UNIVERSITY of FLORIDA

Pre-Health Post-Baccalaureate Program
Study Guide and Practice Problems

Course: CHM2046

Textbook Chapter: 18.5 - 18.9 (Silberberg 6e)

Topics Covered: Acid-Base, Part 2

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1. More K!

Last time, we talked about the acid-ionization constant, which we called K_a. K_a tells us how strong an acid is, because it tells us to what extent that acid dissociates.

We can follow this same process to come up with - yeah, you guessed it - K_b, the base-ionization constant. The higher this value, the more basic a base is.

For the sample reaction:

$$B_{(aq)} + H_2O_{(l)} \rightleftharpoons BH^+_{(aq)} + {}^-OH_{(aq)}$$

The base-ionization constant is give by multiplying K_c by $[H_2O]$, as we did before:

$$K_c = \frac{[BH^+][HO^-]}{[B][H_2O]}$$

$$K_b = [H_2O]K_c = \frac{[BH^+][HO^-]}{[B]}$$

For any A-B reaction, the K_a of the acid multiplied by the K_b of the conjugate base equals K_w. Why is this? Let's take a look mathematically:

$$\frac{[H_3O^+]\cancel{[A^-]}}{\cancel{[HA]}} \times \frac{\cancel{[HA]}[HO^-]}{\cancel{[A^-]}} = [H_3O^+][HO^-]$$

$$K_a \times K_b = K_w$$

2. Using Periodic Trends to Determine Acid Strength

To determine acid strength qualitatively, we will use SERI.

S - size

As the atomic size of an atom bonded to an acidic hydrogen increases, the bond strength between the two atoms decreases, and the hydrogen is more likely to get “plucked off” (donated).

E - electronegativity

As the electronegativity of an atom bonded to an acidic hydrogen increases, the electronegative atom “hogs” the electrons that make up the bond, giving the hydrogen a partial positive charge and making it more likely to get “plucked off” (donated).

R - resonance

{Have you learned this yet?}

If a molecule can be stabilized through resonance once it has been de-protonated, it is more likely to lose its acidic proton.

<u>I - Inductive Effect</u>

{Have you learned this yet?}

If a molecule can be stabilized by neighboring sp3 electron "clouds" once it has been de-protonated, it is more likely to lose its acidic proton.

Two other common cases:

If we are comparing the acidities of oxoacids with different numbers of oxygen atoms, the molecule with more oxygen atoms will be more acidic (better resonance stabilization).

If we have a small but positively charged metal ion surrounded by water molecules, the electron density in the water bonds is drawn towards the metal ion. Other water molecules in solution begin to de-protonate the now more polar bonded water molecules.

The A-B Behavior of Salts in Water

Ions in rxn	relative acidity
SB Cat + SA An	Neutral
WB Cat + SA An	Acidic
Metal Cat + SA An	Acidic
WB Cat + WA An	Acidic or Basic
SB Cat + Polyprotic A	Acidic or Basic

It's easier and more practical to just get good at predicting reaction products than to memorize this table, and using the previous two slides will help.

