2014 thermo 1.

$CO_2 + H_2O \leftrightarrow H_2CO_3$ $K_r = \frac{[H_2CO_3]}{[CO_2]} = 1.7 \times 10^{-3}$.

$H_3O^+ \rightarrow H_2O + H^+$.

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

$$K_{a1} = \frac{[H_3O^+][HCO_3^-]}{[H_2CO_3][H_2O]} = \frac{[H^+][H_2O][HCO_3^-]}{[H_2CO_3][H_2O]} = \frac{[H^+][HCO_3^-]}{[H_2CO_3]}$$

$$K_{a2} = \frac{[H^+][CO_3^{2-}]}{[HCO_3^-]}$$

$[HCO_3^-] = \frac{[H_2CO_3]K_{a1}}{[H^+]}$

$pKa = -\log Ka$

$pKa_1 = 6.37 = -\log Ka_1$, $Ka_1 = 4.26 \times 10^{-7}$

$pKa_2 = 10.25 = -\log Ka_2$, $Ka_2 = 5.62 \times 10^{-11}$

$[CO_2] = K_{CO_2} \cdot P_{CO_2} = 3.4 \times 10^{-2} \frac{mol}{L \cdot atm} \times$

$$Ka_1 \times Ka_2 = \frac{[H^+][HCO_3^-]}{[H_2CO_3]} \times \frac{[H^+][CO_3^{2-}]}{[HCO_3^-]} = \frac{[H^+]^2[CO_3^{2-}]}{[H_2CO_3]} = 2.4 \times 10^{-17}.$$

Thermo 2014 2.

$d\eta = \tau dv - \mathcal{L} dT$

$d\eta(v,T) = \underbrace{\left(\frac{\partial \eta}{\partial v}\right)_T}_{\tau} dv + \underbrace{\left(\frac{d\eta}{dT}\right)_v}_{\mathcal{L}} dT$

$= \frac{\partial}{\partial T}\left(\left(\frac{d\eta}{\partial v}\right)_T\right)_v = \frac{\partial}{\partial v}\left(\left(\frac{d\eta}{dT}\right)_v\right)_T$

$= \left(\frac{d\tau}{dT}\right)_v = -\left(\frac{d\mathcal{L}}{dT}\right)_T.$

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

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

$d\alpha = \tau dv - \mathcal{L}dT + \mathcal{L}dT + T d\mathcal{L} = \tau dv + T d\mathcal{L}$

1# Thermo 4.

Total mole balance

$n_F + n_C = n_R + n_E$

1 Balance

$0.99\, n_F = n_R x_{\alpha 1}$

2 balance

$0.01 n_F = 0.001 n_R + x_{\beta 2} n_E$

3 balance

$n_S = x_{\beta 3} n_E$

Find $\frac{n_S}{n_F}$, $n_S = (n_R + n_E - n_F) = x_{\beta 3} n_E$, $n_R + n_F = (x_{\beta 3} - 1) n_E$, $n_F = \frac{(x_{\beta 3} - 1) n_E}{n_R}$

$$n_F = \frac{n_R x_{\alpha 1}}{0.99} = \frac{0.001 n_R + n_E x_{\beta 2}}{0.01 F} = \frac{(x_{\beta 3} - 1) n_E}{n_R}$$

$$\frac{(x_{\beta 3} - 1) n_E}{n_R} + x_{\beta 3} n_E = n_R + n_E$$

$$(x_{\beta 3} - 1) n_E + x_{\beta 3} n_E n_R = n_R^2 + n_E n_R$$

$$n_R^2 + n_E n_R - (x_{\beta 3} - 1) n_E - x_{\beta 3} n_E n_R = 0$$

$$n_R^2 + (1 - x_{\beta 3}) n_E n_R + (1 - x_{\beta 3}) = 0$$

$$\frac{-(1 - x_{\beta 3}) \pm \sqrt{(1 - x_{\beta 3})^2 n_E^2 - 4(1 - x_{\beta 3})}}{2} = 0$$

$(x-3)(x+1)$

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