PART C — (1 × 15 = 15 marks)

16. (a) Two vessels, A and B, both containing nitrogen, are connected by a valve which is opened to allow the contents to mix and achieve an equilibrium temperature of 27°C. Before mixing in vessel A has pressure 1.5 MPa, temperature 50°C, contents 0.5 kg mole and vessel B has pressure 0.6 MPa, temperature 20°C, contents 2.5 kg mole. Compute the final equilibrium pressure, and the amount of heat transferred to the surroundings. If the vessel is perfectly insulated, calculate the final temperature and pressure which would have been reached. Take $\gamma = 1.4$. (15)

Or

(b) An air-water vapour mixture enters an air-conditioning unit at a pressure of 1.0 bar. 38°C DBT, and a relative humidity of 75%. The mass of dry air entering is 1 kg/s. The air-vapour mixture leaves the air-conditioning unit at 1.0 bar, 18°C, 85% relative humidity. The moisture condensed leaves at 18°C. Sketch the process in the psychrometric chart and determine the heat transfer rate for the process. (15)

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Question Paper Code : 80227

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2019.

Third/ Fourth Semester

Mechanical Engineering

ME 8391 — ENGINEERING THERMODYNAMICS

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

(Regulation 2017)

Time : Three hours Maximum : 100 marks

Use of Standard thermodynamic tables, Mollier diagram and table are permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Differentiate between Intensive and Extensive properties.

2. State the zeroth law of thermodynamics.

3. Define entropy of a pure substance.

4. What is irreversibility of a process?

5. Write a short note on Mollier chart.

6. List the advantages in superheating of steam.

7. State the assumptions made in deriving ideal gas equation using the kinetic theory of gases.

8. What is Clausius-Claperyon equation?

9. Identify the relationship between the partial pressures of the constituents in gas mixtures.

10. How will you define Psychrometrics?

PART B — (5 × 13 = 65 marks)

11. (a) The gas expanding in the combustion space of a reciprocating engine has an initial pressure of 50 bar and an initial temperature of 1623°C. The initial volume is 50000 mm^3 and the gas expands through a volume ratio of 20 according to the law $pV^{1.25}$ = constant. Calculate

(i) the work transfer and

(ii) heat transfer in the expansion process. Take $R = 270$ J/kgK and $C_V = 800$ J/kg K. (13)

Or

(b) The power output of an adiabatic steam turbine is 5 MW, and the state of steam entering the turbine is; pressure 2 MPa; Temperature 400°C; velocity 50 m/s; elevation 10 m. The state of the steam leaving the turbine is: pressure 15 kPa; dryness fraction 0.9; velocity 180 m/s; elevation 6 m. Determine,

(i) the change in enthalpy, kinetic energy and potential energy.

(ii) the work done per unit mass of the steam flowing through the turbine.

(iii) the mass flow rate of the steam. (13)

12. (a) A Carnot heat engine draws heat from a reservoir at temperature 600 K and rejects heat to another reservoir at temperature T_3. The Carnot forward cycle engine drives a Carnot reversed cycle engine or Carnot refrigerator which absorbs heat from reservoir at temperature 300 K and rejects heat to a reservoir at temperature T_3, determine:

(i) The temperature T_3 such that heat supplied to engine Q_1 is equal to the heat absorbed by refrigerator Q_2.

(ii) The efficiency of Carnot engine and C.O.P. of Carnot refrigerator. (13)

Or

(b) Air expands through a turbine from 500 kPa, 520°C to 100 kPa, 300°C. During expansion 10 kJ/kg of heat is lost to the surroundings which is at 98 kPa, 20°C. Neglecting the kinetic and potential energy changes, determine per kg of air,

(i) The decrease in availability,

(ii) The maximum work, and

(iii) The irreversibility. For air $C_p = 1.005$ kJ/kgK and $h = C_pT$. (13)

13. (a) The steam conditions at inlet to the turbine are 42 bar and 500°C, and the condenser pressure is 0.035 bar. Assume that the steam is just dry saturated on leaving the first turbine, and is reheated to its initial temperature. Calculate the Rankine cycle efficiency and specific steam consumption with reheating by neglecting the pump work using Mollier chart. (13)

Or

(b) A pressure cooker contains 1.5 kg of saturated steam at 5 bar. Find the quantity of heat which must be rejected so as to reduce the quality to 60% dry. Determine the pressure and temperature of the steam at the new state. (13)

14. (a) A vessel of capacity 3 m^3 contains 1 kg mole of N_2 at 90°C.

(i) Calculate pressure and the specific volume of the gas.

(ii) If the ratio of specific heats is 1.4, evaluate the values of C_p and C_v

(iii) Subsequently, the gas cools to the atmospheric temperature of 20°C, then evaluate the final pressure of gas.

(iv) Evaluate the increase in specific internal energy, the increase in specific enthalpy, increase in specific entropy and magnitude and sign of heat transfer. (13)

Or

(b) CO_2 flows at a pressure of 10 bar and 180°C into a turbine, located in a chemical plant, and there it expands reversibly and adibatically to a final pressure of 1.05 bar. Calculate the final specific volume, temperature and increase in entropy. Neglect changes in velocity and elevation. If the mass flow rate is 6.5 kg/min, evaluate the heat transfer rate from the gas and the power delivered by the turbine. Assume CO_2 to be a perfect gas and $C_v = 0.837$ kJ/kg K. (13)

15. (a) Atmospheric air at 38°C and 25% relative humidity passes through an evaporator cooler. If the final temperature of air is 18°C, how much water is added per kg of dry air and what is the final relative humidity? (13)

Or

(b) A perfect gas mixture consists of 4 kg of N_2 and 6 kg of CO_2 at a pressure of 4 bar and a temperature of 25°C. Calculate C_v and C_p of the mixture. If the mixture is heated at constant volume to 50°C. Find the change in internal energy, enthalpy and entropy of the mixture. Take: For $N_2 : C_v = 0.745$ kJ/kg K, $C_p = 1.041$ kJ/kg K for $CO_2, C_v = 0.653$ kJ/kg K, $C_p = 0.842$ kJ/kg K. (13)