Ref No. Ex/Che/ES/B/Mech/T/212/2025

B.E. CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAM 2025

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 properties, quasi static process 4+4

b) A 1.8-m3 rigid tank contains steam at 200°C. The half of the volume is in the liquid phase and the rest is in the vapor form. Determine the pressure of the steam, the quality of the mixture, the density, internal energy, enthalpy of the system. 2+3+3+2+2

2. a) Explain a PMM-1 and PMM-2. What is an isolated system? Show that energy of an isolated system remains constant and entropy of an isolated system always increases. 4+2+4

b) 2 kg of water, initially at saturated vapour state at 100OC is heated at constant pressure till the volume becomes double. Determine the pressure, volumes and enthalpies of the initial and final states. Calculate the work transfer and heat transfer during the process. 2+2+2+2+2

3. a) Derive the expression of work done and heat transfer of an ideal gas between two states(state 1 and 2) for an isothermal process, an isobaric process and a reversible adiabatic process. 3+3+4

b) A rigid vessel contains 1 kg H_2O initially at 150^0C with 0.25 m^3 volume. It is allowed to cool until the temperature becomes 90^0C. Show the process on a T-v diagram with respect to saturation lines and determine (i) the initial and final pressure, (ii) the initial and final quality, (iii) the change in entropy (iv) the amount of heat transfer. 2+3+2+3

4. a) Draw the pV and TS diagram of a Carnot cycle and write down the each processes of a Carnot cycle. Also, write down the expression of efficiency of a Carnot cycle. 10

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 300 K. Is this a reasonable claim? Why? 10

5.a) Draw the pv diagram for a pure substance showing critical point, saturated vapour line and saturated liquid lines, isotherms, critical isotherms, subcooled liquid and superheated vapour. Show also an isobaric and isochoric processes. 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. 10

[Turn over

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

6.a) What is a control volume? Derive steady state steady flow energy equation for a control volume. 12

b) Steam enters a turbine at 10 MPa and 500°C at a rate of 3 kg/s and leaves at 20 kPa. Considering an isentropic process find the power output. 8

7. a) Write down the SSSF equation with a sketch for a) a nozzle and b) a heat exchanger. 8

b) A rigid, insulated tank that is initially evacuated is connected through a valve to a supply line that carries helium at 200 kPa and 120°C. Now the valve is opened, and helium is allowed to flow into the tank until the pressure reaches 200 kPa, at which point the valve is closed. Determine the flow work of the helium in the supply line and the final temperature of the helium in the tank. 12

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 for an ideal gas on TS plane. 4+6

b) Consider two bodies of identical mass m and specific heat c used as thermal reservoirs (source and sink) for a heat engine. The first body is initially at an absolute temperature T_1 while the second one is at a lower absolute temperature T_2. Heat is transferred from the first body to the heat engine, which rejects the waste heat to the second body. The process continues until the final temperatures of the two bodies T_f become equal. Show that $T_f = \sqrt{T_1 T_2}$ when the heat engine produces the maximum possible work. 10

9. Steam enters the turbine of a Rankine cycle at 8 MPa and 500^{0}C and enters a condenser at 20 kPa. Considering the mass flow rate as 10 kg/s, determine the net power output, heat input and the efficiency. Draw the block diagram and TS diagram also. 5+5+5+5

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

a) Vapour compression refrigeration Cycle
b) Zeroth law of thermodynamics
c) Reversible process
d) Heat Pump and Refrigerator
e) Compressibility chart
f) Configuration and dissipative work