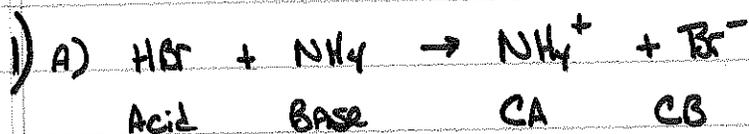
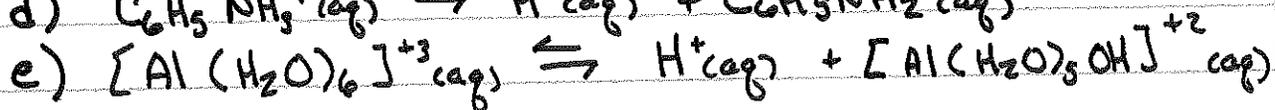
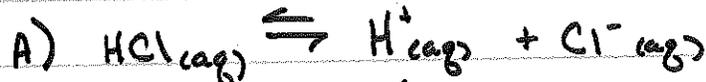


## AP Chem - Unit 10 - NMSI - Acid + Bases



2)



$$60^\circ\text{C} \quad K_w = 1 \times 10^{-13}$$

A)

$$K_w \text{ normally } = 1 \times 10^{-14} \text{ @ } 25^\circ\text{C}$$

So  $K_w$  has increased as system heated

$\therefore K_w \uparrow$  with Temp, think of Energy as a reactant

So the process must be endothermic

B)

$$K_w = [\text{OH}^-][\text{H}_3\text{O}^+]$$

$$[\text{OH}^-] = [\text{H}_3\text{O}^+] \text{ for neutral soln}$$

$$\text{@ } 60^\circ\text{C} \quad 1 \times 10^{-13} = (x)(x)$$

$$x = 3 \times 10^{-7} \text{ M}$$

$$[\text{OH}^-] = [\text{H}_3\text{O}^+] = 3 \times 10^{-7} \text{ M}$$

## AP Chem - Unit 10 - NMSE Acid + Bases

6)  $K_w = 1.0 \times 10^{-14} \text{ M}$   $[\text{H}^+]$  or  $[\text{OH}^-] = ?$

A)  $[\text{OH}^-] = 1.0 \times 10^{-5} \text{ M OH}^-$

$$K_w = [\text{OH}^-][\text{H}^+]$$

$$[\text{H}^+] = \frac{K_w}{[\text{OH}^-]} = \frac{1.0 \times 10^{-14} \text{ M}}{1.0 \times 10^{-5} \text{ M}} =$$

$$[\text{H}^+] = 1.0 \times 10^{-9} \text{ M}$$

$$\text{pH} = -\log[\text{H}^+] = -\log[1.0 \times 10^{-9}]$$

$$\text{pH} = 9.0 \text{ BASIC}$$

B)  $[\text{OH}^-] = 1.0 \times 10^{-7} \text{ M}$

$$K_w = [\text{OH}^-][\text{H}^+]$$

$$[\text{H}^+] = \frac{K_w}{[\text{OH}^-]} = \frac{1.0 \times 10^{-14}}{1.0 \times 10^{-7}}$$

$$[\text{H}^+] = 1.0 \times 10^{-7} \text{ M}$$

$$\text{pH} = -\log[\text{H}^+]$$

$$\text{pH} = 7.0 \text{ Neutral}$$

C)  $[\text{H}^+] = 10.0 \text{ M}$

$$K_w = [\text{OH}^-][\text{H}^+]$$

$$[\text{OH}^-] = K_w / [\text{H}^+] = \frac{1.0 \times 10^{-14}}{10.0}$$

$$[\text{OH}^-] = 1.00 \times 10^{-15}$$

$$\text{pH} = -\log[\text{H}^+] = -\log[10.0]$$

$$\text{pH} = 1.0 \text{ Acidic}$$

## AP Chem - Unit 10 - NMSI - A+B

7) A)  $pOH = -\log[OH^-] = -\log[1.0 \times 10^{-3} M]$   
 $pOH = 3.0$   
 $pH = 14 - 3.0$   
 $pH = 11.0$

B)  $pH = -\log[H^+] = -\log[1.0]$   
 $pH = 0.0$   
 $pOH = 14 - 0.0$   
 $pOH = 14$

8)  $pOH, [H^+], [OH^-] = ?$  for  $pH = 7.41$

$$pOH = 14 - 7.41$$

$$pOH = 6.59$$

$$pH = -\log[H^+]$$

$$7.41 = -\log[H^+] \quad (\text{use } 10^x)$$

$$[H^+] = 10^{-7.41}$$

$$[H^+] = 3.9 \times 10^{-8} M$$

$$pOH = -\log[OH^-]$$

$$6.59 = -\log[OH^-]$$

$$[OH^-] = 2.57 \times 10^{-7}$$

9) A)  $pH = ?$   $0.1 M HNO_3$   $HNO_3$  is strong Acid  $\therefore$  complete dissociation of  $H^+$   
 $pH = -\log[H^+] = -\log[0.10]$   
 $pH = 1.00$

