Thermal Physics II

(Instructor: AKB, Department of Physics, Asutosh College)

Assignment II

Q.1) Consider a metal (say Copper) at $300K$ with the following values, $V = 7.06cm^3/mol, K_T = 7.78 \times 10^{-12} N/m^2, \beta = 50.4 \times 10^{-6} K^{-1}, C_p = 24.5 J/molK$. Determine C_v.

Q.2) Prove that the ratio of adiabatic $\left[\alpha_S = \frac{1}{V}(\frac{\partial V}{\partial T})_S\right]$ to isobaric $\left[\alpha_P = \frac{1}{V}(\frac{\partial V}{\partial T})_P\right]$ coefficient of expansion is $\frac{1}{1-\gamma}$. Also, prove that the ratio of adiabatic $\left[E_S = -V(\frac{\partial P}{\partial V})_S\right]$ to isothermal $\left[E_T = -V(\frac{\partial P}{\partial V})_T\right]$ elasticities is equal to the ratio of specific heats.

Q.3) Prove that the ratio of adiabatic $\left[\beta_S = \frac{1}{P}(\frac{\partial P}{\partial T})_S\right]$ to isochoric $\left[\beta_V = \frac{1}{P}(\frac{\partial P}{\partial T})_V\right]$ pressure coefficient of expansion is $\frac{\gamma}{\gamma - 1}$.

Q.4) (a) If equation of state of certain material satisfies $P = \frac{RT}{V}(1 + \frac{B''}{V})$ where $B'' = B''(T)$, show that

$$C_V = -\frac{RT}{V}\frac{d^2}{dT^2}(B''T) + C_V^{\infty},$$

where C_V^{∞} represents the value of C_V when V is very large. (b) In case $P = \frac{RT}{V}(1 + B'P)$ where $B' = B'(T)$, show that

$$C_P = RTP\frac{d^2}{dT^2}(B'T) + C_P^0,$$

where C_P^0 represents the value of C_P when pressure tends to zero.

Q.5) Using Berthelot's equation of state $P = \frac{RT}{V-b} - \frac{a}{TV^2}$, show that the critical constants are

$$P_c = \frac{1}{12b}\sqrt{\frac{2aR}{3b}}, \; V_c = 3b, \; T_c = \sqrt{\frac{8a}{27bR}}; \quad \frac{RT_c}{P_cV_c} = \frac{8}{3}.$$

Q.6) The boiling point of a liquid at pressure P_0 is T_0. Its molar latent heat of vaporisation is L and molar volume of the liquid phase is negligible as compared to vapour phase. The vapour phase obeys the ideal gas equation. Show that the boiling point T at pressure P is given by,

$$ln\Big(\frac{P}{P_0}\Big) = \frac{L}{RT_0}\Big(1 - \frac{T_0}{T}\Big).$$