1. One gram of nitrogen is contained in a constant volume tank at low pressure. Assuming nitrogen to be an ideal gas, calculate the amount of heat required to rise its temperature from 300 to 1000K.

   For nitrogen $C_p = 6.529 + 1.250x10^{-3} * T$ (in cal/(gram.mol)K.

   (hint : use the relation $C_p - C_v = R$)

   For constant volume process there is no work done and the first law implies $\Delta Q = \Delta U$. Since nitrogen is taken to be an ideal gas

   $$\Delta U = \int_{T_1}^{T_2} C_v dT$$

   To get C_v, we use the relation $C_p - C_v = R$.

   $$\Delta Q = \int_{T_1}^{T_2} (C_p - R) dT$$

   (where R = 1.987 cal/(g.mol)K).

   Substituing back,

   $$\Delta Q = \int_{300}^{1000} (6.529 - 1.987 + 0.00125 * T) dT$$

   Integrating

   $$\Delta Q = 4.542(1000 - 300) + 0.00125/2 * (1000^2 - 300^2) = 3748cal$$

   In joules, 3748 cal = 15,682 Joules.

2. Find the change in the internal energy of a pound of O_2 (assume ideal gas) heated from 20C to 30C at constant pressure of 1atm. Calculate heat capacity at constant volume and internal energy of the system. (specific heat capacity of O2 = 0.231 cal/g . K).

   One pound of O_2 equals 453.6 gms of O_2.

   Using the First law of thermodynamics,

   $$dU = dQ + dW$$

$$P\Delta V = NR\Delta T$$

and from the definition of C_p ($C_p = \frac{dQ}{dT}_P$)

$$C_p\Delta T = \int dQ$$

From the first law, the change in internal energy is given by

$$\Delta U = C_p\Delta T - nR\Delta T$$

Remember that the specific heat capacity is given in 'per gram' units. Since O_2 is a diatomic molecule, one mole of O_2 weighs 32 gms. plugging these conversions in the above equation would lead to $\delta U = 766.5$ calories.

3. Find the change in the internal energy for a crystalline solid with dielectric constant ϵ with the application of external electric field. Assume that the solid has linear response. Assume that the laboratory frame coincides with the crystal a,b and c axes.

Please refer to Example Problems Week 4.