Total Pages—6

(Set-Q₁)

## M.Tech - 1st(Mech-HPE)
## Advanced Engineering Thermodynamics

*Full Marks* : 70

*Time* : 3 hours

Answer any six questions including Q. No. 1
which is compulsory

*The figures in the right-hand margin indicate marks*

Use of standard tables and charts are permitted

1. Explain *all* questions : 2 × 10

   (a) Air at 500K, 500kPa is expanded to 100 kPa in two steady-flow cases. Case 1 is a throttle and case 2 is a turbine. Which has highest exit temperature ? Why ?

   (b) An initially empty cylinder is adiabatically filled with air from 20°C, 100 kPa until it is full. Is the final temperature larger, equal to, or smaller then 20°C ? Does the final $T$ depend on the size of the cylinder ?

   (c) A room is heated with a 1500 W electric

*( Turn Over )*

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heater. How much power can be saved ? If a heat pump with a COP of 2·0 is used instead ?

   (d) A computer chip dissipates 2 kJ of electric work over time and rejects that as heat transfer from its 50°C surface to 25°C ambient. How much entropy is generated in the chip ? How much, if any, is generated outside the chip ?

   (e) An inventor claims to develop an adiabatic, steady flow turbine such that entropy at the exit is less then entropy at inlet. Is the claim true ? Justify.

   (f) The shaft work in a pump to increase the pressure is small compared to the shaft work in an air compressor for the same pressure increase. Why ?

   (g) Does a reversible process change the availability if there is no work involved ?

   (h) A heat engine receives 1000 W heat at 1000 K and gives out 600 W as work with the rest as heat transfer to the ambient. Find the first and second law efficiencies.

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(i) Define enthalpy of formation and its significance in analysis of reactive system.

(j) Discuss metastable equilibrium with suitable examples.

2. (a) A vessel having a volume of 5 m$^3$ contains 0·05m$^3$ of saturated liquid water and 4·95 m$^3$ saturated vapor at 0·1 MPa. Heat is transferred until the vessel is filled with saturated vapor. During the process the vessel is lifted to a height of 100 m at constant velocity from the ground. Determine the heat transfer for the process.      5

(b) Oxygen at 300 kPa and 100°C is in a piston/cylinder arrangement with a volume of 0·1 m$^3$. It is now compressed in a polytropic process with exponent $n = 1·2$ to a final temperature of 200°C. Calculate the heat transfer for the process.      5

3. (a) A 750-L rigid tank, initially contains water at 250°C, which is 50% liquid and 50% vapor, by volume. A valve at the top of the tank

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is opened and saturated vapor is slowly withdrawn. Heat transfer takes place such that the temperature remains constant. Find the amount of heat transfer required to reach the state where half the initial mass is withdrawn.   6

(b) A diffuser, has air entering at 100 kPa and 300 K with a velocity of 200 m/s. The inlet cross-sectional area of the diffuser is 100 mm$^2$. At the exit, the area is 860 mm$^2$, and the exit velocity is 20 m/s. Determine the exit pressure and temperature of the air.   4

4. (a) Air at 300 K and 100 kPa with a volume 0·1 m$^3$ is compressed in a reversible adiabatic process to a final temperature of 700 K. Find the final pressure and volume.      4

(b) A de-superheater works by injecting liquid water into a flow of superheated steam. With 2 kg/s at 300 kPa, 200°C, steam flowing in, what mass flow rate of liquid water at 20°C should be added to generate saturated vapor at 300 kPa ? What will be the rate of entropy generation in the process ?      6