

$$\Delta H_{298} = -400,000 + 196,300 = -203,700 \text{ calories}$$

$$= \Delta H_I = H_b - H_a$$

ΔH_{II} = the heat to raise the temperature of $(n + 2)$ moles of Fe from 298 to 1873°K (ΔH_1) + the heat to raise the temperature of 1 mole of Al_2O_3 from 298 to 1873°K (ΔH_2).

In Fig. 6.18 the slope of each individual segment of the line bc is $(n + 2)c_p(\text{Fe}) + c_p(\text{Al}_2\text{O}_3)$, and the length of each vertical segment equals $(n + 2)\Delta H_{\text{Fe(trans)}}$. Thus the temperature of the point c is determined by the value of n .

$$\begin{aligned} \Delta H_2 &= \int_{298}^{1873} c_p(\text{Al}_2\text{O}_3) dT \\ &= 25.48(1873 - 298) + \frac{4.25}{2} \times 10^{-3} (1873^2 - 298^2) \\ &\quad + 6.82 \times 10^5 \left(\frac{1}{1873} - \frac{1}{298} \right) \\ &= 45,470 \text{ calories} \end{aligned}$$

$$\begin{aligned} \frac{\Delta H_1}{(n + 2)} &= 4.18(1033 - 298) + \frac{5.92}{2} \times 10^{-3} (1033^2 - 298^2) \\ &\quad + 1200 \\ &\quad + 9 \times (1181 - 1033) \\ &\quad + 220 \\ &\quad + 1.84(1674 - 1181) + \frac{4.66}{2} \times 10^{-3} (1674^2 - 1181^2) \\ &\quad + 210 \\ &\quad + 10.5 \times (1808 - 1674) \\ &\quad + 3300 \\ &\quad + 10 \times (1873 - 1808) \\ &= 18,470 \text{ calories} \end{aligned}$$

Thus

$$203,700 = 18,470 n + 36,940 + 45,470$$

or $n = 6.57$ moles of Fe per mole of Fe_2O_3 initially present.

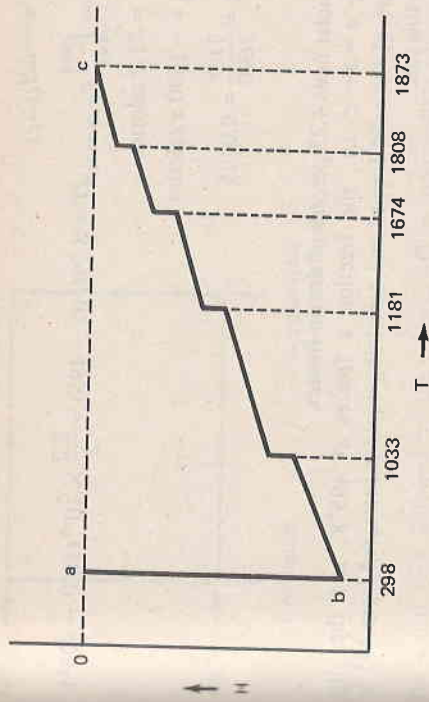


Fig. 6.18.

Example 2

A quantity of supercooled liquid tin is adiabatically contained at 495°K. Calculate the fraction of tin which spontaneously freezes. Given:

$$\Delta H_m(\text{Sn}) = 1690 \text{ calories/mole at } T_m = 505^\circ\text{K}$$

$$c_{p,\text{Sn}(l)} = 8.29 - 2.2 \times 10^{-3} T \text{ calories/degree-mole}$$

$$c_{p,\text{Sn}(s)} = 4.42 + 6.3 \times 10^{-3} T \text{ calories/degree-mole}$$

The equilibrium state of the adiabatically contained system is that in which solid, which has spontaneously formed, and the remaining liquid coexist at 495°K. Thus the fraction of liquid which freezes is of such magnitude as to release the heat necessary to raise the temperature of the system from 495 to 405°K.

Let the molar fraction which freezes equal x and consider 1 mole of the system. In Fig. 6.19 the process is represented by the change of state from a to b , and as the process is adiabatic the enthalpy of the system remains constant;

$$\Delta H = H_c - H_a = 0$$

Two paths can be conveniently considered:

Path I, $a \rightarrow b \rightarrow c$; i.e., all of the liquid is increased in temperature from 495 to 405°K, and then the fraction x freezes at 505°K. In this case,