UNIVERSITY OF GHANA

B.Sc ENGINEERING FIRST SEMESTER EXAMINATION: 2018/2019

DEPARTMENT OF FOOD PROCESS ENGINEERING

FPEN 303: THERMODYNAMICS (2 Credits)

INSTRUCTIONS:

TIME ALLOWED: TWO AND HALF (2½) HOURS

Please read the following INSTRUCTIONS carefully

[1] Answer TWO questions from SECTION A

[2] Answers to SECTION A must be written in an Answer Booklet

[3] Answer ALL questions in SECTION B

[4] Answers to SECTION B must be written on the question paper

[5] Write your STUDENT ID NUMBER on all the applicable question sheets and tie them inside the Answer Booklet

SECTION A: Answer TWO questions

1. For the system ethyl ethanoate (1)/n-heptane (2) at 340.15 K,

   - $ln\gamma_1 = 0.95\, x_2^2$ $\quad ln\gamma_2 = 0.95\, x_1^2$
   - $P_1^{sat} = 79.80\ kPa$ $\quad P_2^{sat} = 40.50\ kPa$
   - $A = 2.771 - 0.00523T(K)$

   Assuming the validity of the modified Raoult's law

   a) Make a BUBL P calculation for T=340.15K, x_1=0.06

   b) Make a DEW P calculation for T=340.15K, y_1=0.06

   c) What is the azeotrope composition at T=340.15K?

2. Consider the txy-diagram given. At a liquid concentration of $x_1 = 0.6$

   (a) First, identify the bubble and dew point curves

   (b) Read the bubble point temperature.

   (c) What is the composition of the bubble produced?

   (d) At a temperature of 71°C, what is the composition of the liquid and vapor in equilibrium with each other?

   (e) What is the percentage of vapour in the vapor-liquid mixture at this temperature and composition?

   (f) For a system consisting of methane (15%), ethylene (25%) and propane (60%) at 40°F and pressure of 300 psia, use the DePriester chart of *K*-values provided to determine the fraction of vapour (α) in the system after flashing, given that the vapour mole fraction is:

$$y_i = \frac{z_i K_i}{1+(K_i-1)\alpha}$$

   where $\{z_i\}$ is the mole fraction set of the mixture.

3. The following reaction reaches equilibrium at 500°C and 2bar:

$$4HCl(g) + O_2(g) \rightarrow 2H_2O(g) + 2Cl_2(g)$$

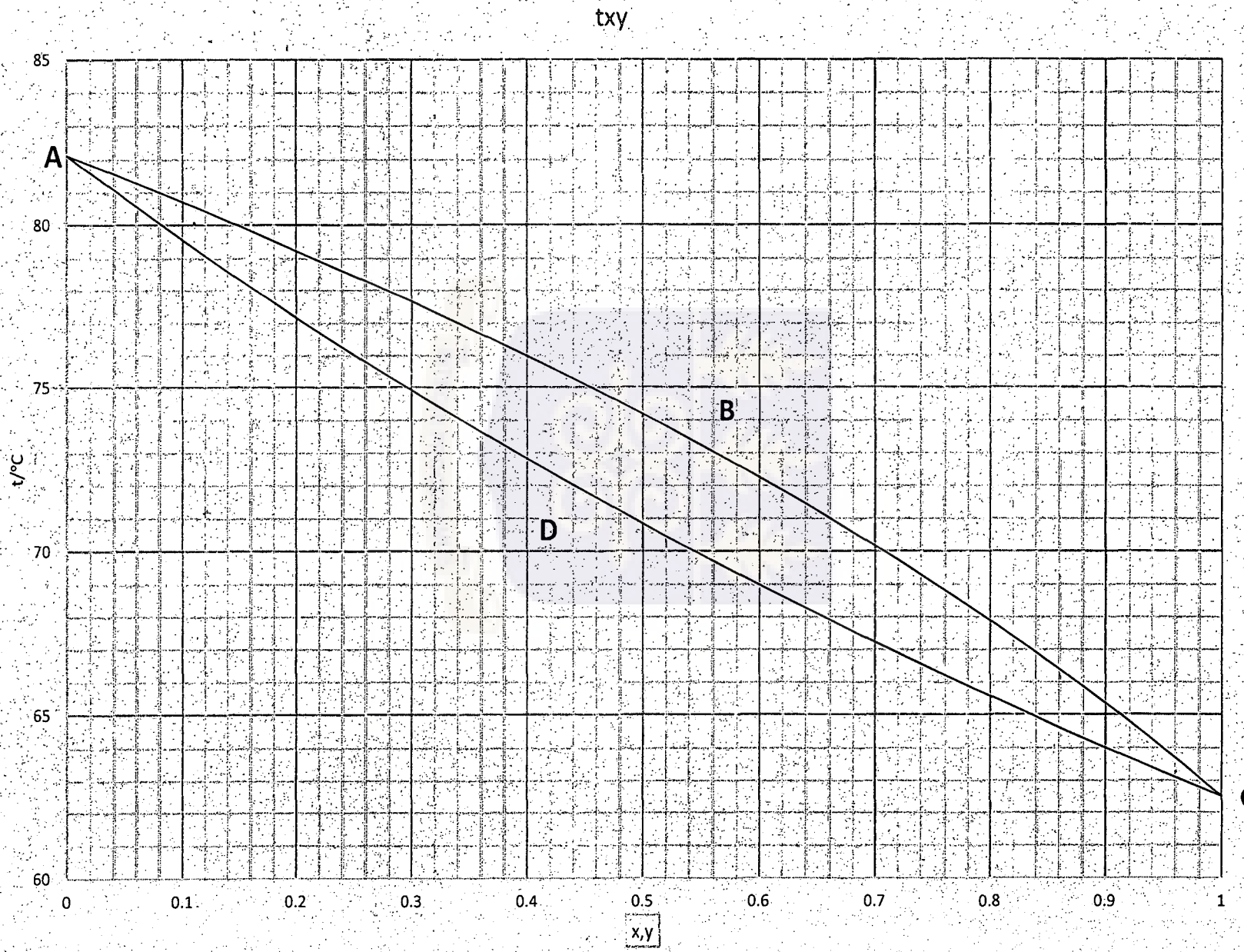
If the system initially contains 4 mol HCl for each mole of oxygen

