CBCS Scheme

USN 1 S B 1 5 M E 0 5 7

15ME33

Third Semester B.E. Degree Examination, June/July 2017
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:
(i) Open system and isolated system
(ii) Intensive property and extensive property.
(iii) Cyclic process and non-cyclic process **(06 Marks)**

b. State zeroth law of thermodynamics and define equality of temperature. **(04 Marks)**

c. The temperature 't' on a linear Celcius scale is related to thermometric property 'X' by the relation, $t = A.\log_e X + B$, where A and B are constants. The value of X was found to be 1.47 and 5.2 at the ice point and steam point which are assigned the numbers 0 and 100 respectively on Celcius scale. Determine the temperature 't' corresponding to a reading of X equal to 2.65. **(06 Marks)**

OR

2 a. Define work from thermodynamic point of view. **(02 Marks)**

b. Derive an expression for the non-flow displacement work done during adiabatic process given by $PV^{\gamma} = C$, where $\gamma = \frac{C_P}{C_V}$. **(06 Marks)**

c. A closed system undergoes two processes one after the other – constant pressure process at a pressure of 5 bar from initial volume of 0.03 m^3 to 0.09 m^3. It is followed by polytropic expansion process according to $PV^{1.3} = C$ from 0.09 m^3 volume to 0.2 m^3 final volume. Sketch the two processes on PV diagram and find
(i) Final pressure after expansion.
(ii) Work done during each process and net work done. **(08 Marks)**

Module-2

3 a. State the I law of thermodynamics for a cyclic process. Obtain an expression for the I law of thermodynamics for a closed system undergoing change of state and prove that internal energy is a property. **(10 Marks)**

b. A steam turbine operating under steady flow conditions receives steam at a steady rate of 0.5 kg/s. Conditions of steam at turbine inlet are specific enthalpy h_1 = 2800 kJ/kg, velocity C_1 = 30 m/s, elevation Z_1 = 4 m. The conditions at the turbine outlet are specific enthalpy h_2 = 2380 kJ/kg, Velocity C_2 = 105 m/s and elevation z_2 = 1 m. Heat loss to the surroundings is 0.4 KJ/s. Using steady flow energy equation, determine power output of the turbine in kW. **(06 Marks)**

OR

4 a. State the limitations of I law of thermodynamics. **(02 Marks)**

b. State the Kelvin-Planck and Clausius statements of II law of thermodynamics. Show that Kelvin-Planck statement is equivalent to Clausius statement. **(08 Marks)**

c. A Carnot heat engine operates between source temperature of T_1K and sink temperature of T_2K. Difference between the source and sink temperature is 240. If the work developed by the Carnot engine is 0.74 times the heat rejected by the Carnot engine to the sink, find the efficiency of the Carnot engine and also source temperature and sink temperature. **(06 Marks)**

Module-3

5 a. Define reversible process and list any four factors that make a process irreversible. Explain any one factor. **(06 Marks)**

b. Prove that 'No heat engine is more efficient than a reversible heat engine, when both engines operate in cycle between same temperatures limits T_1 and T_2 with $T_1 > T_2$. **(06 Marks)**

c. Two reversible engines A and B working on Carnot cycle operate in series such that engine A receives heat from source maintained at 600 K and rejects heat to an intermediate sink maintained at T_I. Engine B receives heat rejected by engine A through intermediate sink and rejects heat to a sink maintained at 300 K. If both the engines have same efficiency, determine the temperature T_I of the intermediate sink. **(04 Marks)**

OR

6 a. State and prove Clausius inequality. **(06 Marks)**

b. Starting from I law show that for a reversible constant pressure process $(s_2 - s_1) = C_P \log_e\left(\frac{T_2}{T_1}\right)$. **(04 Marks)**

c. 1.5 kg of air is heated reversibly at constant pressure from 300 K to 600 K and is then cooled reversibly at constant volume back to initial temperature of 300 K. If initial pressure is 1 bar, calculate the entropy change during each process and net change in entropy. Sketch the processes on T-S diagram. Take C_P = 1.005 KJ/kgK and C_V = 0.718 KJ/kgK. **(06 Marks)**

Module-4

7 a. Define the following: (i) Available energy (ii) Unavailable energy (iii) Effectiveness (iv) Irreversibility. **(08 Marks)**

b. A system at 800 K receives heat at the rate of 4000 KJ/min from a reservoir at 1200 K. The temperature of the surrounding (sink) is 300 K. Assuming that the temperature of the source and the system remain constant during heat transfer, obtain (i) the net change of entropy during heat transfer (ii) The decrease in available energy after heat transfer. **(08 Marks)**

OR

8 a. Define (i) Pure substance (ii) Dryness fraction. **(03 Marks)**

b. Explain with a neat sketch the working of a throttling calorimeter to determine the dryness fraction of wet steam. **(07 Marks)**

c. Superheated steam from an initial condition of 5 bar and 300°C is expanded isentropically to a pressure of 0.5 bar. Calculate : (i) Final condition of steam after expansion. (ii) Change in enthalpy / kg of steam (iii) Change in internal energy / kg of steam. **(06 Marks)**

Module-5

9 a. Define as applied to ideal gas mixtures: (i) Mole fraction (ii) Dalton's law of partial pressures. (iii) Relative humidity.(iv) Due point temperature. **(08 Marks)**

b. A mixture of ideal gases contain 5 kg of N_2 and 8 kg of CO_2. The partial pressure of N_2 in the mixture is 120 KPa. Find (i) Mole fraction of N_2 and CO_2 (ii) Partial pressure of CO_2. (iii) Molecular weight of the mixture. **(08 Marks)**

OR

10 a. Write a brief note on: (i) Reduced properties. (ii) Law of corresponding states. **(04 Marks)**

b. Derive an expression for the Vander Waal's constants 'a' and 'b' in terms of critical properties. **(06 Marks)**

c. 1 kg of CO_2 has a volume of 0.86 m^3 at 120°C. Compute the pressure using
   (i) Ideal gas equation.
   (ii) Vander Waal's equation.

Take Vander Waal's constants for CO_2

$a = 365.6 \frac{KNm^4}{(kgmole)^2}$ and $b = 0.0423 \frac{m^3}{kgmole}$ **(06 Marks)**

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