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BT-3/D-19 **33022**

# THERMODYNAMICS

## ME-201-E

Time : Three Hours] [Maximum Marks : 100

**Note :** Attempt *Five* questions in all, selecting at least *one* question from each Unit. Assume any missing data. Use of steam table is allowed.



### Unit I

1. (a) What is quasi-static process ? What is its characteristic feature ? 8

   (b) A vessel of 0.03 $m^3$ capacity contains gas at 3.5 bar pressure and 35°C temperature. Determine the mass of the gas in the vessel. If the pressure of this gas is increased to 10.5 bar while the volume remains constant. What will be the temperature of the gas ? For the gas take R = 290 J/kgK. 12

2. (a) Derive law of corresponding state from van der Waals equation. 10



   (b) A balloon of spherical shape is 8 m in diameter and is filled with hydrogen at a pressure of 1 bar abs. and 15°C. At a later time, the pressure of gas is 95 per cent of its original pressure at the same temperature. (i) What mass of original gas must have escaped if the dimensions of the balloon are not changed ? (ii) Find the amount of heat to be removed to cause the same drop in pressure at constant volume. 10

### Unit II

3. A heat pump working on a reversed Carnot cycle takes in energy from a reservoir maintained at 5°C and delivers it to another reservoir where temperature is 77°C. The heat pump derives power for its operation from a reversible engine operating within the higher and lower temperatures of 1077°C and 77°C. For 100 kJ/kg of energy supplied to reservoir at 77°C, estimate the energy taken from the reservoir at 1077°C. 20

4. A reversible heat engine operates between two reservoirs at temperatures of 600°C and 40°C. The engine drives a reversible refrigerator which operates beween reservoirs at temperatures of 40°C and –20°C. The heat transfer to

the heat engine is 2000 kJ and the net work output for the combined engine refrigerator is 360 kJ. (i) Calculate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40°C. (ii) Reconsider (iii) given that the efficiency of the heat engine and the C.O.P. of the refrigerator are each 40 per cent of their maximum possible values. 20

## Unit III

5. 1 kg. of ice at 0°C is mixed with 10 kg. of water at 30°C. Determine the net increase in the entropy and unavailable energy when the system reaches common temperature. Assume that surrounding temperature is 10°C. Take, specific heat of water = 4.18 kJ/kg K; specific heat of ice = 2.1 kJ/kg K; latent heat of ice = 333.5 kJ/kg. 20

6. (a) One kg. of water at 273 K is brought into contact with a heat reservoir at 373 K. When the water has reached 373 K, find the entropy change of the water of the heat reservoir, and of the universe. 10

   (b) If water is heated from 273 K to 373 K by first bringing it in contact with a reservoir at 323 K and then with reservoir at 373 K, what will the entropy change of the universe be ? 10



## Unit IV

7. (a) Derive the first and second Tds Equation. 10

   (b) Derive the following thermodynamic relations : 10

$$\left[\frac{\partial u}{\partial v}\right]_T = T\left[\frac{\partial p}{\partial T}\right]_v - p$$

8. (a) Steam initially at 0.3 MPa, 250°C is cooled at constant volume. (a) At what temperature will the steam become saturated vapour ? (b) What is quality at 80°C ? (c) What is the heat transfer per kg. of steam in cooling from 250°C to 80°C ? 10

   (b) Explain the process of steam generation at constant pressure using T-S, P-V and T-Q diagram. 10