

Kevin Marry

Test 2

4-9-20

$$\textcircled{a} \Delta G_{\text{ran}} = (-133 \frac{\text{kJ}}{\text{mol}}) + (-399 \frac{\text{kJ}}{\text{mol}}) - (-963 \frac{\text{kJ}}{\text{mol}}) = -69 \frac{\text{kJ}}{\text{mol}}$$

The reaction is spontaneous under standard conditions because  $\Delta G_{\text{ran}} < 0$ .

$$\textcircled{b} K_p = e^{-\Delta G^\circ / RT} \rightarrow K_p = e^{(69 \text{ kJ/mol}) / (8.314 \times 10^{-3} \text{ kJ/mol K})(80 \text{ K})} = 6.15 \times 10^4$$

$\textcircled{c}$  At a lower temperature, the reaction favors the products.

$$\textcircled{a} \left( \frac{\partial S}{\partial V} \right)_T = \left( \frac{\partial P}{\partial T} \right)_V = \frac{\beta}{\alpha}$$

$$\beta = \frac{1}{V} \left( \frac{\partial V}{\partial T} \right)_P$$

$$\alpha = -\frac{1}{V} \left( \frac{\partial V}{\partial P} \right)_T$$

$$\left( \frac{\partial P}{\partial V} \right)_T = \frac{nR}{V} \leftarrow \frac{nR}{P} \left( \frac{P}{V} \right) \leftarrow \frac{nR}{P} \left( \frac{nRT}{V^2} \right) \leftarrow \left( \frac{\partial V}{\partial T} \right)_P \left( \frac{\partial P}{\partial V} \right)_T$$

$$\left( \frac{\partial P}{\partial V} \right)_T = -P$$

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

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

$\textcircled{b}$  As volume increases, entropy increases.

$$\textcircled{c} \left( \frac{\partial \mu}{\partial P} \right)_{T,n} = - \left( \frac{\partial V}{\partial n} \right)_{T,P}$$

$$\mu = \left( \frac{\partial G}{\partial n} \right)_{T,P}$$

$$V = \left( \frac{\partial G}{\partial P} \right)_{T,n}$$

$$\frac{\partial}{\partial P} \left( \frac{\partial G}{\partial n} \right) \rightarrow \frac{\partial^2 G}{\partial P \partial n}$$

$$\frac{\partial}{\partial n} \left( \frac{\partial G}{\partial P} \right) \rightarrow \frac{\partial^2 G}{\partial n \partial P}$$

$$d) \partial n_{\text{CO}_2} = -\partial n_{\text{CO}} = -\partial n_{\text{C}_2}$$

$$\mu_{\text{CO}_2} = \left( \frac{\partial G_{\text{CO}_2}}{\partial n_{\text{CO}_2}} \right)_{T,P} \rightarrow \frac{\partial}{\partial P} \left( \frac{\partial G_{\text{CO}_2}}{\partial n_{\text{CO}_2}} \right) \rightarrow \frac{\partial^2 G_{\text{CO}_2}}{\partial P \partial n_{\text{CO}_2}}$$

$$V_{\text{CO}_2} = \left( \frac{\partial G_{\text{CO}_2}}{\partial P} \right)_{T,n} \rightarrow \frac{\partial}{\partial n_{\text{CO}_2}} \left( \frac{\partial G_{\text{CO}_2}}{\partial P} \right) \rightarrow \frac{\partial^2 G_{\text{CO}_2}}{\partial P \partial n_{\text{CO}_2}}$$

