Name: **Enrolment No:**	

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, Dec 2022

Course: Thermodynamics -I **Semester: III**
Program: B. Tech (CE+RP) **Time: 3 hrs**
Course Code: CHCE 2012 **Max. Marks: 100**

Instructions: (1) 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
	SECTION A (20 M)		
Q1	Distinguish between 'Heat Engine' and 'Heat Pump'?	**4**	**CO1**
Q2	Explain 'Thermodynamic Equilibrium'?	**4**	**CO1**
Q3	Derive an iterative scheme to estimate the volume of saturated liquid and saturated vapour using the van der Walls equation of state.	**4**	**CO2**
Q4	What is the physical significance of acentric factor? What are the corresponding state parameters?	**4**	**CO1**
Q5	Discuss the limitations of the first law of thermodynamics.	**4**	**CO1**
	SECTION B (40 M)		
Q6	A horizontal piston/cylinder Arrangement is placed in a constant-temperature bath. The piston slides in the cylinder with negligible friction, and an external force holds it in place against an initial gas pressure of 14 bar. The initial gas volume is 0.03 m3. The external force on the piston is gradually reduced, and the gas expands isothermally as its volume doubles. What is the work done by the gas in moving the external force ? If the external force were suddenly reduced to half of its initial value instead of being gradually reduced what is the work done?	**10**	**CO2**
Q7	Compare the displacement work done in the reversible isothermal expansion of gas following the (a) ideal gas equation of state (EOS) (b) van der Waals EOS (c) Dietericie EOS. Which work will be maximum? The Dieterici EOS may be given as $p = \frac{RT}{v-b}\exp(-a/RTv)$	**10**	**CO2**

Q8	An insulated tank of volume 2 m^3 is divided into two equal compartments by a thin and rigid partition. One compartment contains an ideal gas at 400 K and 300 kPa, while the other is completely evacuated. Now, the partition is suddenly removed and the gases are allowed to mix. Find the final pressure, temperature and work done. OR Air at 10^o C and 80 kPa enters the diffuser of a jet engine steadily with a velocity of 200 m/s. The inlet area of the diffuser is 0.4 m^2. The air leaves the diffuser with a velocity that is very small compared with the inlet velocity. Determine (a) the mass flow rate of the air and (b) the temperature of the air leaving the diffuser.	**10**	**CO3**
Q9	The Berthelot EOS is given by $\left(P + \frac{a}{TV^2}\right)(V - b) = RT$ Find the constants *a* and *b* in terms of critical temperature and pressure	**10**	**CO2**
	SECTION C (40 M)		
Q10	One gram mole of nitrogen behaving as an ideal gas undergoes an irreversible isothermal compression from 1 to 10 atm at 400 K in a piston-cylinder assembly. The heat removed from the gas as a result of the compression process is absorbed by a heat sink maintained at 300 K. The irreversible process is 83% efficient as compared to the reversible process. Calculate the entropy change for the gas, heat sink and total entropy change. Is the process spontaneous?	**20**	**CO3**
Q11	Consider 1 mole of nitrogen gas in a piston-cylinder assembly. This gas undergoes a cyclic process, which is described below. The heat capacity is constant, Cp = 2.5 R (i) A reversible, isothermal expansion from 10 bar to 0.1 bar. (ii) A reversible, adiabatic expansion from 0.1 bar and 1000 K to 320 K. (iii) A reversible, isothermal compression at 320 K. (iv) A reversible, adiabatic compression from 320 K to 1000 K and 10 bar. Clearly state all the assumptions. Perform the following analysis: (a) Calculate Q, W, ΔH and ΔU for each of the steps in the cycle. (b) Draw the cycle on a P-V diagram. (c) If all the steps are irreversible with an efficiency of 60 % compared with the corresponding mechanically reversible processes. Calculate Q, W, Δ U, and Δ H for each step of the process and the cycle.	**20**	**CO4**