

NATIONAL EXAMINATIONS - May 2002

98-BS-10, Thermodynamics

3 Hours Duration

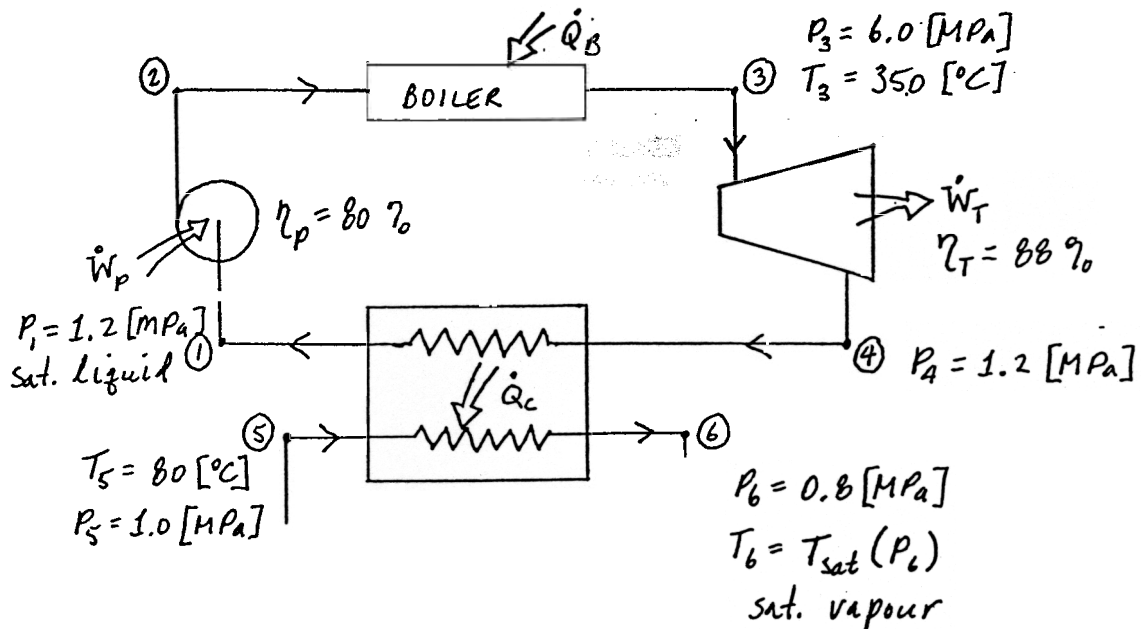
NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit, with the answer paper, a clear statement of any assumptions made.
 2. Any one of the approved Casio or Sharp calculator models is permitted. This is a "Closed-Book" examination with one 8.5×11 inch sheet of notes (both sides) allowed.
 3. Property tables and charts are provided where necessary.
 4. The **two** questions from part "A" plus **four** questions from part "B" (a total of **six** questions) constitutes a complete paper. Unless clearly indicated otherwise by you, only the first two questions from part "A" and the first four questions from part "B" that you answered will be marked.
 5. The mark associated with each question is specified.
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PART A. DO ONLY TWO OF QUESTIONS 1, 2, or 3
(Each question is worth 20 marks)

- 1 In a cogeneration system, a Rankine cycle operates with steam entering the turbine at 6.0 [MPa], 350 [°C], and a condenser pressure of 1.2 [MPa]. The isentropic efficiency of the turbine is 88%. Energy rejected by the condensing steam is transferred to a separate process stream of water entering at 80 [°C], 1.0 [MPa] and exiting as a saturated vapor at 0.8 [MPa].

- (a) Determine the mass flow rate for the working fluid of the Rankine cycle if the mass flow of the process stream is 6 [kg/s].
(b) Calculate the pump power required if the pump has an isentropic efficiency of 80%.



