CBCS SCHEME

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18MR33

Third Semester B.E. Degree Examination, Dec.2023/Jan.2024
Basic Thermodynamics

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of Thermodynamics data hand book is permitted.

Module-1

1 a. State the Zeroth law of thermodynamics and briefly explain its significance. **(04 Marks)**

b. Define the following:
i) Open system
ii) Closed system
iii) Path function. **(06 Marks)**

c. The temperature 't' on a thermometric scale is defined in terms of a property 'K' by the relation: $t = m \ln k + n$, where m and n are constants. The values of k are found to be 1.83 and 6.78 at the ice point and steam point, the temperature of which are as signed the numbers 0 and 100 respectively. Determine the temperature corresponding to a reading of k equal to 2.42 on the thermometer. **(10 Marks)**

OR

2 a. Give the thermodynamics definition of work. Explain how it has wide applications than mechanics definition of work. **(04 Marks)**

b. Derive an expression for the work done by a system during polytropic process. **(06 Marks)**

c. A system of volume 'V' contains a mass 'm' of a gas at a pressure of 'p' and temperature 'T' and these properties are related by:

$\left(p + \frac{a}{V^2}\right)(V - b) = MRT$. Where a, b and R are constants. Obtain an expression for the displacement work done. When the system undergoes an isothermal process from volume V_1 to a final volume V_2, calculate the work for the system which contains 10kg of a gas expanding from $1m^3$ to $10m^3$ at a constant temperature of 293K. Assume $a = 15.7 \times 10^4 Nm^4$, $b = 1.07 \times 10^{-2}\ m^3$ and $R = 0.278kJ/kg\text{-}K$. **(10 Marks)**

Module-2

3 a. Give the precise statement of first law of thermodynamics as applied to a closed system undergoing i) Cyclic process ii) Change of state. **(04 Marks)**

b. Simplify steady flow energy equation for the following:
i) Steam turbine ii) A nozzle iii) Boiler. **(06 Marks)**

c. At the inlet to a certain nozzle, the enthalpy of the fluid passing is 3000kJ/kg and the velocity is 60m/s. At the discharge end, the enthalpy is 2762kJ/kg. The nozzle is horizontal and there is negligible heat loss from it.
i) Find the velocity at the exit of nozzle.
ii) If the inlet area is $0.1m^2$ and specific volume at inlet is $0.187m^3/kg$, find the mass flow rate.
iii) If the specific volume at the exit of the nozzle is $0.498m^3/kg$, find the diameter at the exit section of the nozzle. **(10 Marks)**

OR

4 a. State the Kelvin-Planck and Clausius statements of the second law of thermodynamics and show that violation of the former results in violation of latter. **(08 Marks)**

b. A direct heat engine operating between two reservoirs at 327°C and 27°C drives a refrigerator operating between 27°C and 13°C. The efficiency of the heat engine and the refrigerator are each 70% of their maximum values. The heat transferred to the heat engine is 500kJ. The net heat rejected by the engine and the refrigerator to the reservoir at 27°C is 400kJ. Find the net work output of the engine-refrigerator combination. Draw the schematic representation. **(12 Marks)**

Module-3

5 a. Prove that entropy is a property of a system from Clausius in equality. **(10 Marks)**

b. 0.5kg of ice block at -10°C is brought into contact with 5kg copper block at 80°C in an insulated container. Determine the change in entropy of i) ice block ii) copper block iii) the universe. Given specific heat of ice as 2kJ/kg K, specific heat of water as 4.2kJ/kg K, specific heat of copper as 0.5kJ/kg K, enthalpy of fusion of water at 0°C as 334kJ/kg. **(10 Marks)**

OR

6 a. Mark the following on a P-T diagram: i) Solid, liquid and vapor regions ii) Triple point. **(04 Marks)**

b. With a neat sketch, explain the working of a separating and throttling calorimeter. **(06 Marks)**

c. Determine the dryness fraction of the steam sample tested in a separating and throttling calorimeter.
Pressure of steam sample collected = 15bar
Pressure of steam at exit = 1 bar
Temperature of steam at exit = 150°C
Water collected from separating calorimeter = 0.2kg/min
Discharge collected at exit = 10kJ/min. **(10 Marks)**

Module-4

7 a. Derive Clausius – Claypeyron equation of liquid and explain its significance. **(06 Marks)**

b. Distinguish between: i) Ideal and real gases ii) Perfect gas and semi perfect gas. **(04 Marks)**

c. 2kg of air having C_p = 1.005kJ/kg K and C_v = 0.718kJ/kg K is compressed reversibly according to $pV^{1.3} = C$ from 1 bar, 37°C to 5 bar:

i) Find the increase in internal energy.

ii) Use the relation $\phi = \left[\frac{(\eta - r)}{n-1}\right] C_v(T_2 - T_1)$. Calculate the magnitude and direction of work.

iii) Show the initial and final states and the process path is T-S diagram. **(10 Marks)**

OR

8 a. Explain the changes in internal energy and enthalpy of an ideal gas in a reversible adiabatic process in terms of the pressure ratio. **(12 Marks)**

b. A certain gas has C_p = 1.9 and C_v = 1.5kJ/kg K. Find its molecular weight and the gas constant. A constant volume chamber of $0.3m^3$ capacity contains 2kg of this gas at 8°C. Heat is transferred to the gas until the temperature is 108°C. Find the work done, the heat transferred and the changes in internal energy, enthalpy and entropy. **(08 Marks)**

Module-5

9 a. Define mass fraction and mole fractions of the constituents of an ideal gas mixture. **(04 Marks)**

b. Find the gas constant and apparent molar mass of a mixture of 2kg O_2 and 3kg of N_2, given the universal gas constant is 8.3142J/KmolK molar masses of O_2 and N_2 are 32 and 28 respectively. **(04 Marks)**

c. Write short notes on:
   i) Compressibility charts
   ii) Reduced properties
   iii) Vander Waal's equation of state. **(12 Marks)**

OR

10 a. Show that for an ideal gas $C_p - C_v = R$. **(04 Marks)**

b. Define:
   i) Gas constant for the mixture
   ii) Density of the mixture. **(04 Marks)**

c. State the following and write mathematical expressions:
   i) Dalton's law of partial pressures
   ii) Amagat law of additive volumes
   iii) Law of corresponding states. **(12 Marks)**

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