Q. P. Code: 25655

(3 Hours) **Max. Marks: 80**

1) Question No 1 is compulsory.
2) Attempt any three out of remaining five questions.
3) Figures to the right indicate full marks.
4) Assume suitable data if required.
5) Use of steam Table and moiller chart permitted.

Q.1 a Attempt the following **(Any five)** 20

i) Explain Quasi-static process.

ii) State Zeroth law of Thermodynamics and its significance.

iii) Prove, $(COP)_{H,P} = (COP)_R + 1$

iv) State and explain principle of increase of entropy

v) Define availability, unavailability and irreversibility.

vi) What is cut-off ratio? State its significance?

vii) 2 kg of steam is at 12 bar and 0.85 dry, determine its enthalpy and specific volume.

Q.2 a Show that for a polytropic process. 06

$$Q = \left(\frac{\gamma - n}{\gamma - 1}\right) W$$

Where Q and W are heat and work interactions and n is polytropic index.

b A mass of 8 kg gas expands within a flexible container so that the p–v relationship is of the from $pv^{1.2}$ = constant. The initial pressure is 1000 kPa and the initial volume is 1 m^3. The final pressure is 5 kPa. If specific internal energy of the gas decreases by 40 kJ/kg, Find the heat transfer in magnitude and direction. 06

c At the inlet to a certain nozzle, the enthalpy of the fluid passing is 3000 kJ/kg and the velocity is 60 m/s. At the discharge end, the enthalpy is 2762 kJ/kg. The nozzle is horizontal and there is negligible heat loss from it. 08

(a) Find the velocity at exists from the nozzle.

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(b) If the inlet area is 0.1 m^2 and the specific volume at inlet is 0.187 m^3/kg, find the mass flow rate.

(c) If the specific volume at the nozzle exit is 0.498 m^3/kg, find the exit area of the nozzle.

Q.3 a Define the first law of thermodynamics. Also give supporting mathematical expression for it. 04

b State Kelvin-Planck and Clausis statement of second law of thermodynamics and prove its equivalence. 08

c A heat pump working on the Carnot cycle takes in heat from a reservoir at 5°C and delivers heat to a reservoir at 60°C. The heat pump is driven by a reversible heat engine which takes in heat from a reservoir at 840°C and rejects heat to a reservoir at 60°C. The reversible heat engine also drives a machine that absorbs 30 kW. If the heat pump extracts 17 kJ/s from the 5°C reservoir, determine 08

(a) The rate of heat supply from the 840°C source

(b) The rate of heat rejection to the 60°C sink.

Q.4 a State and Prove Carnot theorem. 07

b State and Prove Clausis inequality 07

c A heat engine receives reversibly 420 kJ/cycle of heat from a source at 327°C, and rejects heat reversibly to a sink at 27°C. There are no other heat transfers. For each of the three hypothetical amounts of heat rejected, in (a), (b), and (c) below, compute the cyclic integral of dQ /T from these results show which case is irreversible, which reversible, and which impossible: 06

(a) 210 kJ/cycle rejected

(b) 105 kJ/cycle rejected

(c) 315 kJ/cycle rejected

Q.5 a Explain the methods to improve the efficiency of the Rankine cycle. 06

b Compare Otto, Diesel and Dual cycle with P-V and T-S diagram. 06

c In a steam turbine steam at 20 bar, 360°C is expanded to 0.08 bar. It then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back the water into the boiler. Assume ideal processes, find per kg of steam the net work and the cycle efficiency. 08

Q.6 a Explain the following terms relating to steam formation : 10

(i) Sensible heat of water, (ii) Latent heat of steam, (iii) Dryness fraction of steam, (iv) Enthalpy of wet steam, and (v) Enthalpy of Superheated steam.

c In an engine working on Dual cycle, the temperature and pressure at the beginning of the cycle are 90°C and 1 bar respectively. The compression ratio is 9. The maximum pressure is limited to 68 bar and total heat supplied per kg of air is 1750 kJ. 10

Determine :

(i) Pressure and temperatures at all salient points

(ii) Air standard efficiency

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