GUJARAT UNIVERSITY

B. E. Sem VI (Chem.) Examination

Chem. Engg. Thermodynamics-II

Friday, 1st June, 2007] Time : 3 Hours

Max. Marks : 100

Instructions : (1) Answer to the two sections must be written in separate answer books.

(2) All notations have conventional meaning.

(3) Assume suitable data if require.

(4) Figures to the right indicate full marks.

(5) Use of K-Charts is allowed.

## SECTION - I

1 Answer the following

(a) A system comprised of four particles has four energy levels with relative energy levels of 0, 1, 2, 3. The total energy of the system is 4 and the degeneracy of the four levels is 4, 4, 3, 3 respectively. Determine the thermodynamic probability for each of the possible distributions assuming Boltzmann's statistics. 10

(b) A refinery gas contains 10% methane, 10% ethylene, 20% propylene, 35% propane and 25% of n-butane by volume. It is to be compressed and liquefied in water–cooled condenser. If the minimum temperature attainable in the condenser is 20 $^0$C, to what pressure should the stream be compressed to achieve the total condensation? 08

2 For A and B are miscible liquids, 16

$G^E/RT = 0.1x_1x_2 \quad \Delta G^o_{298} = -1000$ J

$A \Leftrightarrow B$

Calculate,

1. Equilibrium constant 'K' and Equilibrium composition of A and B.
2. If system is assumed ideal, calculate the error in equilibrium composition of A.

OR

2 Attempt the following 16

(a) Write in brief on various methods for evaluating the equilibrium constant

(b) Derive the relationship between Equilibrium constant and standard Gibbs free energy change.

3 (a) Attempt any two short notes of the following 10

1. Group Contribution Methods.
2. Equilibrium conversion charts.
3. Area tests.

(b) Attempt any one short notes of the following 06

1. Van't Hoff equilibrium box.
2. T-x,y diagram for partially miscible system.

## SECTION -II

4 Answer the following

(a) Discuss the various methods to evaluate the fugacity and fugacity coefficient of pure component? 08

(b) Estimate the fugacity of isobutylene as a gas at 280$^0$C and 20 bar. 10

The required property values for pure isobutylene are:

| ω | $T_c$ | $P_c$ |
|---|---|---|
| 0.194 | 417.9 K | 40.00 bar |

[P.T.O.

5 (a) Prepare plots of (f vs. P) and of ($\phi$ vs. P) for isobutane at 40 $^0$C for the pressure range from 0 to 10 bar. 08

At 40 $^0$C the vapor pressure of isobutane is 5.28 bar.

Data: The molar volume of saturated liquid is given by Rackett equation.

$$V_i^{liq} = V_c Z_c^{(1-T_r)^{0.2857}}$$

The required property values for pure isobutane:

| $\omega$ | $T_c$ | $P_c$ | $V_c$ | $Z_c$ |
|---|---|---|---|---|
| 0.181 | 408.1 K | 36.48 bar | 262.7 cm$^3$/mol | 0.282 |

(b) Write a brief note on retrograde condensation and its application. 08

**OR**

5 (a) Write a brief note on Margules equation and Wilson equation used for non-ideal solutions. 08

(b) Outline the method to evaluate the bubble temperature and dew point temperature for system exhibiting VLE for ideal and nonideal systems. 08