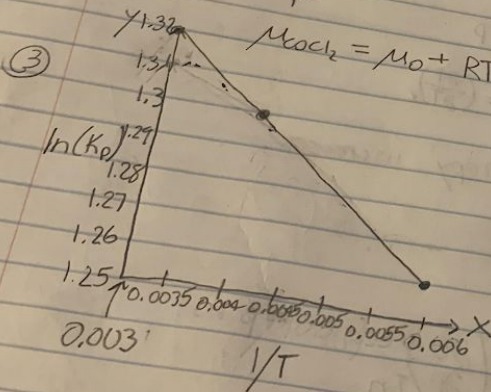
$$V_{\text{CO}_2} = \frac{(n_{\text{CO}_2} + n_{\text{CO}} + n_{\text{C}_2})RT}{P} \rightarrow \frac{n_{\text{CO}_2}RT + n_{\text{CO}}RT + n_{\text{C}_2}RT}{P}$$

$$\frac{\partial V}{\partial n_{\text{CO}_2}} = \frac{RT}{P}$$

Chemical potential will increase as pressure increases.

$$e) \int_{P^0}^P \mu_{\text{CO}_2} dP = \int_{P^0}^P \frac{RT}{P} dP \rightarrow RT \int_{P^0}^P \frac{dP}{P} = RT \ln \frac{P}{P^0}$$

$$\mu_{\text{CO}_2} = \mu_0 + RT \ln \frac{P}{P^0}$$



| T(K) | Kp   |
|------|------|
| 167  | 3.53 |
| 250  | 3.67 |
| 333  | 3.74 |

$$m = \frac{1.32 - 1.30}{0.003 - 0.004} = \frac{-20}{-0.001} = -20$$

$$1.32 = -20(0.003) + b$$

$$1.32 = -0.06 + b \rightarrow b = 1.38$$

$$\Delta H^\circ = -20 \quad \Delta S^\circ = 1.38$$



$$\begin{aligned}\Delta G_1^\circ &= -20 \text{ kJ/mol} - 167 \text{ K} (1.38 \times 10^{-3} \text{ kJ/mol K}) \approx -20.23 \text{ kJ/mol} \\ \Delta G_2^\circ &= -20 \text{ kJ/mol} - 250 \text{ K} (1.38 \times 10^{-3} \text{ kJ/mol K}) \approx -20.345 \text{ kJ/mol} \\ \Delta G_3^\circ &= -20 \text{ kJ/mol} - 333 \text{ K} (1.38 \times 10^{-3} \text{ kJ/mol K}) \approx -20.460 \text{ kJ/mol} \\ \Delta G_{\text{rxn}}^\circ &\approx -20 \text{ kJ/mol}\end{aligned}$$

The reaction is spontaneous because  $\Delta G_{\text{rxn}}^\circ < 0$ .

③ The reaction is entropically driven because  $\Delta S^\circ$  is positive.

④ The second law of thermodynamics is that entropy always increases in an isolated system.

⑤ The third law of thermodynamics is that if the temperature of a system is 0 K, the entropy is 0. This is different than energy or enthalpy because entropy will always be 0 at 0 K.

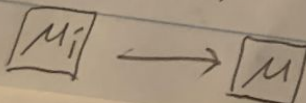
⑥ A perpetual motion machine can't be made because heat can't be converted to work with 100% efficiency.

⑦ Gibbs free energy is more useful to chemists because it's spontaneous (less than 0) at constant volume and pressure while Helmholtz energy is spontaneous at constant volume and temperature.

⑧  $\mu$  = chemical potential

$$\mu = \left( \frac{\partial G_A}{\partial n_A} \right)_{P,T}$$

It's called a potential because it goes from a higher to lower system.



$$\mu_i > \mu$$

⑨ The mixture of different types of molecules is spontaneous because  $\Delta G^\circ < 0$ .

$$\Delta G_{\text{mix}} = nRT \sum x_i \ln x_i = -RT \sum n_i \ln x_i \quad \text{where } x_i < 1 \text{ and } \ln x_i < 0$$

⑩ If  $\Delta G_{\text{mix}}^\circ > 0$  there will be more product than reactant.

$$\Delta G_{\text{mix}}^\circ = \sum \Delta G_{\text{products}}^\circ (n_{\text{products}}) - \sum \Delta G_{\text{reactants}}^\circ (n_{\text{reactants}})$$

EC  $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

The Gibbs free energy equation explains how spontaneous a chemical reaction is. It teaches how a chemical reaction will shift.

My partner was Nicodemo Mazzaferro. I asked no one else for help.