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C 3371

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2008.

Third Semester

(Regulation 2004)

Mechanical Engineering

ME 1201 — ENGINEERING THERMODYNAMICS

(Common to Production Engineering)

(Common to B.E. (Part-Time) – Second Semester – Regulation 2005)

Time : Three hours

Maximum : 100 marks

(Use of standard thermodynamic tables, Mollier diagram, Psychrometric chart
and Refrigerant property tables permitted)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define a thermodynamic system. Classify the following systems as open/closed/isolated : (a) Mixture of ice and water in a metal container
(b) A wind mill.
2. Define heat and thermodynamic definition of work.
3. Give Clausius statement of Second Law of Thermodynamics.
4. What is the principle of increase of Entropy?
5. Define quality of steam. What are the methods of determining quality of steam?
6. Give the flow and T-s diagrams of the regenerative Rankine cycle with single open feed water heater.
7. Explain the following terms : (a) Mole fraction, (b) Mass fraction.

8. Write the Maxwell's equations and also give the basic relations from which these are derived.
9. What do you understand by dry bulb and wet bulb temperatures?
10. Draw a psychrometric chart and show the following processes on it :
 (a) sensible cooling, (b) latent heating, (c) heating and dehumidification and
 (d) cooling and humidification.

PART B — (5 × 16 = 80 marks)

11. (a) (i) A van der Waal gas is compressed reversibly at constant temperature from volume V_1 to V_2 . The equation of state is given by

$$P = \left(\frac{RT}{V-b} \right) - \left(\frac{a}{V^2} \right)$$
. Determine the work done per mole of the gas.

(8)

- (ii) Define a new thermodynamic scale say degree N, in which the freezing point and boiling point of water are 100°N and 300°N respectively. Correlate this temperature scale with centigrade scale.

(8)

Or

- (b) (i) Apply steady flow energy equation for a nozzle. State the assumptions made.

(6)

- (ii) A gas occupies 0.3 m^3 at 2 bar. It executes a cycle consisting of processes : (1) 1-2; constant pressure with work interaction of 15 kJ. (2) 2-3; compression process which follows the law $PV = \text{Constant}$, and $U_3 = U_2$ (3) 3-1; constant volume process, and change in internal energy is 40 kJ. Neglect change in KE and PE. Draw PV diagram for the process and determine network transfer for the cycle. Also show that first law is obeyed by the cycle.

(10)

12. (a) (i) Derive Clausius inequality and mention the criteria for reversibility of a cycle.

(6)

- (ii) A reversible heat engine operates between two reservoirs at 820°C and 27°C . Engine drives a reversible refrigerator which operates between reservoirs at temperatures of 27°C and -15°C . The heat transfer to the engine is 2000 kJ and network available for the combined cycle is 300 kJ. (1) How much heat is transferred to the

refrigerant and also determine the total heat rejected to the reservoir at 27 °C. (2) If the efficiency of the heat engine and COP of the refrigerator are each 40% of their maximum values, determine heat transfer to the refrigerator and also heat rejected to the reservoir at 27°C. (10)

Or

(b) (i) Show that there is a decrease in available energy when heat is transferred through a finite temperature difference. (6)

(ii) In a closed system air is at a pressure of 1 bar, temperature of 300 K and volume of 0.025 m³. The system executes the following processes during the completion of thermodynamic cycle : 1-2; constant volume heat addition till pressure reaches 3.8 bar, 2-3; constant pressure cooling of air, 3-1; isothermal heating to initial state. Determine the change in entropy in each process. Take $C_v = 0.718 \text{ kJ/kgK}$. $R = 287 \text{ J/kgK}$. (10)

13. (a) (i) Draw and explain phase equilibrium diagram for a pure substance on P-T coordinate. Also indicate different regions on the diagram. (8)

(ii) Steam at a pressure of 15 bar and 250°C expands according to the law $PV^{1.25} = C$ to a pressure of 1.5 bar. Evaluate the final conditions, work done, heat transfer and change in entropy. The mass of the system is 0.8 kg. (8)

Or

(b) (i) Why is Carnot cycle not practicable for a steam power plant? (4)

(ii) In a steam power plant the condition of steam at inlet to the steam turbine is 20 bar and 300°C and the condenser pressure is 0.1 bar. Two feed water heaters operate at optimum temperatures. Determine: (1) The quality of steam at turbine exhaust, (2) network per kg of steam, (3) cycle efficiency, and (4) the steam rate. Neglect pump work. (12)

14. (a) (i) Write a short note on Generalized Compressibility chart. (6)

(ii) A mixture of Ideal gases consists of 2.5 kg of N₂ and 4.5 kg of CO₂ at a pressure of 4 bar and a temperature of 25°C. Determine :

(1) Mole fraction of each constituent,

(2) Equivalent molecular weight of the mixture,

- (3) Equivalent gas constant of the mixture,
- (4) The partial pressure and partial volumes,
- (5) The volume and density of the mixture. (10)

Or

- (b) (i) Derive van der Waal's equation in terms of reduce parameters. (8)
 - (ii) Derive TdS equations taking Temperature, volume and temperature, pressure as independent properties (8)
15. (a) Atmospheric air at 1.0132 bar has a DBT of 32°C and a WBT of 26°C. Compute (i) the partial pressure of water vapor, (ii) the specific humidity, (iii) the dew point temperature (iv) the relative humidity, (v) the degree of saturation, (vi) the density of air in the mixture, (vii) the density of vapour in the mixture and (viii) the enthalpy of the mixture. Use thermodynamic table only. (16)

Or

- (b) (i) Explain the process of cooling dehumidification of air. (8)
- (ii) 30 m³/min of moist air at 15°C DBT and 13°C WBT are mixed with 12 m³/min of moist air at 25°C DBT and 18°C WBT. Determine DBT and WBT of the mixture assuming the barometric pressure is one atmospheric. (8)