CBCS SCHEME

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18ME33

Third Semester B.E. Degree Examination, June/July 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 allowed.

Module-1

1 a. With an example define the terms :
(i) Intensive properties (ii) Thermodynamic process
(iii) Closed system (iv) Thermal equilibrium
(v) Microscopic approach **(10 Marks)**

b. With a neat sketch, explain constant volume gas thermometer. **(05 Marks)**

c. The temperature t on a thermometric scale is defined in terms of the thermometric property X by the equation, $t = a \ln X + b$, where a and b are constants. The temperatures of ice and steam points are assigned values of 0° and 100° respectively and the corresponding values are 1.86 and 6.81 for X at ice point and steam point respectively. Evaluate the temperature on this scale when X = 2.5. **(05 Marks)**

OR

2 a. Define Zeroth law of thermodynamics and explain the terms thermometric property and thermometer. **(05 Marks)**

b. With the help of P-V diagram, explain quasistatic process. **(05 Marks)**

c. A platinum wire is used as resistance thermometer. The wire resistance was found to be 10 Ω and 16 Ω at ice and steam points respectively and 30 Ω at sulphur boilidng point 444.6°C. Find the constants a and b in the equation $R = R_0(1 + at + bt^2)$ where t is in $^\circ$C. Also find the resistance of the wire at 500°C. **(10 Marks)**

Module-2

3 a. Write thermodynamic definition of work and write expressions for various displacement work in various processes using P-V diagrams. **(08 Marks)**

b. Write the similarities and dissimilarities between work and heat transfer. **(06 Marks)**

c. A spherical balloon has an initial diameter of 25 cm and contains air at 1.2 bar. Because of heating the diameter of the balloon increases to 30 cm and during the heating process the pressure is found to be proportional to diameter. Calculate the work done during the process. **(06 Marks)**

OR

4 a. With a neat sketch, explain Joule's experiment and hence define first law of thermodynamics. **(06 Marks)**

b. Derive an expression for SFEE and apply the same for nozzles and compressors. **(06 Marks)**

c. Air flows steadily at the rate of 0.4 kg/s through an air compressor entering at 6 m/s at a pressure of 1 bar and a specific volume of 0.85 m^3/kg and leaving at 4.5 m/s with a pressure of 6.9 bar, specific volume of 0.16 m^3/kg . The internal energy of air leaving is 88 kJ/kg greater than that of entering. Cooling water in a jacket surrounding the compressor cylinder absorbs heat from air at a rate of 59 W. Calculate the power required to drive the compressor and the inlet and exit areas of the compressor. **(08 Marks)**

Module-3

5 a. Write Kelvin Planck's and Clausius statement of II law of thermodynamics and prove that they are equivalent. **(06 Marks)**

b. Briefly explain :
(i) Refrigeration
(ii) Thermal reservoir
(iii) Heat pump **(06 Marks)**

c. Two reversible heat engines A and B are arranged in series. Engine A is directly rejecting heat to Engine B. A receives 200 KJ of heat from a source at 421°C, while B is rejecting heat to cold sing at 4.4°C. If the work output of A is twice that of B, find
(i) Intermediate temperature between A and B.
(ii) Efficiency of each heat engine
(iii) The heat rejected to cold sink **(08 Marks)**

OR

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

b. Using the entropy principle, show that the mixing process of two fluids is irreversible. **(07 Marks)**

c. 10 kg of water at 20°C is converted into ice at -10°C in a constant pressure process of 1 atmosphere. Calculate the change in entropy for the process assuming C_p for water as 4.187 kJ/kgK and for ice as 2.093 kJ/kgK. Take LH of ice as 335 kJ/kg. **(08 Marks)**

Module-4

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

b. Derive an expression for the maximum useful work. **(08 Marks)**

c. Calculate the decrease in available energy when 25 kg of water at 95°C mix with 35 kg of water at 35°C. The pressure being taken as constant and the surrounding temperature is 15°C. Take C_P of water as 4.2 kJ/kgK. **(08 Marks)**

OR

8 a. Define the terms :
(i) Triple point
(ii) Sub-cooled liquid
(iii) Latent heat of evaporation
(iv) Dryness fraction **(04 Marks)**

b. With the help of a neat sketch and h-s diagram, explain Throttling calorimeter. **(08 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 the internal energy. **(08 Marks)**

Module-5

9 a. Define ideal gas and briefly explain Amagat's law and Dalton's law for ideal gas mixtures. **(06 Marks)**

b. Using general property relations show that for an ideal gas $PV^{r-1} = C$. **(06 Marks)**

c. A mixture of ideal gases consists of 3kg of nitrogen and 5kg of carbon dioxide at a pressure of 300kPa and a temperature of 20°C. Find :
i) Mole fraction of each constituent
ii) Molecular weight of the mixture
iii) Gas constant of the mixture
iv) Volume and density of the mixture
v) Partial pressures and partial volumes. **(08 Marks)**

OR

10 a. Define the terms :
   i) Compressibility factor
   ii) Law of corresponding states
   iii) Compressibility chart. **(06 Marks)**

   b. Write Vander Waal's equation of state and derive expressions for the constants in terms of critical properties. **(06 Marks)**

   c. Determine the specific volume of H_2 gas when its pressure is 60bar and temperature is 100K by using :
   i) Compressibility chart
   ii) Vander Waal's equation. **(08 Marks)**

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