Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 51337

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2024.

Third/Fourth Semester

Mechanical Engineering

ME 3391 – ENGINEERING THERMODYNAMICS

(Common to : Manufacturing Engineering/Mechanical Engineering (Sandwich)/Agricultural Engineering)

(Regulations 2021)

Time : Three hours Maximum : 100 marks

(Use of steam table and Mollier chart, Psychrometric chart are permitted)

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. Differentiate: Homogeneous and Heterogeneous System with suitable example.

2. What is a PMM1?

3. Differentiate Heat Engine and Refrigerator.

4. How COP of a heat pump is estimated?

5. Comment on the term “available energy” with respect to thermodynamics.

6. What is Helmholtz function?

7. Calculate the dryness fraction (quality) of steam, which has 1.5 kg of water in suspension with 50 kg of steam.

8. List any two advantages obtained by using ‘superheated’ steam.

9. Mention the parameters related by Clausius-Clapeyron equation.

10. State Joule’s Law.

[redacted]

PART B — (5 × 13 = 65 marks)

11. (a) 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?

Or

(b) Air at 1.02 bar, 22 °C, initially occupying a cylinder volume of 0.015 m^3, is compressed reversibly and adiabatically by a piston to a pressure of 6.8 bar. Calculate :

(i) the final temperature ;

(ii) the final volume and

(iii) the work done (4+4+5)

12. (a) A heat engine receives heat at the rate of 1500 kJ/min and gives an output of 8.2 kW. Determine: (6+7)

(i) The thermal efficiency;

(ii) The rate of heat rejection.

Or

(b) Brief on the following (4+4+5)

(i) Clausius Statement

(ii) Kelvin-Planck Statement

(iii) Equivalence of Clausius Statement to the Kelvin-Planck Statement

13. (a) A system at 500 K receives 7200 kJ/min from a source at 1000 K. The temperature of atmosphere is 300 K. Assuming that the temperatures of system and source remain constant during heat transfer. Find out :

(i) The entropy produced during heat transfer (7)

(ii) The decrease in available energy after heat transfer (6)

Or

(b) 1 kg of ice at 0 °C is mixed with 12 kg of water at 27 °C. Assuming the surrounding temperature as 15 °C, Calculate the net increase in entropy and Unavailable energy when the system reaches common temperature.

14. (a) Vessel having a volume of 0.6 m^3 contains 3.0 kg of liquid water and water vapour mixture in equilibrium at a pressure of 0.5 MPa. Calculate:

(i) Mass and volume of liquid (7)

(ii) Mass and volume of vapour (6)

Or

(b) What amount of heat would be required to produce 4.4 kg of steam at a pressure of 6 bar and temperature of 250 °C from water at 30 °C? Take specific heat for superheated steam as 2.2 kJ/kg K.

15. (a) The volume of a high altitude chamber is 40 m^3. It is put into operation by reducing pressure from 1 bar to 0.4 bar and temperature from 25 °C to 5 °C. How many kg of air must be removed from the chamber during the process? Express this mass as a volume measured at 1 bar 25 °C. Take R = 287 J/kg K for air.

Or

(b) A mixture of hydrogen and oxygen is to be made so that the ratio of H_2 to O_2 is 2:1 by volume. If the pressure and temperature are 1 bar and 25 °C respectively Calculate:

(i) The mass of O_2 required (9)

(ii) The volume of the container (4)

PART C — (1 × 15 = 15 marks)

16. (a) A reversible heat Engine operates between two reservoirs at temperature 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 network output of the combined engine refrigerator plant is 360 kJ.

(i) Evaluate the heat transfer to the refrigerant and net heat transfer to the reservoir at 40 °C. (10)

(ii) Reconsider given that the 'η' of the heat engine and COP of the refrigerator are each 40% of their maximum possible values. (5)

Or

(b) (i) Explain : Carnot cycle, its assumptions and reasons for rating it as a theoretical cycle. (5)

(ii) A domestic food refrigerator maintains a temperature of –12 °C. The ambient air temperature is 35 °C. If heat leaks into the freezer at the continuous rate of 2 kJ/s, determine the least power necessary to pump this heat out continuously. (10)

———————