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B. M. S. College of Engineering, Bengaluru - 560019

Autonomous Institute Affiliated to VTU

September / October 2023 Supplementary Examinations

Programme: B.E. **Semester: III**
Branch: Mechanical Engineering **Duration: 3 hrs.**
Course Code: 19ME3ESBTD **Max Marks: 100**
Course: Basic Thermodynamics **Date: 25.09.2023**

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Use of thermodynamics data handbook is permitted.
2. Missing data, if any, may be suitably assumed.

UNIT - I

1. a) Define the following: **06**
   i) Macroscopic and microscopic approaches
   ii) Intensive and extensive property
   iii) Open system and closed system

   b) Explain the working principle of resistance thermometer with the help of neat sketch. **06**

   c) The temperature T on a thermometric scale is defined in terms of a property P by the relation, $T = a\ ln\ (P) + b$, Where a and b are constants. The values of P 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 P equal to 2.42 on the thermometer. **08**

OR

2. a) Derive work transfer expressions for the following: **09**
   i) Pdv work for a process $P\ v^{\gamma} = c$, ii) Electrical work iii) Shaft work.

   b) Work of 150 kJ is supplied to a closed system. If the initial volume is 0.6 m^3 and pressure of the system changes as $p = 8 - 4V$. Where p is in bar and V is m^3, determine i) initial pressure, ii) final volume and iii) final pressure of the system. **08**

   c) Show that heat is a path function and not the system property. **03**

UNIT - II

3. a) State first law of thermodynamics for a closed system undergoing a process and list any two limitations of first law of thermodynamics. **04**

b) What is internal energy? Prove that internal energy is a property of the system. **08**

c) A nozzle is used for increasing the velocity of a steadily flowing stream. 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**

i) Find the velocity at exists from the nozzle.
ii) 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.
iii) If the specific volume at the nozzle exit is 0.498 m^3/kg, find the exit area of the nozzle.

UNIT - III

4. a) What is the qualitative difference between heat and work? Why they are not completely interchangeable forms of energy? **04**

b) State Kelvin-Planck and Clausius statements of second law of thermodynamics. Show the equivalence of Kelvin-Planck and Clausius statements. **08**

c) A heat engine operating between two reservoirs at 1000 K and 300 K is used to drive a heat pump which extracts heat from the reservoir at 300 K at a rate twice that at which the engine rejects heat to reservoir at 300 K. The efficiency of the engine is 40% of the maximum possible and the COP of the heat pump is 50% of the maximum possible. If the rate of heat supply to the engine is 50 kW, determine: i) work input to heat pump, ii) rate of heat rejected by heat engine to reservoir at 300 K, iii) the temperature of the reservoir to which the heat pump rejects heat, iv) the rate of heat rejection from the heat pump. **08**

OR

5. a) State and prove the Clausius's theorem. **06**

b) Prove that entropy is a property of the system. **06**

c) One kg of water at 273 K is brought into contact with a heat reservoir at 373 K. When water has reached 373 K, find the following: i) Heat transfer, ii) entropy change of the water, iii) Entropy change of the heat reservoir, and iv) Entropy change of the universe**.** Take *Cp* for water as 4.18 kJ/kg K **08**

UNIT - IV

6. a) Define the following terms **10**

i) Available energy ii) Unavailable energy iii) Dead state

iv) Second law efficiency v) Irreversibility

b) A 80 kg of water at 100°C is mixed with 50 kg of water which is at 60°C in an insulated tank, while the temperature of the surroundings is 15°C. The pressure is assumed to remain constant. Determine the following: i) total available energy before mixing ii) final temperature of water after mixing, iii) total available energy after mixing and iv) change in available energy due to mixing. Take C_p for water as 4.2 kJ/kg K **10**

UNIT - V

7. a) Write down Vander Waal's equation of state and obtain expressions for the constants *a*, *b* and *R* in terms of critical properties of a Vander Waal's gas. **10**

b) The pressure, temperature and volume of a Neon gas are 56.4 bar, 57.85 K and 0.00305 m^3/kg respectively. Determine i) Critical properties of the gas, ii) Reduced pressure, iii) Reduced temperature, iv) Reduced volume, and v) Compressibility factor. **10**

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