BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(MID SEMESTER EXAMINATION)

CLASS: BE **SEMESTER: III**
BRANCH: CHEMICAL/CHEMICAL (P&P) **SESSION : MO/2018**

SUBJECT : CL3003 CHEMICAL ENGINEERING THERMODYNAMICS

TIME: 1.5 HOURS **FULL MARKS: 25**

INSTRUCTIONS:
1. The total marks of the questions are 30.
2. Candidates may attempt for all 30 marks.
3. In those cases where the marks obtained exceed 25 marks, the excess will be ignored.
4. Before attempting the question paper, be sure that you have got the correct question paper.
5. The missing data, if any, may be assumed suitably.

Q1 (a) Write the characteristics of reversible processes. [2]

(b) A rigid, nonconducting tank with a volume of 4 m^3 is divided into two unequal parts by a thin membrane. One side of the membrane, representing 1/3 of the tank, contains nitrogen gas at 6 bar and 100 °C, and the other side, representing 2/3 of the tank is evacuated. The membrane ruptures and the gas fill the tank. [3]
(a) How much work is done? What is the final temperature of the gas?
(b) Describe a reversible process by which the gas can be returned to its initial state. How much work is done in KJ? Assume nitrogen an ideal gas.

Q2 (a) Draw PT-diagram for a pure substance and show the various regions, curves and points. [2]

(b) Derive expressions for Vander Waals parameters '*a*' and 'b' in terms of critical temperature and pressure. [3]

Q3 (a) Write Kelvin-Planck and Clausius' statements of the 2nd law of thermodynamics. [2]

(b) A Piston-cylinder device initially contains 0.5 m^3 of an ideal gas at 150 kpa and 20 °C. The gas is subjected to a constant external pressure of 400 kpa and compressed in an isothermal process. Assume the surroundings are at 20 °C. Take R = 8.314 J/mol K and assume ideal gas model holds. [3]
(a) Determine the heat transfer (in KJ) during the process.
(b) What is the entropy change of the system, surroundings, and universe?

Q4 One mole of propane gas is to be expanded from 0.001 m^3 to 0.04 m^3 while in contact with a heating bath at 100 °C. The expansion is not reversible. The heat extracted from the bath is 600 J. Using the Vander Waals equation of state, determine the work for the expansion. Given, a = 9.4 x 10^6 cm^6 bar/mol^2. [5]

Q5 (a) What is Otto Cycle. Draw P-V and T-S diagrams of Otto cycle. [2]

(b) Derive an expression for the thermal efficiency of Otto cycle in terms of compression ratio. [3]

Q6 (a) Deduce Clausius-Clapeyron equation for Vapor-Liquid Equilibrium. [2]

(b) Define Residual properties and comment on its significance. Derive the following expression: [3]

$$\frac{G^R}{RT} = \int_0^p \frac{Z-1}{P} dP$$

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