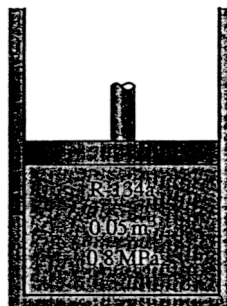
2. A vapor-compression refrigeration system circulates refrigerant 134a at a rate of 6 [kg/min]. The refrigerant enters the compressor at $-10 \text{ [}^\circ\text{C]}$, 140 [kPa] and exits at 700 [kPa]. The isentropic efficiency of the compressor is 67%. There are no appreciable pressure drops as the refrigerant flows through the condenser and evaporator. The refrigerant leaves the condenser at 700 [kPa], 24 [°C]. Ignoring heat transfer between the compressor and its surroundings, determine

- (a) the compressor work (in [W]) and the heat transfers from the condenser and to the evaporator, respectively, and
(b) the coefficient of performance (COP) of the cycle.

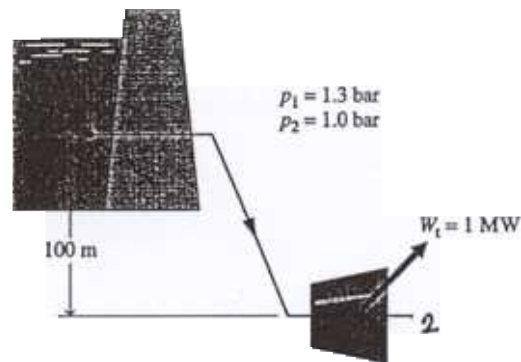
3. An air-water vapour mixture enters a heater–humidifier unit at 5 [°C], 50% relative humidity, at a volumetric flow rate of 0.1 [m³/s]. Liquid water at 10 [°C] is sprayed into the mixture and heat is transferred such that the air-vapour mixture leaves the unit at 30 [°C], 100 [kPa], 50% relative humidity. Using thermodynamic relations and tables (not the Psychrometric chart) determine
- (c) the mass flow rate of liquid water sprayed into the mixture and
 - (d) the rate of heat transfer to the unit.

PART B. DO ONLY FOUR OF QUESTIONS 4, 5, 6, 7 or 8
(Each question is worth 15 marks)

4. Air expands through a turbine from 400 [kPa], 500 [°C] to 100 [kPa], 340 [°C], while it loses 11 [kJ/kg] of heat to the atmosphere at 101.3 [kPa], 20 [°C]. Assuming changes in kinetic and potential energies are negligible, calculate for this process (a) the decrease in stream exergy, (b) the maximum work, and (c) the irreversibility.
5. An adiabatic compressor compresses 90 [kg/hr] of refrigerant 134a from 200 [kPa], 0 [°C] to 1.2 [MPa], 80 [°C] in a steady process. The refrigerant experiences negligible changes in potential and kinetic energy. Determine the isentropic efficiency of the compressor and the irreversibility rate associated with the compressor. Assume the surroundings to be at $T_o = 25$ [°C].
6. An insulated piston-cylinder device contains 0.05 [m³] of saturated vapour refrigerant 134a at 0.8 [MPa]. The refrigerant is now allowed to expand reversibly until the pressure drops to 0.4 [MPa]. Determine the final temperature in the cylinder and the work done by the refrigerant. Sketch the process on a T-s diagram.



7. Water flows from an elevated reservoir through a hydraulic turbine, as shown in the figure below. The pipe diameter is constant and operation is at steady state. Calculate the minimum mass flow rate, in [kg/s], that would be required for a turbine output power of 1 [MW].



8. A $0.3 \text{ [m}^3\text{]}$ rigid reservoir is filled with saturated liquid water at $250 \text{ [}^\circ\text{C]}$. A valve located at the bottom of the reservoir is opened and liquid is withdrawn from the reservoir. During the process, heat is added to the water such that the temperature in the reservoir remains constant. Determine the amount of heat that must be transferred by the time half of the total mass has been withdrawn. Show the process on a T-v diagram.