Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

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A Constituent Institution of Manipal University

I SEMESTER M.TECH (CHEMICAL ENGINEERING)
END SEMESTER EXAMINATIONS, NOV 2018
SUBJECT: ADVANCED THERMODYNAMICS [CHE 5101]
REVISED CREDIT SYSTEM (20/11/2018)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Use of compressibility charts & DePriester charts are permitted

1A.	Determine the pressure of a gas at 588.71 K and 5.77 x 10^{-4} m^3 /mol using the generalized compressibility chart and compare with the actual pressure 6.89 x 10^6 N/m^2. Given that, T_c: 647.3 K; P_c: 221.2 bar	**4**
1B.	Develop an expression for the change in internal energy, enthalpy and entropy for a gas whose equation of state is P (V – a) = RT for an isothermal process:	**6**
2A	The activity coefficient data for a binary solution at fixed temperature and pressure are correlated as: $\ln \gamma_1 = x_2^2(0.5 + 2x_1)$ and $\ln \gamma_2 = x_1^2(1.5 - 2x_2)$ Do the above equations satisfy Gibbs–Duhem equations?	**4**
2B	The molar volume of a binary mixture is given by, $V = 120\ x_1 + 70\ x_2 + (15x_1 + 8x_2)\ x_1x_2$ i. Find the partial molar volumes ii. Check the conservation of volume iii. Prove $\left[\frac{\partial \bar{V}_1}{\partial x_1}\right]_{x1=1} = \left[\frac{\partial \bar{V}_2}{\partial x_1}\right]_{x1=0} = \mathbf{0}$	**6**
3	The vapor pressures of acetone (1) and acetonitrile (2) can be evaluated by the Antoine equations: $\ln P_1^S = 14.5463 - \frac{2940.46}{T - 35.93}$ $\ln P_2^S = 14.2724 - \frac{2945.47}{T - 49.15}$ Where, T is in K and P is in kPa. Assuming that the solutions formed by these are ideal, calculate the following: i. x_1 and $y_1$at 327K and 65 kPa ii. P and y_1 at 327 K and $x_1 = 0.4$ iii. P and x_1 at 327 K and $y_1 = 0.4$ iv. T and y_1 at 65 kPa and $x_1 = 0.4$ v. T and x_1 at 65 kPa and $y_1 = 0.4$	**10**

4A — **5**

The following data were reported for vapour–liquid equilibrium for ethanol–water system at 298 K. Calculate the van Laar constants:

x_1	0.122	0.163	0.226	0.32	0.337	0.437	0.44	0.579	0.83
y_1	0.474	0.531	0.562	0.582	0.589	0.62	0.619	0.685	0.849
P, kPa	5.57	6.02	6.38	6.76	6.8	7.02	7.04	7.3	7.78

The vapor pressures of ethanol and water are 7.86kPa and 3.17 kPa respectively.

4B — **5**

A vapor mixture of ethylene (40%, mol) and propylene (60%, mol) at 40°C and 500 kPa is isothermally compressed. Determine the pressure at which condensation begins and the composition of the first drop of liquid that forms. Use DePriester chart to read K values.

5A — **5**

Acetylene is catalytically hydrogenated to ethylene at 1500 K and 1 bar. Starting with an equimolar mixture of acetylene and hydrogen, what will be the mole fractions at equilibrium? Assume ideal gases.

$C_2H_2 \rightarrow 2C + H_2$; K = 5.2

$2C + 2H_2 \rightarrow C_2H_4$; K = 0.1923

5B — **5**

Acetic acid is esterified in the liquid phase with ethanol at 373 K and 1 bar to produce ethyl acetate and water according to the reaction

$CH_3COOH_{(l)} + C_2H_5OH_{(l)} \rightarrow CH_3COOC_2H_{5\,(l)} + H_2O_{(l)}$

If the feed consists of 1 mol each of acetic acid and ethanol, estimate the mole fraction of ethyl acetate in the reacting mixture at equilibrium.

The standard heat of formation and standard free energy of formation at 298K are given below:

	CH_3COOH	C_2H_5OH	$CH_3COOC_2H_5$	H_2O
ΔH^o_f, kJ/mol	– 484.5	– 277.69	– 463.25	– 285.83
ΔG^o_f, kJ/mol	– 389.9	– 174.78	– 318.22	– 237.13

Assume that the heat of reaction is independent of temperature and the liquid mixture behaves as ideal solution.