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

18ME33

Third Semester B.E. Degree Examination, Dec.2019/Jan.2020
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 and steam tables is permitted.
3. Assume missing data suitably.

Module-1

1 a. Differentiate between micro and macroscopic approach. **(04 Marks)**

b. Define the following terms with neat sketch:
   (i) Open system
   (ii) Closed system
   (iii) Isolated system
   (iv) Quasi-static process **(08 Marks)**

c. The temperature 'T' on a thermometric scale is defined as $T = a\ell n(K) + b$, where a and b are constants. The values of K are found to be 1.83 and 6.78 at 0°C and 100°C, respectively. Calculate the temperature for value of K = 2.42. **(08 Marks)**

OR

2 a. Define:
   (i) Thermodynamic equilibrium
   (ii) Zeroth law of thermodynamics **(04 Marks)**

b. With neat sketch explain the working principle of:
   (i) Electrical resistance thermometer
   (ii) Thermocouple **(08 Marks)**

c. Two Celsius thermometer 'A' and 'B' agree at ice point and steam point, and related by the equation $t_A = L + Mt_B + Nt_B^2$, where L, M and N are constants. When both thermometers are immersed in a fluid, 'A' registers 26°C, while 'B' registers 25°C. Determine the reading of 'A' when 'B' reads 37.4°C. **(08 Marks)**

Module-2

3 a. Define thermodynamic work and heat. **(04 Marks)**

b. Write an expression for displacement of work for the following process with P-V diagrams.
   (i) Constant pressure
   (ii) Constant volume
   (iii) Constant temperature
   (iv) Polytropic process **(08 Marks)**

c. A quantity of gas is compressed in a piston-cylinder from a volume of 0.8611 m^3 to a final volume of 0.1721 m^3. The pressure in (bar) and as a function of volume (m^3) is given by:

$$P = \left(\frac{0.8611}{V} - \frac{8.6067\times10^{-5}}{V^2}\right)$$

   (i) Find the amount of work done in KJ.
   (ii) If the atmospheric pressure is 1 bar, acting on the other side of piston is considered. Find the net work done in KJ. **(08 Marks)**

OR

4 a. State 1st law of thermodynamics. Derive an expression for 1st law of thermodynamics for open system (SFEE). (10 Marks)

b. The working fluid, in a steady flow process at a rate of 220 kg/min. The fluid rejects 100 KJ/s of heat passing through the system. The condition of the fluid at inlet and outlet are given as $\overline{V}_1 = 220$ m/s, $p_1 = 6.0$ bar, $u_1 = 2000$ KJ/kg, $\upsilon_1 = 0.36$ m^3/kg and $p_2 = 1.2$ bar, $\overline{V}_2 = 140$ m/s, $u_2 = 1400$ kJ/kg, $\upsilon_2 = 1.3$ m^3/kg. The suffix 1 and 2 indicates at inlet and outlet conditions respectively. Determine the power capacity of the system in MW. (10 Marks)

Module-3

5 a. Define the following terms:
(i) Thermal reservoir
(ii) Heat engine
(iii) Kelvin-Plank statement of 2nd law
(iv) Clausius statement of 2nd law
(v) Heat pump (10 Marks)

b. A heat engine working on a Carnot cycle absorbs heat from three thermal reservoirs at 1000 K, 800 K and 600 K, respectively. The engine does 10 KW of net work and rejects 400 kJ/min of heat to a heat sink at 300 K. If the heat supplied by the reservoir at 1000 K is 60% of heat supplied by the reservoir at 600K. Find the quantity of heat supplied by each reservoirs. (10 Marks)

OR

6 a. Define entropy and prove that it is a point function. (04 Marks)

b. Discuss the Clausius Inequality. (08 Marks)

c. A steel ball mass of 10 kg at 627°C is dropped in 100 kg of oil at 30°C. The specific heat of steel and oil are 0.5 kJ/kgK and 3.5 kJ/kgK, respectively. Calculate the entropy change of steel, oil and the universe. (08 Marks)

Module-4

7 a. With neat sketch, explain available and Unavailable energy on T-S diagram. (06 Marks)

b. Explain the concept of second law of efficiency. (06 Marks)

c. A Carnot engine works between the temperature limits 225°C and 25°C in which water is used as the working fluid. If heat is supplied to the saturated liquid at 225°C, until it is converted into saturated vapour, determine per kg of water.
(i) Amount of heat absorbed by the fluid
(ii) Available energy
(iii) Unavailable energy
(Take latent heat of water = 1858.5 kJ/kg) (08 Marks)

OR

8 a. With neat sketch explain the working of separating and throttling calorimeter. (10 Marks)

b. A vessel of volume 0.04 m^3 contains a mixture of saturated water and saturated state at a temperature of 250°C. The mass of the liquid present is 9 kg. Find the mass, specific volume, enthalpy, entropy and internal energy of the steam. (10 Marks)

Module-5

9 a. Define:
(i) Mole fraction
(ii) Mass fraction
(iii) Dalton's law
(iv) Amgat's law of volume additives **(10 Marks)**

b. A mixture of gases contain 1 kg of CO_2 and 1.5 kg of N_2. The pressure and temperature of the mixture are 3.5 bar and 27°C. Determine:
(i) Mole fraction of each constituent
(ii) Partial pressure
(iii) Partial volume
(iv) Volume of mixture
(v) Density of mixture **(10 Marks)**

OR

10 a. State and explain the following terms:
(i) Compressibility factor
(ii) Reduced properties
(iii) Real gases
(iv) Relative humidity **(08 Marks)**

b. With usual notations, write the Vandeer Waal equation and explain the terms involved in it. **(04 Marks)**

c. Determine the pressure exerted by CO_2 in a container of 1.5 m^3 capacity when it contains 5 kg at 27°C:
(i) Using ideal gas relation
(ii) Using Vandeer Waal's equation
[Take a = 364.3 kPa $(m^3/kg.mol)^2$; b = 0.0427 $(m^3/kg.mol)$ for Vandeer Waal's constants] **(08 Marks)**

* * * * *