooled from 800 C to room temperature
 $S^\circ(\text{Cu}_2\text{S})=119.6 \text{ J/mol.K}$, $C_p= 81.6 \text{ J/mol.K}$
- 2- Entropy of melting for aluminum is given as 11.54 J/molK. What is the melting point of aluminum?
 $\text{Al(s)} \quad S_{298}=28.34 \text{ J/molK}$, $H_T-H_{298}=-6719 + 20.68T + 0.0062T^2 \text{ J/mol}$
 $\text{Al(l)} \quad H_T-H_{298}= 1381 + 29.30T \text{ J/mol}$
- 3- The normal boiling point of ethanol, $\text{C}_2\text{H}_5\text{OH}$, is 78.3°C, and its molar enthalpy of vaporization is 38.56 kJ/mol. What is the change in entropy in the system when 68.3 g of $\text{C}_2\text{H}_5\text{OH(g)}$ at 1 atm condenses to liquid at the normal boiling point? $MW_{\text{ethanol}}=46 \text{ g}$
- 4- One gram of supercooled liquid zinc at 400 °C is in a container of large heat capacity. Find the entropy change of zinc during solidification
 $\text{Zn(s)} \quad C_p=22.4 + 0.01005 \text{ J/molK}$ $\Delta H_m= 7388 \text{ J/mole at } 420 \text{ }^\circ\text{C}$
 $\text{Zn(l)} \quad C_p= 31.4 \text{ J/molK}$
- 5- Using entropy concept, decide whether the dissociation of H_2 to its ions is spontaneous or not at 298 K
 $\text{H}_2(\text{g}) \rightarrow 2\text{H}^+(\text{g})$
 $S^\circ(\text{H}^+)= 115 \text{ J/mol.K}$
 $S^\circ(\text{H}_2)= 130 \text{ J/mol.K}$, $\Delta H^\circ(\text{H}_2)= -436 \text{ kJ/mol}$
- 6- Using free energy concept determine whether the formation of $\text{CH}_4(\text{g})$ from its elements in their standard states is spontaneous or not
 $\text{CH}_4(\text{g}) \quad S_{298}= 186.28 \text{ J/molK}$ $\Delta H_{298}= -74890 \text{ J/mol}$
 $\text{H}_2(\text{g}) \quad S_{298}= 130.65 \text{ J/molK}$
 $\text{C(s)} \quad S_{298}= 5.7 \text{ J/molK}$
- 7- Normal boiling point for magnesium is 1393 K. By using entropy concept, calculate whether the evaporation is spontaneous or not at 1400 K under 1 atm pressure. Mg vapor is ideal gas
 $\text{Mg(l)} \quad C_p=31 \text{ J/molK}$ $\Delta H_v= 131859 \text{ J/mol}$
 $\text{Mg(s)} \quad S_{298}=32.5 \text{ J/molK}$, $C_p=25.7+0.0063 T+330000/T^2 \text{ J/molK}$
- 8- Calculate the standard entropy change for the following reaction at 298 K:
 $\text{Al}_2\text{O}_3(\text{s})+3\text{H}_2(\text{g}) \rightarrow 2\text{Al(s)}+3\text{H}_2\text{O(g)}$

$$S^\circ(\text{H}_2) = 130.6 \text{ J/mol}\cdot\text{K}$$

$$S^\circ(\text{H}_2\text{O}) = 188.8 \text{ J/mol}\cdot\text{K}$$

$$S^\circ(\text{Al}) = 28.34 \text{ J/mol}\cdot\text{K}$$

$$S^\circ(\text{Al}_2\text{O}_3) = 51.07 \text{ J/mol}\cdot\text{K}$$

- 9- Calculate the isothermal entropy change at 1000K for the process
 $\text{Pb(l)} + \text{CO}_2(\text{g}) = \text{PbO(s)} + \text{CO(g)}$
 $\text{CO(g)} \quad \Delta H_{298} = -110510 \text{ J/mol} \quad C_p = 28.42 + 0.0041T - 46000/T^2 \text{ J/mol}\cdot\text{K}$
 $\text{CO}_2(\text{g}) \quad \Delta H_{298} = -394000 \text{ J/mol}, \quad C_p = 44.3 + 0.0088T - 860000/T^2 \text{ J/mol}\cdot\text{K}$
 $\text{PbO(s)} \quad \Delta H_{298} = -219350 \text{ J/mol}, \quad C_p = 37.9 + 0.0268T \text{ J/mol}\cdot\text{K}, \quad H_T - H_{298} = -3508 + 28.46T \text{ J/mol}$
- 10- The normal boiling point is the temperature at which a pure liquid is in equilibrium with its vapor at a pressure of 1 atm. a) Estimate the normal boiling point of liquid carbon tetrachloride, $\text{CCl}_4(\text{l})$ based on Trouton's rule b) What is the ΔG° for the equilibrium at boiling point
 $\Delta H^\circ(\text{CCl}_4(\text{l})) = -139.3 \text{ kJ/mol}, \quad \Delta H^\circ(\text{CCl}_4(\text{g})) = -106.7 \text{ kJ/mol}$
- 11- The normal boiling point of benzene is at 80 C. Which term is greater for the vaporization of benzene at 100 °C, ΔH or $T\Delta S$?
- 12- An automobile engine has an efficiency of 22.0% and produces 2510 J of work. How much heat is rejected by the engine?
- 13- If 1200 J of heat spontaneously flows through a copper rod from a hot reservoir at 650 K to a cold reservoir at 350 K, determine the amount by which this process changes the entropy of the universe.
- 14- An ideal, or Carnot, heat pump is used to heat a house at 294 K. How much work must the pump do to deliver 3350 J of heat into the house on a day when the outdoor temperature is 273 K?
- 15- On a hot summer day the temperature scale in your kitchen reads 40 °C, you shut the windows and door closed so that the kitchen is isolated and try to cool your kitchen by leaving the refrigerator door open. The refrigerator works at 10% Carnot efficiency. Calculate the final temperature of the room.