Suchismita Sarkar

Total number of printed pages - 7

B. TECH
BENG 1103

2ND SEMESTER EXAMINATION – 2006

THERMODYNAMICS

Full Marks – 70

Time – 3 Hours

The figures in the right hand margin indicate full marks for the questions.

Answer Question No. 1 which is compulsory and any five from the rest.

Use of steam tables is permitted.

For air, take $C_P = 1.005 \frac{kJ}{kg-K}$ and $C_v = 0.718 \frac{kJ}{kg-K}$

1. Answer the following : 2×10

(a) Pick up the intensive properties from the following list :

(i) Specific volume

(ii) Enthalpy

P.T.O.

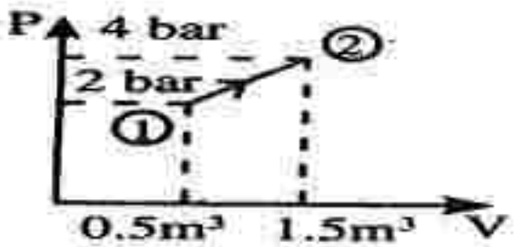
(iii) Specific entropy

(iv) Internal energy

(v) Pressure

(vi) Temperature.

(b) A gas in a cylinder with a spring-loaded piston undergoes an expansion process as shown in the diagram. The initial and final states are shown in the diagram. Find the work done.



(c) Which of the following cyclic integrates is always zero, whatever be the process, reversible or irreversible ? Give reason.

(i) $\oint \delta Q$ (ii) $\oint \frac{\delta Q}{T}$

(iii) $\oint dS$ (iv) $\oint pdV$

(d) A manometer attached to a vessel cotaining a fluid gives a reading of 5 cm of mercury

($f = 13600\ kg/m^3$). What will be the manometer reading if water ($f = 1000\ kg/m^3$) is used as the manometric fluid ?

(e) During an adiabatic process, a system does 50 kJ of work. What is the change in internal energy of the system ?

(f) Saturated steam at 10 bar is cooled at constant pressure until its dryness fraction becomes 50%. What are the changes in temperature and specific volume ?

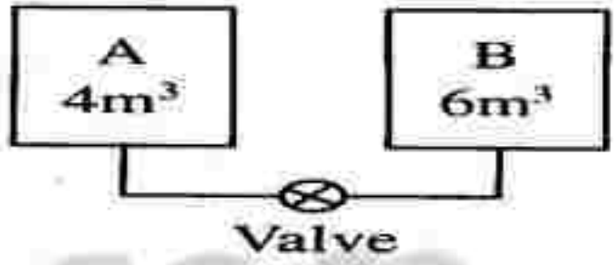
(g) A reservoir at 400 K rejects heat at the rate of 800 kW. Calculate the rate at which its entropy changes.

(h) An air conditioner has a COP of 1.8. If it has to transfer heat at the rate of 3.6 kW from the room it cools, calculate its power consumption.

(i) A system originally at 400 K cools down by rejecting heat to the surroundings at 300 K. The entropy change of the system is −0.4 kJ/K and it transfer 30 kJ of heat to the surroundings. Determine whether this is a possible or impossible process.

(j) Show that $C_P > C_v$ for an ideal gas.

2. Two tanks, A and B having volumes as shown, are rigid and are connected by a pipe with a valve which is initially closed. The air in A is at 2 bar, 40°C and the air in B is at 4 bar, 80°C. The valve is now opened and remains open until the two tanks come to a uniform state in thermal equilibrium with the surroundings at 30°C. Calculate the initial and final masses in A and B assuming air to be an ideal gas. 10



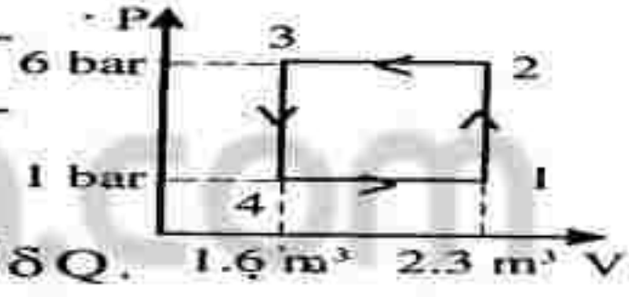
3. 10 kg of saturated liquid water at 1 bar is heated at constant pressure until the temperature becomes 200°C. Calculate :

(a) The initial and final volumes.

(b) The work done.

(c) The heat transferred. 10

4. 2 kg of air undergo a cyclic process as shown in the p-v diagram. The pressure and volume values are shown in the diagram. It may be noted that there are two constant-pressure processes and two constant volume processes.



(a) Calculate $\oint \delta W$ and $\oint \delta Q$.

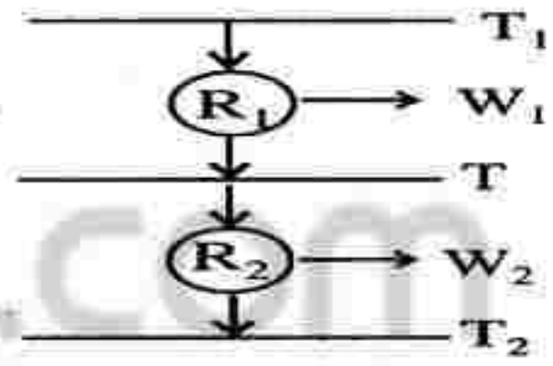
(b) Find the heat transferred during the process 1 –2. 10

5. Steam enters a turbine operating at steady state with a mass flow rate of 4600 kg/hour. The turbine develops a power of 1000 kW. The steam eneters at

60 bar, 400°C and leaves at 0.1 bar., 90% quality. Neglecting changes in kinetic and potential energies of steam, calculate the heat transferred through the turbine casing. 10

6. 5 kg air undergo a polytropic process $pv^{1.3} = c$. The initial condition of air is 1 bar, 27°C while the final pressure is 5 bar. Calculate the entropy change of the air. If the surroundings are at 25°C, what is the entropy change of the universe ? 10

7. Two reveriable engines R_1 and R_2 operate as shown in the figure, R_1 rejecting heat directly to R_2. R_1 operates between temperatures T_1 and T



while R_2 operates between T and T_2, where $T_1 > T > T_2$. Express the temperature T in terms of T_1 and T_2 when (a) the two engines develop equal work and (b) when the engines have the same efficiency. 5+5

8. An engine receives heat from an incompressible body of mass 'm' and specific heat 'c'. This body is initially at T_H. The engine rejects heat to an identical body of mass 'm' and specific heat 'c' but at initial temperature T_C, such that $T_C < T_H$. The engine operates until the two bodies come to the same temperature. Show that the maximum work that can be done by such an arrangement is given by

$$W_{max} = mc\left[\sqrt{T_H} - \sqrt{T_C}\right]^2 . \qquad 10$$