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

Autonomous Institute Affiliated to VTU

December 2023 Supplementary Examinations

Programme: B.E. **Semester: III**
Branch: Mechanical Engineering **Duration: 3 hrs.**
Course Code: 22ME3PCETD **Max Marks: 100**
Course: Engineering Thermodynamics

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may suitably be assumed.
3. Use of steam tables and Mollier chart, Thermodynamics data hand book is permitted.

UNIT - I

1 a) Compare the following with examples: i) Open and closed systems, ii) Extensive and intensive properties, iii) Microscopic and macroscopic approaches and iv) Point and path functions. **08**

b) Explain Zeroth law of thermodynamics with suitable diagram. **04**

c) A spherical balloon has a diameter of 25 cm and contains at a pressure of 1.5 bar. The diameter of the balloon increases to 30 cm in a certain process and during this process the pressure is proportional to the diameter. Determine, (i) pressure in the balloon at the end of the process, (ii) work done by the air inside the balloon, and (iii) work done by balloon on surrounding with pressure of 1 bar during this process. **08**

UNIT - II

2 a) State first law of thermodynamics for a system undergoing a thermodynamic cycle and prove that internal energy is a property of the system. **08**

b) Derive the expressions for mass balance and steady flow energy equation for a single stream entering and leaving a control volume of a steady flow device. **06**

c) A fluid is confined in a cylinder by a spring-loaded, frictionless piston so that the pressure in the fluid is a linear function of the volume ($P = a + bV$). The internal energy of the fluid is given by the equation $U = 34+3.15\,PV$. Where U is internal energy in kJ, P is pressure in kPa, V is volume in m^3, a and b are constants. If the fluid changes from an initial state of 170 kPa, 0.03 m^3 to a final state of 400 kPa, 0.06 m^3, with no work other than that done on piston, find the following: (i) Change in internal energy, (ii) Values of constants a and b, (ii) Magnitude and direction of work transfer and (iii) Magnitude and direction of heat transfer. **06**

UNIT - III

3 a) State Clausius and Kelvin-Planck statements. Establish the equivalence between Clausius and Kelvin-Planck statements. **08**

b) Show that for a reversible heat pump and refrigerator operating under same temperature level, $COP_{HP} = COP_{Ref} + 1$. **04**

c) Two reversible heat engines A and B are arranged in series, engine A rejecting heat directly to engine B. Engine A receives 200 kJ at a temperature of 421 °C from a hot source, while engine B is in communication with a cold sink at a temperature of 4.4 °C. If the work output of engine A is twice that of engine B, find, (i) the intermediate temperature between engine A and engine B. (ii) efficiency of each engine, and (iii) heat rejected to the cold sink. **08**

OR

4 a) Define entropy and prove that entropy is a property of the system. **08**

b) State Carnot and Clausius theorems. Explain how inequality of Clausius provides the criterion of the reversibility and feasibility of a cycle. **04**

c) A reversible engine operates between temperatures T_1 and T_2 ($T_1 > T_2$). The energy rejected from this engine is received by a second reversible engine at the same temperature T_2. The second engine rejects energy at temperature T_3 ($T_3 < T_2$). Show that: **08**

(i) Temperature T_2 is the arithmetic mean of temperatures T_1 and T_3 if the engines produce the same amount of work output.

(ii) Temperature T_2 is the geometric mean of temperatures T_1 and T_3 if the engines have the same cycle efficiencies.

UNIT - IV

5 a) Explain the following: **10**

(i) Vander Waal's equation of state (ii) Compressibility factor

(iii) Reduced Properties (iv) Compressibility chart

b) A spherical shaped balloon of 12 m diameter contains H_2 at 30°C and 1.21 bar. Find the mass of H_2 in the balloon using real gas equation. **10**

UNIT - V

6 a) Explain the following terms with respect to pure substances using P-T diagram. **10**

(i) The sublimation line (ii) The vaporization line (iii) The melting or fusion line (iv) Triple point.

b) Steam at 10 bar, dryness fraction 0.84, is heated reversely in a rigid vessel until the pressure is 20 bar. Calculate the change in entropy and the heat supplied. Show the area which represents the heat supplied on T-S diagram. **10**

OR

7 a) With T-S diagram, carry out the energy analysis for each process in a ideal Rankine Cycle. **05**

b) Discuss the effect of followings on efficiency of Rankine Cycle. **09**

(i) Lowering the Condenser Pressure

(ii) Superheating the Steam to High Temperatures

(iii) Increasing the Boiler Pressure

c) A steam power plant operates between a boiler pressure of 15MPa and 600 ºC and condenser pressure of 9 kPa. If the isentropic efficiency of the turbine is 87 percent and isentropic efficiency of the pump is 85 percent, determine (a) Rankine efficiency of the cycle and (b) the net power output of the plant for a mass flow rate of 15 kg/s. **06**

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