Indian Maritime University

(A Central University, Govt of India)

End Semester Examinations – June 2024

Programme Name: B. Tech (ME)

Semester: II

Subject Code: UG11T4205

Subject Name: BASIC THERMODYNAMICS

Date: 10.06.2024 Max Marks: 70

Duration: 03 Hrs Pass Marks: 35

General Instructions

(i) All Sections (A, B & C) are to be attempted.
(ii) Options, if any, are specified in respective section.
(iii) Steam tables (with Mollier chart) is required.

Section A

Ten MCQs/Fill in the Blanks of 01 Mark each – Choose the correct answer as applicable.

1. Internal energy of a perfect gas depends on:
   (a) temperature, specific heats and pressure
   (b) temperature, specific heats and enthalpy
   (c) temperature, specific heats and entropy
   (d) temperature only

2. Which one of the following is the extensive property of the system?
   (a) Density (b) Volume (c) Pressure (d) Temperature

3. What is the standard fixed point of thermometry?
   (a) The ice point (b) The steam point
   (c) The triple point of water (d) None of the above

4. Consider The general energy equation for a closed system is
   (a) $Q = \Delta KE + \Delta PE - \Delta U + W$
   (b) $Q = \Delta KE + \Delta PE - \Delta U - W$
   (c) $Q = -\Delta KE - \Delta PE + \Delta U + W$
   (d) $Q = \Delta KE + \Delta PE + \Delta U + W$

5. A Carnot cycle has following processes
   (a) 4 reversible isotherms
   (b) 4 reversible adiabatics
   (c) 2 reversible isotherms and 2 reversible adiabatics
   (d) 2 reversible isochoric and 2 reversible isobars

6. A thermal reservoir is a body of:
   (a) Small heat capacity (b) Large heat capacity
   (c) Infinite heat capacity (d) Large work capacity

7. A process 'A' is irreversible and adiabatic process 'B' is reversible and adiabatic. The entropy change in process 'A' and process 'B', respectively are:
   (a) Zero and positive (b) Zero and negative
   (c) Negative and zero (d) Positive and zero

8. Entropy is a
   (a) path function, intensive property
   (b) path function, extensive property
   (c) point function, intensive property
   (d) point function, extensive property

9. Which one of the following remains constant for a system undergoing phase change like melting or vaporization?
   (a) Enthalpy (b) Entropy (c) Volume (d) Temperature

10. The loss of exergy is more when
   (a) the heat loss occurs at a higher temperature.
   (b) the heat loss occurs at a lower temperature.
   (c) depends on the process
   (d) none of the mentioned

Section B

Five Questions of 02 Marks each

11. Define Property of a system. Describe its types with example.
12. Write 1st and 2nd T-ds relationships.
13. Define compressibility factor.
14. Define Heat Engine's Thermal Efficiency.
15. What do you mean by Exergy and Dead State? Write in brief

Section C

Seven Questions of 10 Marks each of which any 05 questions to be answered.

16. (a) Describe different types of system with suitable example and sketch.

    (b) A rigid tank contains a hot fluid that is cooled while being stirred by a paddle wheel. Initially, the internal energy of fluid is 800 kJ. During cooling process, fluid loses 500 kJ of heat & the paddle wheel does 100 kJ of work on fluid. Determine final internal energy of fluid.

    (4 + 6 marks)

17. (a) What do you mean by pure substance? Draw T-v diagram of a pure substance showing distinct regions during phase change.

(b) Find quality, specific volume & specific internal energy of steam at 7 bar and enthalpy 2550 kJ/kg using steam table.

(4 + 6 marks)

18. In a turbomachine, handling an incompressible fluid with a density of 1000 kg/m^3, the conditions of the fluid at the rotor entry and exit are as given below:

Variables	Inlet	Exit
Pressure	1.15 MPa	.05 MPa
Velocity	30 m/s	15 m/s
Height above datum	10 m	2 m

If the volume flow rate of the fluid is 50 m^3/s, estimate the net energy transfer from the fluid as work. Assume no temperature change between inlet and exit, Q=0. (10 marks)

19. (a) Define specific heat C_p & C_v. Derive relation $C_p = C_v$ + R using enthalpy.

(b) B. Steam at 0.4 MPa, 300°C, enters an adiabatic nozzle with a low velocity and leaves at 0.2 MPa with a quality of 90%. Sketch the diagram of the adiabatic nozzle & find the exit velocity, in m/s. Consider $h_{g@300°C\ \&\ 0.4\ MPa} = 3067.1\ kJ/kg$, $h_{f@\ 0.2MPa} = 504.7\ kJ/kg$ & $h_{fg\ @\ 0.2\ MPa} = 2201.6\ kJ/kg$.

(4 + 6 marks)

20. Two reversible heat engines A and B are arranged in series, engine A rejecting heat directly to engine B. Engine A receives 180 kJ at a temperature of 422 °C from a hot source, while engine B is in communication with a cold sink at a temperature of 5.5 °C. If the work output of A is twice that of B, find
(i) the intermediate temperature between A and B,
(ii) the efficiency of each engine and
(iii) heat rejected to the cold sink.

(10 marks)

21. (a) Using relation $s_2 - s_1 = C_{v,avg} \ln\frac{T_2}{T_1} + R \ln\frac{v_2}{v_1}$, derive $Pv^k = \text{Constant}$ for isentropic process of an ideal gas.

(b) 0.04 m^3 of nitrogen contained in a cylinder behind a piston is initially at 1.05 bar & 15°C. The gas is compressed isothermally and reversibly until the pressure is 4.8 bar. Calculate the change of entropy in this process. Assume nitrogen to act as perfect gas & Molar mass of nitrogen is 28 kg/kmol. Take the value of Universal Gas Constant as 8314 J/kmol.K .

(4 + 6 marks)

22. (a) What is Second-Law efficiency? Describe.

(b) Consider a large furnace that can transfer heat at a temperature of 1100 K at a steady rate of 3000 kW. Determine the rate of exergy flow associated with this heat transfer assuming the environment temperature is 25^0 C.

(4 + 6 marks)