Problem Chap 18 #111

What is the pH of 0.150 M KCN?

$$KCN_{(aq)} + H_2O_{(e)} \rightleftharpoons KOH_{(aq)} + HCN_{(aq)}$$

spectator
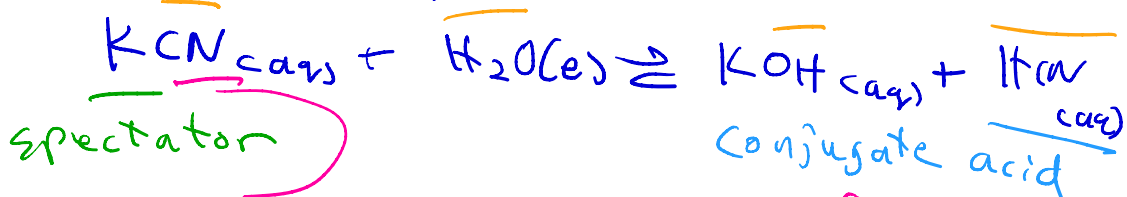
Conjugate acid

CN^- is the conjugate of a weak acid.

$K_{a\,(HCN)} = 6.2 \times 10^{-10}$

Need: K_B of CN^-

$$CN^-_{(aq)} + H_2O_{(l)} \rightleftharpoons OH^-_{(aq)} + HCN_{(aq)}$$
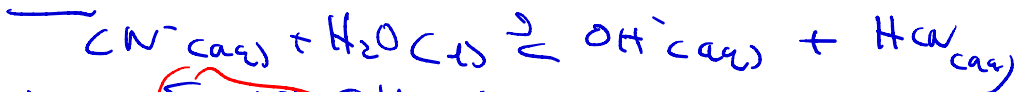
$$K_b = \frac{[OH^-][HCN]}{[CN^-]}$$

once the problem is solved, $[OH^-]$ has to be coverted into pH
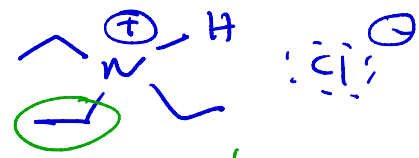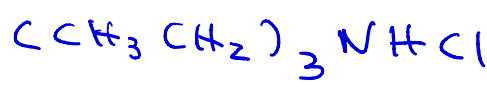

How can the conjugate of a weak acid also be weak?

$$K_b\,(CN^-) = \frac{1.0 \times 10^{-14}}{6.2 \times 10^{-10}} = 1.61 \times 10^{-5}$$
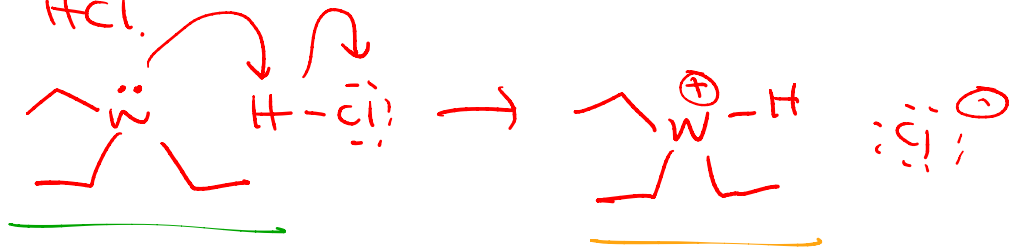
K_w @ 25°C

K_a and $K_b \ll 1 \rightarrow$ both weak

The stronger a conjugate acid is, the weaker the conjugate base is.

what is the pH of 0.40M triethylammonium chloride?

$(CH_3CH_2)_3NHCl$ →

[structure: ethyl-N$^{\oplus}$-H with $:\ddot{Cl}:^{\ominus}$]

ethyl = 2 carbons

This is the product of a base neutralized with HCl.

[reaction structures: Brønsted-Lowry base + $H-\ddot{Cl}:$ → conjugate acid $N^{\oplus}-H$ with $:\ddot{Cl}:^{\ominus}$]

Brønsted-Lowry base

The conjugate is a (weak) acid

Cl^- is ignored because it is the conjugate of an extremely strong acid, so Cl^- is a very weak base (non-reactive)

[equilibrium structures: $N^{\oplus}-H$ ⇌ N + $H^{\oplus}$]

HA$^+$ A   H$^+$
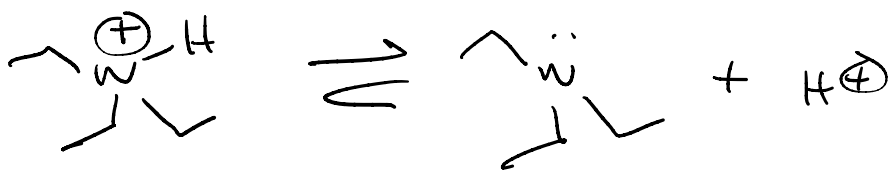
$K_a = \dfrac{[H^+][A]}{[HA^+]}$

conjugate K_a of triethylamine

- Definitions of acids + bases
  (Arrhenius + Brønsted-Lowry)
- strong and weak acids & bases
- the four types of problems
  1) pH(/pOH) of an acid
  2) pH/pOH of a base
  3) pH/pOH of conjugate of acid
  4) pH/pOH of conjugate of base

- K_w, K_a, K_b ($K_w = K_a \cdot K_b$)
- pK_w, pH, pOH $pK_w = pH + pOH$

If you know the pH of an acid and the concentration of the acid, the K_a can be calculated using an ICE table ($pH \rightarrow [H^+] \rightarrow x$)

If only pH is known, not the acid concentration, the strength of the acid cannot be determined. For example, a solution of pH 5 could be a relatively concentrated solution of acetic acid or a very dilute sol'n of HCl.
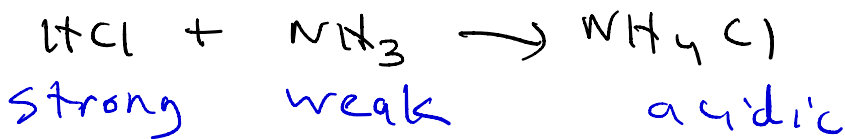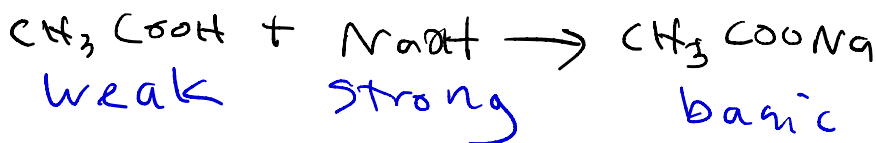
— neutral vs neutralize

$[H^+] = [OH^-]$ $n_{acid} = n_{base}$

not
acid = base

not

$[H^+] = [OH^-]$

If the strength of an acid and base are not the same, even if they react in equal number of moles, they will not dissociate to produce the same amount of H^+ and OH^-, so the soln may be neutralized, but not neutral.

$CH_3COOH + NaOH \longrightarrow CH_3COONa$

weak   strong   basic

$HCl + NH_3 \longrightarrow NH_4Cl$

strong   weak   acidic

Thermodynamics

what is ΔG? $\Delta G < 0$ $\Delta G > 0$

— spontaneous or not

— $\Delta G = \Delta H - T\Delta S$

what is ΔS? $\Delta S < 0$ $\Delta S > 0$

Formation of an aqueous soln of ammonium nitrate.