B.E./B.TECH. Degree Examination, December 2020

Fourth Semester

CH16402 Chemical Engineering Thermodynamics I

(Regulation 2016)

Time: Three hours Maximum : 80 Marks

Answer **ALL** questions

PART A - (8 X 2 = 16 marks)

1. Work done may be calculated by the expression $\int p\, dA$ for _____ processes.
   (A) Non-flow reversible (B) Adiabatic (C) Both (a) and (b) (D) Neither (a) nor (b)
2. Pick out the correct statement.
   (A) Entropy and enthalpy are path functions (B) In a closed system, the energy can be exchanged with the surrounding, while matter cannot be exchanged
   (C) All the natural processes are reversible in nature (D) Work is a state function
3. For a closed system the correct mathematical expression for the first law of thermodynamics is
   (A) dU = dQ + dW (B) dU = dQ + dW (C) dU = dQ-dW (D) dU = Q + W
4. A system receives 13.5 J of heat and at the same time work is transferred to the surroundings. Which of the following amount is possible?
   (A) 13.5 J (B) 20.0 J (C) 1 J (D) 14.5 J
5. How do you classify thermodynamic properties of fluids?
6. Write the Clausius-Clapeyron equation
7. Give the equation for clearance volume in a compressor.
8. Mention the significance of Mach number.

PART B - (4 X16 = 64 marks)

09. (a) (i) Five kilograms of CO_2 gas is contained in a piston cylinder assembly at a pressure of 7.5 bar and a temperature of 300 K. The piston has a mass of 6000 Kg and a surface area of 1 m^2. The friction of the piston on the walls is insignificant. The atmospheric pressure is 1.0135 bar. The latch holding the piston in position is suddenly removed and the gas is allowed to expand. The expansion is arrested when the volume is double the original volume. Determine the work done in the surroundings. **(16)**

(OR)

(b) (i) Show that Work and Heat are Path functions, using a PV diagram. **(8)**

(ii) The potential energy of a body of mass 20Kg is 3.5KJ. What is the height of the body from the ground? If a body of mass 20Kg is moving at a **(8)**

velocity of 50m/s, what is its kinetic energy?

10. (a) (i) Explain in detail the Carnot cycle. Derive the equation for the efficiency of Carnot engine. **(8)**

(ii) A Carnot engine operating between 800°C and 25°C is used to run a Carnot refrigerator operating between -20°C and 25°C. If the engine absorbs 10 KJ/s from the reservoir at 800°C, determine the capacity of the refrigerator. **(8)**

(OR)

(b) (i) Derive the first law of thermodynamics for a steady-state steady-flow process. **(8)**

(ii) A rigid and insulated container of $2m^3$ capacity is divided into two equal compartments by a membrane. One compartment contains Helium at 200KPa and 127°C while the second compartment contains Nitrogen at 400KPa and 227°C. The membrane is punctured and the gases are allowed to mix. Determine the temperature and pressure after equilibrium has been established. Consider Helium and Nitrogen as ideal gases with their C_V as 1.5R and 2.5R respectively. **(8)**

11. (a) (i) Prove $C_P - C_V = TV\beta^2/\kappa$ **(8)**

(ii) Derive the following relations; **(8)**

(a) $dG = -S\,dT + V\,dP$

(b) $dH = T\,dS + V\,dP$

(c) $dU = T\,dS - P\,dV$

(d) $dA = -S\,dT - P\,dV$

(OR)

(b) Prove the following; **(16)**

(i) $dS = C_V\,(dT/T) - [(\partial V/\partial T)_P/(\partial V/\partial P)_T]\,dV$

(ii) $C_P - C_V = -T\,(\partial^2 V/\partial T^2)_P\,(\partial P/\partial V)_T$

(iii) $\Delta S = C_P \ln(T_2/T_1)$

12. (a) Write a brief note on the following; **(4+4+8)**

(i) Adiabatic compression

(ii) Isothermal compression (iii) Multi-stage compression

(OR)

(b) Prove that work required for a multistage compression is **(16)**

$$W_{n\to State} = \frac{nkP_1V_1}{k-1}\left[1-\left(\frac{p_2}{p_1}\right)^{\frac{k-1}{kn}}\right]$$ Where n is number of stages, k is heat capacity ratio.