Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2019

Course: Chemical Engineering Thermodynamics-II **Semester: IV**
Program: B.Tech CERP & APE-Gas **Time 03 hrs.**
Course Code: CHCE-2008 **Max. Marks: 100**

Instructions:

SECTION A
(30 marks)

S. No.		Marks	CO
Q 1	**(a) Explain** the significance of **Virial coefficients** **(b) Differentiate** between **Two-parameter** and **Three-parameter** correspondence state theorems	4 4	CO1
Q 2	**Water (1) – hydrazine (2)** system forms an azeotrope containing **58.5 % (mol)** hydrazine at **393 K** and **101.3 kPa.** Calculate the equilibrium vapor composition for a solution containing **20 % (mol)** hydrazine. The relative volatility of water with reference to hydrazine is **1.6**, is assumed to remain constant in the temperature range involved. The vapor pressure of Hydrazine at **393 K** is **124.76 kPa**. **Use Van laar model.** $A = \ln\gamma_1 (1 + x_2 \ln\gamma_2/x_1 \ln\gamma_1)^2$ $B = \ln\gamma_2 (1 + x_1 \ln\gamma_1/x_2 \ln\gamma_2)^2$	8	CO4
Q 3	**Deduce Gibbs – Duhem** equation for a binary system **Chemical Potential** and also in terms of **activity** & **activity coefficient**	7	CO3
Q 4	**Classify** types of common adsorbents and **discuss** their characteristics	7	CO5

SECTION B
45 marks

S. No.		Marks	CO
Q 7	(a) **Interpret** the following semi-empirical models in thermodynamics **(i)** **Margules 3-suffix** model **(ii)** **Van laar** model (b) **Perform VLE** calculations for the **Methane (1)/ Ethylene (2) / Ethane (3)** system using **K-values** **(i)** **BUBL P**, given $x_1 = 0.1$, $x_2 = 0.5$ and **T = 222.15 K** (ii) **BUBL T**, given $x_1 = 0.12$ and $x_2 = 0.4$ and **P = 17.24 bar**	8 7	CO4

Q 8	The excess Gibbs energy of a binary liquid mixture at T & P is given by, $$G^E/RT = (-2.6x_1 - 1.8x_2)\, x_1x_2$$ (i) Find expression for **$\ln\gamma_1$ & $\ln\gamma_2$ at T & P** (ii) Show that these expressions satisfy **Gibbs-Duhem** equation in terms of activity coefficients. (iii) Show that $(d\ln\gamma_1/dx_1)_{x1=1} = (d\ln\gamma_2/dx_1)_{x1=0} = 0$ (iv) Plot **G^E/RT, $\ln\gamma_1$ and $\ln\gamma_2$** as calculate by the given equation for **G^E/RT** and by the equation developed in **(i)** vs x_1.	**15**	**CO3**
Q 9	The molar volume **$cm^3\ mol^{-1}$** of a binary liquid mixture at **T** and **P** is given by, $$V = 120x_1 + 70\,x_2 + (15\,x_1 + 8\,x_2)\,x_1\,x_2$$ (i) Find the expression for the partial molar volume of species **1 & 2** at **T** and **P**. (ii) Show this equation satisfy the **Gibbs-Duhem** equation in terms of partial molar volumes. (iii) Find the values of **V**, partial molar volume of species **1 & 2** (iv) Show that $(d\acute{V}_1/dx_1)_{x1=1} = (d\acute{V}_2/dx_1)_{x1=0} = 0$	**15**	**CO3**
SECTION-C **1 x 25 = 25 marks**			
Q 10	For the **Acetone (1) / Methanol (2)** system a vapor mixture for which, z_1 = **0.25** and z_2 = **0.75** is cooled to temperature **T** in the two-phase region and flow into a separation chamber at a pressure of **1 bar**. If the composition of liquid product is to be x_1 = **0.175**, what is the required value of **T** and what is the value of y_1? For liquid mixtures of the system to a good approximation $\ln\gamma_1 = 0.64\,x_2^2$ $\qquad\qquad$ $\ln\gamma_2 = 0.64\,x_1^2$ **Acetone (1) : A = 14.3916, B = 2795.82 and C = 230** **Methanol (2) : A = 16.5938, B = 3644.3 and C = 239.76** **OR** A process stream contains light species **"1"** and heavy species **"2"**. A relative pure	**25**	**CO4**

	liquid stream containing mostly **2** is desired obtained by a single-stage liquid and vapor separation. Specifications on the equilibrium composition are x_1 **= 0.002** and y_1 **= 0.950**. Use data given below to determine **T (K)** and **P (bar)** for the separator. Assume modified **Raoult's** law is applies, the calculated **P** should validate this assumption. For liquid phase, $\ln\gamma_1 = 0.93\, x_2^2$ $\ln\gamma_2 = 0.93\, x_1^2$ $\ln P_1^{sat}/\text{bar} = A_i - B_i/T(K)$ $A_1 = 10.08$, $B_1 = 2572.0$, $A_2 = 11.63$ and $B_2 = 6250$		

