CBCS SCHEME

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18ME33

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 DHB and Steam tables permitted.

Module-1

1 a. With an example, define the terms :
(i) Microscopic approach
(ii) Open system
(iii) Intensive properties
(iv) Mechanical equilibrium
(v) Path function. **(10 Marks)**

b. State Zeroth law of thermodynamics and explain the concepts of temperature. **(04 Marks)**

c. A thermocouple with test junction at t °C on gas thermometer scale and reference junction at ice point gives the e.m.f as,
$e = 0.20t - 5\times10^{-4}t^2$ mV
The millivoltmeter is calibrated at ice and steam points. What will be reading on this thermometer where the gas thermometer reads 70 °C? **(06 Marks)**

OR

2 a. Explain Quasi-static process with a neat sketch. **(06 Marks)**

b. With a neat sketch, explain constant volume gas thermometer. **(06 Marks)**

c. A temperature scale of certain thermometer is given by the relation t = a ln p + b where a and b are constants and p is the thermometric property of the fluid in the thermometer. If at the ice point and steam point the thermometric properties are found to be 1.5 and 7.5 respectively. What will be the temperature corresponding to the thermometric property of 3.5 on Celsius scale. **(08 Marks)**

Module-2

3 a. Write the differences and similarities between work and heat transfer. **(06 Marks)**

b. With the help of P-V diagrams derive expressions for various displacement work. **(08 Marks)**

c. To a closed system 150 kJ of work is supplied. If the initial volume is 0.6 m^3 and pressure of the system changes as p = 8 – 4 V, where p is in the bar and V is in m^3, determine the final volume and pressure of the system. **(06 Marks)**

OR

4 a. Explain Joules experiments and hence define first law of thermodynamics. **(06 Marks)**

b. With proper assumptions derive SFEE and apply the same for nozzles and compressors. **(08 Marks)**

c. In a gas turbine unit, the gases flow through the turbine is 15 kg/s and the power developed by the turbine is 12000 kW. The enthalpies of gases at the inlet and outlet are 1260 kJ/kg and 400 kJ/kg respectively and the velocities are 50 m/s and 110 m/s respectively. Calculate (i) The rate at which heat is rejected to the turbine and (ii) Area of the inlet pipe when specific volume of the gas at the inlet is 0.45 m^3/kg. **(06 Marks)**

Module-3

5 a. Briefly explain the terms :
   (i) Thermal reservoir.
   (ii) Reversed heat engine.
   (iii) Kelvin Planck's statement of second law of thermodynamics.
   (iv) PMMII **(08 Marks)**

b. Explain the equivalence of Clausius statement to the Kelvin-Planck statement. **(06 Marks)**

c. A reversible heat engine operates between two reservoirs at temperatures 700 °C and 50 °C. The engine drives a refrigerator which operates between reservoirs at temperatures of 50 °C and −25°C. The heat transfer to the engine is 2500 kJ and the net work output of the combined engine refrigerator plant is 400 kJ. Determine the heat transfer to the refrigerant and the net heat transfer to the reservoir at 50 °C. **(06 Marks)**

OR

6 a. Show that entropy is a property of the system. **(05 Marks)**

b. Explain inequality of Clausius. **(07 Marks)**

c. 3 kg of water at 80 °C is mixed with 4 kg of water at 15 °C in an isolated system. Calculate the change of entropy due to mixing process. **(08 Marks)**

Module-4

7 a. Briefly explain the terms availability and unavailable energy. **(04 Marks)**

b. Derive an expression for maximum useful work in a reversible process. **(06 Marks)**

c. 8 kg of air at 650 K and 5.5 bar pressure is enclosed in a system. If the atmospheric temperature and pressure are 300 K and 1 bar respectively. Determine (i) Availability if the system goes through the ideal work producing process. (ii) Availability and effectiveness if the air is cooled at constant pressure to atmospheric temperature. Take $C_V = 0.718$ kJ/kg K and $C_P = 1.005$ kJ/kgK. **(10 Marks)**

OR

8 a. With a neat sketch and h-s diagram, explain throttling calorimeter. **(08 Marks)**

b. Explain T-S diagram for a pure substance. **(05 Marks)**

c. 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, specific volume, enthalpy, entropy and internal energy. **(07 Marks)**

Module-5

9 a. Briefly explain Dalton's law of partial pressures and Amagat's law of additive volumes. **(04 Marks)**

b. Differentiate between ideal gas and real gas. **(04 Marks)**

c. A mixture of ideal gases contains and 4 kg of nitrogen and 6 kg of carbon dioxide at a pressure of 4 bar and temperature of 20 °C. Find :
   (i) Mole fraction of each constituents.
   (ii) Equivalent molecular weight of the mixture.
   (iii) Equivalent gas constant of the mixture.
   (iv) Partial pressures and partial volumes.
   (v) Volume and density of the mixture. **(12 Marks)**

OR

10 a. Briefly explain law of corresponding states and compressibility factor. **(04 Marks)**

b. Write Vanderwaal's constants in terms of critical properties. **(08 Marks)**

c. 1 kg of carbon di oxide has a volume of 1 m^3 at 100 °C. Compute the pressure by
   (i) Vanderwaal's equation
   (ii) Perfect gas equation. **(08 Marks)**

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