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B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2022.

Third / Fourth Semester

Automobile Engineering

ME 8391 – ENGINEERING THERMODYNAMICS

(Common to Industrial Engineering / Mechanical Engineering / Mechanical and Automation Engineering / Plastic Technology)

(Regulations 2017)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. How the first law of thermodynamics is applied to a closed system undergoing a non cyclic process?

2. What is a quasi-static process?

3. Show the equivalence of two statements of 2nd law of thermodynamics.

4. Why Carnot cycle is a theoretical cycle?

5. Draw a p-T (Pressure - temperature) diagram for a pure substance.

6. Define Dryness fraction

7. What is the compressibility factor of Wander's wall gas at critical point?.

8. List various thermodynamic potentials used for deriving Maxwell's relations?

9. State Amagat's law of partial volumes.

10. What is the need for dehumidification during summer air conditioning?

PART B — ($5 \times 13 = 65$ marks)

11. (a) A cylinder contains 1 kg of a certain fluid at an initial pressure of 20 bar. The fluid is allowed to expand reversibly behind a piston according to a law pV^2 = Constant until the volume is doubled. The fluid is then cooled reversibly at constant pressure until the piston regains its original position; heat is then supplied reversibly with the piston firmly locked in position until the pressure rises to the original value of 20 bar. Calculate the net work done by the fluid, for an initial volume of 0.05 m^3

Or

(b) (i) Define the following terms : (2+2)

(1) Macroscopic approach

(2) Continum

(ii) A gas of mass 1.5 kg undergoes a quasistatic expansion. which follows a relationship P = a+bV where a and b are constants. The initial and final pressures are 1000 kPa and 200 kPa respectively and the corresponding volume are 0.2 m^3 and 1.2 m^3. The specific internal energy of the gas is given by the relation U (1.5 PV- 85) kJ/kg, where p is in kPa and V is in m^3. Calculate the net heat transfer and the maximum internal energy of the gas attained during expansion. (9)

12. (a) (i) State Clausius inequality. (3)

(ii) An ideal gas of mass 0.25 kg has a pressure of 3 bar, a temperature of 80°C and a volume of 0.07 m^3 The gas undergoes an irreversible adiabatic process to a final pressure of 3 bar and a final volume of 0.10 m^3, during which the work done on the gas is 25 kJ. Evaluate C_p and C_v of the gas and increase in entropy of the gas. (10)

Or

(b) A reversible heat engine operates between two reservoirs at temperatures of 600° C and 40° C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 40°C and –20°C. The heat transfer to the heat engine is 2000 kJ and the net work output of the combined engine refrigerator plant is 360 kJ.

(i) Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40°C.

(ii) Reconsider given that the efficiency of the heat engine and the COP of the refrigerator are each 40% of their maximum possible values.

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13. (a) Steam turbine receives steam at a pressure of 20 bar superheated at 300°C. The exhaust pressure is 0.07 bar and expansion takes place isentropically using steam table calculate the following.

(i) Heat supplied assuming that the feed pump supplies water to the boil at 20 bar.

(ii) Heat rejected

(iii) Work done

(iv) Theoretical steam consumption

Or

(b) A large insulated vessel is divided into two champers, one containing 5 kg of dry saturated steam at 0.2 MPa and the other 10 kg of steam, 0.8 quality at 0.5 MPa. If the partition between the chambers is removed and the steam is mixed thoroughly and allowed to settle, find the final pressure, steam quality, and entropy change in the process

14. (a) Describe the use of reduced properties, principle of corresponding states and compressibility chart.

Or

(b) Using Clausius – Claperyon's equation, estimate the enthalpy of vapourisation. The following data is given :

At 200°C; Vg = 0.1274 m3/kg; vf = 0.001157 m³/kg; $\left(\frac{dp}{dt}\right) = 32$ kPa/K

15. (a) (i) State Dalton's law (3)

(ii) The exhaust gas of an internal combustion engine is found to have 9.8% CO_2, 0.3 % Co, 10.6% H_2O, 4.5% O_2 and 74.8 % N_2 by volume. Calculate molar mass and gas constant of the exhaust gas. If the volume flow rate of exhaust gas is 2 m^3/h at 100 kPa and 573 K, calculate its mass flow rate. (10)

Or

(b) An air conditioning system is designed under the following conditions:

Out door conditions –30°C dbt, 75% R.H

Required indoor conditions –22°C dbt, 70% R.H

Amount of free air circulated – 3.33 m³/s

Coil dew point temperature – 14°C

The required condition is achieved first by cooling and dehumidification, and then by heating. Estimate (a) the capacity of the cooling coils in tonnes. (b) the capacity of the heating coil in kW and (c) the amount of water vapour removed in kg/s.

PART C — (1 × 15 = 15 marks)

16. (a) Atmospheric air at 43° C and 40 % relative humidity is to conditioned to a temperature of 25°C and 50° relative humidity. The method employed is to lower the temperature to dew point of conditioned air and then to raise it to the required temperature. The volume of the conditioned air is $25m^3$/min. Find

(i) Dew point

(ii) Mass of water vapour drained out

(iii) Amount of heat required to raise the temperature from the dew point to that of conditioned air.

Or

(b) One kg-mol of oxygen undergoes a reversible non-flow isothermal compression and the volume decreases from 0.2 m^3/kg to 0.08 m^3/kg and the initial temperature is 60°C, if the gas obeys Vander Waals's equation find:

(i) The work done during the process

(ii) The final pressure