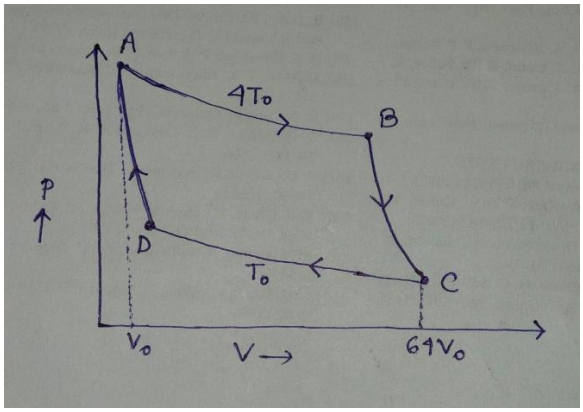
Assignment 1

Topic: Thermodynamics

1. An ideal gas is expanded adiabatically from (P_1 , V_1) to (P_2 , V_2). Then it is compressed isobarically to (P_2 , V_1). Finally presuure is increased to P_1 at constant volume V_1.
   Show that the efficiency of the cycle is , $\eta = 1 - \frac{\gamma\left(\frac{V_2}{V_1}-1\right)}{\left(\frac{P_1}{P_2}-1\right)}$
2. One kilogram of water is heated by an electrical resistor from 20^0 C to 99^0 C at constant atmosphereic pressure. Estimate
   (a) The change in internal energy of the water.
   (b) The change in entropy of the water.
3. A solid has density ρ, mass M and coefficient of linear expansion α. Show that at pressure P, the heat capacities C_p and C_v are related by, $C_p - C_v = \frac{3\alpha MP}{\rho}$
4. A carnot engine has a cycle as shown in Fig. If W and W' represent work done by 1 mole of monoatomic and diatomic gas respectively. Then calculate W'/W.



5. 10 kg of water at 20^0 C is converted into ice at -10^0 C by being put in contact with a reservoir at -10^0 C. This process takes place at constant pressure and heat capacities at constant pressure of water and ice are 4180 and 2090 J/kg deg respectively. The heat of fusion of ice is 3.34×10^5 J/Kg. Calculate the change in entropy of the universe.

6. (a) Derive the Maxwell relation, $\left(\frac{\partial s}{\partial v}\right)_T = \left(\frac{\partial p}{\partial T}\right)_v$
   (b)From the electromagnetic theory maxwell found that pressure p from an isotropic radiation field is equal to one-third the energy density u(T). p = $\frac{1}{3}\ u(T) = \frac{U(T)}{3V}$.
   Where V is the volume of the cavity. Using part (a) along with second law of thermodynamics prove the Stefan's law relating u and T ($u=aT^4$).