Recitation 3

Problem 1

A gas is confined in a cylinder by a piston. The initial pressure of the piston is 2 atm, and the volume is $1m^3$. The piston is held in place by latches in the cylinder wall. Now, we place the apparatus in total vacuum.

1. What is the energy change of the apparatus if the retaining latches are removed so that the gas suddenly expands to double its initial volume? The piston is again held by latches at the end of the process.
   Since the question concerns the entire apparatus, the system is taken as the gas, piston and cylinder. No work is done during the process, because no force external to the system moves, and no heat is transferred to the vacuum surrounding the apparatus. Therefore, the total energy of the system remains unchanged

2. What can you say if the same process is carried out in the atmosphere? Assume that the heat transfer rate is much slower than the rate at which the process occurs.
   In this case, work is done by the atmospheric pressure as the piston advances. The work done on the system is given by the product of the force exerted by the atmospheric pressure on the piston and the displacement of the piston. If the area of the piston is A, the force is $F = P_{atm}A$. *The displacement* $\triangle l$ *of the piston is equal to the volume it expands divided by its area, or* $\triangle l = \frac{\triangle V}{A}$. *Therefore, the work done on the system by its surroundings is given by*

   $$W = -F\triangle l = -P_{atm}\triangle V \tag{1}$$

   Since we can neglect any heat transfer, the energy change undergone by the system is given by

   $$\triangle U = 0 - P_{atm}\triangle V \tag{2}$$

   Therefore, the system decreases its energy

Problem 2

Identify what is wrong with the following assertions:

- The internal energy change undergone by an adiabatic system is always proportional to the heat released by it, provided no work is performed on the system at the same time.
  The statement is wrong because in any adiabatic system, the internal energy change is numerically identical to the work exchanged by the system and its surroundings

- When an ideal gas inside a piston increases its temperature at constant volume, the work done by it is numerically equal to the increase in its internal energy.
  We know that for a process involving an ideal gas

$$dW = -PdV \tag{3}$$

  Therefore, the work exchanged by the system and its surroundings during a process at constant volume is zero. The change in internal energy of an ideal gas, however, will be proportional to the change in its temperature.

- When a horse is adiabatically lifted against a gravitational field, the work done during the process constitutes a state function.
  Nothing is wrong with this statement