53 (ME 301) BATD

2019

BASIC THERMODYNAMICS

Paper : ME 301

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

*Answer **any five** questions.*

1. *(a)* Define the following with examples : 8

   (i) Open system

   (ii) Closed system

   (iii) Path function

   (iv) Point function.

   (b) Distinguish between : 6

   (i) Intensive and extensive properties

   (ii) Thermal equilibrium and mechanical equilibrium

   (iii) Microscopic and macroscopic point of view.

Contd.

(c) Define 'heat' and bring out dissimilarities between heat and work. 6

2. (a) Specify the most widely used sign convention for work and heat interaction. 4

(b) Derive the expression for work done in a polytropic process. 5

(c) Write the steady flow energy equation for an open system and explain the terms involved in it and simplify SFEE for the following systems : 6

(i) Steam turbine

(ii) Nozzle.

(d) Derive the expression of work done for the following processes : 5

(i) $P = \frac{C}{V}$ and

(ii) $P = \frac{C}{V^2}$, where P is pressure, V is volume & C is constant.

3. (a) During a certain process, the specific heat of the working fluid of a system undergoes change as per the relation

$$C = \left(0{\cdot}2 + 2 \times 10^{-3} T\right) kJkg^{-1}K^{-1}$$

where T represents the system temperature in kelvin. Calculate the amount of heat required to raise the temperature of $20kg$ of this fluid from $300K$ to $400K$. 6

(b) During a non-flow reversible process, a gas enclosed in a cylinder piston assembly expands from $2m^3$ to $4m^3$. The pressure-volume correlation is given by

$P = V^2 + 6/V$, where (P) is in *bar*.

Determine the work done by the system. 7

(c) The properties of a closed system change following the relation between pressure and volume as $PV = 3$, where P is in *bar* and V is in m^3. Calculate the work done when the pressure increases from 1·5 *bar* to 7·5 *bar*. 7

4. *(a)* A cylinder containing the air comprises the system. Cycle is completed as follows : 7

(i) 82000 *Nm* of work is done by the piston on the air during compression stroke and 45*kJ* of heat are rejected to the surroundings.

(ii) During expansion stroke 100000 *Nm* of work is done by the air on the piston.

Calculate the quantity of heat added to the system.

(b) A fluid is contained 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 the following equation

$$U = 42 + 3{\cdot}6PV$$

where U is in *kJ*, P in *kPa*, and V in cubic metre. If the fluid changes from an initial state of $190kPa, 0{\cdot}035m^3$ to a final state of $420kPa, 0{\cdot}07m^3$, with no work other than that done on the piston, find the direction and magnitude of the work and heat transfer. 10

(c) Define enthalpy. How is it related to internal energy ? 3

5. *(a)* Prove that a heat pump is more efficient than a refrigerator. 5

(b) What is thermal energy reservoir ? Explain source and sink. 4

(c) A heat engine, a heat pump, and a refrigerator receive 600*kJ* of heat each. But they reject 350*kJ*, 700*kJ* and 800*kJ* of heat respectively. Determine 8

(i) the efficiency of heat engine

(ii) the COP of the heat pump

(iii) the COP of the refrigerator.

(d) Write the limitations of first law of thermodynamics. 3

6. *(a)* What is a pure substance ? 2

(b) Define triple point. 2

(c) Explain the following terms relating to steam formation : 6

(i) Sensible heat of water

(ii) Latent heat of steam

(iii) Dryness fraction of steam.

(d) A vessel having a capacity of $0{\cdot}08m^3$ contains a mixture of saturated water and saturated steam at a temperature of 300°C. The mass of the liquid present is $12kg$. Find the following : 10

(i) The pressure

(ii) The mass

(iii) The specific volume

(iv) The specific enthalpy

(v) The specific entropy

(vi) The specific internal energy.

7. Write short notes on : ***(any five)*** 4×5=20

(i) Working of Carnot cycle

(ii) Thermodynamic equilibrium

(iii) Difference between external and internal combustion engine

(iv) Statements of 2nd law of thermodynamics

(v) Pressure measuring instruments

(vi) Perpetual motion machine of the second kind.

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