

B.TECH
(SEM III) THEORY EXAMINATION 2022-23
THERMODYNAMICS

Time: 3 Hours

Total Marks: 100

Note: Attempt all Sections. If require any missing data; then choose suitably.

SECTION A

1. Attempt all questions in brief.

2 x 10 = 20

- (a) What is the concept of continuum in thermodynamics?
- (b) Explain the state, path and cycle for a thermodynamics process.
- (c) Define COP. Derive an expression between COP of refrigerator and heat pump.
- (d) State the Clausius theorem.
- (e) Distinguish between Helmholtz function and Gibb's function.
- (f) Define coefficient of volume expansion.
- (g) What do you understand by second law efficiency? How does it differ from first law efficiency?
- (h) What is meant by saturated states, sub cooled liquid and superheated vapour state?
- (i) Define Unit of Refrigeration.
- (j) Describe different types of refrigerants.

SECTION B

2. Attempt any three of the following:

10x3=30

- (a) What do you mean by an isolated system? Give the concept of temperature and differentiate among heat, temperature and internal energy.

An insulated rigid tank contains 0.6 m³ of air at 12 bar and 150°C. This air is allowed to expand to 1 bar. Find the maximum work that can be obtained from the escaping air in a adiabatic process. Take R=0.277 kJ/kg-K and C_p= 1.005 kJ/kg-K for air.

- (b) Show that the entropy change of 1 kg gas between state 1 and 2 is given as:

$$S_2 - S_1 = R \ln (V_2/V_1) + C_v \ln (T_2/T_1)$$

- (c) Define Joule- Thomson coefficient. Also explain the significance of inversion curve.
- (d) 3 kg of steam at 18 bars occupies a volume of 0.225m³. The steam expands at constant volume to a pressure of 10 bars. Determine final dryness fraction, final internal energy, change in entropy and work done.
- (e) Sketch and explain the actual vapour compression refrigeration cycle. Discuss the effect of evaporator and condenser pressure on performance of vapour compression refrigeration cycle.

SECTION C

3. Attempt any one part of the following: 10x1=10

- (a) What is perpetual motion machine of second type? A gas of mass 1.5 Kg undergoes a quasi static process expansion which follow relationship $p = a + bV$, where a and b are constants. The initial and final pressures are 100 kPa and 200 kPa respectively and the corresponding volumes are 0.20 m³ and 1.20 m³. The specific internal energy of the gas is given by the relation.

$$U = 1.5 pV - 85 \text{ kJ/Kg}$$

Where p is the KPa and v is in m³/Kg. Calculate net heat transfer and the maximum internal energy of the gas attained during expansion.

- (b) A gas undergoes a thermodynamic cycle consisting of three processes beginning at an initial state where $p_1 = 1 \text{ bar}$, $V_1 = 1.5 \text{ m}^3$ and $U_1 = 512 \text{ kJ}$. The processes are as follows:
- (i) Process 1–2: Compression with $pV = \text{constant}$ to $p_2 = 2 \text{ bar}$, $U_2 = 690 \text{ kJ}$
 - (ii) Process 2–3: $W_{23} = 0$, $Q_{23} = -150 \text{ kJ}$, and
 - (iii) Process 3–1: $W_{31} = +50 \text{ kJ}$.

Neglecting KE and PE changes, determine the heat interactions Q_{12} and Q_{31} .

4. Attempt any one part of the following: 10x1=10

- (a) A heat engine is used to drive a heat pump. The heat transfers from the heat engine and from the heat pump are used to heat the water circulating through the radiators of a building. The efficiency of the heat engine is 27% and the COP of the heat pump is 4. Evaluate the ratio of the heat transfer to the circulating water to the heat transfer to the heat engine.
- (b) Estimate the change of entropy of the universe due to each of the following processes:
- (i) A copper block of mass 0.6 kg at 100°C is placed in lake of water at 10°C.
 - (ii) Two such blocks at 100°C and 10°C are joined together. Take C_p (for copper) = 0.393 kJ/ Kg-K.

5. Attempt any one part of the following: 10x1=10

- (a) Explain Clausius- Clapeyron equation. Represent it on p-T diagram.
- (b) A pressure vessel has a volume of 1 m³ and contains air at 1.4 MPa, 175°C. The air is cooled to 25°C by heat transfer to the surroundings at 25°C. Calculate the availability in the initial and final states and the irreversibility of this process. Take $p_0 = 100 \text{ kPa}$.

6. Attempt any one part of the following: 10x1=10

- (a) A cyclic steam power plant is to be designed for a steam temperature at turbine inlet of 360°C and an exhaust pressure of 0.08bar. After isentropic expansion of steam in the turbine, the moisture content at the turbine exhaust is not to exceed 15%. Determine the greatest allowable steam pressure at the turbine inlet, and calculate the Rankine efficiency.
- (b) With help of psychometric chart, explain the followings:
- (i) Heating and dehumidification processes
 - (ii) Cooling and humidification processes
 - (iii) Sensible heating
 - (iv) Sensible cooling.

7. Attempt any one part of the following: 10x1=10

- (a) Explain the working of a Reversed Carnot cycle of refrigeration with P-V and T-S Diagrams. What are the limitations of Carnot cycle of refrigeration?
- (b) In a refrigeration plant working on Bell Coleman cycle, air is compressed to 5 bar from 1 bar. Its initial temperature is 10°C. After compression, the air is cooled up to 20° C in a cooler before expanding to a pressure of 1 bar. Determine the theoretical C.O.P of the plant and net refrigerating effect. Take $C_p = 1.005 \text{ KJ/Kg K}$ and $C_v = 0.718 \text{ KJ/Kg K}$.