10 DEC. 2025 SE CHEMICAL (SEM-III) (NEP-2020) CET-I QP CODE: 10099784

Time: 2 Hours **Total Marks : 60**

N.B. : (1) Question No. 1 is compulsory.
(2) Attempt any three questions out of the remaining five questions.
(3) Assume suitable data wherever required.
(4) Figures to the right indicate full marks.

Q.1. Answer **any three** of the following questions:

(a) Show that the first law of thermodynamics leads to the result that the energy of an isolated system is conserved. **05**

(b) Explain the concept of Heat Engine and Heat Pump. **05**

(c) What is exergy? What are the applications of exergy? **05**

(d) Explain T-S diagram and its applications. **05**

(e) What is Throttling process (Joule-Thomson expansion)? Define Joule-Thomson coefficient. **05**

Q.2. (a) Calculate the change in internal energy, change in enthalpy, work done, and the heat supplied in the following processes : **10**

(i) An ideal gas is expanded from 5 bar to 4 bar isothermally at 600 K.

(ii) An ideal gas contained in a vessel of 0.1 m^3 capacity is initially at 1 bar and 298 K. It is heated at constant volume to 400 K. (Assume that C_p = 30 J/mol.K)

(b) Explain Clausius Inequality. **05**

Q.3. (a) A 40 kg steel casting (C_p = 0.5 kJ/kg.K) at a temperature of 450^{0}C (723.15 K) is quenched in 150 kg of oil (C_p= 2.5 kJ/kg.K) at 25^{0}C (298.15 K). If there are no heat losses, what is the change in entropy of (i) the casting, (ii) the oil, and (iii) both considered together? **08**

(b) Derive the expressions for van der Waals constants a and b in terms of critical temperature and critical pressure. **07**

Q.4. (a) Derive Maxwell's equations. **08**

(b) Carbon dioxide at 1 bar and 300 K is to be compressed to a pressure of 10 bar in a single-stage compressor at a rate of 100 m^3/h. Assuming that CO_2 behaves as an ideal gas, calculate the temperature of the gas after compression and the work required. Take γ = 1.3. **07**

Q.5. (a) Calculate the compressibility factor and molar volume for methanol vapour at 500 K and 10 bar using the virial equation of state. **08**
Data : B = -2.19 x 10^{-4} m^3/mol and C = -1.73 x 10^{-8} m^6/mol^2 for methanol.

(b) Explain Carnot Cycle and Carnot Principle. **07**

Q.6. (a) Derive the relations for the enthalpy and entropy departure for a gas that obeys the van der Waals equation of state. **08**

(b) Using the first law of thermodynamics, derive the expression describing the transient flow process of discharging of a tank. **07**
