Sem-III - Thermal Physics II

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

Assignment I: 0^{th} law & Thermodynamic Systems

Submission due date: 07/08/2019

Q.1) (a) The equation of state of an ideal gas is $PV = RT$. Show that $\beta = T^{-1}$ and $\kappa = P^{-1}$. (b) The equation of state of a real gas at moderate pressure is $P(V-b) = RT$. Show that

$$\beta = T^{-1}/\{1 + bP/RT\}, \text{ and } \kappa = P^{-1}/\{1 + bP/RT\}.$$

(c) The equation of state of a real gas at moderate pressure is $PV = RT(1 + B/V)$ with $B = B(T)$. Show that

$$\beta = T^{-1}\{V + B + T(dB/dT)\}/\{V + 2B\}, \text{ and } \kappa = P^{-1}/\{1 + bRT/PV^2\}.$$

Q.2) Systems A, B, and C are gases with coordinates $(P, V), (P', V'), (P'', V'')$. When A and C are in thermal equilibrium, the equation

$$PV - nbP - P'V' = 0$$

is found to be satisfied. When B and C are in thermal equilibrium, the relation

$$P'V' - P''V'' + \frac{nB'P''V''}{V'} = 0$$

holds. The symbols n, b and B' are constants. (a) What are the three functions which are equal to one another at thermal equilibrium and each of which is equal to an empirical temperature T? (b) What is the relation expressing thermal equilibrium between A and B?

Q.3) A liquid is irregularly stirred in a well-insulated container and thereby undergoes a rise in temperature. If we regard the liquid as the system, (a) Has heat been transferred? (b) Has work been done? (c) What is the sign of ΔU?

Q.4) Systems A and B are paramagnetic salts with coordinates $\mathcal{H}, M$ and $\mathcal{H}', M'$ respectively. System C is a gas with coordinates P, V. When A and C are in thermal equilibrium, the equation

$$4\pi nRC_c\mathcal{H} - MPV = 0$$

is found to hold. When B and C are in thermal equilibrium, we get

$$nR\Theta M' + 4\pi nRC_c'\mathcal{H}' - M'PV = 0,$$

where n, R, C_c, C_c' and Θ are constants. (a) What are the three functions that are equal to one another at thermal equilibrium? (b) Set each of these functions equal to the ideal-gas temperature T and see whether any of these equations are equation of state for paramagnetic substance (Curie's law $M = C_c'\frac{\mathcal{H}}{T}$).

Q.5) The equation of state of an ideal elastic substance is $\Im = KT(\frac{L}{L_0} - \frac{L_0^2}{L^2})$ where K is a constant and zero tension value of $L = L_0(T)$. (a) Show that the isothermal Young's modulus Y and at zero tension Y_0 are given by

$$
Y = \frac{kT}{A}\Big(\frac{L}{L_0} + \frac{2L_0^2}{L^2}\Big),\ Y_0 = \frac{3KT}{A}.
$$

(b) Show that the linear expansivity is given by

$$
\alpha = \alpha_0 - \frac{\Im}{AYT} = \alpha_0 - \frac{L^3/L_0^3 - 1}{T(L^3/L_0^3 - 2)},
$$

where $\alpha_0 = \frac{1}{L_0}\frac{dL_0}{dT}$ is the linear expansivity at zero tension.