PH207: Year 2023
Problem Set-II
Instructor: **Subhradip Ghosh**

1. Show that for a stretched wire the heat capacities are given by,

$$\begin{aligned} C_L &= \left(\frac{\partial U}{\partial T}\right)_L \\ C_T &= \left(\frac{\partial U}{\partial T}\right)_\tau - \tau L\alpha, \end{aligned}$$

   L is the length of the wire, τ is the tension in the wire and α is the coefficient of linear expansion,

2. Consider a system whose internal energy $U = U(T, P)$. Derive the equations:

$$\begin{aligned} a)\left(\frac{\partial U}{\partial T}\right)_P &= C_P - PV\beta \\ b)\left(\frac{\partial U}{\partial P}\right)_T &= PV\kappa - (C_P - C_V)\,\frac{\kappa}{\beta} \end{aligned}$$

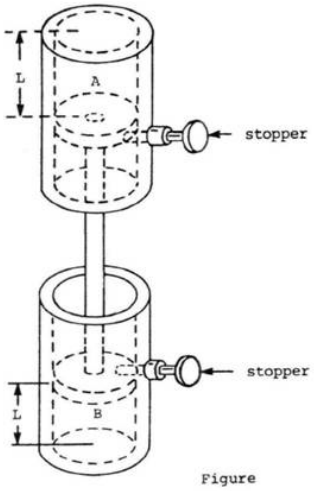
3. One mole of gas obeys Van Der Waal's equation of state:

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

   Its molar energy is given by, $U = \frac{3}{2}RT - \frac{a}{V}$ where V is the molar volume at temperature T. Find the difference between C_P and C_V.

4. An ideal gas is contained in a large jar of volume V_0. Fitted to the jar is a glass tube of cross-sectional area A in which a metal ball of mass M fits. The equilibrium pressure in the jar is slightly higher than atmospheric pressure p_0 due to the weight of the ball. If the ball is displaced slightly from equilibrium it will execute simple harmonic motion (neglecting friction). if the states of the gas represent a quasi static adiabatic process and γ is the ratio of the specific heats, find a relation between oscillation frequency f and variables of the problem.

5. Two identical, well insulated piston cylinder devices of 100 cm^2 area are placed as shown in the figure. Both have metallic pistons and connecting rods. The first cylinder contains gaseous helium at 2 atm and the second contains gaseous helium at 1 atm. The temperature in both cylinders is 0^0C. When the stopper is removed the pressures will become identical and all oscillations will cease.(a) Calculate the final temperatures after the oscillations cease, if the gas is assumed to be ideal with a constant C_v. Also neglect the masses of cylinders and pistons. (b) Calculate the final temperatures for the same situation, but with well insulated pistons and connecting rods of low thermal conductivity.



Figure