

7. Proton Competition and Keq

a) Question to Consider for any Acid and Base Equilibrium:

“Which side of the equilibrium is favored?”

(i.e.: which side, product or reactant, has a greater [])

(i.e.: if there are two acids in an equilibrium, which acid donates the proton better?)

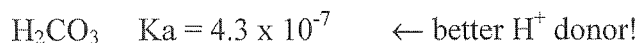


b) Proton Competition (Method 1)



i) The two acids are: H₂CO₃ and HCN

ii) The stronger acid will be a better proton donor:



iii) Therefore, the forward reaction is favored because H₂CO₃ is more successful at making its products. Thus, the **product side of the equilibrium is favored**.

c) Keq (Method 2)

i) Keq for an acid-base equilibrium can have the form:

$$\text{Keq} = \frac{\text{Ka}(\text{reactant acid})}{\text{Ka}(\text{product acid})}$$

(if desired, see p.131 for how this formula is derived)

$$\text{ii) Keq} = \frac{\text{Ka of H}_2\text{CO}_3}{\text{Ka of HCN}} = \frac{4.3 \times 10^{-7}}{4.9 \times 10^{-10}} = 880$$

iii) Large Keq (Keq > 1) means the **product side is favored**.

d) Examples

i) When NO_2^- and HC_2O_4^- are mixed:

a) What is the Bronsted-Lowry equilibrium?



b) Does equilibrium favor products or reactants?

Method 1

Compare HC_2O_4^- to HNO_2

HNO_2 is stronger, so reactants are favored.

Method 2

$$K_{\text{eq}} = \frac{K_{\text{a}}(\text{HC}_2\text{O}_4^-)}{K_{\text{a}}(\text{HNO}_2)} = \frac{6.4 \times 10^{-5}}{4.6 \times 10^{-4}} = 0.14$$

$K_{\text{eq}} < 1$ so reactants are favored.

ii) When HSO_3^- and H_2PO_4^- are mixed:

a) What is the Bronsted-Lowry equilibrium?



(Note: it is not $\text{HSO}_3^- + \text{H}_2\text{PO}_4^- \rightleftharpoons \text{H}_2\text{SO}_3 + \text{HPO}_4^{2-}$ because between the two reactants, HSO_3^- is the stronger acid so HSO_3^- donates the proton)

b) Does equilibrium favor products or reactants?

Method 1

Compare HSO_3^- to H_3PO_4

H_3PO_4 is stronger, so reactants are favored.

Method 2

$$K_{\text{eq}} = \frac{K_{\text{a}}(\text{HSO}_3^-)}{K_{\text{a}}(\text{H}_3\text{PO}_4)} = \frac{1.0 \times 10^{-7}}{7.5 \times 10^{-3}} = 1.3 \times 10^{-5}$$

$K_{\text{eq}} < 1$ so reactants are favored.