Ashley Faro | Problem Set # 4 | 3/24/20

analytical problems

1) Reversible process entropy transfer is taking place by heat interactions $\rightarrow \Delta S = \frac{dq_{rev}}{T}$

adiabatic process, means the system is closed & no heat is entered into the system

$$q \geq 0$$

$\hookrightarrow$ rev. adiabatic process, $\Delta S = 0$

2a. H, U, S (enthalpy, internal energy, entropy) are state functions. Cyclic process - initial & final state are same. Change in state property for cyclic process is zero. $\Delta H = 0$, $\Delta S = 0$, $\Delta U = 0$

2b Process $b \to c$ & $d \to a$ are adiabatic process $\to q = 0$

during $a \to b$ temp is constant $\to \Delta U = 0$

The work done by the system is being carried out by heat supplied to the system. work done by the system in reversible process = w

$w = -nRT_h\left(\ln \frac{V_b}{V_a}\right)$ $\Delta U = 0 = q + w$ $q = -w = -(-nRT_h \ln\left(\frac{V_b}{V_a}\right)$

$q = nRT_h \ln (V_b / V_a)$

2c. $w_{net} = w_{ab} + w_{bc} + w_{cd} + w_{da}$

$$= -nRT_h \ln\left(\frac{V_b}{V_a}\right) - nRT_c \ln\left(\frac{V_A}{V_b}\right)$$

$$w_{net} = -(T_h - T_c)\, nR \ln\left(\frac{V_B}{V_A}\right)$$

total work done is negative from system potential view

2d efficiency $(n) = \frac{\text{network done by heat engine}}{\text{heat absorbed by heat engine}} = \frac{-w}{q}$

$$\downarrow$$

$$= \frac{-\left[-(T_h - T_c)\, nRT \ln\left(\frac{V_B}{V_A}\right)\right]}{nRT_h \ln\left(\frac{V_B}{V_A}\right)} = \frac{T_h - T_c}{T_h} = 1 - \frac{T_{cold}}{T_{hot}}$$

3A. $S = f(P, T)$ $\quad dS = \left(\frac{\partial S}{\partial P}\right)_T dp + \left(\frac{\partial S}{\partial T}\right)_p dT$

Maxwells Relations $\qquad \left(\frac{\partial S}{\partial P}\right)_p = \frac{C_p}{T}$

$$\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_p = -BV$$

$dS = \frac{C_p}{T} dT - \left(\frac{\partial V}{\partial T}\right)_p dp$ where $\beta = 1/V \left(\frac{\partial V}{\partial T}\right)_p$ $\quad \alpha_{P_2} = -1/V \left(\frac{\partial V}{\partial P}\right)_T$

3b $dS = \frac{C_p}{T} dT - \beta V dP$ $\qquad \Delta S = \int_{T_1}^{T_2} \frac{C_p}{T} dT - \int_{P_1}^{P_2} \beta V dp$

Numerical problems

1A $\Delta H_{rxn} = \sum \Delta H_f^\circ \text{prod} - \sum \Delta H_f \text{ reactants} = -[1364 - 2 + 8 - 394] - 1273]$

$\Delta H_{rxn} = -763$ kJ/mol

$\Delta S_{rxn} = \sum S_{products} - \sum S_{reactants} \to [192 + 161 + 213] - [209]$

$= 357$ J/mol K