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

Autonomous Institute Affiliated to VTU

May 2023 Semester End Main Examinations

Programme: B.E. **Semester: III**
Branch: Mechanical Engineering **Duration: 3 hrs.**
Course Code: 19ME3ESBTD **Max Marks: 100**
Course: Basic Thermodynamics **Date: 12.05.2023**

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 Thermodynamics Data Hand Book is permitted.

UNIT - I

1 a) Define the terms: i) system ii) state iii)point function iv) property **04**

b) Comment whether the following quantities can be called as properties or not :(i) pdV , (ii) Vdp , and (iii) pdV + Vdp. **06**

c) A temperature scale of certain thermometer is given by the relation t = *a* ln p + *b* where *'a'* and *'b'* are constants and p is the thermometric property of the fluid in the thermometer. If at the ice point and steam point the thermometric properties are found to be 1.5 and 7.5 respectively what will be the temperature corresponding to the thermometric property of 3.5 on Celsius scale. **06**

d) Define Intensive and extensive properties, and thermodynamic equilibrium. **04**

OR

2 a) Demonstrate the equivalence of heat and work with the help of Joule's experiment. **06**

b) Show that energy is a point function. **06**

c) To a closed system 150 kJ of work is supplied. 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 in m^3, determine the final volume and pressure of the system. **08**

UNIT - II

3 a) The following equation gives the internal energy of a certain substance u = 3.64 pv + 90 where u is kJ/kg, p is in kPa and v is in m^3/kg. A system composed of 3.5 kg of this substance expands from an initial pressure of 500 kPa and a volume of 0.25 m^3 to a final pressure 100 kPa in a process in which pressure and volume are related by $pv^{1.25}$ = constant. (i) If the expansion is quasi-static, find Q, ΔU and W for the process. (ii) In another process, the same system expands according to the same pressure-volume relationship as in part (i), and from the same initial state to the same final state as in part (i), but the heat transfer in this case is 32 kJ. Find the work transfer for this process. (iii) Explain the difference in work transfer in parts (i) and (ii). **10**

b) In an air compressor air flows steadily at the rate of 0.5 kg/s through an air compressor. It enters the compressor at 6 m/s with a pressure of 1 bar and a specific volume of 0.85 m^3/kg and leaves at 5 m/s with a pressure of 7 bar and a specific volume of 0.16 m^3/kg. The internal energy of the air leaving is 90 kJ/kg greater than that of the air entering. Cooling water in a jacket surrounding the cylinder absorbs heat from the air at the rate of 60 kW. Calculate : (i) the power required to drive the compressor, and (ii) inlet and output pipe cross-sectional areas. **10**

UNIT - III

4 a) State and prove Clasius and Kelvin Plank statements equivalence. **10**

b) A reversible heat engine operates between two reservoirs at temperatures 700°C and 50°C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 50°C and – 25°C. The heat transfer to the engine is 2500 kJ and the net work output of the combined engine refrigerator plant is 400 kJ. Determine, (i) the heat transfer and net heat transferto the refrigerant and the net heat transfer to the reservoir at 50°C, (ii) considering that the efficiency of the heat engine and the C.O.P. of the refrigerator are each 45 % of their maximum possible values in the case (i) determine the heat transfer and net heat transfer. **10**

OR

5 a) State and prove Clausius Inequality. **08**

b) Air at 20°C and 1.05 bar occupies 0.025 m^3. The air is heated at constant volume until the pressure is 4.5 bar, and then cooled at constant pressure back to original temperature. Calculate :(i) The net heat flow from the air. (ii) The net entropy change. Sketch the process on T-s diagram **12**

UNIT - IV

6 a) A 8 kg of air at 650 K and 5.5 bar pressure is enclosed in a closed system. If the atmosphere temperature and pressure are 300 K and 1 bar respectively, determine, (i) the availability if the system goes through the ideal work producing process, (ii) the availability and effectiveness if the air is cooled at constant pressure to atmospheric temperature without bringing it to complete dead state. Take C_v = 0.718 kJ/kg K ; C_p= 1.005 kJ/kg K. **10**

b) Air expands in a turbine adiabatically from 600 kPa, 400 K and 150 m/s to 120 kPa 300 K and 75 m/s. The environment is at 100 kPa and 17 ◦C. Calculate per kg of air: (i) the actual amount of work required;(ii) the minimum work required; and (iii) the irreversibility of the process **10**

UNIT - V

7 a) Define the following as applied to mixture of Ideal gases, (i) mole Fraction, (ii) mass fraction, iii) law of corresponding states, iv) Vander Waal's equation (v) compressibility chart **10**

b) One kg of CO_2 has a volume of 1 m^3 at 100°C. Compute the pressure by (i) Van der Waals' equation and (ii) perfect gas equation. **10**

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