USN | | | | | | | | | | |

15ME33

Third Semester B.E. Degree Examination, July/August 2021
Basic Thermodynamics

Time: 3 hrs. Max. Marks: 80

Note:1. ***Answer any FIVE full questions.***
2. ***Use of thermodynamic data hand book permitted.***

1 a. Define thermodynamics. Explain the macroscopic and microscopic approaches. **(03 Marks)**

b. Define (i) Open system (ii) Closed system (iii) Property. **(05 Marks)**

c. The temperature T on a scale is given by $T = a \ln x + b$, where a and b are constants and x is thermometric property. The values of x at ice and steam points are 1.83 and 6.78. The corresponding temperatures are assigned values 0 and 100 respectively. Determine temperature when $x = 2.42$. **(08 Marks)**

2 a. Define work according to thermodynamics. **(02 Marks)**

b. Derive expressions for the displacement work for polytropic process. **(06 Marks)**

c. Air is compressed from atmospheric pressure and 0.2 m^3 to 5 bar in a polytropic process with an index of compression of 1.4. Calculate the work needed for compression. Had the compression been carried out hyperbolically between the some initial state and the same final pressure, what would be the work needed? **(08 Marks)**

3 a. State the first law of thermodynamic for closed system. **(04 Marks)**

b. Prove that energy is a property of system. **(04 Marks)**

c. At the inlet of a nozzle, the enthalpy of working fluid is 3 MJ/kg and the velocity is 60 m/s, At the exit, the enthalpy is 2.76 MJ/kg. The nozzle is horizontal and is insulated. Calculate the velocity at the exit. If the diameter of inlet is 357 mm and density of working fluid at inlet is 5.35 kg/m^3, determine the mass flow rate. If the density of working fluid is 2 kg/m^3 at exit, determine the exit diameter. **(08 Marks)**

4 a. A Carnot engine has a rated output of 5 kW. The heat supplied is 6 kW. Calculate the efficiency and heat rejected. Also determine the source and sink temperatures, if the difference is 300°C. **(06 Marks)**

b. With the help of a schematic diagram, show that Kelvin-Planck and Clausius statements of second law of thermodynamics are equivalent. **(10 Marks)**

5 a. Define reversible and irreversible processes. What is the need to define a reversible process as it is not at all practical? **(03 Marks)**

b. Explain the factors that make a process irreversible. **(05 Marks)**

c. Prove the basic equation of absolute thermodynamic temperature scale $\frac{Q_1}{Q_2} = \frac{T_1}{T_2}$ for a reversible heat engine. **(08 Marks)**

6 a. Prove that entropy is indeed a property. **(03 Marks)**

b. 1.2 kg of nitrogen at 120 kPa, 300 K is compressed polytropically until the volume reduces by 50%. The index of compression is 1.3 and C_P = 1.04 kJ/kgK. Determine the entropy change during compression. **(08 Marks)**

c. Draw Carnot cycle on a T-S plot and show that the network is given by $(T_1 - T_2)\ \Delta S$. **(05 Marks)**

7 a. Air expands in a turbine from 500 kPa, 520˚C to 100 kPa, 300˚C. The heat loss to the surroundings is 10 kJ/kg, and surrounding is at 20˚C. Determine available energy and irreversibility per kg of air. **(08 Marks)**

b. Derive Maxwell's relations. **(08 Marks)**

8 a. Draw representative P-T diagram for water and explain the regions. **(04 Marks)**

b. Steam initially at 150 bar, 500˚C expands reversibly and adiabatically in a turbine to a pressure of 0.1 bar. If the steam flow rate is 600 tons per hour. Determine the work output of turbine. Use steam tables for the properties of steam. **(08 Marks)**

c. Steam flows in a pipe at 15 bar. After expanding to 1 bar in a throttling calorimeter, the temperature is found to be 110˚C. Determine the quality of steam in the pipe using Mollier chart. **(04 Marks)**

9 a. A mixture of ideal gases consists of 79 kg Nitrogen and 21 kg oxygen at 1 bar. Calculate the (i) Partial pressures, (ii) Equivalent molecular weight of the mixture, and (iii) Equivalent gas constant of the mixture. **(09 Marks)**

b. Define (i) Specific humidity and (ii) Relative humidity. **(02 Marks)**

c. Atmospheric air at mean sea level and 30˚C has a relative humidity of 80% using psychrometric chart, find (i) wet bulb temperature (ii) specific humidity and (iii) dew point temperature. **(05 Marks)**

10 a. What are the limitations of ideal gas equation? **(02 Marks)**

b. Estimate the pressure of 100 kg of Nitrogen, which occupies a volume of 0.375 m^3 at 175 K using (i) Ideal gas equation, and (ii) Vander Waal's equation. Take Vander Waal's constants a = 136.6 kN $m^4/kmol^2$ and b = 0.0386 m^3/Kmol. **(08 Marks)**

c. Determine the density of steam in a boiler at 406˚C and 332 bar using generalized compressibility chart. **(06 Marks)**

* * * * *