

## Henry's Law

### Acid

$$H_{eff} = K_H \left( 1 + \frac{K_1}{[H+]} \left( 1 + \frac{K_2}{[H+]} \right) \right)$$

### Base

$$H_{eff} = K_H \left( 1 + \frac{K_1}{K_2} [H+] \right)$$

### Where

$$K_H = k_{h298} \exp(dh_r \left( \frac{1}{T} - \frac{1}{298} \right))$$

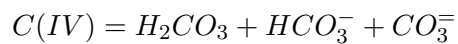
$$K_1 = k_{1298} \exp(dh_{1r} \left( \frac{1}{T} - \frac{1}{298} \right))$$

$$K_2 = k_{2298} \exp(dh_{2r} \left( \frac{1}{T} - \frac{1}{298} \right))$$

$$[H+] = 10^{-pH}$$

### Example Derivation of $H_{eff}$ for $CO_2$

Assume the compound and its anions are in equilibrium. Define a family for that species.  
For example,



Find the effective Henry's Law for that family,

$$H_{eff} = \frac{[C(IV)]}{pCO_2}$$

where  $p_{CO_2}$  is the partial pressure of  $CO_2$ . Based on the equilibria,

$$\begin{aligned} [H_2CO_3] &= K_H p_{CO_2} \\ [HCO_3^-] &= K_1 \frac{[H_2CO_3]}{[H^+]} \\ [CO_3^{=}] &= K_2 \frac{[HCO_3^-]}{[H^+]} \end{aligned}$$

substitute those equilibria into the  $C(IV)$  equation giving

$$H_{eff} = \left( K_H p_{CO_2} + K_1 \frac{[H_2CO_3]}{[H^+]} + K_2 \frac{[HCO_3^-]}{[H^+]} \right) / p_{CO_2}$$

and further substitution gives

$$H_{eff} = K_H + K_H \frac{K_1}{[H^+]} + K_H \frac{K_1 K_2}{[H^+]^2}$$

resulting in

$$H_{eff} = K_H \left( 1 + \frac{K_1}{[H^+]} \left( 1 + \frac{K_2}{[H^+]} \right) \right)$$