Exercise 2

1)

a) Air at state 1,0 MPa, 200 ºC expands reversibly and adiabatically through a nozzle to the pressure 0,1 MPa. The kinetic energy of the air entering the nozzle can be neglected.
-- Determine the temperature and the velocity of the air coming out of the nozzle. The air can be assumed an ideal gas with constant C_p and C_v.

b) Air of the same inflow state expands in a throttle valve to 0,1 MPa. In this case the change of kinetic energy is negligible. The remaining assumptions are the same as above,
-- Determine the exit temperature in this case and the entropy generation (per kg of air).

C_p =1,0 kJ/(kgK) and $k = C_p/C_v$=1,4; and use $R = C_p(1-k^{-1})$ for consistency
Hint: ”expands reversibly and adiabatically” means isentropic expansion.

2)

An isolated container of volume 1 m^3 is to be filled with air until the pressure reaches 1,5 MPa. Prior to the filling, the container contains air at state 0,1 MPa, 20 ºC. The container is filled by leading air at state 2,0 MPa, 20 ºC through a throttle valve and into the container. The air speed is low before the throttle valve. The air can be assumed as an ideal gas with constant C_p and C_v, where C_p =1,0 kJ/(kgK) and $k = C_p/C_v$=1,4. The state of the surroundings is 0,1 MPa, 20 ºC.

a) put up the 1st law for the process.
b) determine the temperature in the container when the filling process is completed.
c) Determine the change of entropy in the container and the entropy generation of the process.

3)

A gas turbine plant operates in a simple Brayton process.

The state of the working medium entering the compressor is 1 bar, 27 ºC. At the turbine inlet , the state is 5 bar, 830 ºC. The isentropic efficiencies of the turbine and the compressor are both 0,9.

The working medium is an ideal gas with constant C_p =1,0 kJ/(kgK) and $k = C_p/C_v$=1,4.The state of the surroundings is 1 bar, 20 ºC.

a) draw a flow sheet for the plant
b) sketch the process in a T-s diagram
c) determine the compressor work per unit of mass of the working medium (kJ/kg)
d) determine the turbine work per unit of mass (kJ/kg)
e) determine the thermal efficiency of the plant