

Thermodynamics Homework #3

Stanley Goodwin
(10/15/2023)

$$1) dU = TdS - PdV + \mu dN$$

a) $dV = dN = 0$ for C_V by definition.

$$\Rightarrow dU = TdS \Rightarrow \frac{dU}{dT} = T \frac{dS}{dT} \Rightarrow \boxed{C_V = T \left(\frac{dS}{dT} \right)_{V,N}}$$

b) $dP = dN = 0$ for C_P by definition

$$dU = TdS - PdV + dH - TdS - VdP = dH - PdV$$

$$\Rightarrow \frac{dU}{dT} = \frac{dH}{dT} - P \frac{dV}{dT} \Rightarrow \boxed{C_P = \frac{dH}{dT} - P \frac{dV}{dT}}$$

$$2) \Delta G = \Delta H - T\Delta S, T = 298K$$

$$N_2 + 3H_2) \quad G_0 = 0 + 3 \cdot 0 = 0 \text{ kJ}$$

$$H_0 = 0 + 3 \cdot 0 = 0 \text{ kJ}$$

$$S_0 = 191.61 \text{ J/K} + 3 \cdot 130.68 \text{ J/K} = 583.65 \text{ J/K}$$

$$2NH_3) \quad G_1 = 2 \cdot (-16.45 \text{ kJ}) = -32.90 \text{ kJ}$$

$$H_1 = 2 \cdot (-46.11 \text{ kJ}) = -92.11 \text{ kJ}$$

$$S_1 = 2(192.45 \text{ J/K}) = 384.90 \text{ J/K}$$

$$\Delta G = \Delta H - T\Delta S = (H_1 - H_0) - T(S_1 - S_0)$$

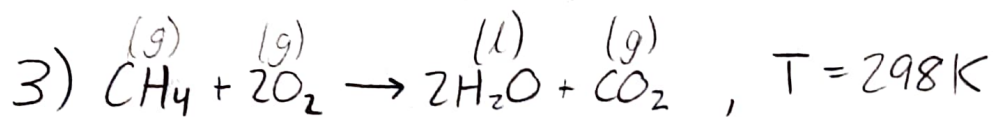
$$= -92.11 \text{ kJ} - (298K)(-198.75 \text{ J/K})$$

$$= -92.11 \text{ kJ} + 59.23 \text{ kJ}$$

$$= \boxed{-32.88 \text{ kJ}}$$

$$\Delta G = G_1 - G_0$$

$$= \boxed{-32.90 \text{ kJ}}$$



$$\begin{array}{l|l} \Delta H_0 = -74.81\text{kJ} + 2(0) & H_1 : 2(-285.83\text{kJ}) - 393.51\text{kJ} \\ G_0 : -50.72\text{kJ} + 2(0) & G_1 : 2(-237.13\text{kJ}) - 394.36\text{kJ} \end{array}$$

$$a) \Delta H = H_1 - H_0 = -890.36\text{kJ/mol}$$

$$\Delta G = G_1 - G_0 = -817.90\text{kJ/mol}$$

$$b) W = -\Delta G = 817.90\text{kJ/mol} \cdot 1\text{mol} = \boxed{817.90\text{kJ}}$$

$$c) Q = -\Delta H = 890.36\text{kJ/mol} \cdot 1\text{mol} = \boxed{890.36\text{kJ}} \quad \text{Exothermic}$$

$$d) W = nFV, n = 8\text{mol } e^-, F = 96.485 \frac{\text{kJ}}{\text{V mol } e^-}$$

$$V = \frac{W}{nF} = \frac{817.90\text{kJ}}{(8\text{mol } e^-)(96.485 \frac{\text{kJ}}{\text{mol } e^- \text{V}})} = \boxed{1.0596\text{V}}$$