31N1001/31N1101

Roll No. _____ Total No. of Pages: 4

31N1001/31N1101

B. Tech. III - Sem. (Main) Exam., May – 2023

Mechanical Engineering

3ME4 - 01 Engineering Thermodynamics

Common to ME, MX

Time: 3 Hours **Maximum Marks: 70**

Instructions to Candidates:

Part – A: *Short answer questions (up to 25 words) 10 × 2 marks = 20 marks. All **ten** questions are compulsory.*

Part – B: *Analytical/Problem solving questions 5 × 4 marks = 20 marks. Candidates have to answer **five** questions out of **seven**.*

Part – C: *Descriptive/Analytical/Problem Solving questions 3 × 10 marks = 30 marks. Candidates have to answer **three** questions out of **five**.*

Schematic diagrams must be shown wherever necessary. Any data you feel missing may suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly.

Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. Steam Table & Mollier chart 2. NIL

PART – A

Q.1 What is a thermodynamic system? What is the difference between a closed system and an open system?

Q.2 What is the difference between work transfer and heat transfer?

Q.3 To produce network in a thermodynamic cycle, a heat engine has to exchange heat with two thermal reservoirs. Explain

Q.4 Explain Perpetual motion machine of second kind. Why is it impossible?

Q.5 What do you understand by the entropy principle?

Q.6 What do you understand by exergy and anergy?

Q.7 What is quality of steam?

Q.8 Why does the fusion line for water have negative slope on the p-T diagram?

Q.9 What is the air standard cycle of spark ignition engine? What are its four processes?

Q.10 What are the four basic components of a steam power plant?

PART – B

Q.1 One kg of air at 4 bar and 290 K (state 1) is heated at constant pressure till the volume is doubled (state 2) and then it is allowed to expand reversibly and adiabatically till the temperature is reduced 290 K (state 3). Calculate the heat and work interactions. If it is desired to restore the system from state 3 to its original state by a reversible isothermal path, determine the work to be done on the system.

Q.2 What are limitations of First Law of Thermodynamics? State Kelvin, Planck and Clausius statements of Second Law of Thermodynamics and prove that these statement are equivalent.

Q.3 A reversible heat engine is supplied 900 kJ of heat from a source at 500 K. The engine develops 300 kJ of network and reject heat to two heat sinks at 400 K and 300 K. Determine -

(i) Thermal efficiency of engine.

(ii) Heat magnitude of heat interaction with each of the sink.

Q.4 Prove that the entropy change for an ideal gas undergoing polytropic process is given by -

$$s_2 - s_1 = \left(\frac{\gamma - n}{\gamma - 1}\right) R \ln \left(\frac{v_2}{v_1}\right)$$

Q.5 Derive the expression for the maximum work obtainable by using one finite body at temperature T and a thermal energy reservoir at temperature T_0, $T > T_0$.

Q.6 Derive an expression for the air standard efficiency and mean effective pressure for ideal Otto cycle. Show the cycle on P-v and T-s diagram.

Q.7 Discuss the desirable characteristics of a working fluid in a vapour power cycle. Discuss the effect of boiler pressure, condenser pressure and superheating on Rankine efficiency.

PART – C

Q.1 Air at a temperature of 20°C passes through a heat exchanger at velocity of 40 m/s where its temperature is raised to 820°C. It then enters a turbine with same velocity of 40 m/s and expands till the temperature falls to 620°C. On leaving the turbine, the air is taken at a velocity of 55 m/s to a nozzle where it expands until the temperature has fallen to 510°C. If the air flow rate 2.5 kg/s, calculate (i) Rate of heat transfer to the air in the heat exchanger (ii) The power output from the turbine assuming no heat loss (iii) The velocity at exit from the nozzle, assuming no heat loss. Take the enthalpy of air as $h = c_p t$, where c_p is the specific heat equal to 1.005 kJ/kg°C and t the temperature.

Q.2 Define available energy. Calculate the decrease in available energy when 25 kg of water at 95°C mix with 35 kg of water at 35°C, the pressure being taken as constant and the temperature of the surrounding being 15°C (c_p of water = 4.2 kJ/kgK).

Q.3 With the help of first and second TdS equations and derive the expression for the difference in heat capacities, C_p and C_v and discuss its significance. Also show that the expression may be written in the following form, where β is volume expansivity and k_T is isothermal compressibility.

$$C_p - C_v = \frac{TV\beta^2}{k_T}$$

Q.4 What is the effect of irreversibilities in turbine and compressor on Brayton cycle efficiency? Derive the expression of optimum pressure ratio for maximum efficiency in an ideal Brayton cycle.

Q.5 In a Rankine cycle steam leaves the boiler and enters the turbine at 4 MPa (40 bar) and 400°C. The condenser pressure is 10 kPa. Determine the cycle efficiency.
