

**Code Number :.....**

**THERMODYNAMICS QUALIFYING EXAM**

**January 2009**

**OPEN BOOK (two book allowed) & CLOSED NOTES**

**Answer all four questions**

**All questions have equal weight**

**TIME: 3.0 hrs**

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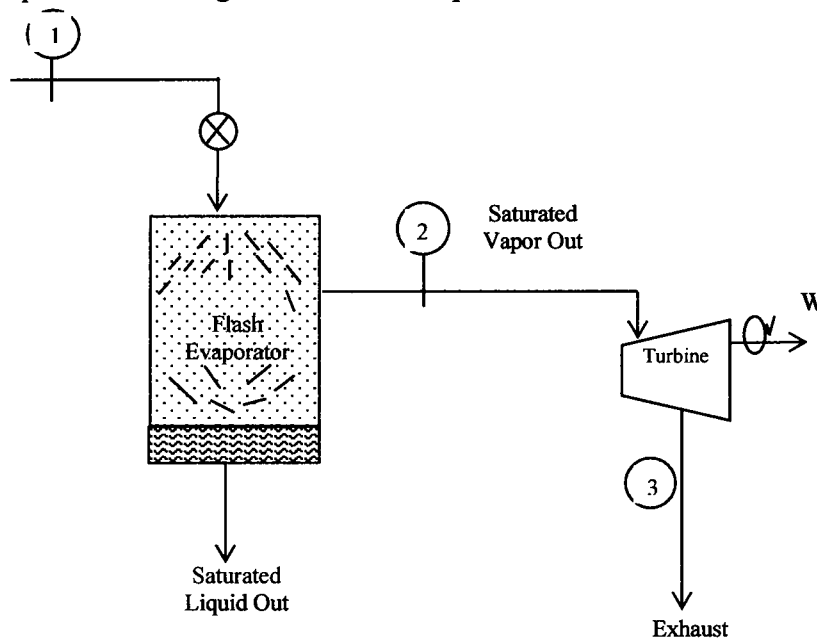
- .....
- Take any required property from your book, approximate values if necessary.
  - If you make any assumption to reach a solution state it clearly
- .....

Date \_\_\_\_\_

Name \_\_\_\_\_

January 2009 Qualifying Exam

1. It is proposed to use a geothermal supply of hot water to operate a steam turbine, as shown in the figure below. The high pressure water at 1.5 MPa, 180<sup>o</sup> C is throttled into an insulated flash evaporator, forming liquid and vapor at a lower pressure, 400 kPa. The liquid exits at the bottom, while the vapor is drawn off and fed to the turbine, as shown. Steam exits from the turbine at 10 kPa, 90% quality. If the turbine produces a power output of 1000 kW, how much hot water is required from the geothermal source per hour?



2. Conduct a first law analysis of the adiabatic saturation process. Consider an air-water vapor mixture having a dry-bulb temperature of  $30^{\circ}\text{C}$ , a wet-bulb (adiabatic saturation) temperature of  $20^{\circ}\text{C}$ , and a pressure of 100 kPa. Determine the humidity ratio and relative humidity of this mixture.

### Question # 3

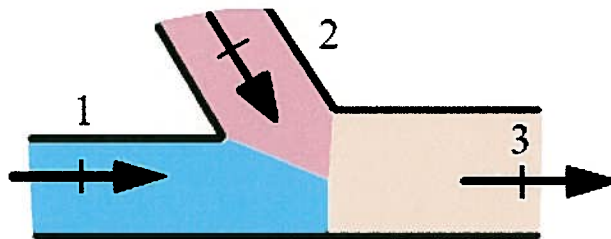
a) Air is expanded from 400 kPa, 600 K in a polytropic process to 150 kPa, 400 K in a piston cylinder arrangement. Using constant specific heat capacity, determine:

- i) The polytropic exponent  $n$
- ii) The work transfer per unit mass
- iii) The heat transfer per unit mass

b) Can the combined pump-motor efficiency be greater than either the pump efficiency or the motor efficiency? Explain.

c) In what forms can energy cross the boundaries of a closed system?

d) To keep a jet engine cool, some intake air bypasses the combustion chamber and later mixes with the hot air coming out of the combustion chamber as shown in the figure below. Assume 2 kg/s hot air at 2000 K, 500 kPa is mixed with 1.5 kg/s air 500 K, 500 kPa without any external heat transfer. Find the mixture exit temperature.



#### **Question # 4**

- a) Heat is pumped from an outdoor cold air temperature of  $-5^{\circ}\text{C}$  to a house whose temperature must be maintained at  $24^{\circ}\text{C}$ . If the house loses heat at a rate of 80,000 kJ/h. Show if a 2 kW power will be sufficient or not to drive this pump?
- b) Refrigerant-134a enters an adiabatic compressor as saturated vapor at 160 kPa at a rate of  $2\text{ m}^3/\text{min}$  and is compressed to a pressure of 900 kPa. Determine the minimum power that must be supplied to the compressor.