B.Tech. / B.E. Mechanical Engineering (Model Curriculum) Semester-III

PCC-ME201 - Thermodynamics

P. Pages : 3 **GUG/W/24/14058**

Time : Three Hours * 5 5 7 5 * Max. Marks : 80

Notes :
1. All questions carry equal marks.
2. Assume suitable data wherever necessary.
3. Illustrate your answers wherever necessary with the help of neat sketches.
4. Use of Steam tables, Mollier's chart, Drawing instruments, Thermodynamic tables for moist air, Psychrometric charts and Refrigeration charts and use of non programmable calculator is permitted.
5. Attempt Q.1 or Q.2, Q.3 or Q.4, Q.5 or Q.6, Q.7 or Q.8, Q.9 or Q.10.

1. a) What do you mean by thermodynamic work? Derive an expression for the displacement work. **8**

b) The temperature t on a thermodynamic scale is defined in terms of property K by the relation, t = a InK + b, where a and b are constants. The values of K are found to be 1.83 and 6.78 at the ice point and the steam point, the temperatures of which are assigned the numbers 0 and 100 respectively. Determine the temperature corresponding to a reading of K equal to 2.42 on the thermometer. **8**

OR

2. a) What do you mean by microscopic and macroscopic approach of studying thermodynamics? Explain difference between them. **8**

b) In a piston cylinder arrangement, the pressure is inversely proportional to the square of the volume. The initial pressure is 10 bar in the cylinder and the initial volume is $0.1m^3$. The volume is now changed so that the final pressure is 2 bar. Find the work done in KJ. **8**

3. a) Prove that energy is property of system. **8**

b) A system undergoes cyclic process composed of four processes 1-2, 2-3, 3-4, 4-1. The energy transfer is tabulated below. Complete the following table. **8**

Process	Q, KJ/min	W, KJ/min	Δ U, KJ/min
1-2	400	150	---
2-3	200	---	300
3-4	-200	---	---
4-1	0	75	---

OR

4. a) Explain first law of thermodynamics as applied to a closed system undergoing a change of stateor process. **4**

b) Explain heat transfer in: **4**

i) Isobaric process

ii) Isothermal process in detail.

c) 10 kg. of gas undergoes a process for which $P = (15/v) - (v^2/100)$, where p is the pressure in bar and v is the volume in m^3. The initial volume is $5 m^3$ and the temperature is 200ºC. The final volume is $10 m^3$ and the temperature is $-100^o C, u = (0.71T + 2) kJ/kg$, where T is in k, find: (i) Work done, (ii) Change in internal energy (iii) Heat transfer **8**

5. a) Write down the general steady flow energy equation and simplify it for the following system: **8**

i) Nozzle & Diffuser
ii) Turbine & Compressor
iii) Throttling device

b) At the inlet to a convergent-divergent 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 2757 kJ/kg. The nozzle is horizontal and heat loss during flow is negligible. Find: **8**

i) Velocity of fluid at exit of nozzle.
ii) If the inlet area is $0.1 m^2$ and specific volume at inlet is $0.187 m^3/kg$, find the mass flow rate of fluid and
iii) If the specific volume at outlet is $0.498 m^3/kg$, find the area at exit of nozzle.

OR

6. a) Write short notes on: **4**

i) Control volume

ii) Energy conservation principle

b) Air at a temperature of 15ºC passes through a heat exchanger at a velocity of 30 m/s where its temperature is raised to 800ºC. It then enters turbine with same velocity of 30 m/s and expands until temperature falls to 650ºC. On leaving the turbine air is taken at a velocity of 60 m/s to a nozzle where it expands until temperature has fallen to 500ºC. If air flow rate is 2 kg/s. **12**

Calculate:

i) Rate of heat transfer to air in heat exchanger
ii) Power output from the turbine assuming no heat loss,
iii) Velocity at the exit from nozzle, assuming no heat loss. Take enthalpy of air as h = Cp. T, where Cp is specific heat and equal to 1.005 kJ/kg.K and T=temperature.

7. a) With block diagram explain the operation of heat engine, refrigerator and heat pump. Also, What are their performance parameters? **8**

b) A heat pump working on the Carnot cycle takes in heat from a reservoir at 5ºC and delivers heat to a reservoir at 60ºC. The heat pump is driven by a reversible heat engine which takes in heat from a reservoir at 840ºC and rejects heat to a reservoir at 60ºC. The reversible heat engine also drives a machine that absorbs 30 kW. If the heat pump extracts 17 kJ/s from the 5ºC reservoir, determine: **8**

i) The rate of heat supply from the 840ºC source, and

ii) The rate of heat rejection to the 60ºC sink.

OR

8. a) Explain the principle of increase of entropy. **4**

b) A piston cylinder device contains 1.2 kg of nitrogen gas at a 120 kPa and 27ºC. The gas is now compressed slowly in a polytropic process during which $pV^{1.3} = \text{constant}$. The process ends when the volume is reduced by one half. Determine the entropy change of nitrogen during this process. **12**

9. a) State and explain the following terms: **8**

(i) Dryness fraction, (ii) Degree of superheat, (iii) Latent heat of vaporization, (iv) Triple point of water.

b) What is wet, dry and Superheated steam? Determine the state of the steam, i.e. Whether it is wet, dry or superheated in the following cases: **8**

i) Steam has a pressure of 10 bar and specific volume 0.175 m3/kg.

ii) Steam has a pressure of 15 bar and a temperature of 220ºC.

iii) Steam has a pressure of 20 bar and if 2700 kJ/kg of heat is required to generate the steam from water at 0ºC.

OR

10. a) What is quality of steam? What are the different methods of measurement of quality? Explain any one in detail. **8**

b) A vessel of volume $0.04\,m^3$, contains a mixture of saturated water and saturated steam at a temperature of 250ºC. The mass of liquid present is 9 kg. Find the pressure, the mass, specific volume, enthalpy and entropy and internal energy? **8**

****