CBCS SCHEME

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21MR34

Third Semester B.E. Degree Examination, Dec.2023/Jan.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 Thermodynamic data handbook is permitted.*

Module-1

1 a. State the Zeroth law of thermodynamics and briefly explain its significance. **(05 Marks)**

b. Classify the following as heat and work interactions. The system to be considered is shown underlined:

(i) A honeybee sucking nectar from a flower.
(ii) Baking of Bread in an oven
(iii) A person drawing money from his ATM Cash Counter.
(iv) The sprouting of a Sunflower Plant in the presence of sun light.
(v) A Dentist grinding a damaged tooth. **(05 Marks)**

c. Two Celsius thermometers 'A' and 'B' agree at ice point and steam point and the related equation is $t_A = L + Mt_B + Nt_B^2$, where L, M and N are constants. When both thermometers are immersed in fluid. 'A' registers 26°C while 'B' registers 25°C. Determine the reading of 'A' when 'B' reads 37.4°C. **(10 Marks)**

OR

2 a. Starting from a common state point, draw the following processes on the P-V plane and write expression for the work in each case:

(i) Isochronic process (ii) Isobasic process (iii) Isothermal process
(iv) Isentropic process (v) Polytropic process **(10 Marks)**

b. A fluid undergoes the following processes in sequence to complete a cycle.

(i) Heated reversibly at constant pressure of 1.05 bar until it has a volume of 0.02 m^3.
(ii) It is then compressed reversibly according to a law PV = C to a pressure of 4.2 bar
(iii) It is then allowed to expand reversibly according to a law $PV^{1.3} = C$
(iv) Finally it is heated at constant volume back to initial conditions.

If the work done during the constant pressure process is 515 Nm, calculate the net work done on or by the cycle. Sketch also the cycle on a P-V diagram. **(10 Marks)**

Module-2

3 a. State the limitations of first law of thermodynamics. **(04 Marks)**

b. Obtain a relation between COP's of a refrigerator and heat pump. **(06 Marks)**

c. Two reversible heat engine A and B are arranged in series, A rejecting heat to B through an intermediate reservoir. Engine A receives 200 kJ at a temperature of 421°C from a hot source while engine B is in communication with a cold sink at a temperature of 4.4°C. If the work output of A is twice that of B, find: (i) Intermediate temperature ; (ii) Efficiency of each engine ; (iii) Heat rejected to the cold sink. **(10 Marks)**

OR

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

b. Prove that entropy in a property. **(04 Marks)**

c. A volume of 0.05 m^3 of a perfect gas for which R = 0.297 kJ/kgK is compressed reversibly in a cylinder according to the law $PV^n = C$ and then cooled at constant pressure. The initial temperature is 27°C and the final pressure is 8.5 times the initial pressure. The final volume is 0.007 m^3. Determine the following: (i) The final temperature after compression (ii) The final temperature ; (iii) The net heat transfer per kg ; (iv) The net change in specific entropy. **(10 Marks)**

Module-3

5 a. Explain reduced properties and compressibility factor. **(05 Marks)**

b. Write a short note on compressibility chart. **(05 Marks)**

c. Write notes on: (i) Tds relations (ii) Clausius-Clapeyron equation **(10 Marks)**

OR

6 a. Explain the following terms with reference to a combustion process:
(i) Stoichiometric air (ii) Air fuel ratio (iii) Adiabatic flame temperature
(iv) Enthalpy of formation (v) Enthalpy of reaction **(10 Marks)**

b. A sample of fuel has the following percentage composition by weight C = 86%, H_2 = 8%, S = 3%, O_2 = 2%, Ash = 1%.
(i) Determine the stochiometric air fuel ratio by mass.
(ii) If 20% excess air is supplied find the percentage composition of dry flue gases by mean and by volume. **(10 Marks)**

Module-4

7 a. Define the following with respect to steam formation:
(i) Sub cooled liquid (ii) Dryness fraction
(iii) Latent of vaporization (iv) Degree of superheat **(06 Marks)**

b. Describe with neat sketch working of throttling calorimeter. **(06 Marks)**

c. Steam at 1 MPa and 250°C enters a nozzle with a velocity of 60 m/s and leaves the nozzle at 10 kPa. Assuming the flow process to be isentropic and mass flow rate to be 1 kg/s, determine: (i) The exit velocity (ii) The exit diameter **(08 Marks)**

OR

8 a. Sketch and explain the flow diagram and corresponding T-S diagram of practical regenerative Rankine cycle. **(10 Marks)**

b. In a steam power plant operating on a Rankine cycle. Steam enters the turbine at 8 bar 300°C. The condenser pressure is 0.1 bar. Adiabatic efficiency of the turbine is 0.9. Calculate the thermal efficiency and the quality of steam at the exit of turbine. Neglect pump work. **(10 Marks)**

Module-5

9 a. Derive an expression of air standard efficiency of an Otto cycle with PV and T-S diagram. **(10 Marks)**

b. The compression ratio of an air standard diesel cycle is 16. The temperature and pressure at the beginning of isentropic compression are 15°C and 0.1 MPa respectively. During the constant pressure process, the heat is added until the temperature reaches 1480°C. Determine: (i) The cut-off ratio (ii) The heat supplied per kg of air (iii) The cycle efficiency (iv) The m.e.p. **(10 Marks)**

OR

10 a. Derive an expression for the optimum pressure ratio for the maximum network output in an Brayton cycle. **(10 Marks)**

b. Air enters the compressor of an ideal air standard Brayton cycle at 100 kPa, 300 K with a volumetric flow rate of 6 m3/s. The compressor pressure ratio is 10. The turbine inlet temperature is 1500 K. Determine: (i) Thermal efficiency (ii) Work ratio (iii) Power developed. **(10 Marks)**