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| **Name:**<br>**Enrolment No:** | UPES UNIVERSITY WITH A PURPOSE |

**UNIVERSITY OF PETROLEUM AND ENERGY STUDIES**
**Online End Semester Examination, Dec 2020**

**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, Q12 has an internal choice
(2) Assume appropriate value of missing data, if any.
(3) The thermodynamic terms have their usual meanings as described in the class

**SECTION A (30 M)**

| S. No. | | Marks | CO |
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| Q1 | Explain the Macroscopic and Microscopic aspects of thermodynamics | **5** | **CO1** |
| Q2 | Explain the significance of (i) Helmholtz free energy (ii) Gibbs free energy (iii) Joule Thomson Coefficient | **5** | **CO4** |
| Q3 | Explain the terms 'state function' and 'path function'. | **5** | **CO1** |
| Q4 | Show that entropy is a property of a system | **5** | **CO3** |
| Q5 | Discuss the three-parameter theorem of the corresponding state | **5** | **CO2** |
| Q6 | Explain the working of a Carnot refrigerator and discuss its coefficient of performance | **5** | **CO5** |
| | **SECTION B (50 M)** | | |
| Q 7 | A gas obeying the Clausius equation of state is isothermally compressed from 5 MPa to 15 MPa in a closed system at 400 K. The Clausius equation of state is $P=\frac{RT}{v-b(T)}$ **;** where P is the pressure, T is the temperature, $v$ is the molar volume and R is the universal gas constant. The parameter b in the above equation varies with temperature as $b(T)=b_o+b_1T$ with $b_o=4\times10^{-5}$ m$^3$ mol$^{-1}$ and $b_1$ = 1.35 x 10$^{-7}$ m$^3$ mol$^{-1}$ K$^{-1}$. The effect of pressure on the molar enthalpy (h) at a constant temperature is given by | **10** | **CO4** |

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| | $\left(\frac{\partial h}{\partial P}\right)_T = v - T\left(\frac{\partial V}{\partial T}\right)_P$. Let $h_i$ and $h_f$ denote the initial and final molar enthalpies, respectively. Find the change in the molar enthalpy $h_f - h_i$ (in J mol$^{-1}$) for this process. | | |
| Q8 | Explain the working of a simple vapor power plant, Carnot cycle and Rankine cycle with the help of T-S diagram. Why does the efficiency of a Rankine cycle increase with decreasing condenser pressure ? | **10** | **CO5** |
| Q9 | A gas in a piston-cylinder assembly undergoes an expansion process for which the relationship between pressure and volume is given by $PV^n$ = constant. The initial pressure is 3 bar, the initial volume is 0.1m$^3$ and the final volume is 0.2m$^3$. Determine the work for the process, in kJ, if (a) n = 1.5 (b) n = 1.0 and (c) n = 0. Derive the expressions for work done in all three cases. | **10** | **CO1** |
| Q10 | 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. The equilibrium is established by equalizing the pressure and temperature. Estimate the change in entropy of the gas | **10** | **CO3** |
| Q11 | If $CO_2$ gas follows an EOS, $\left(P + \frac{365}{V^2}\right)(V - 0.043) = RT$. Find the change in internal energy per kg-mole pf the gas undergoes isothermal expansion from 10,132 kPa to 101.32 kPa at 100 $^oC$ , the corresponding molar volume of the gas are 0.215 m$^3$/ kmol and 30.53 m$^3$/kmol respectively. | **10** | **CO2** |

| SECTION C (20 M) | | | |
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| Q12 | It is found that at a particular hill station water boils at 95 $^{o}$C. It is known that at mean sea level where pressure is 1 bar, water boils at 373.15 K, with latent heat of vaporization 2256.94 kJ/kg. Assuming the atmosphere is isothermal at 25 $^{o}$C, estimate the altitude of hill station above the mean sea level. Take molecular weight of air = 28.97.<br><br>OR<br><br>Show that<br><br>$\left(\frac{\partial T}{\partial V}\right)_S = \frac{-T\beta}{\kappa C_v}$<br><br>Suppose that the liquid water at 25 $^{o}$C is isentropically compressed such that its volume decreases by 10 %. What would be the rise in temperature of water. For liquid water<br><br>$\beta = 2\times 10^{-4} K^{-1}, v = 0.0010029 m^3 / kg$<br>$\kappa = 4.85\times 10^{-4} MPa^{-1}\ and \quad C_v = 4.2 kJ / kg - K$ | **CO4** | **20** |