1. A heat pump heats a house in the winter and then reverses to cool it in the summer. The interior temperature would be 20℃ in the winter and 25℃ in the summer. Heat transfer through the walls and ceiling is estimated to be 2000 kJ per hour per degree temperature difference between the inside and outside.

   (1) If the winter outside temperature is 0℃, what is the minimum power required to drive the heat pump?　(15%)

   (2) For the same power as in part (1), what is the maximum outside summer temperature for which the house can be maintained at 25℃?　(20%)

2. Calculate the work involved in expanding 20L of an ideal gas to a final volume of 80L against a constant external pressure of 3.5 bar.　(15%)

3. Where P_1, P_2, P_3, P_4 is pressure at state 1,2,3,4 respectively,

   　　　T_1, T_2, T_3, T_4 is temperature at state 1,2,3,4 respectively,

   　　　h_1, h_2, h_3, h_4 is enthalpy at state 1,2,3,4 respectively,

   　　　s_1, s_2, s_3, s_4 is specific entropy at state 1,2,3,4 respectively,

   T_0 is environment temperature,

   $\dot{W}_{s,in}$ is shafted worked done rate on the pump,

   $\dot{W}_{s,out}$ is output power by the turbine,

   $\dot{Q}_{in,h}$ is the inlet heat transfer rate on the boiler with phase change on high temperature,

   $\dot{Q}_{out,L}$ is the outlet heat transfer rate on the condenser with Low temperature.
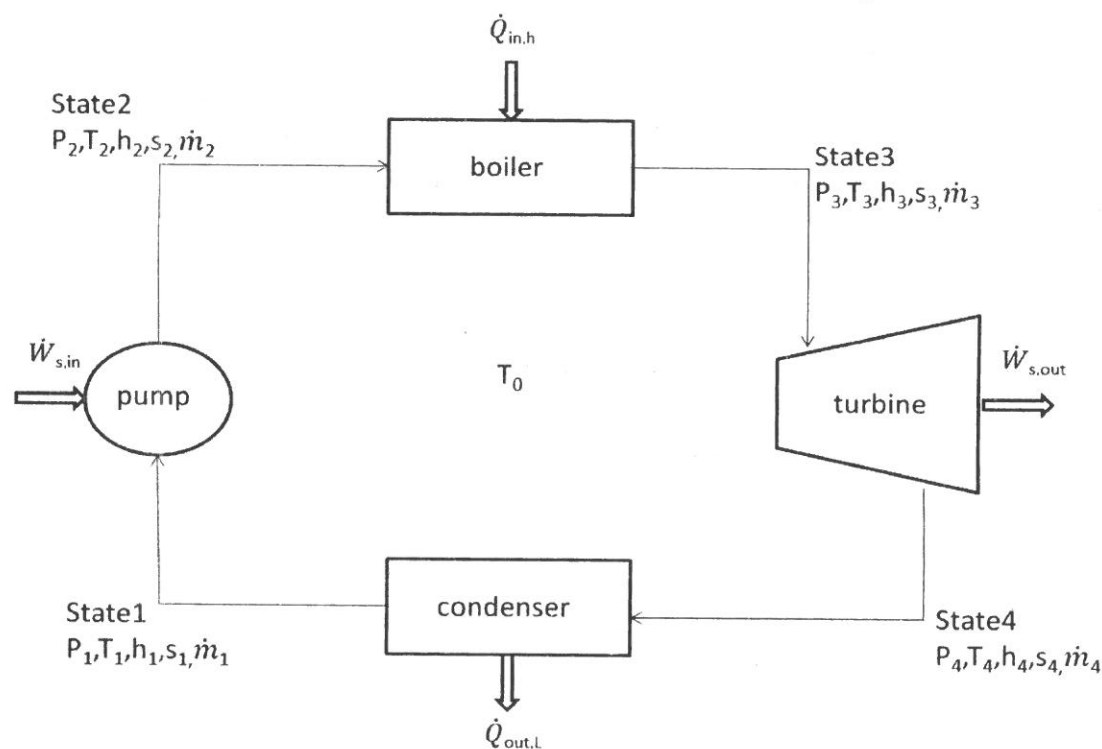

Fig1: steam power plant cycle

Given the properties of a steam power plant operates on a cycle with state and process as designated in Fig.1.

(1) Define the property and explained physical means as following. 6%
　　A.　Availability.
　　B.　Irreversibility.
　　C.　Reversible work.

(2) Find and prove that the availability of turbine by equation (1). 9%

(3) What is conditions the availability on turbine as following equation. 5%

$$P_t = \dot{W}_{s,out}^{Rev} - T_0 \dot{P}_{s,t} \cdots (1)$$

Where Rev is reversible process.

$\dot{W}_{s,out}^{Rev}$ is the output shaft worked rate by the turbine of reversible process,

$\dot{P}_{s,t}$ is the entropy generation rate on the turbine,

P_t is the output power of turbine.

(4) Find the availability on pump, where given $\dot{P}_{s,t}$ is entropy generation rate on pump. 5%

4. Given the properties the same problem1.

(1) How to define the entropy change and the entropy generation rate. 5%

(2) What is thermodynamics conditions on the boiler as equation (2)

$$\dot{Q}_{in,h} = \dot{m}_3 s_3 - \dot{m}_2 s_2 \ \ldots(2)$$

and prove equation (2). 5%

(3) Find $\dot{Q}_{out,L}$ by reversible and irreversible process on condenser. 5%

(4) The steam power plant operating on cycle. 10%
　　A.　Can be bypass the condenser from state 4 to state 2 by pumping mechanic.
　　B.　Prove that answer by 1st Law、 2nd Law of thermodynamic.