

INSTRUCTIONS

1. This question paper consists of two parts. Part A is close book and Part B is open **(only text)** book.
2. Part-B answer book will be supplied after you return Part-A answer book.
3. Make and state suitable, logical and scientifically justifiable assumptions if necessary.
 - ❖ Give just **2 iterations** for iterative procedure(s).
 - ❖ **Be to the point**. Show all steps systematically.

If words are required, answer in bulleted points. Do not use paragraphs.

PART A (CLOSE BOOK)

Q1. [10 Marks] *Kinetic Theory of Gases*: List all the assumptions in a systematic manner. In a step-by-step manner, derive the expressions using which you can give insight into 2 important thermodynamic variables: pressure (P) and temperature (T). Give the physical significance thus evolved.

Q2. [10 Marks] Systematically, develop mathematical expressions for *ideal work* and *lost work*. Show : how shall you use these concepts in thermodynamic analysis of steady-state flow processes?

PART B (ONLY OPEN TEXT BOOK)

Q3. [12 Marks] Use the Peng/Robinson equation to calculate the molar volumes of saturated liquid and saturated vapor for Sulfur Dioxide at 110°C where $P^{\text{sat}} = 35.01$ bar and compare results with values found by suitable generalized correlations.

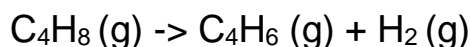
Q4. [12 Marks] Estimate Z , H^R and S^R for the *equimolar* mixture of Ethane and Ethylene at 350 K and 75 bar, by the Lee/Kesler correlations.

Q5. [12 Marks] For the system ethyl ethanoate (1) / *n*-heptane (2) at 343.15 K : $P_1^{\text{sat}} = 79.80$ kPa ; $P_2^{\text{sat}} = 40.50$ kPa; $\ln Y_1 = 0.95x_2^2$; $\ln Y_2 = 0.95x_1^2$. Assume the validity of *Modified Raoult's Law*.

- (a) Make a *BUBL P* calculation for $T = 343.15$ K, $x_1 = 0.05$;
- (b) Make a *DEW P* calculation for $T = 343.15$ K, $y_1 = 0.05$;
- (c) What is the azeotrope composition and pressure at $T = 343.15$ K?

Q6. [12 Marks] Estimate $\hat{f}_1, \hat{f}_2, \hat{\phi}_1, \text{ and } \hat{\phi}_2$ for the system ethylene(1)/propylene(2) as a gas at $T = 423.15$ K, $P = 30$ bar, and $y_1 = 0.35$: **(a)** Using virial equation of state; **(b)** Assuming that the mixture is an ideal solution.

Q7. [12 Marks] Catalytic dehydrogenation of 1-butene to 1, 3-butadiene proceeds as follows:



Side reactions are suppressed by the introduction of steam. If equilibrium is attained at 1000 K and 1.3 bar and if the reactor product contains 13-mol% butadiene, determine: **(a)** The mole fractions of the other species in the product gas; **(b)** The mole fraction of steam required in the feed.

END