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Question Paper Code: 55901

B.E./B.Tech. DEGREE EXAMINATION, NOV 2019

Fifth Semester

Chemical Engineering

15UCH501-CHEMICAL ENGINEERING THERMODYNAMICS

(Regulation 2015)

(Steam table and compressibility chart permitted in examinations)

Duration: Three hours

Maximum: 100 Marks

Answer ALL Questions

PART A - (10 x 1 = 10 Marks)

- In an ideal gas mixture, the fugacity of a component in the mixture is equal to CO1- R
(a) Partial pressure (b) Chemical Potential (c) Mole fraction (d) Total pressure
- Excess property is the difference between actual property and the property CO1- R
that would be calculated for
(a) Same pressure (b) Same temperature
(c) Volume (d) Same pressure, temperature and composition
- Helmholtz free energy is defined as CO2- R
(a) $A = U - TS$ (b) $A = S - UT$ (c) $A = T - US$ (d) $A = U + TS$
- As pressure approaches zero, the ratio of fugacity to pressure (f/P) for a CO2- R
gas approaches
(a) Zero (b) An indeterminate value (c) Unity (d) Infinity
- Which of the following liquid models will be unsuitable for representing a CO3- R
mixture of water and n – butanol?
(a) NRTL (b) WILSON (c) UNIFAC (d) UNIQUAC
- The activity coefficient of benzene in a benzene- toluene mixture is CO3- R
(a) Infinity (b) Unity
(c) Zero (d) Depends on temperature and pressure

7. A gas mixture of three components is brought in contact with a dispersion of an organic phase in water. The degrees of freedom of the system are CO4- R
- (a) 4 (b) 3 (c) 5 (d) 6
8. For a highly favorable chemical reaction, the standard free energy change is CO4- R
- (a) Zero (b) Unity (c) Positive (d) Negative
9. A system is said to be at equilibrium, if the entropy of the system has reached _____ value. CO5- R
- (a) Minimum (b) Zero (c) Maximum (d) High
10. Out of the following refrigeration cycles, which one has maximum COP ? CO5- R
- (a) Air cycle
- (b) Carnot cycle
- (c) Ordinary vapor compression cycle
- (d) Vapor compression with a reversible expansion engine

PART – B (5 x 2= 10Marks)

11. Distinguish between molar volume and partial molar volume. CO1- R
12. Discuss the effect of pressure on the azeotropic composition. CO2- R
13. State the Duhem's theorem CO3- R
14. Define equilibrium constant K of a chemical reaction. CO4- R
15. List the various methods of refrigeration. CO5- R

PART – C (5 x 16= 80 Marks)

16. (a) Describe schematically an experimental technique for the determination of volume change and enthalpy change in mixing. CO1-App (16)
- Or
- (b) A container is divided into two compartments. One contains 3.0 moles hydrogen at 298 K and 1 bar and the other contains 1.0 mol, nitrogen at 298 K and 3 bar. Calculate the free energy of mixing when the partition is removed. CO1-App (16)
17. (a) Show that for a stable liquid phase, the fugacity of each component in a binary mixture always increases with increase in concentration at constant temperature and pressure. CO2-U (16)
- Or
- (b) Deduce the Clapeyron equation using the criterion of Equilibrium $dG=0$. CO2-U (16)

18. (a) Derive the following activity co-efficient models for over all CO3-App (16)
mixture composition.
(i) Wohl's three-suffix Equation
(ii) Margules Equation
(iii) Van Laar Equation

Or

- (b) Show that the following equations provide the criteria of CO3-App (16)
equilibrium under certain constraints
(i) $dU_{S,V} = 0$,
(ii) $dS_{H,P} = 0$

19. (a) A gas mixture containing 3 mol CO_2 , 5 mol H_2 and 1 mol water is CO4-App (16)
undergoing the following chemical reactions,
 $\text{CO}_2 + 3 \text{H}_2 \rightarrow \text{CH}_3\text{OH} + \text{H}_2\text{O}$
 $\text{CO}_2 + \text{H}_2 \rightarrow \text{CO} + \text{H}_2\text{O}$
Develop expressions for the mole fraction of the species in terms of
the extent of reaction.

Or

- (b) Ammonia synthesis reaction is represented by CO4-App (16)
 $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$
The reactant stream consists of 1 mol N_2 , 3 mol H_2 and 2 mol
Argon. The temperature and pressure of the reaction are 675 K and
20 bar. The equilibrium constant for the reaction is 2×10^{-4} .
Determine how the conversion of nitrogen is affected by the
presence of argon.

20. (a) Explain the working of Vapour Absorption Refrigeration with a neat CO5-App (16)
sketch.

Or

- (b) 28 tonnes of ice from and at 0°C is produced per day in an ammonia CO_2 -App (16) refrigerator. The temperature range in the compressor is from 25°C to -15°C . The vapour is dry and saturated at the end of compression and an expansion valve is used. Calculate COP of the system and heat rejected in the condenser. Also calculate the power required to drive the compressor if the actual co-efficient of performance is 62% of the theoretical.

Temperature $^{\circ}\text{C}$	Enthalpy kJ/kg		Entropy of liquid kJ/kg K	Entropy of vapour kJ/kg K
	Liquid	Vapour		
25	100.04	1319.22	0.3473	4.4852
-15	-54.56	1304.99	-2.1338	5.0585