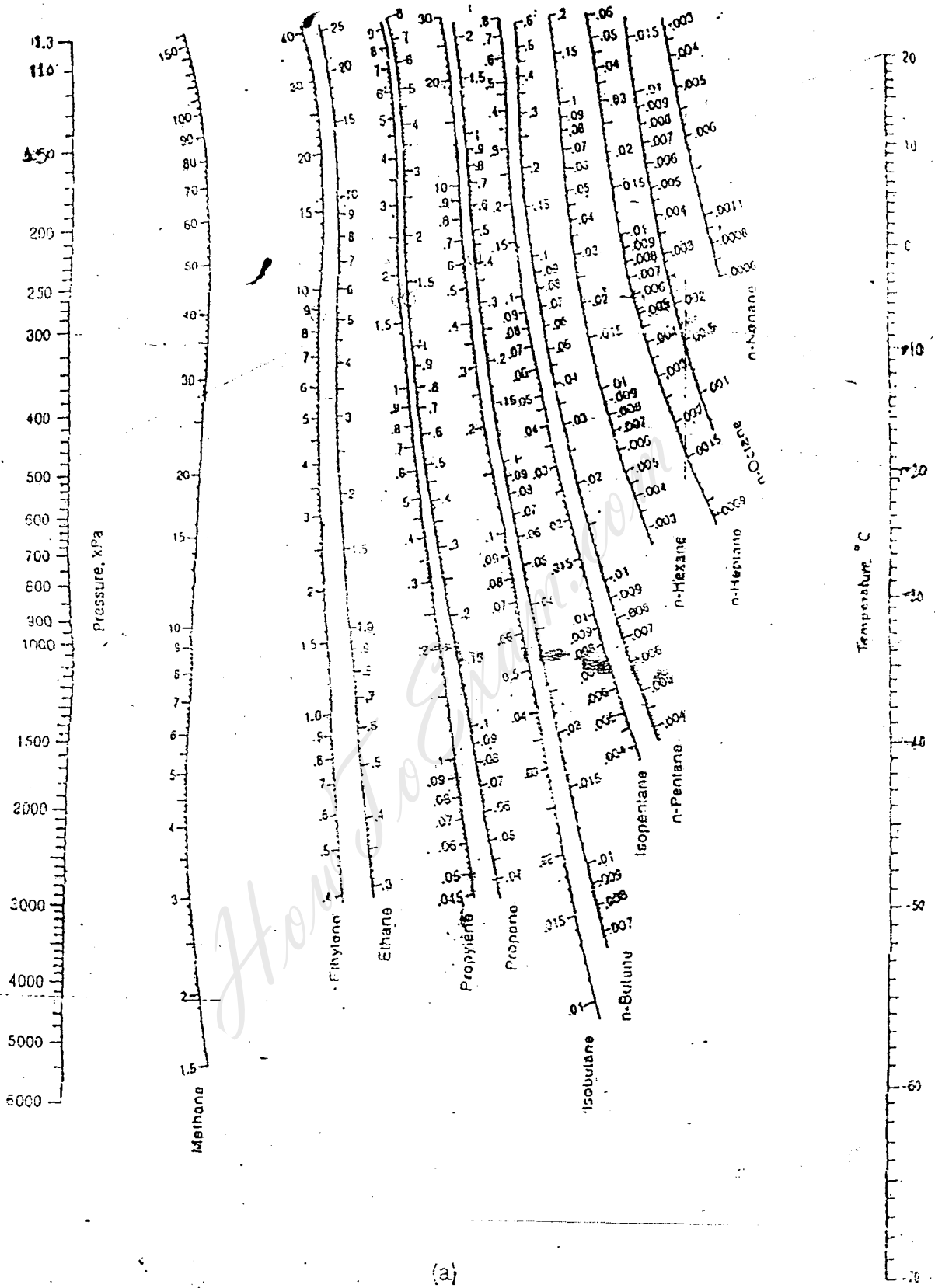
6 Answer the following

Perry (table13-1) quotes the following T-x,y data for Acetone (1) and methanol (2) at 101.3 kPa total pressure. Estimate the Van Laar constants $A_{12}$ and $A_{21}$. 16

| T / $^0$C | $x_1$ | $y_1$ | T / $^0$C | $x_1$ | $y_1$ |
|---|---|---|---|---|---|
| 64.65 | 0.0 | 0.0 | 55.78 | 0.578 | 0.631 |
| 61.78 | 0.091 | 0.177 | 55.41 | 0.687 | 0.707 |
| 59.60 | 0.190 | 0.312 | 55.29 | 0.756 | 0.760 |
| 58.14 | 0.288 | 0.412 | 55.37 | 0.840 | 0.829 |
| 56.96 | 0.401 | 0.505 | 55.54 | 0.895 | 0.880 |
| 56.22 | 0.501 | 0.579 | 55.92 | 0.954 | 0.946 |
| | | | 56.21 | 1.000 | 1.000 |

**OR**

6 A binary system of 1 and 2 consists of vapor and liquid phases in equilibrium at temperature T. The overall mole fraction of 1 in the system is 0.6 for which $P_{1sat}$ = 32.27kPa, $P_{2sat}$ = 73.14kPa and $G^E/RT = 0.95\, x_1 x_2$. Making relevant assumptions, determine the range of the pressures for which the system exist as two phases at given temperature T and overall mole fraction. Also determine the pressure and the composition of the azeotrope at temperature T, if formed. 16