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Course Code: CHCE-2008 — **Max. Marks: 100**

Instructions:

SECTION A
(30 marks)

S. No.		Marks	CO
Q 1	**Deduce** an expression for **Pitzer** correlation for Second Virial Coefficient	**8**	**CO1**
Q 2	Under atmospheric conditions, the **Acetone (1)-Chloroform (2)** azeotrope boils at **64.6^{O}C** and contains **33.5 mol. %** Acetone. The vapor pressure of Acetone and Chloroform at this temperature are **995 mmHg** and **885 mmHg** respectively. Calculate the composition of the vapor at this temperature in equilibrium with a liquid analyzing **11.1 mol. %** Acetone. Apply **Van laar** equations of the following form: $A = \ln\gamma_1 \left(1 + x_2 \ln\gamma_2 / x_1 \ln\gamma_1 \right)^2 \quad B = \ln\gamma_2 \left(1 + x_1 \ln\gamma_1 / x_2 \ln\gamma_2 \right)^2$	**8**	**CO4**
Q 3	**Deduce Gibbs – Duhem** equation for a binary system **Chemical Potential** and also in terms of **activity** & **activity coefficient**	**7**	**CO3**
Q 4	**Classify** types of common adsorbents and **discuss** their characteristics	**7**	**CO5**

SECTION B
45 marks

S. No.		Marks	CO
Q 7	(a) **Interpret** the following semi-empirical models in thermodynamics **(iii)** **Margules 3-suffix** model **(iv)** **Van laar** model (c) **Perform VLE** calculations for the **Methane (1)/ Ethylene (2) / Ethane (3)** system using **K-values** **(iii)** **DEW P**, given $y_1 = 0.5$, $y_2 = 0.25$ and $T = 222.15$ K (iv) **DEW T**, given $y_1 = 0.43$ and $y_2 = 0.36$ and $P = 17.24$ bar	**8** **7**	**CO4**
Q 8	**Derive** the expressions for G^{id}, S^{id}, V^{id} and H^{id} for Ideal solutions mixtures with proper assumptions	**15**	**CO3**
Q 9	For a binary liquid mixture at **T** and **P**, the molar volume is given by, $V = 120x_1 + 70x_2 + (15x_1 + 8x_2)x_1x_2$ (v) **Deduce** the expression for the partial molar volume of species **1 & 2** at **T**	**15**	**CO3**

	and **P**. (vi) **Prove** the equation satisfy the **Gibbs-Duhem** equation in terms of partial molar volumes. (vii) Show the values of **V**, partial molar volume of species **1 & 2** (viii) Show that $(d\acute{V}_1/dx_1)_{x1=1} = (d\acute{V}_2/dx_1)_{x1=0} = 0$		
SECTION-C **1 x 25 = 25 marks**			
Q 10	A system consists of a vapor mixture of **Acetone (1) / Methanol (2)** in which, z_1 = **0.35** and z_2 = **0.65** is cooled to temperature **T** in the two-phase region and flow into a separation chamber at a pressure of **1 bar**. If the composition of liquid product is to be x_1 = **0.275**, what is the required value of **T** and what is the value of y_1? For liquid mixtures of the system to a good approximation $\ln\gamma_1 = 0.63\, x_2^2$ $\ln\gamma_2 = 0.63\, x_1^2$ **Acetone (1) : A = 14.3916, B = 2795.82 and C = 230** **Methanol (2) : A = 16.5938, B = 3644.3 and C = 239.76** **OR** A process stream contains light species **"1"** and heavy species **"2"**. A relative pure liquid stream containing mostly **2** is desired obtained by a single-stage liquid and vapor separation. Specifications on the equilibrium composition are x_1 = **0.002** and y_1 = **0.950**. Use data given below to determine **T (K)** and **P (bar)** for the separator. Assume modified **Raoult's** law is applies, the calculated **P** should validate this assumption. For liquid phase, $\ln\gamma_1 = 0.64\, x_2^2$ $\ln\gamma_2 = 0.64\, x_1^2$ $\ln P_1^{sat}/\text{bar} = A_i - B_i/T(K)$ $A_1 = 10.08$, $B_1 = 2572.0$, $A_2 = 11.63$ and $B_2 = 6250$	25	CO4