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15ME33

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

Time: 3 hrs. Max. Marks: 80

Note: 1. ***Answer FIVE full questions, choosing one full question from each module.***
2. ***Use of thermodynamic data hand book is permitted.***

Module-1

1 a. Distinguish between the following:
(i) Microscopic and macroscopic point of view of thermodynamics.
(ii) Extensive and Intensive properties. **(05 Marks)**

b. Define the zeroth law of thermodynamics. A constant volume gas thermometer containing Helium gives a reading of gas pressure `P' of 1000 mmHg and 1366 mmHg at ice point and steam point respectively. Assuming a linear relationship of the form, t = a + PP , express the gas thermometer Celcius temperature 't' in terms of gas pressure 1°. What is the temperature recorded by the thermometer when it registers a pressure of 1074 mmHg? **(06 Marks)**

c. Explain the thermodynamic definition of work with suitable diagram. **(05 Marks)**

OR

2 a. Explain thermodynamic equilibrium concept. **(05 Marks)**

b. Deduce the expression for work in case of shaft work and electrical work. **(05 Marks)**

c. The combustion gases of an IC engine expand with in an enclosed piston and cylinder arrangement and follow the path PV" = C . The pressure at the beginning of the power stroke is 5 MPa and volume 50 cm^3. At the end of the stroke the volume is 1500 cm^3. Calculate (i) The work developed during power stroke (ii) Average power developed by the gas if there are 20 power strokes per second. **(06 Marks)**

Module-2

3 a. Explain the Joule's experiment and describe how it leads to the foundation of first law of thermodynamics. **(05 Marks)**

b. A nozzle is used to convert enthalpy into kinetic energy. Air enters the nozzle at a pressure of 2700 KPa at a velocity of 30 m/s with an enthalpy of 923 KJ/kg and leaves with a pressure of 700 KPa and enthalpy of 660 KJ/kg. (i) If the heat loss is 0.96 KJ and mass flow rate is 0.2 kg/s, find the exit velocity (ii) Find the exit velocity for adiabatic conditions. **(07 Marks)**

c. State both Kelvin Planck and Clausius statements of thermodynamics. **(04 Marks)**

OR

4 a. Explain PMMI and PMMII with suitable diagrams. **(06 Marks)**

b. 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 the reservoir at temperature of 40°C and —20'C . The heat transfer to the heat engine is 2000 KJ and the network output of the combined engine refrigerator plant is 360 KJ. Evaluate the heat transfer to the refrigerator and net heat transfer to the reservoir at 40°C. **(07 Marks)**

c. Comment on the limitations of the first law of thermodynamics. **(03 Marks)**

Module-3

5 a. What are the factors, that makes a process irreversible? **(05 Marks)**

b. Derive Clausius inequality and comment on its outcome. **(05 Marks)**

c. A heat engine is shown in the Fig. Q5 (c) where 10000 KJ/hr of heat is supplied from source at 1400°C while the working fluid is at 540°C. 8000 KJ/hr of heat is rejected to a sink at temperature 5°C and working fluid is at 60°C. Calculate the following:

(i) Actual efficiency of the engine.
(ii) Fraction of the actual efficiency of the internally reversible efficiency.
(iii) Fraction of actual efficiency of the external reversible efficiency. **(06 Marks)**

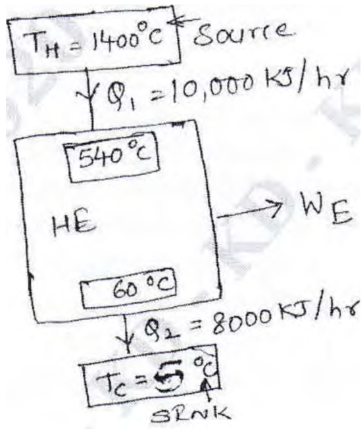

Fig. Q5 (c)

OR

6 a. Prove that entropy is a property. **(05 Marks)**

b. A closed system contains air at pressure I bar, temperature 290 K and volume 0.02 m'. The system undergoes a thermodynamic cycle consisting of the following three processes:
(i) Process 1 — 2 : constant volume heat addition till the pressure becomes 4 bar.
(ii) Process 2 — 3 : Constant pressure cooling (iii) Process 3 — 1 : Isothermal heating to initial state. Represent the cycle in T-S and P-V plot. Evaluate the change of entropy for each case. Take C_v = 718 J/kg K, R = 287 J/kgK. **(07 Marks)**

c. Write a comment on thermodynamic temperature scale. **(04 Marks)**

Module-4

7 a. Explain the concept of availability and unavailability. **(04 Marks)**

b. Explain the working of throttling calorimeter with a neat diagram. **(05 Marks)**

c. Find the maximum work/kg of air that can be obtained from a piston cylinder arrangement if the air expands from the initial state of P, = 6 bar, t =170 C to a final pressure of P_2 = 1.4 bar, t2 = 60°C. Neglecting changes in KE and PE and assuming t_0 =15' C , calculate the availability in the initial and final states.
Compare the two results (Cp),,,, = 1.005 KJ/kgK, **R =** 287 J/kg K. **(07 Marks)**

OR

8 a. Explain the PT diagram of a pure substance with all necessary points on it. **(05 Marks)**

b. Show that the change in availability is equal to the change in Gibbs function when the temperature and pressure of the system are constant. **(05 Marks)**

c. Steam from a boiler is delivered at 15 bar absolute and dryness fraction of 0.85 into a steam super heater where an additional heat is added at constant pressure. Steam temperature now increases to 573K. Determine amount of heat added and change ;ya0*Kigte,,,&iergy for unit mass of steam. **(06 Marks)**

Module-5

9 a. Explain the Amagat's law of additive volume. **(05 Marks)**

b. State Vander Waal's equation of state and Beattie-Bridgeman equation. **(05 Marks)**

c. The air at DBT 28°C and 1 bar has a specific humidity of 0.016 kg per kg of dry air. Determine

(i) Partial pressure of water vapour.

(ii) Relative humidity.

(iii) Dew point temperature. **(06 Marks)**

OR

10 a. Explain the Dalton's law of partial pressures. **(04 Marks)**

b. Determine the pressure exerted by oxygen in a container of 2 m^3 capacity when it contains 5 kg at 27°C using (i) Ideal gas equation (ii) Vander Waals equation.

Take $a = 139.250 \dfrac{kNm^4}{(kgmole)^2}$; $b = 0.0314 \dfrac{m^3}{kgmole}$ **(07 Marks)**

c. Write short note on compressibility chart and its usefulness. **(05 Marks)**