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# Question Paper Code : 11518

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2012.

Third Semester

Mechanical Engineering

ME 2202/113301/ME 33/10122 ME 303/ME 1201/080190005 — ENGINEERING THERMODYNAMICS

(Regulation 2008)

(Common to PTME 2202 Engineering Thermodynamics for B.E. (Part-Time) Third Semester Mechanical Engineering – Regulation 2009)

Time : Three hours Maximum : 100 marks

(Use of approved thermodynamic tables, Mollier diagram, Psychometric chart and Refrigerant property tables permitted in the examination)

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. What is meant by quasi-static process in thermodynamics?
2. Distinguish between 'Macroscopic energy' and 'Microscopic energy'.
3. List the limitations of First Law of Thermodynamics.
4. In an isothermal process 1000 kJ of work is done by the system at a temperature of 200°C. What is the entropy change of this process?
5. What is a pure substance? Give examples.
6. Distinguish between 'flow process' and 'non-flow process'.
7. What is meant by equation of state? Write the same for an ideal gas.
8. In what way the Clausius Clapeyron equations is useful?
9. What is the relative humidity of air if the DPT and DBT are 25°C and 30°C at 1 atmospheric pressure?
10. What is adiabatic evaporative cooling?

PART B — (5 × 16 = 80 marks)

11. (a) (i) Define the following terms :

(1) Thermodynamics

(2) Macroscopic approach

(3) Continuum. (6)

(ii) A gas of mass 1.5 kg undergoes a quasistatic expansion, which follows a relationship P = a + bV, where 'a' and 'b' are constants. The initial and final pressures are 1000 kPa and 200 kPa respectively and the corresponding volumes are 0.2 $m^3$ and 1.2 $m^3$. The specific internal energy of the gas is given by the relation U = (1.5PV – 85) kJ/kg, where P is in kPa and V is in $m^3$. Calculate the net heat transfer and the maximum internal energy of the gas attained during expansion. (10)

Or

(b) (i) Define enthalpy. How is it related to internal energy? (4)

(ii) A fluid is confined in a cylinder by a spring-loaded, frictionless piston so that the pressure in the fluid is a linear function of the volume (p = a + bV). The internal energy of the fluid is given by U = (34 + 3.15 pV) where U is in kJ, p in kPa and V in cubic meter. If the fluid changes from an initial state of 170 kPa, 0.03 $m^3$ to a final state of 400 kPa, 0.06 $m^3$, with no work other than that done on the piston, find the direction and magnitude of the work and heat transfer. (12)

12. (a) (i) Define the terms 'Irreversible process' and 'Reversible process'. Give an example of each. (6)

(ii) In a Carnot cycle the maximum pressure and temperature are limited to 18 bar and 410°C. The volume ratio of isentropic compression is 6 and isothermal expansion is 1.5. Assume the volume of the air at the beginning of isothermal expansion as 0.18 $m^3$. Show the cycle on p-V and T-s diagrams and determine

(1) The pressure and temperature at main points

(2) Thermal efficiency of the cycle. (10)

Or

(b) (i) State and prove Clausius inequality. (6)

(ii) A metal block with m = 5 kg, c = 0.4 kJ/kg.K at 40°C is kept in a room at 20°C. It is cooled in the following two ways :

(1) Using a Carnot engine (executing integral number of cycles) with the room itself as the cold reservoir;

(2) Naturally.

In each case, calculate the changes in entropy of the block, of the air of the room and of the universe. Assume that the metal block has constant specific heat. (10)

13. (a) (i) Explain the phase transformation that takes place when ice (solid) is heated continuously till superheated steam is obtained. Name the different states involved. Sketch the transformation on a 'temperature' vs 'heat added' diagram. (8)

(ii) A vessel of volume 0.04 $m^3$ contains a mixture of saturated water and saturated steam at a temperature of 250°C. The mass of the liquid present is 9 kg. Find the pressure, mass, the specific volume, the enthalpy, the entropy and the internal energy. (8)

Or

(b) (i) Define specific steam consumption, specific heat rate and work ratio. (6)

(ii) Steam enters the turbine at 3 MPa and 400° C and is condensed at 10 kPa. Some quantity of steam leaves the turbine at 0.6 MPa and enters feed water heater. Compute the fraction of the steam extracted per kg of steam and cycle thermal efficiency. (10)

14. (a) (i) Explain the physical significance of the compressibility factor Z. (6)

(ii) An insulated rigid tank is divided into two compartments by a partition. One compartment contains 7 kg of oxygen gas at 40°C and 100 kPa and the other compartment contains 4 kg of nitrogen gas at 20°C and 150 kPa. $C_{v,\ N2}$ = 0.743 kJ/kg.K and $C_{v,O2}$ = 0.658 kJ/kg.K. If the partition is removed and the two gases are allowed to mix, determine

(1) The mixture temperature and

(2) The mixture pressure after equilibrium has been established. (10)

Or

(b) (i) Derive the T dS equation taking T and V as independent variables. (8)

(ii) Show that for a gas that obeys the law $p(V - b) = RT$, a Joule-Thomson expansion from pressure $P_1$ to $P_2$ produces a temperature change which can be found from the solution of

$$P_1 - P_2 = \frac{C_p}{b}(T_2 - T_1).$$ (8)

15. (a) Atmospheric air at 1.0132 bar has 20°C DBT and 65% RH. Find the humidity ratio, wet bulb temperature, dew point temperature, degree of saturation, enthalpy of the mixture, density of air and density of vapour in the mixture. (16)

Or

(b) (i) Atmospheric air at 38°C and 25% relative humidity passes through an evaporative cooler. If the final temperature of air is 18°C, how much water is added per kg of dry air and what is the final relative humidity? (10)

(ii) Show the process of adiabatic mixing on a sketch of skeleton psychrometric chart and explain the process. (6)

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