Ref No. Ex/Che/ES/B/Mech/T/212/2024(S)

B.E. CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER SUPPLEMENTARY EXAM 2024

Engineering Thermodynamics

Full Marks: 100 Time : 3 hour

(Tables and charts for thermodynamic properties are allowed)

Answer any five questions

1. a) Explain the following: Thermodynamic equilibrium, quasi static process 4+4

b) A 1.8-m3 rigid tank contains steam at 220°C. One-third of the volume is in the liquid phase and the rest is in the vapor form. Determine (a) the pressure of the steam, (b) the quality of the saturated mixture, and (c) the density of the mixture. 4+4+4

2. Draw a neat sketch and working principle of a heat engine and explain second law of thermodynamics. What is a PMM-2? What is the difference between a reversible and irreversible heat engine? What is an isolated system? Define entropy and show that entropy of an isolated system always increases. 10+2+2+2+2+2

3. a) Show that for a quasi static process work done of a compressible system is expressed as integral of pdv between two states. 8

b) 1 kg of water, initially at saturated liquid state at 100°C is heated at constant temperature till it becomes saturated vapour. Determine the pressure, volumes and enthalpies of the initial and final states.Calculate the work transfer during the process. 6+6

4. a) What do you mean by heat and work? What are the similarities between two? 4+4

b) An inventor claims to have developed a heat engine that receives 700 kJ of heat from a source at 500 K and produces 300 kJ of net work while rejecting the waste heat to a sink at 290 K. Is this a reasonable claim? Why? 12

5.a) Show the critical point, saturated liquid line, saturated vapour line, constant pressure line and critical isobar on T-v plane for a pure substance with a sketch. 8

b) A piston–cylinder device contains steam initially at 1 MPa, 450°C, and 2.5 m^3. Steam is allowed to cool at constant pressure until it first starts condensing. Show the process on a T-v diagram with respect to saturation lines and determine (i) the mass of the steam, (ii) the final temperature, and (iii) the amount of heat transfer. 4+4+4

[Turn over

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6.a) Derive the expression of work done and heat transfer for an ideal gas for a) an isothermal process, b) an isobaric process 10

b) A piston–cylinder device contains 1.2 kg of saturated water vapor at 200°C. Heat is now transferred to steam, and steam expands reversibly and isothermally to a final pressure of 800 kPa. Determine the heat transferred and the work done during this process. 5+5

7. a) Draw and explain a Carnot cycle on pv and TS plane. 8

b) Steam enters an adiabatic turbine at 8 MPa and 500°C at a rate of 3 kg/s and leaves at 20 kPa. If the power output of the turbine is 2.5 MW, determine the temperature, enthalpy and entropy at the turbine exit. What is the entropy generation in the process? Neglect kinetic energy changes. 4+2+4+2

8. a) Derive the expression of change in entropy for an ideal gas. Draw an isothermal process, reversible adiabatic process, isobaric process and isochoric process on TS plane. 4+6

b) Water at 1.5 MPa, 150^{O}C is throttled adiabatically through a valve to 0.2 MPa. The inlet velocity is 5 m/s. Determine the exit enthalpy, temperature, specific volume and entropy if velocities at exit and inlet are equal. 2+2+2+2+2

9. a)Define: exergy, irreversibility, dead state and boundary work. 2+2+2+2

b) Air goes through a polytropic process from 125 kPa and 325K to 300 kPa and 500 K. Find the polytropic exponent n and the specific work in the process. 6+6

10. Write short notes on any four (5x4)

a) Rankine Cycle
b) Zeroth law of thermodynamics
c) SSSF equation of a Control Volume
d) Heat Pump and Refrigerator
e) Compressibility chart
f) Clausius inequality