a) Develop expressions for the mole fractions of reacting species as functions of reaction coordinate
b) Write an expression for the equilibrium constant in terms of the constituent mole fractions.
c) What is the equilibrium constant at the standard state?
d) What is the equilibrium constant at 500°C and 3bar?

Assume ideal gases.
Data:

Compound	$\Delta H^o_{f,298}$ (J/mol)	$\Delta G^o_{f,298}$ (J/mol)
HCl	- 92,307	- 95,299
H_2O	- 241,818	- 228,572

R = 8.314 J/mol.K



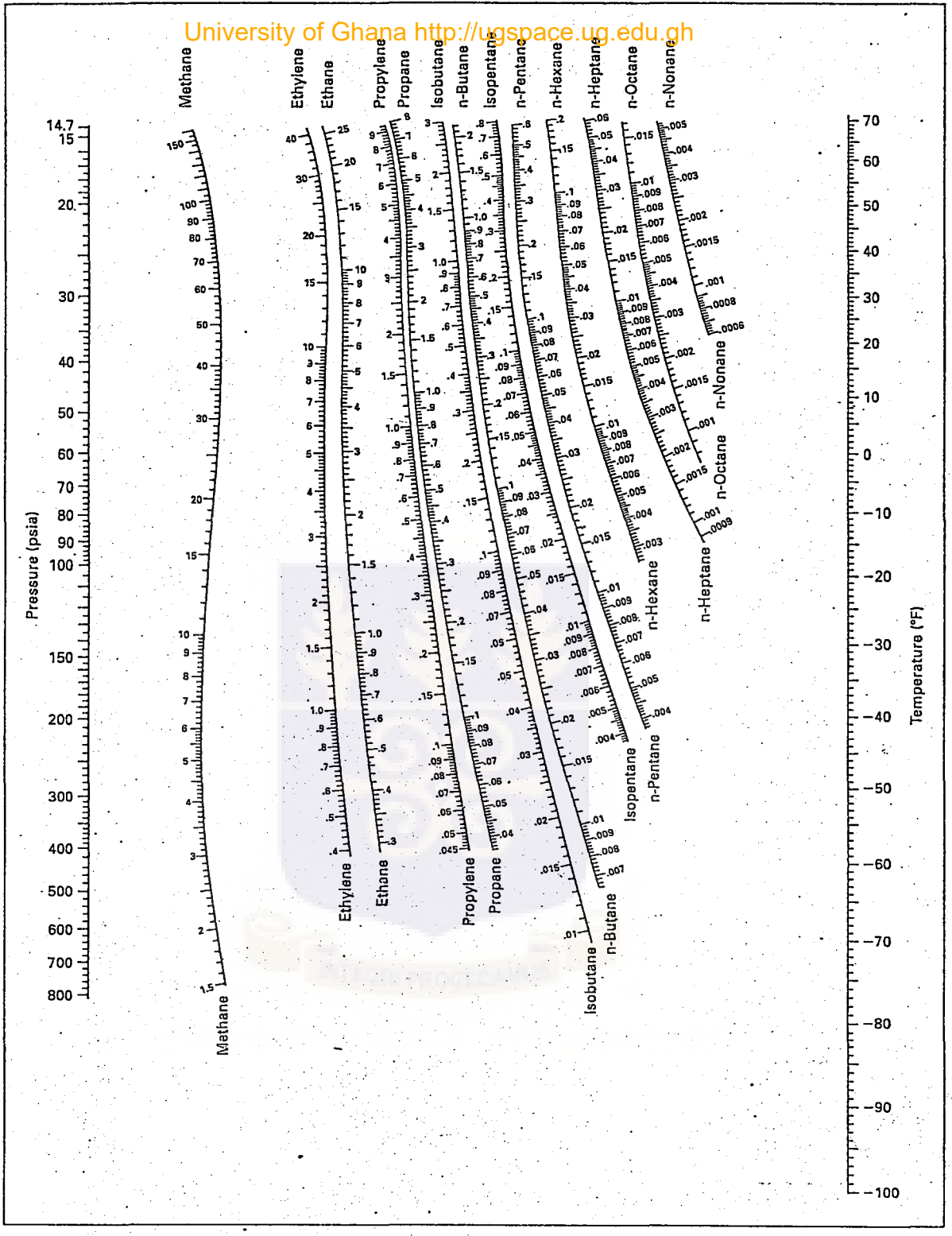


Figure 10.13: K-values for systems of light hydrocarbons. Low-temperature range. (Reproduced by permission from C. L. DePriester, *Chem. Eng. Progr. Symp. Ser. No. 7*, vol. 49, p. 41, 1953.)