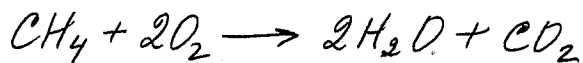


## Homework #10

### Problem #1



(a)  $\Delta_f$  of reactants from  $\Delta_f$  of the products we have

$$\Delta H = 2(-285.83 \text{ kJ}) + (-393.51 \text{ kJ}) - (-74.81 \text{ kJ}) = -890.36 \text{ kJ}$$

$$\Delta G = 2(-237.13 \text{ kJ}) + (-394.36 \text{ kJ}) - (-50.72 \text{ kJ}) = -817.9 \text{ kJ}$$

(b) Under ideal conditions all decrease in Gibbs free energy goes into electrical work.

$$W = -\Delta G = 818 \text{ kJ}$$

(c) The difference between  $\Delta H$  and  $\Delta G$  must be released as heat  $Q = 72 \text{ kJ}$ .

(d) For each methane molecule, eight electrons goes around the circuit

$$\cancel{W} = V = \frac{W}{q \cdot 8 \cdot N_A} = \frac{818 \text{ kJ}}{6 \cdot 10^{23} \cdot 8 \cdot 1.6 \cdot 10^{-19}} = 1.06 \text{ V}$$

Homework. #10

Problem #2.

$$dG = -SdT + VdP.$$

$S$  is known from the table, then

$$\Delta G = -(69.91 \text{ J/K}) \cdot (5 \text{ K}) = -350 \text{ J}$$

to compensate this change we apply some pressure.

$V = 18 \cdot 10^{-6} \text{ m}^3$  - volume of 1 mole of water.

$$\Delta P = \frac{(-\Delta G)}{V} = 1.93 \times 10^7 \text{ Pa} = 193 \text{ atm}$$

Problem #3 Homework #10.

Prove that  $K_T = K_S + \frac{TV\beta^2}{C_p}$ , where

$$K_T = -\frac{1}{V} \left( \frac{\partial V}{\partial P} \right)_T \quad \text{isothermal compressibility}$$

$$K_S = -\frac{1}{V} \left( \frac{\partial V}{\partial P} \right)_S \quad \text{isentropic compressibility (no heat is added or taken from the system in compression process)}$$

$$\beta = \frac{1}{V} \left( \frac{\partial V}{\partial T} \right)_P \quad \text{coefficient of thermal expansion.}$$

$$C_p = T \left( \frac{\partial S}{\partial T} \right)_P \quad \text{specific heat at constant pressure.}$$

$V(P, T)$  - equation of state.

$$(1) \quad dV = \left( \frac{\partial V}{\partial P} \right)_T dP + \left( \frac{\partial V}{\partial T} \right)_P dT$$

↳ this term is simply related to  $K_T$ .

$T(S, P)$  - another way to write equation of state.

$$(2) \quad dT = \left( \frac{\partial T}{\partial P} \right)_S dP + \left( \frac{\partial T}{\partial S} \right)_P dS$$

if  $dS = 0$  (we keep entropy constant in the process we have combining (1) and (2))

$$(3) \quad \left( \frac{\partial V}{\partial P} \right)_S = \left( \frac{\partial V}{\partial P} \right)_T + \left( \frac{\partial T}{\partial P} \right)_S \cdot \left( \frac{\partial V}{\partial T} \right)_P$$

$$\begin{array}{cccc} \downarrow & \downarrow & \downarrow & \downarrow \\ \{ & \{ & ? & \beta \\ K_S & K_T & & \end{array}$$

We may re-write (3) as

$$k_T - k_S = \beta \left( \frac{\partial T}{\partial P} \right)_S.$$

Therefore from (4) and (5) we have

$$k_T - k_S = \beta \cdot \left( \frac{\partial V}{\partial T} \right)_P \cdot \left( \frac{\partial T}{\partial S} \right)_P$$

and from (6) and (7)

$$k_T = k_S + \frac{\beta^2 \cdot V \cdot T}{C_p}.$$

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$$dH = + TdS + VdP.$$

Maxwell relation for  $H$

$$\left( \frac{\partial T}{\partial P} \right)_S = + \left( \frac{\partial V}{\partial S} \right)_P \quad (4)$$

$$\left( \frac{\partial V}{\partial S} \right)_P = \left( \frac{\partial V}{\partial T} \right)_P \cdot \left( \frac{\partial T}{\partial S} \right)_P \quad (5)$$

this simply differentiating of complex function

$$\left( \frac{\partial T}{\partial S} \right)_P = \left[ \left( \frac{\partial S}{\partial T} \right)_P \right]^{-1} = \frac{T}{C_p} \quad (6)$$

$$\left( \frac{\partial V}{\partial T} \right)_P = \beta \cdot V \quad (7)$$