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10ME/AU33

Third Semester B.E. Degree Examination, Dec.2019/Jan.2020

Basic Thermodynamics

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting at least TWO questions from each part.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

PART – A

1 a. Explain the following:
i) Closed system ii) Open system iii) Isolated system
iv) Mechanical equilibrium v) Thermal equilibrium **(10 Marks)**

b. State zeroth law of thermodynamics and explain how this law is used to measure the temperature of a given system. **(04 Marks)**

c. The resistance of the winding of a motor at room temperature 28°C and at full load under steady state conditions is given at 75Ω and 90Ω respectively. The windings are made of copper with temperature t°C is given by $R_{tp} = R_0(1 + 0.004t)$. If R_0 is the resistance at 28°C, find the temperature of the coil at full load. **(06 Marks)**

2 a. Define thermodynamic definition of work and heat. Make comparison between work and heat. **(06 Marks)**

b. The initial pressure and volume of a gas in a cylinder filled with a moveable piston are P_1 bar and V_1 m^3 respectively. Calculate the work done by a system if gas expands reversibely to a volume V_2 m^3 during the following processes.
i) Isothermal process
ii) Polytropic process **(06 Marks)**

c. A gas is taken in a piston and cylinder arrangement at an initial pressure of 25 bar. It undergoes a cyclic process as follows:
- The gas expanded reversibely according to the relation $PV^{2.5} = C$ until the volume is doubled.
- Then the gas is cooled reversibely at constant pressure until the piston reaches the initial position.
- Now the piston is kept fixed and heat is added until the pressure rises to the original value of 25 bar.

Calculate: (i) The network done by the fluid (ii) Sketch the cycle on P-V diagram. Take the initial volume is 0.05 m^3 and mass is 1 kg. **(08 Marks)**

3 a. Using I-law of thermodynamics show that energy is a property of a system. **(06 Marks)**

b. Derive the steady flow energy equation for a single stream of fluid entering and a single stream of fluid leaving the control volume. **(08 Marks)**

c. A small turbine runs an aircraft refrigeration system. Air enters the turbine at 4 bar and 40°C with a velocity of 40 m/s. At the exit the air is at 1 bar, 2.5°C and having velocity of 200 m/s. If the work output of the turbine is 52 kJ/kg of air. Calculate the heat transferred per kg of air using SFEE. Take C_p of air = 1.005 kJ/kg-K and R = 0.287 kJ/kg-K. **(06 Marks)**

4 a. Prove that $COP_{Heat\ pump} = 1 + COP_{Refrigerator}$. **(06 Marks)**

b. Explain Kelvin Plank and Clausius statements of II-law of thermodynamics. **(06 Marks)**

c. A reversible heat engine takes heat at the rate of 500 kJ per second from a heat source at 700 K. The work done by the cyclic device is 200 kJ per second and rejects heat to two sinks at 400 K and 500 K. Calculate: (i) the engine thermal efficiency (ii) amount of heat rejected to each sink.

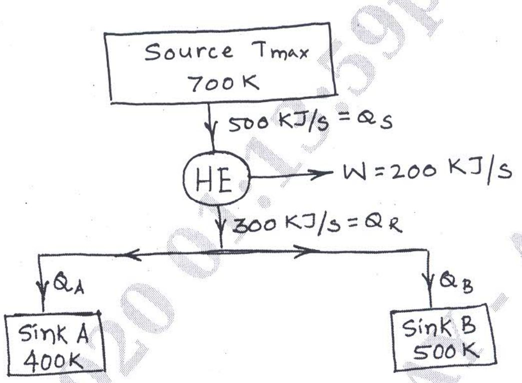

Fig.Q4(c) **(08 Marks)**

PART – B

5 a. Define entropy and show that entropy is a property of a system. **(08 Marks)**

b. State and prove Clausius theorem. **(08 Marks)**

c. A hot copper block of 6 kg is cooled by using a reversible heat engine from 50°C to 30°C by transferring heat of hot block to the reversible heat engine. The room air at 30°C serves as sink for the engine. Calculate the change in entropy for the block. Take C_p for copper = 0.4 kJ/kg-K. **(04 Marks)**

6 a. Sketch the pressure-temperature (P-T) phase diagram for water mark on it the following solid region, liquid region, vapour phase, triple point and critical point. **(06 Marks)**

b. Explain the following terms with T-S diagram:
i) Sensible heat ii) Latent heat iii) Total heat iv) Super heat. **(08 Marks)**

c. Steam at 20 bar and 300°C passes through a pipe at the velocity of 100 m/s. If steam flows at the rate of 400 kg/hr. Calculate the diameter of the pipe. **(06 Marks)**

7 a. Prove that:

i) Specific heat at constant volume $C_V = T\left[\dfrac{\partial S}{\partial T}\right]_V$

ii) Specific heat at constant pressure $C_p = T\left[\dfrac{\partial S}{\partial T}\right]_P$ **(06 Marks)**

b. Derive Clausius Clapeyson equation. **(06 Marks)**

c. One kg of air at a pressure of 8 bar and temperature 100°C undergoes a reversible polytropic process following the law $PV^{1.2}$ = constant. If the final pressure is 1.8 bar. Determine:
i) Final specific volume ii) Final temperature iii) Increase in entropy
iv) Work done v) Heat transfer **(08 Marks)**

8 a. Define Ideal gas and Real gas. **(04 Marks)**

b. Explain: (i) Compressibility chart (ii) Generalised compressibility chart **(08 Marks)**

c. Compute from the Vanderwaals equation the pressure exerted by 1 kg of CO_2 at 100°C if the specific volume is 3 m^3/kg. Also computer the results of CO_2 is treated as an ideal gas. Take

$a = 365.6\ \dfrac{kNm^4}{(kg.mol)^2}$, $b = 0.0423\ \dfrac{m^3}{kg.mol}$ and $\bar{R} = 8.314\dfrac{kJ}{kg.mol.K}$ **(08 Marks)**

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