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Question Paper Code : 81647

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2025.

Third Semester

Mechanical Engineering

ME 3391 – ENGINEERING THERMODYNAMICS

(Common to Mechanical Engineering (Sandwich))

(Regulations 2021)

Time : Three hours Maximum : 100 marks

(Use of Steam table, Mollier Chart, Psychrometric Chart is permitted)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What are the different mechanisms of transferring energy to or from a control volume?

2. Differentiate between extensive properties and intensive properties.

3. State Kelvin Plank and Clausius statements on a second law of thermodynamics.

4. Draw P – V and T – S diagrams of a Carnot cycle.

5. Define availability.

6. Give examples for low grade and high grade energy.

7. What is pure substance and give examples?

8. What is latent heat and sensible heat?

9. What is the significance of the compressibility chart?

10. Under what conditions Clausius-Clapeyron equation is used?

PART B — (5 × 13 = 65 marks)

11. (a) A gas occupies 0.3 m^3 at 2 bar. It executes a cycle consisting of processes (i) 1 – 2 constant pressure with work interaction of 15 kJ. (ii) 2 – 3 compression process which follows the law PV = constant and $U_3=U_2$ (iii) 3 – 1 constant volume process and change in internal energy is 40 kJ. Neglect changes in KE and PE. Draw the PV diagram of the processes and determine network transferred in the cycle.

Or

(b) Steam at 5 MPa and 400°C enters a nozzle steadily with a velocity of 80 m/s, and it leaves at 2 MPa and 300°C. The inlet area of the nozzle is 50 cm^2, and heat is being lost at a rate of 120 kJ/s. Determine (i) the mass flow rate of the steam (ii) the exit velocity of the steam, and (iii) the exit area of the nozzle.

12. (a) Explain the working of heat pump and refrigerator. Give the expressions for COP.

Or

(b) State and prove the inequality of Clausius.

13. (a) 4 m^3 of air at a pressure of 500 kPa and a temperature of 27°C expand reversibly in a cylinder to a pressure of 100 kPa. The final volume is 20 m^3. Assume constant specific heat for this process, calculate (i) heat transferred during the process, (ii) the change of entropy during the process.

Or

(b) Air in a piston cylinder arrangement is heated at constant pressure by addition of 100 kJ/kg of air. The air is initially at 28°C while the surroundings is at 21°C. Calculate the change in availability per kilogram of air.

14. (a) Determine the condition of steam whether it is wet, dry or superheated for the following cases.

(i) Steam at a pressure of 10 bar and specific volume 0.22 m^3/kg. (4)

(ii) Steam at a pressure 15 bar and temperature 225°C. (3)

(iii) Steam at a temperature 200°C and specific enthalpy 2790.9 kJ/kg. (3)

(iv) Steam at a temperature of 120°C and specific entropy 7 kJ/kgK. (3)

Or

(b) Find the specific volume, specific entropy, and specific enthalpy of steam at 9 bar when the condition of steam is (i) wet with dryness fraction 0.98 (ii) dry saturated and (iii) superheated with the temperature of 240°C.

15. (a) Determine the specific volume of superheated water vapor at 10 MPa and 400°C, using (i) the ideal-gas equation, (ii) the generalized compressibility chart, and (iii) the steam tables. Also determine the error involved in the first two cases.

Or

(b) State and prove all Maxwell's relations from basic equations of thermodynamic properties.

PART C — (1 × 15 = 15 marks)

16. (a) A pressure cooker shown in Fig.1 has a volume of 6 Lit and an operating pressure of 75 kPa gage. Initially, it contains 1 kg of water. Heat is supplied to the pressure cooker at a rate of 500 W for 45 min after the operating pressure is reached. Assuming an atmospheric pressure of 100 kPa, determine (i) the temperature at which cooking takes place and (ii) the amount of water left in the pressure cooker at the end of the process.

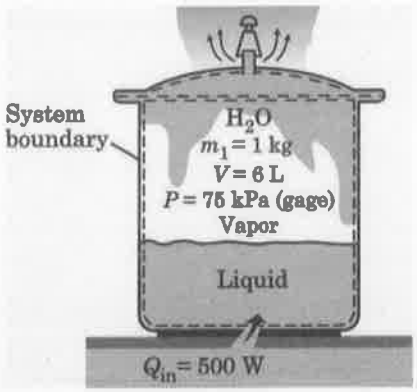

Fig. 1

Or

(b) A heat engine is supplied with 1130 kW of heat at a constant temperature of 292°C and it rejects the heat at 5°C. The following results were recorded.

Case I – 834 kW of heat rejection

Case II – 556 kW of heat rejection

Case III – 278 kW of heat rejection.

Determine whether results report a reversible cycle, irreversible cycle or impossible cycle.

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