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

FIRST SEMESTER, 2022 – 2023 | CHE G622 Advanced Chemical Engineering Thermodynamics | Mid-Semester Test

Time: 4.00 to 5.30 PM | Maximum Marks: 60 (30 %) | Date: 31. 10. 2022 (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.**

PART A (CLOSE BOOK

Q1. [20 Marks]

Visualize an open system. Use generic nomenclature. In a systematic manner, giving step-by-step details and considering all aspects, develop 3 balances: Mass, Energy and Entropy.

Q2. [6 Marks]

A material is transformed from solid to gas state. If gas is at temperature T, how will you express its absolute entropy? Represent it mathematically, giving the physical significance of each term. *Assume*: entropy is zero at T = 0 K and gas is not ideal at T. Lay down your assumptions, if any, justifying them scientifically. Do not forget to define the nomenclature used.

PART B (ONLY OPEN TEXT BOOK)

Q3. [14 Marks]

A portable power supply consists of a 28-liter bottle of compressed helium, charged to 13.8 MPa at 300 K connected to a small turbine. During operation, helium drives the turbine continuously until the pressure in the bottle drops to 0.69 MPa. The turbine exhausts at 0.1 MPa. Neglecting heat transfer, calculate the maximum possible work from the turbine. Assume helium to be an ideal gas with C_p = 20.9 J/mol-K.

Q4. [20 Marks]

A natural-gas fuel contains 85 mol-% methane, 10 mol-% ethane, and 5 mol-% nitrogen. **(a)** What is the standard heat of combustion ($kJ \cdot mol^{-1}$) of the fuel at 25°C with $H_2O(g)$ as a product? **(b)** The fuel is supplied to a furnace with 50% excess air, both entering at 25°C. The products leave at 600°C. If combustion is complete and if no side reactions occur, how much heat (kJ per mol of fuel) is transferred in the furnace?

END