1. Gas is confined in a chamber by a piston. In this closed system. In this closed system, a constant pressure of 10 atms is applied through the piston to reduce the volume of the gas from $3m^3$ to $2m^3$.

   (a) What is the work done by the system?

   The input information needs to be made uniformly either SI units or CGS. Converting to SI units, $1atm = 10^5 Nm^{-2}$. Work done **by** system is given by

$$
\begin{aligned}
W &= \int_{V_0}^{V_1} PdV \\
&= P(V1 - V0) = -10^5 Nm
\end{aligned}
$$

   (b) what is the change in the internal energy in the process?

   The first law of thermodynamics states

$$dU = dQ + dW$$

   In the problem statement, enough information is not provided to estimate internal energy. As the system given is a closed system, we would need information about heat exchange (dQ) to calculate the internal energy of the system.

2. Check the following statements : true or false? (under what conditions?)

   (a) Internal energy of a system is a state function.

   True. The first law provides the definition of a state function, Internal energy. Internal energy is always a state function with no exceptions.

   (b) Internal energy is an intensive property.

   False. It is more like an extensive quantity. Internal energy doubles with two identical systems are added.

   (c) In an adiabatic system, work done is a state function.

   True. The first law of thermodynamics gives

$$dU = dQ + dW$$

   In an adiabatic system, there is no exchange of heat energy$(dQ = 0)$. Since by definition internal energy is a state function the work done is also a state function.

   (d) Work done is a state function during isothermal process.

   False. During an isothermal process, heat is exchanged to keep the system isothermal.

resistance 1Kiloohms is used to provide heat to this chamber for 10 seconds (current I = 15 milli amps). Calculate the heat transferred and internal energy of the system.

(a) in closed system with chamber boundary as the system boundary.

Since this is a closed system, heat can flow across the boundaries of the system. The amount of energy supplied by the heating coil is given by

$$\begin{aligned} heatsupplied &= \int V dQ \\ &= \int_{t_0}^{t_1} IR.Idt = I^2R(t_1 - t_0) = 15 * 15 * 10^{-6} * 10^3 * 10 ampere^2.ohm.second \\ &= 2.25 Joules \end{aligned}$$

Assuming all the energy gets transferred to the system as heat, using First law of thermodynamics,

$$dU = dQ + dW$$

With no work done by the system (piston is clamped), the change is internal energy is entirely due to the exchange of heat.

$$\Delta U = \Delta Q = 2.25 Joules.$$

(b) In a adiabatic system with boundary similar to the above problem 1.

If the system is adiabatic and there is no work done, the internal energy remains constant.

(c) In a adiabatic system which includes the resistive coil (the walls of the container are thermally conducting)

This is similar to the case when a heating coil is kept a system with adiabatic system boundaries. In this case, there is **no heat flow across the system boundaries** and hence $dq = 0$. However, there is work done on the system by the application of potential difference across the heating coil which leads to pumping of 2.25 Joules of energy. The change in internal energy would be

$$\Delta U = \int dw = 2.25 Joules.$$

4. The bulk modulus, K, of an isotropic linear elastic solid is defined by the dialation, $\Delta V/V_0$, response to hydrostatic pressure P:

$\frac{\Delta V}{V_0} = \frac{V - V_0}{V_0} = -\frac{P}{K}$

Typical values of K for an ionic crystal are about 100 GPa. (GPa = 1 Gigapascal, 1 atm $\approx 10^{-1}$ MPa) ceptibility, $\chi(P = k_0 \chi E)$, of an ionic crystal are about 50 (unitless).

The permittivity of vacuum, μ_0 , is 4x$10^{-7} T^2 m^3 / J$(T is a tesla). The magnetic susceptibility, ψ ($\vec{I} = \mu_0 \psi \vec{H}$), of a typical paramagnetic ionic crystal is about 10 (unitless).

Calculate all the ratios of: stored elastic energy, stored polarization energy, and stored magnetic energy in a typical ionic crystal at 1 atm, 220 volts/m, and in the earth's magnetic field.

For a solution to this problem please refer to last year's recitation notes 4.