D 4060

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2007.

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 Steam Tables, Mollier Chart, Psychrometric Chart permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is meant by internal energy?

2. A rigid tank is insulated around both its sides and ends. It is separated initially into two equal volumes by a partition. When one side contains 1 kg of gas at 100 kPa and 345°C, the other side remains evacuated. If the partition is removed, find final pressure and temperature.

3. What do you understand by a reversible process?

4. What are the two major conclusions deduced from the Carnot principles?

5. Define triple point and identify the triple point of water.

6. Steam in a pipeline with a pressure of 1000 kPa flows through a throttling calorimeter where pressure is 100 kPa and temperature is 120°C. What is the initial quality of steam if enthalpy remains constant during throttling?

7. What is equation of state? Write the same for an ideal gas.

8. What is the significance of compressibility factor?

9. What is specific humidity and how do you calculate it?

10. What is meant by adiabatic saturation temperature?

PART B — (5 × 16 = 80 marks)

11. (a) (i) Deduce the expression for the displacement work in an isothermal process. (4)

(ii) Three grams of nitrogen gas at 6 atm and 160°C is expanded adiabatically to double its initial volume, then compressed at constant pressure to its initial volume and then compressed again at constant volume to its initial state. Calculate the net work done on the gas. Draw the p-V diagram for the process. Specific heat ratio of nitrogen is 1.4. (10 + 2)

Or

(b) (i) Describe steady flow energy equation and deduce suitable expression for the expansion of gas in a gas turbine with suitable assumptions. (8)

(ii) Air expands by isentropic process through a nozzle from 784 kPa and 220°C to an exit pressure of 98 kPa. Determine the exit velocity and the mass flow rate, if the exit area is 0.0006 m^2. (8)

12. (a) (i) What are the conditions for reversibility? Explain. (4)

(ii) An 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/kgK. The water enters the heat exchanger at 21°C. Determine the net change in the entropy due to 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. (8 + 4)

Or

(b) (i) Deduce Clausius inequality and interpret it. (4 + 2)

(ii) An ideal gas of 0.12 m^3 is allowed to expand isentropically from 300 kPa and 120°C to 100 kPa. 5 kJ of heat is then transferred to the gas at constant pressure. Calculate the change in entropy for each process. Assume $\gamma = 1.4$ and $C_p = 1.0035$ kJ/kg-K. If these two processes are replaced by a reversible polytropic expansion, find the index of expansion between original and final states. What will be the total changes in entropy? (4 + 4 + 2)

13. (a) (i) Draw p-T diagram and label various phases and transitions. Explain the process of isobaric heating above triple point pressure with the help of p-T diagram. (4 + 4)

(ii) 2 kg of water at 200°C are contained in a 20 m^3 vessel. Determine the pressure, enthalpy, mass and volume of vapour within the vessel. (8)

Or

(b) (i) Draw Rankine cycle with one open type feed water heater. Assume the condition of the steam before entering the turbine to be superheated. Sketch the cycle on T-s diagram. (6)

(ii) In an ideal reheat cycle, the steam enters the turbine at 30 bar and 500°C. After expansion to 5 bar, the steam is reheated to 500°C and then expanded to the condenser pressure of 0.1 bar. Determine the cycle thermal efficiency, mass flow rate of steam. Take power output as 100 MW. (6 + 4)

14. (a) (i) Deduce Maxwell's relations. (6)

(ii) Explain the Joule Thomson effect with the help of T-p diagram and derive the expression for Joule Thomson coefficient. Show that the value of this coefficient for an ideal gas is zero. (4 + 4 + 2)

Or

(b) (i) What are the differences between real and ideal gases? (4)

(ii) Write down the van der Waal's equation of state for real gases and how is it obtained from ideal gas equation by incorporating real gas corrections? (2 + 4)

(iii) A tank contains 0.2 m^3 of gas mixture composed of 4 kg of nitrogen, 1 kg of oxygen and 0.5 kg of carbon-di-oxide. If the temperature is 20°C, determine the total pressure, gas constant and molar mass of the mixture. (6)

15. (a) (i) Draw the psychrometric chart and show any two psychrometric processes on it. (6)

(ii) A sample of moist air at 1 atm and 25°C has a moisture content of 0.01% by volume. Determine the humidity ratio, the partial pressure of water vapour, the degree of saturation, the relative humidity and the dew point temperature. (10)

Or

(b) (i) Describe the process of adiabatic mixing of two streams and deduce the ratio of masses of two streams in terms of humidity and/or enthalpy. (10)

(ii) The temperature of the windows in a house on a day in winter is 5°C. When the temperature in the room is 23°C, and the barometric pressure is 74.88 cm Hg, what would be the maximum relative humidity that could be maintained in the room without condensation on the window panes? Under these conditions, find the partial pressure of the water vapour and air, the specific humidity and the density of the mixture. (6)
