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B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2023.

Third/Fourth Semester

Manufacturing Engineering

ME 3391 – ENGINEERING THERMODYNAMICS

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

(Regulations – 2021)

Time : Three hours Maximum : 100 marks

(Permitted : Steam table, Mollier chart, Psychrometric chart)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is meant by quasi-static process?
2. Differentiate between intensive and extensive properties.
3. Mention the expression for COP of heat pump.
4. Specify the two major conclusions deduced from the Carnot principles.
5. State the causes of irreversibility.
6. Brief the following terms.

   (a) available energy (b) unavailable energy of a system.
7. Find the enthalpy and entropy of steam, when the pressure is 2 MPa and the specific volume is 0.09 m^3/kg .
8. What do you understand by dryness fraction?
9. What does the Joule-Thomson coefficient represent?
10. Define the term compressibility factor.

PART B — (5 × 13 = 65 marks)

11. (a) A piston cylinder machine contains a fluid system which passes through a complete cycle of four processes. During a cycle the sum of all heat transfers is –170 kJ. The system completes 100 cycles per minute. Complete the following table showing the method for each item and compute the network output in kW.

Process	Q(kJ)	W(kJ)	ΔU(kJ)
1–2	0	2170	?
2–3	21000	0	?
3–4	–2100	?	–36600
4–1	?	?	?

Or

(b) Air flows steadily at the rate of 0.5 kg/s through an air compressor entering at 7 m/s velocity, 100 kPa pressure and 0.95 m^3/kg specific volume and leaving at 5 m/s, 700 kPa and 0.19 m^3/kg. The internal energy of air leaving is 90 kJ/kg greater than that of the air entering. Cooling water in the compressor jackets absorb heat at the rate of 58 kW. Calculate the rate of shaft work input to the compressor.

12. (a) Deduce the expression for in-equality of Clausius and interpret the results.

Or

(b) A heat exchanger circulates 5000 kg/hr of water to cool oil from 150°C to 50°C. The rate of flow of oil is 2500 kg/hr. The average specific heat of oil is 2.5 kJ/kg K. The water enters the heat exchanger at 21°C. Determine the net change in the entropy due to the heat exchange process and the amount of work obtained if cooling of oil is done by using the heat to run a Carnot engine with sink temperature of 21°C.

13. (a) A heat source at 627°C transfer heat at the rate 3000 kJ/min to a system remaining at 287°C. There is available a heat sink at 27°C. Assuming that these temperatures remain constant, find

(i) the change in entropy of the source

(ii) the entropy production accompanying the heat transfer

(iii) the original available energy and

(iv) the available energy after heat transfer

Or

(b) A hot iron forging of mass 30 kg and at a temperature of 500°C is dropped in 200 kg of oil at 20°C and having a specific heat of 2.5kJ/kgK for quenching. The iron forging has surroundings. Determine (i) entropy change of forging (ii) entropy change of oil and (iii) entropy change of universe. Assume the specific heat of the iron forging as 0.5kJ/kgK.

14. (a) Define pure substances. Draw and explain the p – V, p – T, T – s diagrams for pure substance.

Or

(b) A piston, cylinder contains 3 kg of wet steam at 1.4 bar. The initial volume is 2.25 m^3. The steam is heated until its temperature reaches 400°C. The piston is free to move up or down unless it reaches the stops at the top. When the piston is up against the stops the cylinder volume is 4.65 m^3. Determine the amount of work and heat transfer to or from steam.

15. (a) Derive Maxwell's equations.

Or

(b) 0.5 kg of helium and 0.5 kg of nitrogen are mixed at 20°C and at a total pressure of 100 kPa. Find (i) the volume of the mixture (ii) partial volumes of the constituents (iii) partial pressures of the constituents (iv) mole fractions of the constituents.

PART C — (1 × 15 = 15 marks)

16. (a) A household refrigerator is maintained at a temperature of 2°C. Every time the door is opened, warm material is placed inside, introducing an average of 420 kJ, but making only small changes in the temperature of the refrigerator. The door is opened 20 times a day, and the refrigerator operates at 15% of the ideal COP. The cost of work is 550 paise per kW-hr. What is the monthly bill for this refrigerator? The atmosphere is at 30° C.

Or

(b) 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.