Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE III SEMESTER VI – EXAMINATION – SUMMER 2016

Subject Code: 2163611 Date: 11/5/2016

Subject Name: Chemical Engineering Thermodynamics & Kinetics

Time: 10.30 AM to 1.00 PM 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)** Starting from fundamentals, Derive a mathematical expression of the first law of thermodynamics for a steady state flow process. **07**

(b) Nitrogen gas is confined in a cylinder and the pressure of the gas is maintained by a weight placed on the piston. The mass of the piston and the weight together is 50 kg. The acceleration due to gravity is 9.81 m/s^2 and the atmospheric pressure is 1.01325 bar. Assume frictionless piston. Determine: **07**

i) The force exerted by the atmosphere, the piston and the weight on the gas if the piston is 100 mm in diameter.

ii) The pressure on the gas.

iii) If the gas is allowed to expand pushing up the piston and the weight by 400 mm, what is the work done by the gas in kJ?

Q.2 **(a)** Differentiate with suitable examples

(1) State function vs. path function **03**

(2) Intensive property vs. extensive property **04**

(b) Derive Constant T_c, P_c, and V_c, in terms of a & b in Van Der Waal's Equation of State. **07**

OR

(b) One kilo mol CO_2 occupies a volume of 0.381 m^3 at 313 °K. Compare the pressures given by a). Ideal gas equation b). van der Waals equation. Take the van der Waals constants to be a = 0.365 Nm^4/mol^2 and b = 4.28 x 10^{-5} m^3/mol. **07**

Q.3 **(a)** Write the various representational forms of second law of thermodynamics establishing the equivalency of Kelvin and Clausius Statements. **07**

(b) Oil at 500 K is to be cooled at a rate of 5000Kg/h in a counter- current exchanger using cold water available at 295 K. A temperature approach of 10 K is to be maintained at both ends of the exchanger. The specific heats of oil and water are respectively 3.2 and 4.2 KJ/Kg K. Determine the total entropy change in the process. **07**

OR

Q.3 **(a)** Describe the various thermodynamic diagrams.

(b) a) Explain the characteristics of an ideal solution? **03**

b) Explain P – x – y diagram. **04**

Q.4 **(a)** Write a short note on the classification of thermodynamic properties. **07**

(b) Establish the following Maxwell's relations **07**

$$\left[\frac{\partial T}{\partial V}\right]_S = -\left[\frac{\partial P}{\partial S}\right]_V \qquad \left[\frac{\partial S}{\partial V}\right]_T = \left[\frac{\partial P}{\partial T}\right]_V$$

OR

Q.4 **(a)** Explain the significance of Clapeyron and Clausius Clapeyron Equations **07**

(b) A 30% by mole methanol – water solution is to be prepared. How many cubic meters of pure methanol (molar volume 40.727 x 10^{-6} m^3/mol) and pure water (molar volume 18.068 x 10^{-6} m^3/mol) are to be mixed to prepare 2m^3 of desired solution? The partial molar volume of methanol in water in a 30% solution are 38.632 x 10^{-6} m^3/mol and 17.765 x 10^{-6} m^3/mol respectively. **07**

Q.5 **(a)** Derive the criteria for chemical reaction equilibrium for the reaction represented by the scheme $aA + bB \rightarrow lL + mM$ **07**

(b) The standard heat of formation and standard free energy of formation of ammonia at 298 K are -46100 J/mol and -16500 J/mol respectively. Calculate the equilibrium constant for the reaction **07**

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

at 500 K assuming standard heat of reaction constant in the temperature range 298 to 500 K.

OR

Q.5 **(a)** Express the relationship between Equilibrium constant relating to partial pressure and concentration. **07**

(b) Discuss the effect of temperature and pressure on Equilibrium. **07**

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