Seat No.: _____ *Enrolment No._____*

GUJARAT TECHNOLOGICAL UNIVERSITY

BE SEMESTER IV EXAMINATION – SUMMER 2015

Subject code: 140502 **Date: 01/06/2015**

Subject Name: Chemical Engineering Thermodynamic- I

Time: 10.30am-01.00pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Define: (i) internal energy, (ii) heat capacity, (iii) path function (iv) intensive property, (v) reversible process (vi) triple point, (vii) Isobaric process. **07**

(b) What is thermodynamics? Derive a mathematical expression of the first law of thermodynamics for a steady state flow process. **07**

Q.2 **(a)** Air at 1 bar and 25 °C enters a compressor at low velocity, discharges at 3 bar and enters a nozzle in which it expands to a final velocity of 600 m s^{-1} at the initial condition of temperature and pressure. If the work of compression is 240 kJ per kg of air, how much heat must be removed during compression? **07**

(b) Write a short note on Mollier diagram and P H diagram. **07**

OR

(b) Describe PVT behavior of pure substances using PV and PT diagrams. **07**

Q.3 **(a)** State various equations of state for real gas. Discuss Van der Waals equation in detail. **07**

(b) Estimate the change in enthalpy and entropy when liquid ammonia at 270 K is compressed from its saturation pressure of 381 kPa to 1200 kPa. For saturated liquid ammonia at 270 K, $V^1 = 1.551\times10^{-3}\ m^3\ kg^{-1}$ and $\beta = 2.095\times10^{-3}\ k^{-1}$. **07**

OR

Q.3 **(a)** Derive the expression for change in entropy when an ideal gas changes its state from (P_1, V_1, T_1) to (P_2, V_2, T_2). **07**

(b) A mass of 500 gm of gaseous ammonia is contained in a 30000 cm^3 vessel immersed in a constant temperature bath at 65 °C. Calculate the pressure of the gas by using generalized virial coefficient correlation. **07**

Data Given:

Molecular weight of ammonia = 17 gm/mol

At 65 °C, Tc= 405.7 K, Pc=111.32 atm, Acentric factor (w) = 0.253

$$B^0 = 0.083 - \frac{0.422}{T_r^{1.6}} \qquad and \qquad B^1 = 0.139 - \frac{0.172}{T_r^{4.2}}$$

Q.4 **(a)** For homogeneous fluid of constant composition write down fundamental property relation and Maxwell Equations using Born diagram. **07**

(b) For two phases α and β of pure species coexisting at equilibrium giving relation between molar gibbs energies of individual phase, derive Clausius Clapeyron equation. Clearly mention all assumptions required. **07**

OR

Q.4 **(a)** Using Maxwell's equation prove that : **07**

$dH = Cp\ dT + V(1 - \beta T)\ dP$

$dS = Cp\ dT/T - \beta V\ dP.$

Where β = Volume expansivity.

(b) Give general definition for Residual properties. Derive equation to calculate residual molar volume (V^R) of any pure component gas. Calculate the residual molar volume (V^R) of isopropanol vapor at temperature 473 K and pressure 1000 kPa. **07**

Data given: At 473 K and 1000 kPa, Compressibility factor (z) = 0.9014

Q.5 **(a)** Explain in detail multistage compression process. **07**

(b) Describe absorption refrigeration cycle. **07**

OR

Q.5 **(a)** Briefly explain heat engine and heat pump. **07**

(b) Explain the linde process for gas liquefaction. **07**

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