CBCS SCHEME

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21ME34

Third Semester B.E. Degree Examination, June/July 2024
Thermodynamics

Time: 3 hrs. Max. Marks: 100

Note: 1. *Answer any FIVE full questions, choosing ONE full question from each module.*
2. *Use of Thermodynamics data handbook is permitted.*

Module-1

1 a. State Zeroth law of thermodynamics and state its significance. **(06 Marks)**
b. Derive an expression for work done during polytropic process. **(08 Marks)**
c. Prove that work and heat are path function. **(06 Marks)**

OR

2 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. **(12 Marks)**
b. Clearly write the steady flow energy equation for an open system and explain the terms involved. Apply steady flow energy equation to:
(i) Turbine (ii) Steam nozzle (iii) Heat exchanger **(08 Marks)**

Module-2

3 a. Explain the limitations of first law of thermodynamics. **(06 Marks)**
b. Explain the Kelvin-Plank statement of the second law of thermodynamics. Explain the PMM I and PMM II Kind. **(08 Marks)**
c. A reversible heat engine operates with two environments. In the first it draws 12000 KW from a source at 400°C and in the second it draws 25000 KW from a source at 100°C. In both operations the engine rejects heat to a thermal sink at 20°C. Determine the operation in which the engine delivers more power. **(06 Marks)**

OR

4 a. Explain the Clausius statement of second law of thermodynamics. Explain the Carnot cycle with P-V and T-S diagram. **(10 Marks)**
b. Prove that entropy is a property. Explain available energy. **(06 Marks)**
c. A rigid tank contains air at 35°C and is stirred by a paddle wheel which does 500 kJ of work on the air. During the stirring process, the temperature of air remains constant because of heat transfer to surroundings at 15°C. Estimate the change in entropy of air in the tank and the change is entropy of the surroundings. **(04 Marks)**

Module-3

5 a. Clearly distinguish between ideal and real gases. Mention any two equations you know off. **(06 Marks)**
b. Write a note on compressibility factor. **(04 Marks)**
c. State Dalton's law of partial pressure and derive an expression for the gas constant of a mixture of ideal gases. **(06 Marks)**
d. A gas mixture consists of 6 Kmol of H_2 and 4 Kmol of N_2. Determine the mass of each gas and the gas constant of the mixture. **(04 Marks)**

OR

6 a. Explain the following terms with reference to a combustion process:
(i) Enthalpy of formation
(ii) Enthalpy and internal energy of combustion
(iii) Adiabatic flame temperature
(iv) Combustion efficiency **(08 Marks)**

b. A blast furnace gas has the following volumetric composition:
$CO_2 = 11\%$, $CO = 27\%$, $H_2 = 2\%$ and $N_2 = 60\%$
Find the theoretical volume of air required for the complete combustion of 1 m^3 of the gas. Find the percentage composition of dry flue gases by volume. Assume that air contains 21% of O_2 and 79% of N_2 by volume. **(12 Marks)**

Module-4

7 a. Define the following: (i) Pure substance (ii) Triple point (iii) Critical point **(06 Marks)**

b. Briefly explain what you understand by two property rule. **(04 Marks)**

c. Define dryness fraction and briefly explain how one could estimate the same using separating and throttling calorimeter. **(06 Marks)**

d. A rigid container is filled with steam at 600 kPa and 200°C. At what temperature the steam begins to condense when cooled? Determine the corresponding pressure. **(04 Marks)**

OR

8 a. List out the factors affecting the efficiency of the Rankine cycle. **(05 Marks)**

b. Compare the Rankine and the Carnot cycles of steam power plants. **(05 Marks)**

c. In a steam power cycle, the steam supply is at 15 bar and dry saturated. The condenser pressure is 0.4 bar. Calculate Carnot and Rankine efficiency of the cycle neglect the pump work. **(10 Marks)**

Module-5

9 a. Compare the Otto, diesel and dual cycles on P-V diagram and T-S diagrams, when heat is supplied to each cycle is same. **(10 Marks)**

b. Derive air standard efficiency for dual combustion cycle. **(10 Marks)**

OR

10 a. With a schematic diagram, explain a closed cycle gas turbine. **(10 Marks)**

b. Consider on air standard cycle in which air enters the compressor at 1 bar and 20°C, the pressure of air leaving the compressor is 3.5 bar and temperature at turbine inlet is 600°C, determine per kg of air.
(i) Thermal efficiency
(ii) Heat supplied
(iii) Work available at the shaft
(iv) Heat rejected to the cooler
(v) Temperature of air leaving the turbine
(vi) Work ratio
Take $\gamma = 1.4$ and $C_p = 1.005$ kJ/kg°K. **(10 Marks)**

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