(3 Hours) [Total Marks: 80]

1) Question No.1 is compulsory
2) Attempt any three questions out of remaining five questions
3) Figures to right indicate full marks
4) Assume suitable data if necessary
5) Answers to questions should be grouped and written together.
6) Use of steam table is allowed.

Q1. Attempt any four: 5*4 = 20

a) Prove that energy is a property of a system?
b) Derive an expression for heat absorbed or rejected during polytropic process for ideal gas?
c) Explain energy balance for steady flow open system?
d) State the principle of increase of entropy of the universe and discuss anyone application ?
e) Derive an expression for decrease in availability due to heat transfer with finite temperature difference?

Q.2 a) A spherical balloon of 30 cm diameter contains air at a pressure of 1.5 bar. The diameter of the balloon is increased to 40 cm by heating and during the process the pressure is proportional to its diameter. Calculate the work done assuming the process to be quasistatic? 6

Q. 2 b) 0.06 meter cube air at 5 bar and 200 degree celsius expands isentropically until the pressure becomes at 2 bar. It is then heated at constant pressure until the enthalpy increase during the process is 80 kJ. Calculate work done in each process and total work done? 8

Q. 2 c) Write a short note on Joule-Thompson porous plug experiment with its significance? 6

Q.3 a) Show that the efficiency of all reversible heat engines operating between the same temperature limits is same? 5

Q. 3 b) A house is maintained at 23 degree celsius throughout the year. A heat pump is used to cool the house in summer and heat the house in winter. The heat loss is 0.4 kW per degree difference between outside and inside temperatures. The outside temperature in winter and summer is -3 degree celsius and 43 degree celsius respectively. Find power required to drive the heat pump for both cooling and heating ? 8

Q. 3 c) Show that no heat pump working between two fixed temperature reservoirs have COP greater than that of a reversible heat pump working between the same temperature limits? 7

Q. 4 a) A reversible heat engine operates between three heat reservoirs as shown in figure. The engine receives 4000 kJ/s of heat from reservoir A at temperature 1000 K and produces the work of 1600 kJ/s. Calculate the heat transfer with reservoirs B and C in magnitude and direction using the entropy concept. Hence, calculate the thermal efficiency? 8

Q. 4 b) Derive Maxwell Equations and explain them? 5

Q. 4 c) 2 kg of water at 50 degree celsius is mixed with three kg of water at 100 degree celsius in a steady flow process. Calculating the temperature of the resulting mixture state whether the mixing is isentropic? If no, what is the entropy change and unavailable energy with respect to the surroundings at 50 degree celsius? 7

Q. 5 a) Calculate the volume, density, enthalpy and entropy of 2 kg of steam at 80 degree celsius and dryness fraction of 0.85 ? 6

Q. 5 b) Determine the mass of 0.25 meter cube of steam at 5 bar pressure and 0.85 dryness fraction. Proceed to calculate the heat content 1 meter cube of this steam? 4

Q. 5 c) The power output of a steam turbine is 5 MW. The inlet conditions are 2 Mpa of pressure, 400 degree celsius of temperature, 50 m/s of velocity and 10 m of elevation. The exit conditions are 15 kPa. 0.9 dry qualtiy, 180 m/s and 6 m elevation. Compute 1) The magnitude of delta h, delta ke and delta pe. 2) Work done per kg of steam 3) Mass flow rate of steam. 10

Q. 6 a) Explain the working of vane type blower with the help of neat sketch? 6

Q. 6 b) In a Rankine cycle, the maximum pressure of steam supplied is 6 bar. The dryness fraction is 0.9.The exhaust pressure is 0.7 bar. Find the theoretical work done and Rankine efficiency? 8

Q. 6 c) Derive an expression for efficiency of dual cycle? 6
