ME 501 Advanced Thermodynamics
Take-Home Mid-term Examination Fall 2001
Due: November 6, 2001
(Submission through Digital Drop Box only)
Maximum: 100 points

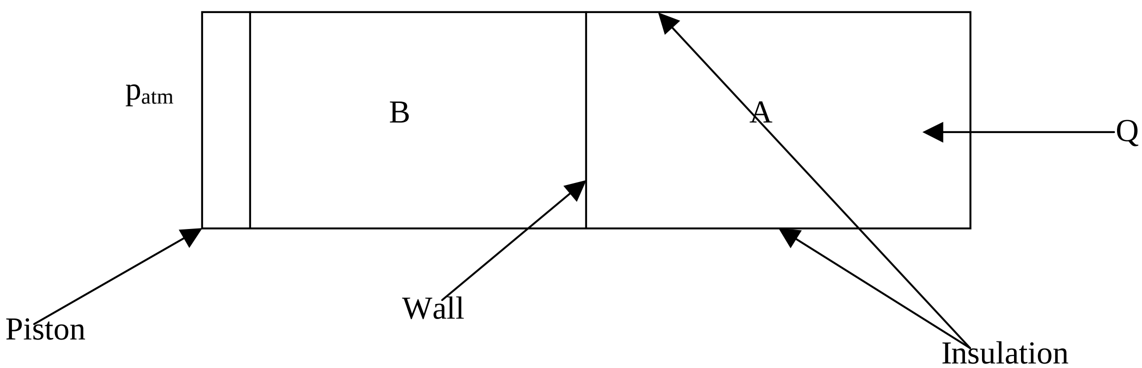

Figure Q1

1. A piston-cylinder assembly (shown in Fig. Q1) is divided into two chambers A and B by a perfectly conducting rigid fixed wall. The chamber A receives heat Q from surroundings. If the mass of air (assumed to behave like a perfect gas) in each chamber is equal, show that the work done by the piston is $(\gamma-1)Q/(\gamma+1)$, where γ is the ratio of specific heats of air at constant pressure and constant volume. The piston is massless, frictionless and exposed to a constant atmosphere. *(25 points)*

2. Steam enters a non-adiabatic turbine in a steady state steady flow process at 100 bar as saturated vapor and undergoes irreversible expansion to a quality of 0.9 at 1 bar. The heat loss to the ambient at 300 K is 50 kJ/kg of steam. Determine: (a) actual work output (b) entropy generation due to all irreversibilities present (c) optimum work (d) irreversibility (e) specific availabilities at inlet and exit and (f) second-law efficiency of the process. *(25 points)*

3. Consider the following general form of cubic equation of state:
$$p = \frac{RT}{V-b} - \frac{a}{V^2 + ubV + wb^2}$$, where a, b, u and w are constants.
Derive an expression for fugacity coefficient of a real gas, obeying the above equation of state. Find out the values of a, b, u and w for Peng-Robinson, Redlich-Kwong and Soave-Redlich-Kwong equations of state and use the expression of

fugacity coefficient to determine the fugacity of water at 250 bar and 673 K using RK, SRK and PR EOS.

(25 points)

4. Show that for a pure fluid,

$$\left(\frac{\partial u}{\partial v}\right)_T = T^2\left(\frac{\partial (P/T)}{\partial T}\right)_v$$

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Hence, show that for a fluid, whose internal energy and enthalpy are functions of temperature only, P/T and v/T are functions of volume only and pressure only respectively. (*Do not assume ideal gas equation of state)*

Use this result to show that Pv/T = constant is a necessary condition for internal energy and enthalpy to be functions of temperature only.

(25 points)