# ME 354 THERMODYNAMICS - 2

9 February 1998

Midterm Examination R. Culham

- This is a two-hour, closed-book examination.
- You are permitted to use one 8.5 in.$\times$ 11 in. crib sheet. (one side only)
- There are 3 questions to be answered. Read the questions very carefully.
- Clearly state all assumptions.
- It is your responsibility to write clearly and legibly.

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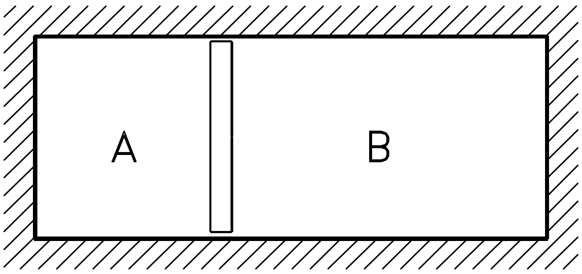
**Question 1** (15 marks)

Consider a rigid, adiabatic tank with a movable piston as shown below. Initially, Side A contains 2.5 $kg$ of air at 250 $°C$ and 500 $kPa$, while Side B contains 0.5 $kg$ of air at 70 $°C$ and 50 $kPa$. The piston then moves (slowly because of friction) to a new position where the pressures on each side will be equal. Since the piston is not adiabatic, the temperatures on each side will eventually equalize.

a) Determine the final temperature.
b) Determine the final pressure.
c) Determine the availability destroyed $[kJ]$ if the dead state temperature and pressure are $T_0 = 20\ °C$ and $P_0 = 1\ atm$, respectively.



**Problem 2** (15 marks)

Air enters an adiabatic gas turbine at 900 $°C$, 275 $kPa$ and leaves at 110 $kPa$. The turbine efficiency is 0.80. The mass flow rate is 1000 $kg/hr$. Assume constant specific heat.

a) Determine the rate of work transfer [$kW$]
b) Determine the exit temperature.
c) Determine the rate of flow availability [$kW$] leaving with the exit flow stream if $T_0 = 20\ °C$ and $P_0 = 101\ kPa$.

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**Question 3** (20 marks)

A reheat Rankine cycle that uses water as its working fluid operates a boiler at 6000 $kPa$, the reheat section at 1000 $kPa$, and the condenser at 50 $kPa$. The inlet temperature at turbine 1 is 400 $°C$ while the inlet temperature at turbine 2 is 300 $°C$. The system is sized such that the net power produced by the turbines is 300 $kW$. Assume all processes are steady state and reversible.

a) Determine the rate at which heat is added in the steam generator.
b) Determine the power required to operate the pump.
c) Determine the cycle's thermal efficiency.
d) Why is reheat used in a Rankine cycle?
e) Determine the cycle's thermal efficiency if reheat was not included in the process. Assume the same mass flow rate used in part a).