(a)

Figure (a) De Priester chart — K-values for hydrocarbons, low temperature

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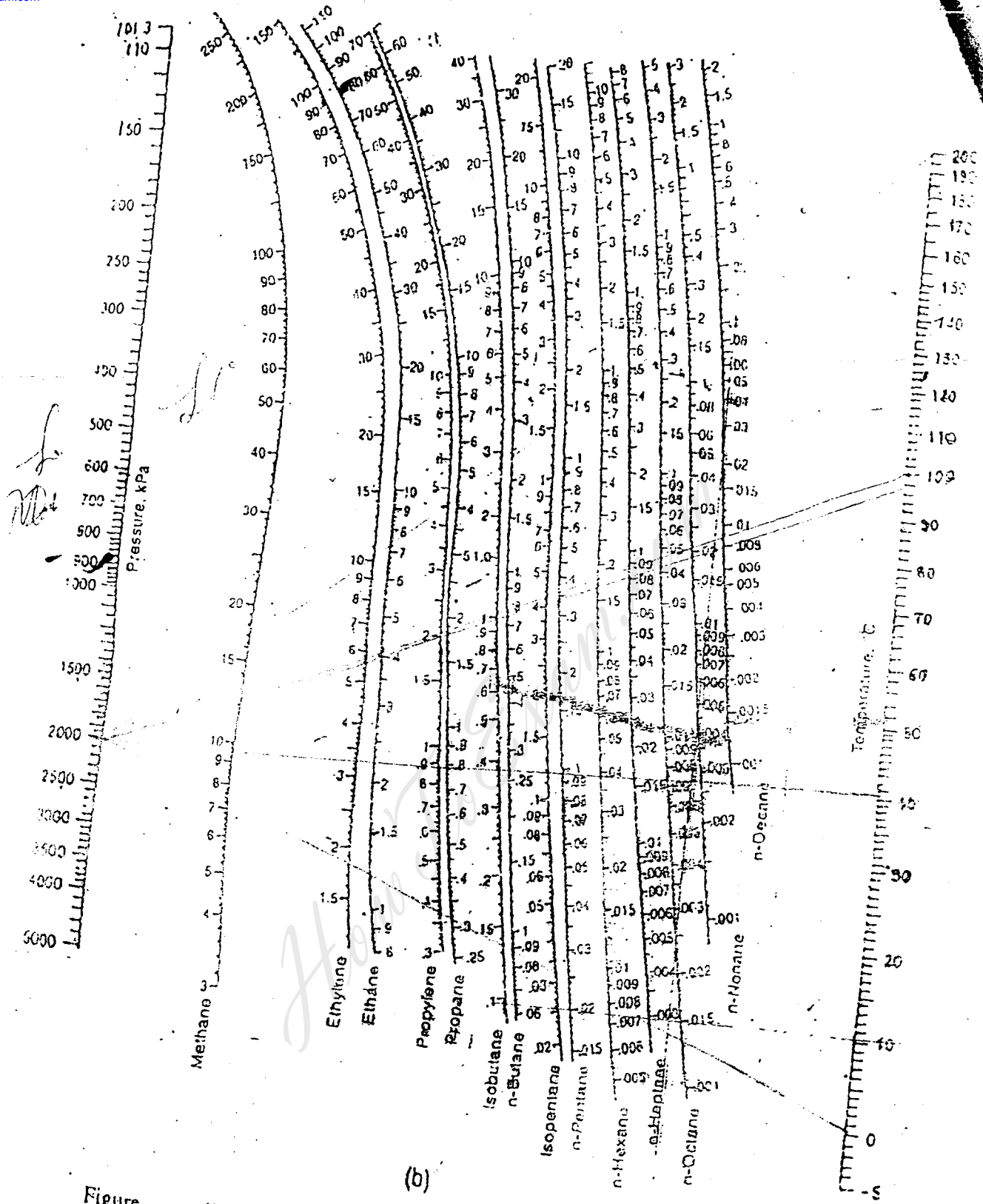


Figure (b) De Priester chart—$K$-values for hydrocarbons, high temperature