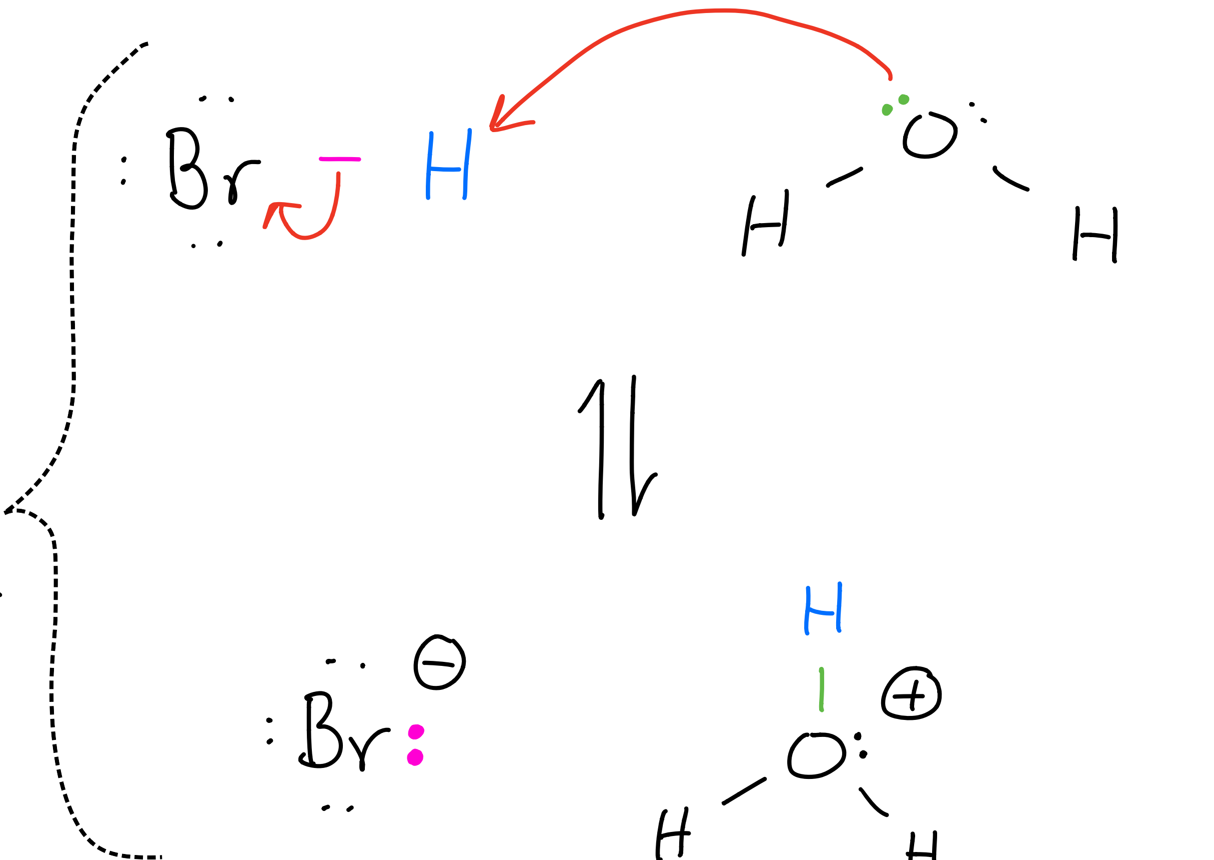
<u>Lewis A-B Definition</u>

B-L A-B is all about protons: acids donate protons, while bases accept protons.

Lewis A-B is all about electron pairs: acids accept electron pairs (electrophiles, get “attacked”), while bases donate electron pairs (nucleophiles, “attackers”).

reaction equation { $HBr + H_2O \rightleftharpoons H_3O^+ + Br^-$ }

reaction mechanism



Problems:

① $(CH_3)_2NH$ has a K_b of 5.9×10^{-4}. What is the pH of 1.5 M $(CH_3)_2NH$?

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	$(CH_3)_2NH_{(aq)}$	$+ H_2O_{(l)}$	$\rightleftharpoons (CH_3)_2\overset{\oplus}{N}H_{2\,(aq)}$	$+ HO^{\ominus}_{(aq)}$
I	1.5	—	0	0
C	$-x$	—	$+x$	$+x$
E	$1.5 - x$	—	x	x

$$K_b = \frac{[(CH_3)_2\overset{\oplus}{N}H_2][HO^{\ominus}]}{[(CH_3)_2NH]} \approx \frac{x^2}{1.5} = 5.9 \times 10^{-4}$$

$$x = \sqrt{(5.9 \times 10^{-4})(1.5)} = [HO^{\ominus}] = 3 \times 10^{-2}\,M$$

$$pH = -\log[H_3O^{\oplus}] = -\log\left(\frac{K_w}{[HO^{\ominus}]}\right)$$

$$= -\log\left(\frac{1 \times 10^{-14}}{3 \times 10^{-2}}\right)$$

$$= 12.48$$

(2) Write the A-B reaction equation for the reaction between sodium benzoate ($C_6H_5COO^{-}Na^{+}$) and water, and then predict if sodium benzoate is acidic, basic, or neutral.

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$$C_6H_5COO^{\ominus}_{(aq)} + H_2O_{(l)} \rightleftharpoons C_6H_5COOH_{(aq)} + HO^{\ominus}$$

$HO^{\ominus}$ is produced, ∴ basic

③ Define, in your own words, the following terms:

a) B-L acid

b) B-L base

c) Lewis acid

d) Lewis base

③ Define, in your own words, the following terms:

a) B-L acid

$H^{\oplus}$ donor

b) B-L base

$H^{\oplus}$ acceptor

c) Lewis acid

Electron pair acceptor

d) Lewis base

Electron pair donor

④ Identify the Lewis acid and base in the following reaction:

$$Na^{\oplus} + 6\,H_2O \rightleftharpoons Na(H_2O)_6^{\oplus}$$

(4) Identify the Lewis acid and base in the following reaction:

$$Na^{\oplus} + 6\,H_2O \rightleftharpoons Na(H_2O)_6^{\oplus}$$

acid base