Reg. No. \_\_\_\_\_\_\_\_\_\_\_\_



**End Semester Examination – Nov / Dec – 2019**

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| **Code :** | **17BT2027** | **Duration :** | **3hrs** |
| **Sub. Name :** | **CHEMICAL AND BIO-THERMODYNAMICS** | **Max. Marks :** | **100** |

**ANSWER ALL QUESTIONS (5 x 20 = 100 Marks)**

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| **Q. No.** | **Sub Div.** | **Questions** | **Course**  **Outcome** | **Marks** |
| 1. | a. | Differentiate between intensive and extensive properties of a thermodynamic system with examples.  Why heat and work involved in a process are referred to as “path function”? | CO1 | 6 |
| b. | Gas confined in a cylinder undergoes following series of the process before brought back to initial condition:  **Step 1**: A constant pressure process – receives 50J work and gives up 25 J of heat.  **Step 2:** Constant volume process received 80 J of heat.  **Step 3:** An adiabatic process.  Determine the change in internal energy and work done in each of the steps. | CO1 | 14 |
| **(OR)** | | | | |
| 2. | a. | When we know H=U+PV, show that CP=and CV=. Additionally, show CP-CV = R | CO1 | 6 |
| b. | Heat capacity of gas Cv=20.8 and CP=29.1 J/mol K. Gas at 10 bar 280 K undergoing change to 1 bar 340 K. Calculate the change in internal energy and enthalpy. | CO1 | 14 |
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| 3. | a. | Illustrate P-T diagram of phase change for a pure compound. Highlight the triple point and critical points with explanations. | CO3 | 6 |
| b | Deduce that pressure and volume changes in the adiabatic process are related through is constant, where γ=Cp/Cv. | CO3 | 14 |
| **(OR)** | | | | |
| 4. | a. | Write down a virial equation for compressibility factor ‘Z’ in terms of volume ‘V’. Using the virial equation, calculate the molar volume for isopropanol at 473 K and 10 bar. The virial coefficients are given as B= -3.88×10-4 m3/mol and C=-2.6×10-8 m6/mol2 | CO4 | 10 |
| b. | From the fundamental relation dH=TdS+VdP, show = . | CO4 | 10 |
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| 5. | a. | Estimate the fugacity coefficient of gas at 10 bar 298 K, obeying EOS as P(V-b) = RT and b= 3.70×10-5 m3/mol.  Explain how residual volume can be utilized for the estimation of fugacity. | CO2 | 10 |
| b. | Define partial molar property, and deduce the expression showing its relation to solution property, i.e., . | CO2 | 10 |
| **(OR)** | | | | |
| 6. | a. | Describe Lewis/Randall rule and define activity coefficient of component species for a non-ideal solution. | CO2 | 6 |
| b. | Molar volume of a binary mixture *V*=120*x*1+70*x*2+(15*x*1+8*x*2)*x*1*x*2. Calculate partial molar volume of each species when *x*1 = *x*2 = 0.5 | CO2 | 14 |
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| 7. | a. | A binary mixture of C1 and C2 conforms to Raoult’s law. The vapor pressure of pure species is given by Antoine Equations:  and ,where pressures are in kPa and Temperatures in Kelvin. Calculate liquid and vapor phase composition (*x*1, *y*1) at 75°C, 67 kPa. | CO3 | 14 |
| b. | Draw a P-x-y diagram for binary VLE system. Explain why P-*x*1 is a straight line whereas P-*y*1 is a curve. How would you graphically determine equilibrium composition of the system at any pressure? | CO3 | 6 |
| **(OR)** | | | | |
| 8. | a. | Discuss the different approaches of Fugacity estimation for a pure liquid (with relevant mathematical expressions). | CO4 | 10 |
| b. | Calculate fugacity and fugacity coefficient for super-heated steam at 573K and 4000 kPa. Given enthalpy H and entropy S at this condition are 2962 J g-1 and 6.36 J g-1 K-1, respectively. The respective H, S values at 1 kPa 573 K are 3076 J g-1 and 10.34 J g-1 K-1. | CO4 | 10 |
|  | | **Compulsory**: |  |  |
| 9. | a. | Two moles of H2O(g) and 1 mole of CO(g) takes part in a water-gas-shift reaction as . Calculate fraction of steam reacted under equilibrium, where K=1. | CO5 | 10 |
| b. | Calculate the equilibrium constant at 298 K for N2O4 (*g*)🡪2NO2(*g*), given standard free energies of formation are 97540 J/mol and 51310 J/mole for N2O4, and NO2 respectively. | CO5 | 10 |