U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

May 2023 Semester End Main Examinations

Programme: B.E. **Semester: III**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code:19CH3DCTD1 **Max Marks: 100**
Course: Process Engineering Thermodynamics-I **Date: 08.05.2023**

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. Use of steam tables is permitted.

UNIT - I

1 a) A spherical balloon of diameter 0.5 m contains a gas at 1 bar and 300 K. The gas is heated, and the balloon is allowed to expand. The pressure inside the balloon is found to vary linearly with the diameter. What would be the work done by the gas when the pressure inside reaches 5 bar? **10**

b) State the zeroth law of thermodynamics **04**

c) Distinguish between intensive and extensive properties with examples. **06**

UNIT - II

2 a) Derive an expression for first law of thermodynamic applied to steady state flow system. **10**

b) Water is flowing in a straight horizontal insulated pipe of diameter 25mm. There is no device present for adding or removing energy as work. The upstream velocity is 10 m/s. The water flows in a section where the diameter is suddenly increased. **10**

i. Estimate the change in enthalpy if the downstream diameter is 50 mm.

ii. Calculate the maximum enthalpy change for a sudden enlargement in pipe.

OR

3 a) Calculate the internal-energy and enthalpy changes that occur when air is changed from an initial state of 277 K and 10 bar, where its molar volume is 2.28 m^3/kmol to a final state of 333 K and 1 atm. Assume that the change occurs in two steps, first step air is cooled at constant volume to final pressure and in other step air is heated at constant pressure to final temperature. Data: C_V = 21.0 kJ/k mol K and C_P = 29.3 kJ/k mol K. **10**

b) Explain the principle and working of flow calorimeter with a neat diagram **10**

UNIT - III

4 a) Derive an expression to find the work done in an adiabatic process. **10**

b) An ideal gas is undergoing a series of three operations. The gas is heated at constant volume from 300 K and 1 bar to a pressure of 2 bar. It is expanded in a reversible adiabatic process to a pressure of 1 bar. It is cooled at constant pressure of 1 bar to 300 K. Determine the heat and work effects for each step. Assume C_P = 29.3 kJ/kmol K. **10**

OR

5 a) Determine the molar volume of n-butane at 510 K and 25 bar using the following methods **10**

i. The ideal-gas equation

ii. The generalized compressibility factor correlation

Critical temperature and pressure values are 425 K and 37.96 bars. Complexity functions Z^0 and Z^1 values are 0.865 and 0.03 respectively. Assume $\omega = 0.2$.

b) How does van der Walls equation of state explains the deviation from ideal behaviour with the help of PV diagram. **10**

UNIT - IV

6 a) Define sensible heat and explain the temperature effect on heat capacity. **06**

b) Calculate the standard heat at 298.15K for the following reaction **06**

$$4HCl(g) + O_2(g) \rightarrow 2H_2O(g) + 2Cl_2(g)$$

Standard heat of formation at 25℃ for HCl is -92.307kJ and H_2O is -241.818kJ.

c) Derive an expression to investigate the effect of temperature on heat of reaction. **08**

UNIT – V

7 a) Define the term entropy and prove that it is a state function. **06**

b) Derive the mathematical expression for Clausius inequality in a cyclic process **06**

c) A steel casting at a temperature 725 K and weighing 35 kg is quenched in 150 kg oil at 275 K. If there are no heat losses, determine the change in entropy. The specific heat (C_P) of steel is 0.88 kJ/kg K and that of oil is 2.5 kJ/kg K. **08**

******