MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

Paper Code : PC-ME-301

PUID : 03491 (To be mentioned in the main answer script)

THERMODYNAMICS

Time Allotted : 3 Hours | *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

   i) A thermodynamic system refers to

   a) any defined region in space

   b) a specific mass in fluid flow

   c) a specific region of constant volume

   d) a prescribe and identifiable quantity of matter.

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   i) A thermodynamic system refers to

   a) any defined region in space

   b) a specific mass in fluid flow

   c) a specific region of constant volume

   d) a prescribe and identifiable quantity of matter.

ii) An isolated thermodynamic system manifests when

a) matter is not allowed to cross the boundary, but energy transfer does occur across the boundary

b) there is transfer of both mass and energy across the system boundaries

c) there is only transfer of mass, but no heat and work energy transfer are transferred across the boundary of the system

d) neither mass nor energy cross the system boundary.

iii) The open thermodynamics system is

a) Manual ice cream freezer

b) Centrifugal pump

c) Pressure cooker

d) Automobile storage battery.

iv) Which one of the following properties given below is an intensive property of the system ?

a) Entropy b) Volume

c) Energy d) Temperature.

v) The value of intensive property is independent on

a) mass of the system

b) pressure of system

c) heat of system

d) temperature of system.

vi) For an irreversible process, change in entropy is

a) greater than $\frac{\delta Q}{T}$ b) less than $\frac{\delta Q}{T}$

c) zero d) equal to $\frac{\delta Q}{T}$.

vii) Isentropic process is represented on Mollier diagram by

a) horizontal straight line

b) a vertical straight line

c) an inclined line

d) none of these.

viii) Dryness fraction of a steam is given by

a) $\frac{m_s}{m_s + m_w}$ b) $\frac{m_w}{m_s + m_w}$

c) $\frac{m_w}{m_s}$ d) $\frac{m_s}{m_w}$.

ix) A perpetual motion machine (PMM) is

a) a thermodynamic machine

b) a non-thermodynamic machine

c) a real machine

d) a hypothetical machine operation which violates the laws of thermodynamics.

x) The Carnot cycle gives

a) maximum efficiency

b) efficiency less than Rankine cycle

c) maximum turbine work output

d) none of these.

xi) Which one is the correct relationship ?

a) $dh = Tds - vdp$ b) $dh = Tds + vdp$

c) $dh = Tds - pdv$ d) $dh = Tds + pdv$.

xii) The behaviour of which of the following vapour is closer to that of a gas ?

a) Wet vapour

b) Dry vapour

c) Superheated vapour

d) Wet and dry vapour.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. Explain PMM2 and Clausius inequality.

3. A vacuum gauge fitted on a condenser reads 750 mm of Hg when the barometer reads 755 mm of Hg. Find the absolute pressure inside the condenser in N/m^2 and kg/cm^2.

4. Explain the Zeroth law of Thermodynamics. Why is it called Zeroth law ?

6. What is meant by mass fraction and molar fraction ? Define partial pressure of a gas mixture component.

GROUP – C
(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. a) Derive the efficiency Carnot cycle and sketch the same on p-v diagram and T-s diagram.

   b) A heat engine is used to drive a heat pump. The heat transfer from the heat engine and heat pump are used to heat the water circulating, through the radiators of a building. The engine has thermal efficiency of 27% and the coefficient of performance (COP) for the heat pump is 4. Determine the ratio of heat transfer to the circulating water to the heat supplied to the engine.

8. a) Derive the efficiency Rankine cycle and sketch the same on p-v diagram and T-s diagram.

   b) A steam turbine working on Rankine cycle is supplied with dry saturated steam at 25 bar and exhaust takes place at 0.2 bar. For a steam flow rate of 10kg/s, determine :

      i) Quality of steam at the end of expansion

ii) Turbine work

iii) Rankine efficiency

iv) Power required to drive the pump

v) Work ratio

vi) Heat flow in the condenser.

9. a) Illustrate Steady Flow Energy Equation (SFEE) alongwith the assumptions.

b) A locomotive train of 2×10^6 kg mass is driven by an energy generated device, which is burning coal. The train requires an effort of 40 N per 1000 kg of mass of train. What distance the train will travel if it consumes 1000 kg of coal and 10% of heat generated by burning coal is converted into mechanical work. Consider the calorific value of coal (energy released per kg of coal) is 3200 kJ/kg.

10. a) One kg of air at 1 bar and 300 K is compressed adiabatically till its pressure becomes 5 times the original pressure. Subsequently it is expanded at constant pressure and finally cooled at constant volume to return to its original state. Calculate the heat and work interaction and change of internal energy for each process and for cycle.

b) A piston cylinder arrangement of engine contains 0.04 m^3 of a gas at 24 bar pressure and 2000 K temperature. The gas is allowed to expand to a volume of 0.06 m^3 and a pressure of four bar. The variation of specific heats with temperature is represented by the expression $c_p = a + 0.0001\ T$ and $c_v = b + 0.0001\ T$ and at 2000 K the values of c_p and c_v are considered as 1.095 kJ/kg-K and 0.7 95kJ/kg-K respectively. Determine (i) index of expansion and final temperature (ii) work done by the gas (iii) change in internal energy (iv) heat flow to and from the gas and (v) polytropic specific heat.

11. a) Explain isentropic efficiency of compressor, turbine and nozzzle with neat sketch of h-s diagram.

b) m_1 kg of water at T_1 is mixed isobarically and adiabatically with m_2 kg of water at T_2 ($T_1 > T_2$). Show that for equal masses of water, the entropy change of the mixture is given by $(ds)_{universe} = 2mc_p ln\left[\frac{T_1 + T_2}{2\sqrt{T_1 T_2}}\right]$ and also prove that the process is irreversible.