

Sem-III - Thermal Physics II

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Assignment III: Pure Substances

Submission due date: 13/09/2019

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

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

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

Q.4) (a) If equation of state of certain material satisfies $P = \frac{RT}{V} \left(1 + \frac{B''}{V}\right)$ 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

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

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,

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