CBCS SCHEME

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18MR33

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 Thermodynamic data Hand book is permitted.

Module-1

1 a. Define the following with examples:
i) Open system
ii) Closed system
iii) Path function
iv) Point function. **(08 Marks)**

b. Distinguish between
i) Intensive and extensive properties
ii) Microscopic and macroscopic point of view. **(04 Marks)**

c. State Zeroth law of thermodynamics. The temperature, t, on a certain scale is defined in terms of the thermometric property x by the relation $t = a \cdot \ln x + b$ where a and b are constants. On this scale the temperature of ice and steam points are 0 and 100, respectively. Experiments reveal that $x_i = 1.86$ and $x_s = 6.81$. Find the temperature for an x value of 2.3 on this thermometer. **(08 Marks)**

OR

2 a. List the dissimilarities between head and work. **(04 Marks)**

b. Derive the expression for the displacement work in polytropic process ($PV^n = c$). **(06 Marks)**

c. A certain mass of air is compressed from 1 bar, $0.1m^3$ to 6 bar in a piston cylinder device according to $PV^{1.4} = c$. Find the work of compression for air. Had the compression been carried out hyperbolically between the same initial state and the same final pressure as above? What would be the work done on air? **(10 Marks)**

Module-2

3 a. State and explain the first law of thermodynamics. Give its equation with reference to a cyclic and non cyclic process. **(06 Marks)**

b. A fluid is confined in a cylinder by spring loaded, frictionless piston so that the pressure in the fluid is linear function of the volume $P = a + b V$. The internal energy of the fluid is given by $U = 34 + 3.15PV$, where U is in kJ, P in kPa and V in m^3. If the fluid changes from an initial state of 170kPa, $0.03m^3$ to a final state of 400kPa, $0.06m^3$, with no work other than that done on the piston, find the direction and magnitude of the work and heat transfer. **(08 Marks)**

c. Steam at a rate of 0.42kg/s and enthalpy of 2785kJ/kg and a velocity of 33.3m/s is supplied to a steadily operating turbine. The steam leaves the turbine at 100m/s and an enthalpy of 2512kJ/kg. The inlet pipe is 3m above the exit pipe. Rate of heat loss from the turbine casing is 0.29kJ/s. What is the power output of the turbine? **(06 Marks)**

OR

4 a. Define Kelvin-Plank statement and Clausius statement of 2nd law of thermodynamics show that they are equivalent. **(10 Marks)**

b. A heat pump working on a carnot cycle takes in energy from a reservoir maintained at 5°C and delivers it to another reservoir where temperature is 77°C. The heat pump derives power for its operation from a reversible heat engine operating with in the higher and lower temperature of 1077°C and 77°C for every 100kJ/kg of energy supplied to reservoir at 77°C, estimate the energy taken from the reservoir at 1077°C. **(10 Marks)**

Module-3

5 a. State and prove Clausius in equality. What is the significance of Clausius in equality? **(10 Marks)**

b. An adiabatic vessel contains 85kg of oil at a temperature of 27°C. A spherical ball made of steel of 10kg at 727°C is immersed in oil. Determine change in entropy for the universe. Take $C_{P_{oil}} = 3.5kJ/kgK$, $C_{P_{steel\ ball}} = 0.5kJ/kgK$. **(10 Marks)**

OR

6 a. Define dryness fraction of steam? What are methods used to measure dryness fraction? With neat sketch explain any one. **(10 Marks)**

b. A rigid vessel of $2m^3$ volume is filled with superheated steam at 20 bar and 350°C. The vessel is cooled until the steam is just dry saturated. Calculate the mass of steam in the vessel, the final pressure of steam and amount of energy transferred as heat to the surroundings. **(10 Marks)**

Module-4

7 a. Write Maxwell relations. **(04 Marks)**

b. Show that the change in entropy when a perfect gas under goes a polytropic change $PV^n = C$ is given by $(S_2 - S_1) = \left(\frac{\gamma - n}{n-1}\right) C_v \ell_n \left(T_1/T_2\right)$. **(06 Marks)**

c. 0.2kg of air with pressure 1.5 bar and temperature 27°C is compressed to a pressure of 15 bar according to the law $PV^{1.25} = C$. Determine: i) Work done on or by the air ii) Heat flow to or from the air iii) Change in entropy for air R = 0.287kJ/kgK r = 1.4 $C_v = 0.718kJ/kgK$. **(10 Marks)**

OR

8 a. Show the internal energy of an ideal gas is a function of temperature only. **(08 Marks)**

b. A gas of mass 1.5kg undergoes a quasistatic expansion which follows a relationship P = a + bv, where a and b are constants. The initial and final pressure are 100kPa and 200kPa respectively and the corresponding volumes are $0.2m^3$ and $1.2m^3$. The specific internal energy of the gas is given by the relation u = 1.5pv – 85kJ/kg, where P is the kPa and V is the m^3/kg. Calculate the net heat transfer and the maximum internal energy of the gas attained during expansion. **(12 Marks)**

Module-5

9 a. Explain:
i) Daltoni law of partial pressures
ii) Amagets law of additive volumes **(10 Marks)**

b. A ballon of spherical shape 6m in diameter is filled with hydrogen gas at a pressure of 1 bar abs and 20°C. At a later time the pressure of the gas is 94% of its original pressure at the same temperature.
i) What mass of the original gas must have escaped if the dimensions of the ballon is not changed?
ii) Find the amount of heat removed to cause the same drop in pressure at constant volume. Take C_v for hydrogen as 10400J/kgK. **(10 Marks)**

OR

10 a. Write a short note on:
i) Compressibility factor
ii) Law of corresponding states
iii) Compressibility chart
iv) Vanderwaal's equation of state. **(12 Marks)**

b. A mixture of 0.5kg of CO_2 and 0.3kg of N_2 is compressed from P_1 = 1atm T_1 = 20°C to P_2 = 5atm in a polytropic process for which η = 1.3. Find : i) Find final temperature ii) The work iii) The heat transfer iv) the change in entropy of the mixture. **(08 Marks)**

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