Indian Institute of Technology Guwahati
Department of Biosciences and Bioengineering
End-Semester Examination (November 21, 2021)
Bio - Thermodynamics (BT 202)

Answer ALL the questions

All the assumptions made should be explicitly defined with suitable justification

ALL the Question no(s) with respective answers should be written LEGIBLY

Duration: 2 hrs.   **Total Marks: 50**

1. What are the Maxwell's equations and what is their importance in establishing relationships between thermodynamic properties?   (5 marks)

2. Show that for a gas obeying van der waals equations of state,   (5 marks)

$$C_P - C_V = \frac{R}{1 - 2a(V-b)^2/(RTV^3)}$$ Where a and b are Van der Waals Constant

3. Derive the following thermodynamic relations: (5) marks
$$C_P - C_V = \beta^2 VT/\kappa$$

4. A 40kg steel casting (Cp= 0.5 KJ Kg^{-1} K^{-1}) at a temperature of 450°C is quenched in 150kg of oil (Cp= 2.5 KJ Kg^{-1} K^{-1}) at 25°C. If there are no heat losses, what is change in entropy of (a) the casting, (b) the oil, and (c) both considered together   (5 marks)

5. The enthalpy of a binary liquid system of species 1 and 2 at fixed T and P is:

$$H = 400x_1 + 600x_2 + x_1 x_2 (40x_1 + 20x_2)$$

Determine expressions for $\bar{H}_1$ and $\bar{H}_2$ as functions of x_2, numerical values for the pure-species enthalpies H_1 and H_2 , and numerical values for the partial enthalpies at infinite dilution $\bar{H}_1^{\infty}$ and $\bar{H}_2^{\infty}$ (8 marks)

6. Determine the increase in entropy of solid magnesium when the temperature is increased from 300 K to 800 K at atmospheric pressure. The heat capacity is given by the following relation

$$C_P = 26.04 + 5.586 \times 10^{-3}\, T + 28.476 \times 10^4\, T^{-2}$$

Where C_P is in J/mol K and temperature in K.   (5 marks)

7. The molar volume of an organic liquid at 300 K and 1 bar is 0.1 m³/kmol and its coefficient of expansion is 1.25×10^{-3} K⁻¹. What would be the change in entropy if the pressure is increased to 20 bar at 300 K? What assumption is involved in the solution?   (5 marks)

8. Determine the enthalpy and entropy changes of liquid water for a change of state from 1 bar and 25°C to 1000 bar and 50°C. The data for liquid water: $C_P = 75.31$ J/mol ; $\beta = 513 \times 10^{-6}$ K
                                                                              (5marks)

9. Consider a system in which the following reactions occur,

$$CH_4 + H_2O \rightarrow CO + 3H_2 \qquad CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$$

if there are present initially 2 mol CH_4 and 3 mol H_2O, determine expressions for the y_i as functions of ε_1 and ε_2.   (7 marks)