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B.Tech.

(SEM-III) THEORY EXAMINATION 2017-18

THERMODYNAMICS

Time: 3 Hours *Total Marks: 70*

Note: 1. Attempt all Sections. If require any missing data; then choose suitably.

2. Use of Steam Tables and Mollier chart is permitted.

SECTION A

1. **Attempt *all* questions in brief.** **2 x7 = 14**

a. What is quasi static process? Discuss it.

b. Define the Carnot theorem.

c. What is the concept of entropy?

d. What is the second law efficiency? Define it.

e. Define a Joule-Thomson coefficient.

f. Discuss the triple point and critical point.

g. What is the refrigeration effect?

SECTION B

2. **Attempt any *three* of the following:** **7 x 3 = 21**

a. Derive Steady Flow Energy Equation (S.F.E.E.). Also write the steady flow energy equation for heat exchanger, nozzle, turbine, pump and boiler with suitable assumptions.

b. The following equation gives the internal energy of a certain substance

$u = 3.4\ pv + 85$; where u is kJ/kg, p is in kPa and v is in m^3/kg.

A system composed of 2.5 kg of this substance expands from an initial pressure of 500 kPa and a volume of 0.25 m^3 to a final pressure 100 kPa in a process in which pressure and volume are related by $pv^{1.25}$ = **constant**.

(i) If the expansion is quasi-static, find Q, dU and W for the process (ii) In another process, the same system expands according to the same pressure-volume relationship as in part (i), and from the same initial state to the same final state as in part (i), but the heat transfer in this case is 32 kJ. Find the work transfer for this process. (iii) Explain the difference in work transfer in parts (i) and (ii).

c. Two reversible heat engines 'A' and 'B' are arranged in series, engine 'A' rejecting heat directly to engine 'B'. 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) The intermediate temperature between engine 'A' and engine 'B'

(ii) The efficiency of each engine

(iii) The heat rejected to the cold sink.

d. An iron cube at a temperature of 400°C is dropped into an insulated bath containing 10 kg water at 25°C. The water finally reaches a temperature of 50 °C at steady state. Given that the specific heat of water is equal to 4186 J/kg K. Find the entropy changes for the iron cube and the water. Is the process reversible? If so why?

e. Discuss the coefficient of **volume expansion, adiabatic and isothermal compressibility.** Also find the loss in available energy due to given heat transfer. If 3 kg of gas (c_v = 0.81 kJ/kg K) initially at 2.5 bar and 400 K receives 600 kJ of heat from an infinite source at 1200 K and the surrounding temperature is 290 K.

SECTION C

3. Attempt any *one* part of the following: **7x 1 = 7**

(a) A nozzle is a device for increasing the velocity of a steadily flowing stream. At the inlet to a certain nozzle, the enthalpy of the fluid passing is 3000 kJ/kg and the velocity is 60 m/s. At the discharge end, the enthalpy is 2762 kJ/kg. The nozzle is horizontal and there is negligible heat loss from it.

(i) Find the velocity at exists from the nozzle.

(ii) If the inlet area is 0.1 m and the specific volume at inlet is 0.187 m^3 /kg, find the mass flow rate.

(iii) If the specific volume at the nozzle exit is 0.498 m^3/kg, find the exit area of the nozzle.

(b) A mass of 8 kg gas expands within a flexible container so that the p–v relationship is of the from pv = constant. The initial pressure is 1000 kPa and the initial volume is 1 m^3. The final pressure is 5 kPa. If specific internal energy of the gas decreases by 40 kJ/kg, find the heat transfer in magnitude and direction.

4. Attempt any *one* part of the following: **7x 1 = 7**

(a) Two kg of water at 80°C are mixed adiabatically with 3 kg of water at 30°C in a constant pressure process of 1 atmosphere. Find the increase in the entropy of the total mass of water due to the mixing process (c_p of water = 4.187 kJ/kg K).

(b) What are limitations of the first law of thermodynamics? Discuss the statements of the second law of thermodynamics. Also prove that the violation of the Kelvin–Planck statement leads to the violation of the Clausius statement.

5. Attempt any *one* part of the following: **7x 1 = 7**

(a) What is the maximum useful work which can be obtained when 100 kJ are abstracted from a heat reservoir at 675 K in an environment at 288 K? What is the loss of useful work if a temperature drop of 50°C is introduced between the heat source and the heat engine, on the one hand, and the heat engine and the heat sink.

(b) Discuss the Clapeyron equation and also explain the Joule-Kelvin effect with help of inversion curve and inversion temperature.

6. Attempt any *one* part of the following: **7x 1 = 7**

(a) Explain the Rankine cycle with the help of neat sketch, P-V and T-S diagram. If 5 kg of water at 45°C is heated at a constant pressure of 10 bar until it becomes superheated vapour at 300°C. Find the change in volume, enthalpy, internal energy and entropy.

(b) A turbine operates under steady flow conditions, receiving steam at the following state: Pressure 1.2 MPa, temperature 188°C, enthalpy 2785kJ/kg, velocity 33.3 m/s and elevation 3 m. The steam leaves the turbine at the following state: Pressure 20 kPa, enthalpy 2512 kJ/kg, velocity 100 m/s, and elevation 0 m. Heat is lost to the surroundings at the rate of 0.29kJ/s. If the rate of steam flow through the turbine is 0.42 kg/s, what is the power output of the turbine in kW?

7. Attempt any *one* part of the following: **7x 1 = 7**

(a) Explain the vapour compression refrigeration cycle and its C.O.P. with the help of T-S, P-H and flow diagram. Can this cycle be reversible? If not, why?

(b) A refrigerator working on Bell Coleman cycle operates between pressure limits of 1.05 bar and 8.5 bar. Air is drawn from the cold chamber at 10℃, Air coming out compressor is cooled ta 30℃ before entering the expansion cylinder. Expansion and compression follow the $pv^{1.35}$= constant. Determine C.O.P of the system.