B10704007
邱允平
四材三甲

Thermodynamics of Materials II Homework#2

$$1\ \ atm = 760\ \ mmHg = 1.01 \times 10^5\ \ N\ \ m^{-2}, R = 8.314\ \ J\ \ mol\ \ K^{-1}$$

1 The vapor pressure of water is given in the following relation:

$$\ln P = 25.275 - \frac{5132}{T}$$

轉 atm

The vapor pressure of ice is given in the following relation:

$$\ln P = 28.868 - \frac{6133}{T}$$

The units of $P$ and $T$ are *Pa* and *K* for these two equations, respectively.

1.1 Estimate the normal boiling temperature.

1.2 Estimate the pressure and the temperature at the triple point.

1.3 Calculate the enthalpy of vaporization at the normal boiling temperature.

1.4 Calculate the enthalpy of fusion at the triple point.

$\hookrightarrow s \to l$

1.5 Calculate the difference between the heat capacity of water and that of ice.

1.1 By $\ln P = 25.275 - \frac{5132}{T}$ $\Rightarrow$ put $P = 1.01 \cdot 10^5 \, N m^{-2}$ $\Rightarrow 11.52 = 25.275 - \frac{5132}{T}$, $T = \underline{373.1K}$ #

1.2 By $P_{triple\ s\to v} = P_{triple\ l\to v} \Rightarrow 25.275 - \frac{5132}{T} = 28.868 - \frac{6133}{T} \Rightarrow T_{triple} = \underline{278.6K}$ #

$\ln P_{triple} = 25.275 - \frac{5132}{278.6} = 6.854$

$P_{triple} = \underline{947.8\ N/m^2}$ #

1.3 $\frac{d\ln P}{dT} = \frac{5132}{T^2} = \frac{\Delta H_{l\to v}}{RT^2} \Rightarrow \Delta H_{l\to v} = 5132 \cdot 8.314 = \underline{42667.45\ J/mol}$ #

1.4 $\Delta H_{s\to l} = \Delta H_{s\to v} - \Delta H_{l\to v}$, $\frac{d\ln P}{dT} = \frac{6133}{T^2} = \frac{\Delta H_{s\to v}}{RT^2} \Rightarrow \Delta H_{s\to v} = 6133R$

$\therefore \Delta H_{s\to l} = 6133R - 5132R = 1001R = \underline{8322.3\ J/mol}$ #

1.5 $C_{P_l} - C_{P_s} = \Delta C_{P_{s\to l}} = \left(\frac{\partial \Delta H_{s\to l}}{\partial T}\right)_P = \underline{0\ J/mol\cdot K}$ #

2 Two ideal gases are mixed in the container at the constant temperature of T. The initial states of the two gases are:

Gas A: 2 atm, V $m^3$

Gas B: 1 atm, V $m^3$

The volume of the container is 2V $m^3$. Assume that T and V are known parameters.

2.1 Calculate the change of the total Gibbs free energy.

2.2 Calculate the change of the total enthalpy.

2.3 Calculate the change of the total entropy.

2.1 By $\Delta G'_{mix} = n_A RT \ln \frac{pA}{P_A} + n_B RT \ln \frac{pB}{P_B}$ $\quad n_A = \frac{2V}{RT}$, $n_B = \frac{V}{RT}$, $n_A : n_B = 2:1$

$\Rightarrow x_A = \frac{2}{3}$, $x_B = \frac{1}{3}$, $\quad p'(2V) = \left(\frac{2V}{RT} + \frac{V}{RT}\right) RT$, $p' = \frac{3}{2}$ atm

$\therefore pA = x_A p' = \frac{2}{3} \times \frac{3}{2} = 1$ atm, $pB = x_B p' = \frac{1}{3} \cdot \frac{3}{2} = \frac{1}{2}$ atm

$\Rightarrow \Delta G'_{mix} = \left(\frac{2V}{RT}\right) RT \ln \left(\frac{1}{2}\right) + \left(\frac{V}{RT}\right) RT \ln \left(\frac{\left(\frac{1}{2}\right)}{1}\right) = 3V \ln \frac{1}{2} = -2.08V$ (atm·$m^3$) $= -2.1 \cdot 10^5 V J$ #

2.2 Because of ideal gas, $\Delta H_{mix} = 0 J$ *

2.3 $\Delta S'_{mix} = \frac{-\Delta G'_{mix}}{T} = \frac{2.1 \cdot 10^5 \cdot V}{T} J/K$ *