U.S.N

P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belagavi)

Third Semester, B.E. - Mechanical Engineering
Semester End Examination; Dec.-2019
Basic Thermodynamics

Time: 3 hrs *Max. Marks: 100*

Note: i) PART - A is compulsory. **Two** marks for each question.
ii) PART - B: Answer any **Two** sub questions (from a, b, c) for Maximum of **18 marks** from each unit.

Q. No.	Questions	Marks
	I : PART - A	**10**
I a.	An open system defined for a fixed region and a closed system defined for a fixed mass, how?	2
b.	Write the mass balance and steady flow energy equation for a system having two stream of fluid enters and leaves through a single exit.	2
c.	Recall the definitions of dryness fraction and a pure substance.	2
d.	Show that the COP of a heat pump is greater than the COP of a refrigerator by unity.	2
e.	Show that area under a reversible path on the T-S plot represents heat transfer.	2
	II : PART - B	**90**
	UNIT - I	**18**
1 a.	Explain the following types of work transfer: i) Shaft work ii) Electric work iii) Work done in stretching a wire	9
b.	A thermometer is calibrated with ice and steam points as fixed points referred to as 0°C and 100°C respectively. The equation used to establish the scale is $t = a\ lnx + b$ i) Determine the constants a and b in terms of x_s and x_I, where x_s and x_I are the thermometric properties at steam point and ice point respectively ii) Prove that $t^{\circ}C = 100\dfrac{l_n\left(u/x_1\right)}{\ln\left(\dfrac{x_s}{x_1}\right)}$ iii) Determine the thermometer reading when the thermometric property is 57. The thermometric properties at ice point and steam point are 6.5 and 98.5.	9
c.	An elastic sphere of one meter diameter contains a gas at 150 kPa. Heating of the sphere increases the pressure to 450 kPa and during this process the pressure of the gas is proportional to the diameter cubed of the sphere. Determine; i) The work done by the gas ii) If the process is assumed to be of the form PV^n = C, find the value of 'n'.	9

UNIT - II **18**

2 a. With the help of simple sketches explain the Joule's experiment to prove the first law of thermodynamics for a system undergoing a thermodynamic cycle. How it is modified for a process in a closed system? 9

b. A gas undergoes a thermodynamic cycle as follows:

i) Process 1 – 2, constant pressure, P = 3 bar, $V_1 = 0.5\ m^3$, $W_{12} = 20$ kJ

ii) Process 2 – 3, isothermal $U_3 = U_2$

iii) Process 3 – 1, constant volume, $U_1 - U_3 = -50$ kJ neglecting the changes in K.E and P.E.

Determine; 9

I) Net work done

II) Net heat transfer

III) Net internal energy

IV) Sketch the cycle on the PV diagram

c. Air at a temperature of 15°C passes through a heat exchanger at a velocity of 30 m/s where its temperature is raised to 800°C. If then enters a turbine with the same velocity of 30 m/s and expands until the temperature falls to 650°C. On having the turbine, the air is taken at a velocity of 60 m/s to a nozzle where it expands until the temperature has fallen to 500°C. If the air flow rate is 2 kg/s, calculate; 9

i) The rate of heat transfer to the air in the heat exchanger

ii) The power output from the turbine assuming no heat loss

iii) The velocity at exit from the nozzle, assuming no heat loss.

Take the enthalpy of air as $\eta = C_p t$, where C_p is the specific heat equal to 1.005 kJ/kg-K and t is the temperature.

UNIT - III **18**

3 a. With the help of simple sketches explain the procedure to plot PV diagram of a pure substance other than water, whose volume increases on melting. 9

b. Sketch and explain the procedure to determine the quality of the steam using combined separating and throttling calorimeter. Why cannot a throttling calorimeter measure the quality if the steam is very wet? 9

c. A vessel of volume $0.004\ m^3$ 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, the mass, the specific volume, the enthalpy the entropy and the internal energy. 9

UNIT - IV **18**

4 a. Explain the working principle of Carnot cycle, also derive the expression for efficiency of Carnot cycle considering the work done during all the process. 9

Contd....3

b. Explain the equivalence of two statements of second law of thermodynamics. 9

c. A reversible heat engine operates between two reservoirs at temperatures of 600°C and 40°C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 40°C and −20°C. The heat transfer to the heat engine is 2000 kJ and the net work output of the combined engine refrigerator plant is 360 kJ. 9

i) Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40°C

ii) Reconsider (i) given that the efficiency of the heat engine and the COP of the refrigerator are each 40% of their maximum possible values.

UNIT - V **18**

5 a. State and prove Clausius inequality and prove that entropy is property of the system. 9

b. Derive the following entropy change equations for ideal gas *K*, 9

i) $S_2 - S_1 = C_v \ln (T_2/T_1) + R \ln (V_2/V_1)$

ii) $S_2 - S_1 = C_v \ln (P_2/P_1) + C_p \ln (V_2/V_1)$

iii) $S_2 - S_1 = C_p \ln (T_2/T_1) + R \ln (P_2/P_1)$

c. 0.25 kg of air at a pressure of 1.5 bar and volume 0.12 m^3 is compressed to 10 bar according to the law $PV^{1.35} = C$. Determine; 9

i) Change in internal energy of the air

ii) The work done on or by the air

iii) The heat received or rejected by the air

Take C_p = 1.005 kJ/kg-K, and C_v = 0.718 kJ/kg-K.

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