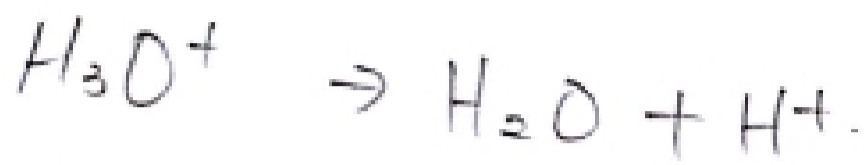
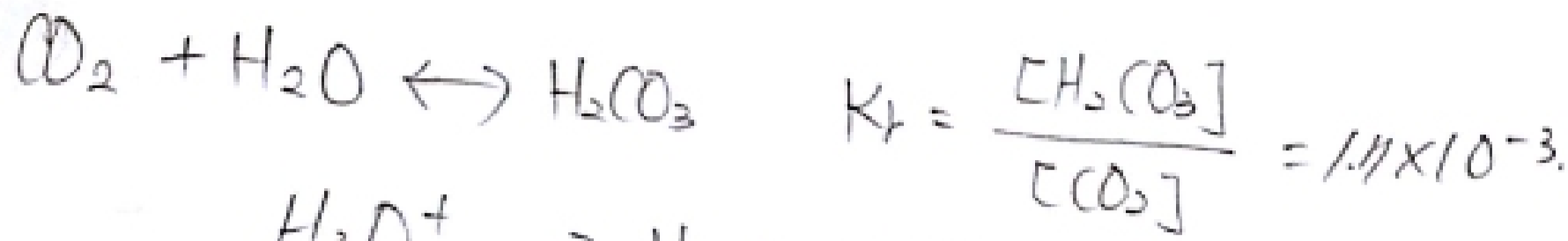


2014 thermo 1.



$$K_w = [\text{H}^+][\text{OH}^-] = 10^{-14}$$

$$K_{a1} = \frac{[\text{H}_3\text{O}^+][\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3][\text{H}_2\text{O}]} = \frac{[\text{H}^+][\text{H}_2\text{O}][\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3][\text{H}_2\text{O}]} = \frac{[\text{H}^+][\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]}$$
$$[\text{HCO}_3^-] = \frac{[\text{H}_2\text{CO}_3]K_{a1}}{[\text{H}^+]}$$

$$K_{a2} = \frac{[\text{H}^+][\text{CO}_3^{2-}]}{[\text{HCO}_3^-]}$$

$$pK_a = -\log K_a$$

$$pK_{a1} = 6.37 = -\log K_{a1}, \quad K_{a1} = 4.26 \times 10^{-7}$$

$$pK_{a2} = 10.25 = -\log K_{a2}, \quad K_{a2} = 5.62 \times 10^{-11}$$

$$[\text{CO}_2] = K_{\text{CO}_2}, \quad p_{\text{CO}_2} = 3.4 \times 10^{-2} \frac{\text{mol}}{\text{L} \cdot \text{atm}} \times$$

$$K_{a1} \times K_{a2} = \frac{[\text{H}^+][\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]} \times \frac{[\text{H}^+][\text{CO}_3^{2-}]}{[\text{HCO}_3^-]} = \frac{[\text{H}^+]^2 [\text{CO}_3^{2-}]}{[\text{H}_2\text{CO}_3]} = 2.4 \times 10^{-17}$$

hermo 2014 2.

$$d\eta = \lambda dV - \mathcal{L} dT$$

$$d\eta(V, T) = \underbrace{\left(\frac{\partial \eta}{\partial V}\right)_T}_{\lambda} dV + \underbrace{\left(\frac{\partial \eta}{\partial T}\right)_V}_{-\mathcal{L}} dT$$

$$\lambda = \frac{\partial}{\partial T} \left(\frac{\partial \eta}{\partial V}\right)_V = \frac{\partial}{\partial V} \left(\left(\frac{\partial \eta}{\partial T}\right)_V\right)_T$$

$$= \left(\frac{\partial \lambda}{\partial T}\right)_V = - \left(\frac{\partial \mathcal{L}}{\partial T}\right)_T.$$

b) $\alpha = \eta + T\mathcal{L}$

$$d\alpha = d\eta + \mathcal{L} dT + T d\mathcal{L}$$

$$d\alpha = \lambda dV - \mathcal{L} dT + \mathcal{L} dT + T d\mathcal{L} = \lambda dV + T d\mathcal{L}$$

Thermo

Total mole balance

$$n_F + n_G = n_R + n_E$$

1 Balance

$$0.99 n_F = n_R \times \alpha_1$$

2 Balance

$$0.01 n_F = 0.04 n_R + \alpha_2 n_E$$

3 Balance

$$n_S = \alpha_3 n_E$$

Find $\frac{n_S}{n_F}$, $n_S = (n_R + n_E - n_F) = \alpha_3 n_E$, $n_R + n_F = (\alpha_3 - 1) n_E$, $n_F = \frac{(\alpha_3 - 1) n_E}{n_R}$

$$n_F = \frac{n_R \alpha_1}{0.99} = \frac{0.001 n_R + n_E \alpha_2}{0.01} = \frac{(\alpha_3 - 1) n_E}{n_R}$$

$$\frac{(\alpha_3 - 1) n_E}{n_R} + \alpha_3 n_E = n_R + n_E$$

$$(\alpha_3 - 1) n_E + \alpha_3 n_E n_R = n_R^2 + n_E n_R$$

$$n_R^2 + n_E n_R - (\alpha_3 - 1) n_E - \alpha_3 n_E n_R = 0$$

$$n_R^2 + (1 - \alpha_3) n_E n_R + (1 - \alpha_3) = 0$$

$$\frac{-(1 - \alpha_3) \pm \sqrt{(1 - \alpha_3)^2 n_E^2 - 4(1 - \alpha_3)}}{2} = 0$$

$$n_R = \frac{-(1 - \alpha_3) \pm \sqrt{\alpha_3^2 - 2\alpha_3 + 1 - 4 + 4\alpha_3}}{2} = \frac{-(1 - \alpha_3) \pm \sqrt{\alpha_3^2 + 2\alpha_3 - 3}}{2}$$