B.E. Chemical Engineering Second Year First Semester Supplementary Examination 2023

Engineering Thermodynamics

Full Marks: 100 **Time : 3 hours**

Tables and charts for thermodynamic properties are allowed

Answer any five questions

1.a) Definethermodynamic system, equilibrium and property. What do you mean by intensive and extensive properties? Give suitable example. 6+2+2

b) A vessel contains some air at pressure 200 kPa, volume 0.2 m^3 and temperature 300 K. The system undergoes an isothermal expansion process while the final volume becomes double. Determine a) the mass of the air, b) the final pressure, c) the work done, d) the change in internal energy and e) the change in entropy. 2+2+2+2+2

2.a) What do you mean by a control volume and control surface? 4

b) Derive the equation of conservation of mass for a control volume. 6

c) Derive the SSSF energy equation for a control volume. 10

3.a) What do you mean by internal energy and enthalpy? Show that for a closed system in a constant pressure process,change in enthalpy equal to total heat transfer. For an ideal gas, explain what is the change in enthalpy for an isothermal process? 4+4+2

b) Calculate the specific volume of superheated steam at 2 MPa and 300^0C using a) property table and b) ideal gas equation. What is the percentage error using ideal gas equation? If you consider a compressibility factor of 0.93, what is the specific volume? What is the percentage error using compressibility factor? 3+3+1+2+1

4.a) Explain with a neat sketch the principle of working of a heat engine with two thermal reservoirs. Define the efficiency of a heat engine. What is the efficiency of a reversible Carnot heat engine? What do you mean by a PMM-2. What is the efficiency of a PMM-2? How does it violate second law? 4+2+2+2+1+1

b) An inventor claims to construct a heat engine that receives 100 kJ from a source at 600 K while rejects 40 kJ at 300 K to a sink. Is this heat engine acceptable? What is the maximum work obtainable for the aforementioned source and sink, if heat transfer from the source is 100 kJ? What is the minimum heat to be rejected? 4+3+3

5.a) Show with neat sketch on T-v plane: subcooled liquid zone, liquid-vapour

mixture zone, superheated vapour zone, critical point, saturated liquid line, saturated vapour line, constant pressure line starting from subcooled state upto superheated state. 1+1+1+1+1+1+2

b) A spherical balloon contains 2 kg of air at 100 kPa, 300 K. If the pressure inside the balloon is proportional to its diameter, calculate the work done, final temperature, change in internal energy and change in entropy, if the volume of the balloon doubles due to heating. 4+3+2+3

6.a) A piston-cylinder assembly contains some gas inside. There is external atmospheric pressure p_0. Weight of the piston is F and initial cylinder volume is $V_1$and the cross-sectional area of the piston is A. The cylinder is slowly heated from the bottom until the volume of the cylinder is V_2. a) What is the expression of initial pressure? b) What is the work done from state 1 to 2? c) Plot the process on p-V plane. 3+3+2

b) A rigid sealed vessel of volume 0.2 m^3 contains saturated vapour of R-134a at 0^0 C. It is cooled to -20^0C. Determine a) the total mass of the refrigerant, b) initial and final quality, c) final volume of liquid, d) The work done,e) Plot the process on p-v plane. 2+4+2+2+2

7.a) Draw the block diagram and p-V and T-S plot of a Carnot cycle 2+4+4

b) Steam enters an adiabatic turbine at 10 MPa and 500°C at a rate of 2 kg/s and leaves at 10 kPa. If the power output of the turbine is 3.5 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 of an ideal gas from state 1 to state 2. Hence, show the expression of entropy change from state 1 to 2 for an isothermal process and a constant volume process. 4+2+2

b) 1 kg of water at 200 kPa pressure and 0.05 m^3 volume is heated at constant pressure until it becomes saturated vapour. Calculate a) initial quality, b) initial enthalpy, c) final quality, d) final volume, e) final enthalpy, f) heat transfer 2+2+2+2+2+2

9.a) What do you mean by isolated system? Show that energy of an isolated system remains constant. Also show that entropy of an isolated system increases. What do you mean by entropy generation? What is the entropy generation for a reversible and irreversible process? 2+2+2+2+2

b) A heat engine operating between 300 K and 1000 K is receiving 500 kJ while delivering a net work output of 100 kJ. What is the actual work, reversible work, second law efficiency and irreversibility? 2+2+2+2+2

10. Write short notes on any four 5×4=20

a) Macroscopic and Microscopic approach
b) Vapour Compression refrigeration Cycle
c) Exergy and irreversibility
d) SSSF process in a turbine
e) Kelvin Planck and Clausius statement of second law