# Lecture Notes P: Acid-Base Chemistry III

## *1) Who wants protons more (or who wins in a fight for protons)*

Mix HF with NaCN, or mix NaF with HCN

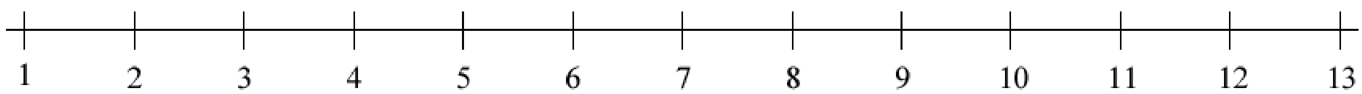
| | | | | |
|---|---|---|---|---|
| $HF + H_2O \rightleftharpoons$ | $H_3O^+ + F^-$ | $K_a = 6.6 \times 10^{-4}$ | $pKa = 3.18$ |
| $HCN + H_2O \rightleftharpoons$ | $H_3O^+ + CN^-$ | $K_a = 6.17 \times 10^{-10}$ | $pKa = 9.21$ |

***concept***
You have 50 ml of a complex mixture of weak acids that contains some HF and some HCN. Which is larger, $[F^-]/[HF]$ or $[CN^-]/[HCN]$?

(a) $[F^-]/[HF]$ (b) $[CN^-]/[HCN]$ (c) can't tell from available information

## *2) Once you know the pH, what does a weak acid look like.*

If you know the temperature of Pittsburgh, you can say what it feels like. This is much easier than calculating/predicting the temperature of Pittsburgh.



***Concept***

Some side chains in proteins contain sites that can exchange protons with the surrounding water (i.e. they are weak acids). Consider a protein with the following side chains,

| Amino Acid | side-chain | Amino Acid | side-chain |
|---|---|---|---|
| Arginine | $pK_a = 12.48$ | Histidine | $pK_a = 6.04$ |
| Aspartic Acid | $pK_a = 3.90$ | Lysine | $pK_a = 10.79$ |
| Cysteine | $pK_a = 8.33$ | Tyrosine | $pK_a = 10.13$ |
| Glutamic acid | $pK_a = 4.07$ | | |

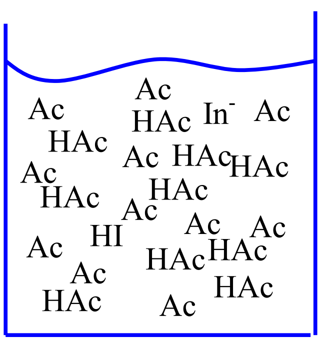
Given that the pH of blood is about 7.3, how many of the above side chains would be in their ionic form ($A^-$) in blood?

A) 2 B) 3 C) 4 D) 5

### 3) pH indicators

Consider an indicator that is a weak acid with $K_a = 1.4 \times 10^{-9}$ ($pK_a = 8.8$). The protonated form (HIn) is colorless, and the deprotonated form ($In^-$) is pink. [This is similar to the indicator Phenolphtalein.]

**Who is controlling the pH, and who is being controlled by the pH?**




What is the ratio between the protonated and deprotonated forms ([HA]/[$A^-$]) when the pH is 7.8?

What is the ratio between the protonated and deprotonated forms ([HA]/[$A^-$]) when the pH is 8.8?

What is the ratio between the protonated and deprotonated forms ([HA]/[$A^-$]) when the pH is 9.8?

### *4) How buffers work.*

As the pH changes, the ratio of $[A^-]/[HA]$ changes.

Corollary: To change the pH you have to change the ratio $[A^-]/[HA]$.

So if you have a bunch of $[A^-]$ and $[HA]$ present, and you want the pH to go up, you have to convert most of the HA into $A^-$.

Consider starting with 100ml of a mixture in which $[A^-] = [HA] = 1M$.

Now add enough $OH^-$ to convert half the HA into $A^-$ (50ml of 1M NaOH).

$$HA + OH^- \leftrightarrow A^- + H_2O \qquad K = 1/K_b = K_a/K_w >> 1$$

If you had added 50ml of 1M NaOH to 100ml of water, the pH would be:

Similarly, if you add enough $H_3O^+$ to convert half the $A^-$ into HA (50 ml of 1M HCl).

$$A^- + H_3O^+ \leftrightarrow HA + H_2O \qquad 1/K_a >> 1$$

If you had added 50ml of 1M NaOH to 100ml of water, the pH would be: