Total number of printed pages – 7

B. Tech

BENG 1103

Second Semester Examination – 2008

THERMODYNAMICS

Full Marks – 70

Time : 3 Hours

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

The figures in the right-hand margin indicate marks.

Use of steam table is allowed.

1. Answer the following questions : 2 × 10

   (a) When a system is said to be in thermodynamic equilibrium ?

   (b) How a pure substance is defined ?

P.T.O.

(c) How the state of a pure substance can be fixed when the system is in equilibrium.

(d) Convert 40 cm Hg Vacuum to absolute pressure in KPa when barometer reading is 760 mm of Hg.

(e) A platinum resistance thermometer has a resistance of 2.5 ohm at 0 °C and 4.0 ohm at 100 °C. Calculate the temperature when the resistance indicates 5.8 ohm.

(f) Thermal efficiency of a heat engine is always less than 100%. Justify the statement.

(g) What is the difference between a Nozzle and a Diffuser ?

(h) Show that the enthalpy of the fluid remains same as the fluid flows through a constricted passage of an insulated tube.

(i) Write the S.I. units of kinetic viscosity, latent heat, specific enthalpy and specific entropy.

(j) How the Cop of a heat pump is related to that of a refrigerator ? Prove it.

2. (a) 1.5 kg of liquid having a constant specific heat of 2.5 kJ/kgK is stirred in a well insulated chamber. The temperature rises by 15 °C. Find the change in internal energy and work done during the process. 4

(b) At the begining of the compression stroke of a two cylinder internal combustion engine the air is at a pressure of 101.325 KPa. Compression reduces the volume to 1/5 of its original volume and the compression index is 1.2. The bore and stroke of each cylinder is 0.15 m and 0.25 m respectively. If each cylinder undergoes

500 compression strokes per minute, determine the power absorbed in kW by the engine during compression. 6

3. (a) The steam supply to an engine comprises two streams which mix before entering the engine. One stream is supplied at the rate of 0.01 kg/s with an enthalpy of 2952 kJ/kg and a velocity of 20 m/s. The other stream is supplied at 0.1 kg/s with an enthalpy of 2569 kJ/kg and a velocity of 120 m/s. At the exit from the engine the fluid leaves as two streams, one of water at the rate of 0.001 kg/s with an enthalpy of 420 kJ/kg and the other of stream. The engine develops a shaft power of 25 kW. Neglecting the fluid velocities at the exit and the heat transfer, find out the enthalpy of the second exit stream. 6

(b) What is free expansion ? Why does it have zero work transfer ? 4

4. A heat engine operating between two reservoirs at 1000 K and 300 K is used to drive a heat pump which extracts heat from the reservoir at 300 K at a rate twice that at which the engine rejects heat to it. If the efficiency of the engine is 40% of the maximum possible and the COP of the heat pump is 50% of the maximum possible. What is the temperature of the reservoir to which the heat pump rejects heat ? What is the rate of heat rejection from the heat pump if the rate of heat supply to the engine is 50 kW ? 10

5. Steam flows through a small turbine at the rate of 5000 kg/hr entering at 15 bar, 300 °C and leaving at 0.1 bar with 4% moisture. The steam enters at 80 m/s at a point 2 m above the discharge and leaves at 40 m/s. Compute the

shaft power assuming that the device is adiabatic. Calculate the diameters of the inlet and discharge tubes. 10

6. 0.5 kg of air is expanded reversibly and adiabatically from 0.4 MPa and 527 K to 80 KPa and then compressed at constant pressure to the original volume. Sketch the processes on the p-v and T-s planes. Compute the heat transfer and work transfer for the whole path. 10

7. One kg of ice at −7 °C is exposes to the atmosphere which is at 27 °C. The ice melts and comes into thermal equilibrium with atmosphere. (a) Determine the entropy increase of the universe, (b) What is the minimum amount of work necessary to convert the water back into ice at −7 °C ? C_p of ice is 2.0 kJ/kgK and latent heat of fusion is 333.3 kJ/kg. 10

8. (a) Show that the efficiency of a reversible engine is independent of nature or amount of the working fluid going through the cycle. 5

(b) Show that heat is a path function and not a property. 5