USN

Third Semester B.E. Degree Examination, Aug./Sept.2020
Basic Thermodynamics

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer any FIVE full questions, selecting at least TWO questions from each part.***
2. ***Use of steam tables is permitted.***

PART – A

1 a. Define the following :
(i) Open system (ii) Closed system (iii) Isolated system
(iv) Point function (v) Path function **(10 Marks)**

b. State the zeroth law of thermodynamics and briefly explain its significance. **(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 as 75 Ω and 90 Ω 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 0°C, find the temperature of the coil at full load. **(06 Marks)**

2 a. State and explain thermodynamic definition of work. **(04 Marks)**

b. Derive an expression for displacement of the system follows the law PV^n = constant. **(06 Marks)**

c. A system of volume V contains a mass m of gas at a pressure of P and the temperature T, these properties are related by $\left(P + \frac{a}{V^2}\right)(V - b) = mRT$, where a, b, R are constants, obtain an expression for the displacement work done when the system undergoes an isothermal process from volume 'V_1' to a final volume 'V_2'. Calculate the work for the system which contain 10 kg of gas expanding from $1 m^3$ to $10 m^3$ at a constant temperature of 293 K. Assume $a = 15.7 \times 10^4$ Nm^4, $b = 1.07 \times 10^{-2}$ m^3 and R = 0.278 kJ/kg-K. **(10 Marks)**

3 a. Give the precise statement of first law of thermodynamics as applied to a closed system undergoing a process and hence prove that internal energy is a property. **(08 Marks)**

b. A nozzle is a device for increasing the velocity of a steadily flowing stream. At the inlet to a certain nozzle, the enthalpy of the fluid passing is 3000 kJ/kg and the velocity is 60 m/s. At the discharge end, the enthalpy is 2762 kJ/kg. The nozzle is horizontal and there is a negligible heat loss from it.
(i) Find the velocity at the exit of nozzle
(ii) If the inlet area 0.1 m^2 and specific volume at inlet is 0.187 m^3/kg, find the mass flow rate
(iii) If the specific volume at the exit of the nozzle is 0.498 m^3/kg, find the diameter at the exit section of the nozzle. **(12 Marks)**

4 a. State the Kelvin-Plank and Clausius statements of the second law of thermodynamics and show that the violation of the former results in the violation of the latter. **(08 Marks)**

b. A direct heat engine operating between two reservoirs at 327°C and 27°C drives a refrigerator operating between 27°C and 13°C. The efficiency of the heat engine and the refrigerator are each 70% of their maximum values. The heat transferred to the heat engine is 500 kJ. The net heat rejected by the engine and the refrigerator to the reservoir at 27°C is 400 kJ. Find the net work output of the engine refrigerator combination. Draw the schematic representation. **(12 Marks)**

PART – B

5 a. Prove that entropy is a property of a system from Clausius inequality. **(10 Marks)**

b. 0.5 kg of ice block at −10°C is brought into contact with 5 kg copper block at 80°C in an insulated container. Determine the change in entropy of (i) ice block (ii) copper block (iii) the universe. Given specific heat of ice = 2 kJ/kgK, specific heat of water = 4.2 kJ/kgK, specific heat of copper = 0.5 kJ/kgK, enthalpy of fusion of water at 0°C = 334 kJ/kg. **(10 Marks)**

6 a. Sketch the temperature-pressure phase diagram for water mark on it the following regions of solid, liquid and vapour phase triple point and critical point. **(05 Marks)**

b. Sketch and explain Separating Calorimeter. **(05 Marks)**

c. Determine the dryness fraction of the steam sample is tested in a separating and throttling calorimeter and the following data were obtained:
(i) Pressure of steam sample = 15 bar
(ii) Pressure of steam at exit = 1 bar
(iii) Temperature of steam at exit = 150°C
(iv) Water collected from the separating calorimeter = 0.2 kg/min
(v) Discharge collected at the exit = 10 kg/min **(10 Marks)**

7 a. Derive Clausius Clayperson's equation of liquid and explain the significance. **(06 Marks)**

b. Distinguish between:
(i) Ideal gas and real gas
(ii) Perfect gas and semi perfect gas **(04 Marks)**

c. 2 kg air (C_p = 1.005 kJ/kgK and C_v = 0.718 kJ/kgK) is compressed reversibly according to $PV^{1.3}$ = constant from 1 bar, 37°C to 5 bar:
(i) Find the increase in internal energy
(ii) Use the relation $\varphi = [(n-\gamma)/(n-1)]C_V(T_2 - T_1)$. Calculate the magnitude and direction of work.
(iii) Show the initial and final states and the process path on T-S diagram. **(10 Marks)**

8 a. Define mass fractions and mole fractions of the constituents of an ideal gas mixture. **(04 Marks)**

b. Find the gas constant and apparent molar mass of a mixture of 2 kg O_2 and 3 kg of N_2, given the inversed gas constant is 8314.2 J/KmolK, molar masses of O_2 and N_2 are respectively 32 and 28. **(04 Marks)**

c. Write short notes on:
(i) Vander Waal's equation of states
(ii) Reduced properties
(iii) Compressibility charts **(12 Marks)**

* * * * *