This question paper contains 4 printed pages.

3265 *Your Roll No.* .....

B. Tech. (M) / II **J**

Paper IV— THERMAL ENGINEERING – I

(EME–204)

Time : 3 hours *Maximum Marks* : 70

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt any five questions.

Assume missing data suitably, if any.

Use of steam tables and Mollier charts permitted.

1. (*a*) A stationary fluid system goes through a cycle comprising the following processes:

   (*i*) Process 1–2 isochoric heat addition 235 kJ/kg

   (*ii*) Process 2–3 Adiabatic expansion to its original pressure with loss of 70 kJ/kg in internal energy

   (*iii*) Process 3–1 isobaric compression to its original volume with heat rejection of 200 kJ/kg.

   Determine the heat transter, work transfer and change in internal energy for each process and for entire cycle.

P. T. O.

(*b*) Show that isentropic process is represented by PV^{γ} = constant. 9,5

2. (*a*) Air flows steadily at the rate of 0·5 kg/s through an air compressor, entering at 7 m/s velocity, 100 kPa pressure and 0·95 m^3/kg volume, and leaving at 5 m/s, 700 kPa and 0·19 m^3/kg. The internal energy of the air leaving is 90 kJ/kg greater than that of the air entering. Cooling water in the compressor jackets absorbs heat from the air at the rate of 58 kJ/s. Determine the rate of work input to the air in kW and find the ratio of inlet pipe diameter to outlet pipe diameter.

(*b*) Explain the following:

(*i*) Carnot theorem

(*ii*) Clausius Inequality. 9,5

3. (*a*) A reversible engine works between three thermal reservoirs A, B and C. The engine absorbs an equal amount of heat from the thermal reservoirs A and B kept at temperatures T_A and T_B respectively and rejects heat to the thermal reservoir C kept at temperature T_C. The efficiency of the engine is α times the efficiency of the reversible engine which works between two reservoirs A and B. Prove that:

$$\frac{T_A}{T_B}=(2\alpha-1)+2(1-\alpha)\frac{T_A}{T_C}$$

(*b*) One kg of ice at 0°C is exposed to the atmosphere

which is at 20°C. The ice melts and comes into thermal equilibrium with the atmosphere.

Determine the entropy increase of the universe. Latent heat of fusion of ice is 333·33 kJ/kg. 7,7

4. (*a*) Explain the combustion phenomenon in SI engines.

(*b*) What are the factors affecting knock intensity in SI engines?

(*c*) Explain the following:

(*i*) Rating of fuels

(*ii*) Supercharging. 6,3,5

5. (*a*) Describe with a neat sketch the working of Benson Boiler. What do you mean by boiler efficiency?

(*b*) Explain with a neat sketch pulverised fuel firing.

(*c*) What are the advantages of preheating the air? 6,6,2

6. (*a*) Explain with the help of neat diagram a regenerative steam power cycle and state advantages of this cycle.

(*b*) Steam at 100 bar and 500°C is supplied to a steam turbine. The steam is reheated to its original temperature passing the steam through reheater at 12 bar. The expansion after reheating takes place to condenser pressure of 0·08 bar. Find the

efficiency of reheat cycle and work output if flow of steam is 5 kg/s. Do not neglect the pump work. 5,9

7. (*a*) Explain the phenomenon of supersaturated flow in a steam nozzle. What is Wilson line?

(*b*) Steam at 30 bar, 350°C expands through a convergent-divergent nozzle. The exit pressure is 3 bar. The flow rate is 0·5 kg/s and the nozzle efficiency is 0·8. Assuming that the velocity at inlet is negligible, determine the throat and exit areas, steam velocity at exit and quality of steam at exit. 4,10

8. (*a*) Show that optimum blade speed for maximum efficiency of 50% reaction turbine is given by $\rho = \cos\alpha$ and hence prove that maximum blade efficiency is given by:

$$(\eta_b)_{max} = \frac{2\cos^2\alpha}{1+\cos^2\alpha}$$

where α – nozzle angle

ρ – speed ratio.

(*b*) What are the functions of a condenser in a steam power plant?

(*c*) What is a surface condenser? Why does cooling water flow inside the tubes and steam condense outside the tubes? Draw the neat sketch of surface condenser. 8,2,4