Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2019

Course: Advanced Thermodynamics — **Semester: 1**
Program: MTech (CE+PD) — **Time 03 hrs.**
Course Code: CHPD 7003 — **Max. Marks: 100**

Instructions:

1. **The exam is closed book and closed notes**
2. **Use of mobile phone and other electronic equipment is strictly prohibited**
3. **Use of unfair means during exam will be severely dealt with.**

SECTION A

S. No.		Marks	CO
Q 1	Write down the enthalpy form of the fundamental property relation from combined first and second law.	4	CO1
Q 2	Express $\left(\frac{\partial T}{\partial P}\right)_S$ in terms of specific heats and P-V-T relations.	4	CO2
Q 3	Define excess volume of a mixture. How is it related to the activity coefficient?	4	CO3
Q 4	A system initially containing 5 moles of C_2H_4 and 8 moles of O_2 undergo the multiple reactions: C_2H_4 (g) + 1/2 O_2 (g) →((CH_2)$_2$)O (g) C_2H_4 (g) + 3 O_2 (g) →CO_2 (g) + 2H_2O (g) Develop expressions for the mole fraction of the reacting species as a function of the reaction coordinate of the two reactions.	4	CO4
Q 5	State the relation between entropy and probability of microstates in a canonical ensemble.	4	CO5

SECTION B

Q 6	A heat engine operating in outer space may be assumed equivalent to a Carnot engine operating between reservoirs at temperatures T_H and T_C. The only way the heat can be discarded from the engine is by radiation, the rate of which is given approximately by the equation, $$\lvert\dot{Q}_C\rvert = kAT_C^4$$ where k is a constant and A is the area of the radiator. Prove that, for a fixed power output $\lvert\dot{W}\rvert$ and for fixed temperature T_H, the radiator area is a minimum when the temperature of the cold to the heat reservoir is 0.75.	10	CO1
Q 7	Determine expressions for G^R and U^R as implied by the van der Waals' equation of state	10	CO2
Q 8	Show that, $$\gamma_i = \hat{\varphi}_i / \varphi_i$$ where the symbols have their usual meanings.	10	CO3

Q 9	The canonical partition function of a monoatomic ideal gas is given by the formula, $$Q(N,V,T) = \frac{1}{N!}\left(\frac{2\pi m k_B T}{h^2}\right)^{3N/2} V^N$$ where, N = total number of particles present, m = mass of each particle, T = temperature of the system, V = volume of the system, h = Planck's constant. Find expressions for the pressure and energy.	**10**	**CO5**
SECTION C			
Q 10	For ideal gases, exact mathematical expressions can be derived for the effect of temperature and pressure on the equilibrium conversion, ε_e. Show that: $$\left(\frac{\partial \varepsilon_e}{\partial T}\right)_P = \frac{K_y}{RT^2}\frac{d\varepsilon_e}{dK_y}\Delta H°$$ $$\left(\frac{\partial \varepsilon_e}{\partial P}\right)_T = \frac{K_y}{P}\frac{d\varepsilon_e}{dK_y}(-\nu)$$ where the symbols have their usual meanings.	**20**	**CO4**
Q 11	Derive expressions for the probabilities of different microstates in the case of a grand canonical ensemble.	**20**	**CO5**