Name: Enrolment No:	

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, Dec 2023

Course: Chemical Engg. Thermodynamics -I **Semester: III**
Program: B. Tech Chemical **Time: 3 hrs**
Course Code: CHCE 2012 **Max. Marks: 100**

Instructions: (1) This is an **Open Books and Open notes examination**. Students can carry ***ANY ONE*** textbook of their choice and class notes/photocopy in the examination hall. Answer **ALL** questions.
(2) Assume the appropriate value of missing data, if any.
(3) The thermodynamic terms have their usual meanings as described in the class

S. No.		Marks	CO
Q1	Determine the volume expansion ratios for both the isothermal and adiabatic stages of a Carnot cycle operating between thermal reservoirs at temperatures of 673 K and 288 K. The given overall volume expansion ratio is 20, and the specific heat ratio (C_P/C_v) is assumed to be 1.4.	**15**	**CO1 & CO2**
Q2	In the P-T phase diagram, water exhibits an unusual characteristic: the fusion curve possesses a negative slope, unlike other substances where the fusion curve typically has a positive slope. Provide two examples where this distinctive behavior of water on P-T diagram proves to be beneficial.	**15**	**CO2 & CO3**
Q3	Exergy analysis is often regarded as a powerful tool for evaluating the quality of energy within a system. Can you elaborate on practical applications where exergy analysis can be instrumental in pinpointing opportunities for enhanced resource utilization and sustainability in chemical engineering processes or in real world application. (Restrict your answer within 250-300 words)	**15**	**CO3**
Q4	One mole of a gas following the Redlich Kwong equation of state (EOS) is compressed isothermally from volume V_1 to V_2. Calculate the reversible work of compression. The Redlich Kwong EOS (a and b are constants) may be given as $\left(P+\frac{a}{T^{0.5}V(V+b)}\right)(V-b)=RT$	**20**	**CO2**
Q5	Liquefied nitrogen gas (LNG) is commonly utilized at 8000 kPa pressure for various purposes. The gas is distributed to different locations, and a purchase order was released for an LNG cylinder containing 7 kg of nitrogen gas. However, an error occurred when the operator mistakenly filled the nitrogen cylinder with ethylene gas at 8000 kPa and	**35**	**CO4**

-20.76 °C. If the same cylinder had been filled with nitrogen gas at the specified temperature and pressure, it would have contained approximately 6.8 kg of nitrogen. After filling the nitrogen cylinder with the ethylene gas, the operator realized the mistake. What is the approximate weight of the ethylene gas filled in the nitrogen cylinder at 8000 kPa and -20.76 °C.

Data: The critical properties of nitrogen are Pc = 3394 kPa and Tc = 126.2 K, and the critical properties of ethylene are Pc = 5117 kPa and Tc = 283.1 K.

[Hint: You can use the generalized compressibility factor chart given below. Use the two-parameter theorem of corresponding state to solve this problem. You can also use approximate values. Focus on the application of the correct approach]

The generalized compressibility factor chart

Source: Gour-Jen Su, "Modified Law of Corresponding States," Ind. Eng. Chem. (international ed.) 38 (1946), p. 803