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

Programme Name: M Tech (Chemical Engineering) **Semester : II**
Course Name   : Advanced Thermodynamics **Time   : 03 hrs**
Course Code   : CHPD7003 **Max. Marks: 100**
Nos. of page(s)   : 2
Instructions: Assume the values of parameters logically where necessary

SECTION A			
S. No.		**Marks**	**CO**
Q 1	Define Work thermodynamically. Provide a short discuss on the different classifications of Work generally encountered in thermodynamic system.	4	CO1
Q 2	Are 1 N and 1 kgf (kg-force) similar quantity? Provide the correct definition for each term.	4	CO1
Q 3	Provide your argument why Gibbs Free Energy is considered as the generating function for various thermodynamic relationships. Explain with example.	4	CO1
Q 4	Discuss concisely the difference between the Clausius-Clapeyron and modified Clausius-Clapeyron equation.	4	CO2
Q 5	Define Corresponding States Principle and draw a representative plot.	4	CO2
SECTION B			
Q 6	Discuss the conditions for **test for exactness** used in partial differential equation with an example.	10	CO3
Q 7	Apply the 1st law of thermodynamics to derive the expression for energy and work. **Or** Derive the expression for vapor/liquid phase equilibrium of a pure component with mass transfer.	10	CO3
Q 8	Air at 1 bar and 25°C enters a compressor at low velocity, discharges at 3 bar, and enters a nozzle in which it expands to a final velocity of 600 m/s at the initial conditions of pressure and temperature. If the work of compression is 240 kJ per kilogram of air, how much heat must be removed during compression?	10	CO4
Q 9	Apply the 1st law of thermodynamics formulation to derive the Maxwell's relationship **dh = Tds + vdP**	10	CO4
SECTION C			
Q 10	A liquid-vapor mixture contains n-hexane (component 1) and n-heptane (component 2) at 27°C. Estimate the composition of the liquid and vapor phases as a function of total pressure if the phases behave as ideal solution. Plot the results in P-x-y diagram. P1 and P2 are the vapor pressure of pure n-hexane and pure n-heptane respectively. $lnP1 = 18.057 - (3837.4/T)$ $lnP2 = 18.217 - (4231.0/T)$ **or**	20	CO5

Calculate the internal energy and enthalpy changes resulting if air changes from an initial state of 5°C and 10 bar, where its molar volume is 2.312×10^{-3} m³/mol, to a final state of 60°C and 1 bar. Assume also that air remains a gas for which PV/T is constant and that $C_V = 20.785$ and $C_P = 29.100$ J/mol K

Q 11	Acetic acid is esterified in the liquid phase with ethanol at 100°C and atmospheric pressure to produce ethyl acetate and water according to the reaction: CH_3COOH (l) + C_2H_5OH (l) → $CH_3COOC_2H_5$(l) + H_2O(l) If initially there is one mole each of acetic acid and ethanol, **estimate** the mole fraction of ethyl acetate in the reacting mixture at equilibrium.	20	CO5

	ΔH°_{f298}	ΔG°_{f298}
ethyl acetate (l)	- 480,000	- 332,200
acetic acid (l)	−484,500	−389,900
Ethanol (l)	−277,690	−174,780
Ethanol (g)	−235,100	−168,490
Water (g)	−241,818	−228,572
Water (l)	−285,830	−237,129