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

PCC-ME201 - Thermodynamics

P. Pages : 3 **GUG/S/25/14058**

Time : Three Hours * 2 3 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 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) State and explain the Zeroth law of thermodynamics. How it is used to measure the temperature? **4**

b) A system of volume V contains a mass m of the gas at pressure P and temperature T. The microscopic properties of system obey the relationship $\left(p + aV^2\right)(V - b) = mRT$, where a, b and R are constants. Obtain an expression for the displacement work done by the system during a constant temperature expansion from volume V_1 to V_2. Calculate the work done by a system which contains 10kg of this gas expanding from $1m^3$ to $10m^3$ at temperature of 293K. Use the values $a = 15.7 \times 10 Nm^4$, $b = 1.07 \times 10^{-2} m^3$ and $R = 0.278 kJ/kg - k$. **12**

OR

2. a) Write short notes on- **4**

i) Avogadro's Hypothesis ii) Universal Gas constant

b) Prove that, $C_p - C_v = R$. Where all the notations have their usual meanings. **4**

c) A Mass of gas is compressed in a quasi-static process from 80 kPa, $0.1m^3$ to $0.4 MPa, 0.03m^3$. Assuming that the pressure and volume are related by pV^n =const. Find the work done by the gas system. **8**

3. A piston cylinder machine contains a fluid system which passes through a complete cycle of four processes. During the cycle the sum of all heat transfers is -170 kJ. The system completes 100 cycles per minute. Complete the following table showing the method for each item and compute the net rate of work output. **16**

Process	Q, KJ/min	W, KJ/min	ΔU, KJ/min
a-b	0	2170	….
b-c	21000	0	….
c-d	-2100	….	-36600
d-a	…..	….	….

OR

4. a) Derive the expression for displacement work in polytropic process? **8**

b) 10kg of gas undergoes a process for which $P = (15/v) - \left(v^2/100\right)$, where p is the pressure in bar and v is the volume in m^3. The initial volume is $5m^3$ and the temperature is 200ºC. The final volume is $10m^3$ and the temperature is -100ºC. u = 0.71T + 2kJ/kg, where T is in k, find- **8**

i) Work done
ii) Change in internal energy
iii) Heat transfer

5. a) Write down the general steady flow energy equation. Derive the simplified form when it used for- **8**

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

OR

6. a) What do you mean by flow work? How it can be calculated? **4**

b) Write short notes on- **4**

i) Control volume ii) Energy conservation principle

c) A reciprocating air compressor takes in $2m^3/min$ at 0.11 MPa, 20ºC which it delivers at 1.5 MPa, 111ºC to an aftercooler where the air is cooled at constant pressure to 25ºC. The power absorbed by the compressor is 4.15 kW. Determine the heat transfer in- **8**

i) The compressor and
ii) The cooler

7. a) Write short notes on- **8**

i) Statements of second law of thermodynamics

ii) Carnot cycle

b) A heat engine operates on a Carnot cycle between source and sink temperatures of 337ºC and 57ºC respectively. If the heat engine receives 400 kJ of heat flow from source, find the efficiency, net work done and heat rejected to sink. **8**

OR

8. a) Using an engine of 30% thermal efficiency to drive a refrigerator having a COP of 5, what is the heat input into the engine for each MJ removed from the cold body by the refrigerator? If this system is used as a heat pump, how many MJ of heat would be available for each MJ of heat input to the engine? **4**

b) 4kg of air is compressed from 40ºC and 125 kPa to 250ºC and 875 kPa. It is then throttled to 257 kPa. Finally, it is cooled to a pressure of 125 kPa and 180ºC. Calculate the overall change in entropy? Take $C_p = 1.005$ kJ/kg.K and $C_v = 0.717$ kJ/kg.K. **12**

9. a) Explain briefly- **4**

i) Volume of superheated steam ii) Critical point

b) State and explain the following terms- **4**

i) Latent heat of vaporization

ii) Triple point of water

c) 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) Define dryness fraction of steam? With neat sketch and T-s diagram, explain the procedure of measuring dryness fraction of the steam using throttling calorimeter? **8**

b) A pressure Cooker contains 2kg of steam at 5 bar pressure and 0.9 dryness fraction. Find the quantity of steam which must be transferred so as the quality of steam becomes 60% dry. Also, calculate the pressure and temperature of the steam that exists in the cooker after the heat rejection. **8**

****