

**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 m<sup>3</sup> 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<sub>p</sub>= 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 0.225m<sup>3</sup>. 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  $0.20 \text{ m}^3$  and  $1.20 \text{ m}^3$ . 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  $\text{m}^3/\text{Kg}$ . 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  $100^\circ\text{C}$  is placed in lake of water at  $10^\circ\text{C}$ .
  - (ii) Two such blocks at  $100^\circ\text{C}$  and  $10^\circ\text{C}$  are joined together. Take  $C_p$  (for copper) =  $0.393 \text{ kJ/Kg-K}$ .

**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  $1 \text{ m}^3$  and contains air at 1.4 MPa,  $175^\circ\text{C}$ . The air is cooled to  $25^\circ\text{C}$  by heat transfer to the surroundings at  $25^\circ\text{C}$ . 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  $360^\circ\text{C}$  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  $10^\circ\text{C}$ . After compression, the air is cooled up to  $20^\circ\text{C}$  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  $C_v = 0.718 \text{ KJ/Kg K}$ .