**BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE (BITS) PILANI – Pilani Campus**

FIRST SEMESTER, 2023 – 2024 | CHE G622 Advanced Chemical Engineering Thermodynamics | Comprehensive Examination

**Time: 2.00 to 5.00 PM | Maximum Marks: 80 (40 %) | Date:** 11. 12. 2023 (Monday) | **CLOSE + OPEN BOOK**

**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 $P^{sat}$ = 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 : $P_1^{sat}$ = 79.80 kPa ; $P_2^{sat}$ = 40.50 kPa; $\ln\gamma_1 = 0.95x_2^2$ ; $\ln\gamma_2 = 0.95x_1^2$. 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 $\hat{f}_1,\ \hat{f}_2,\ \hat{\phi}_1,$ 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:

$$C_4H_8\,(g) \rightarrow C_4H_6\,(g) + H_2\,(g)$$

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**