B)  $pH = ?$   $1.0 \times 10^{-10} M HCl$   $HCl$  is strong Acid But  $1.0 \times 10^{-10}$  is so small that  $[H^+]$  has no effect  
 $\therefore pH$  is of pure water  $= 7.00$

AP Chem - Unit 10 - NMSI - A+B

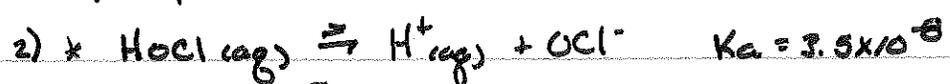
b)  $\text{pH} = ?$   $5.0 \times 10^{-2} \text{ M NaOH soln}$   
 $\text{pOH} = -\log[\text{OH}^-] = -\log[5.0 \times 10^{-2}]$   
 $\text{pOH} = 1.3$

$\text{pH} = 14 - 1.3$   
 $\boxed{\text{pH} = 12.7}$

11)  $\text{HOCl}$   $K_a = 3.5 \times 10^{-8}$   $\text{pH} = ?$   $0.100 \text{ M HOCl(aq)}$   
 weak acid

steps

1) major species  $\text{HOCl} + \text{H}_2\text{O}$  Both produce  $[\text{H}^+]$



$\text{HOCl}$  is much stronger than  $\text{H}_2\text{O}$   $\therefore$   $\text{HOCl}$  only species for  $[\text{H}^+]$

3)  $K_a = \frac{[\text{H}^+][\text{OCl}^-]}{[\text{HOCl}]}$

$3.5 \times 10^{-8} = \frac{(x)(x)}{0.100}$

$x = 5.9 \times 10^{-5}$

	$\text{HOCl}$	$\rightleftharpoons$	$\text{H}^+(\text{aq})$	$+$	$\text{OCl}^-(\text{aq})$
I	.100M		0		0
C	-x		+x		+x
E	.100 - x		x		x

.100 Because  $K_a$  so small ignore x

4) 5% Rule?

$\frac{x}{[\text{HOCl}]_0} \times 100 \Rightarrow \frac{5.9 \times 10^{-5}}{.100} \times 100 = 0.059\% \therefore$  WAS OK to ignore

5)  $\text{pH} = -\log[\text{H}^+]$   
 $\text{pH} = -\log[5.9 \times 10^{-5}]$   
 $\text{pH} = 4.2$

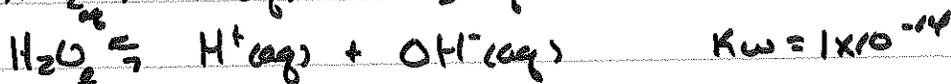
## AP Chem - Unit 10 - NMSI - Acids &amp; Base

12) Given: soln of 1.00 M HCN  $K_a = 6.2 \times 10^{-10}$  Find: PH ?  
 5.00 M HNO<sub>2</sub>  $K_a = 4.0 \times 10^{-4}$  [CN<sup>-</sup>]

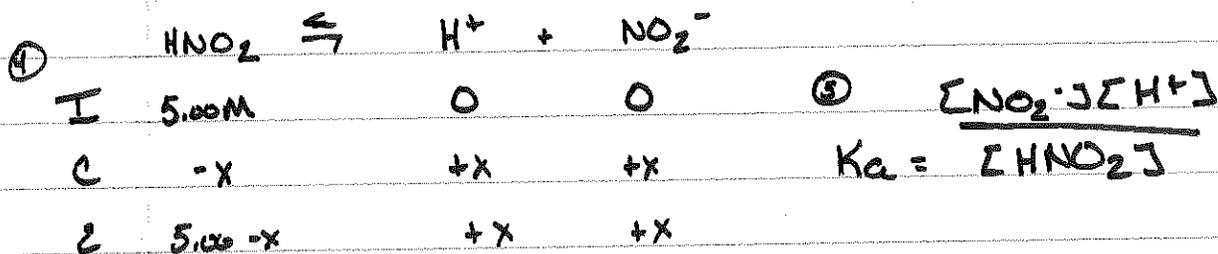
① Major species



② All 3 produce [H<sup>+</sup>]



③ HNO<sub>2</sub> is a much stronger Acid than HCN & H<sub>2</sub>O due to its  $K_a$  value  $\therefore$  HNO<sub>2</sub> is dominate H<sup>+</sup> producer



$\therefore$  Assume x is below 5% Rule

$$K_a = \frac{(x)(x)}{[5.00]}$$

$$5.00(4.0 \times 10^{-4}) = x^2$$

$$x = 0.045$$

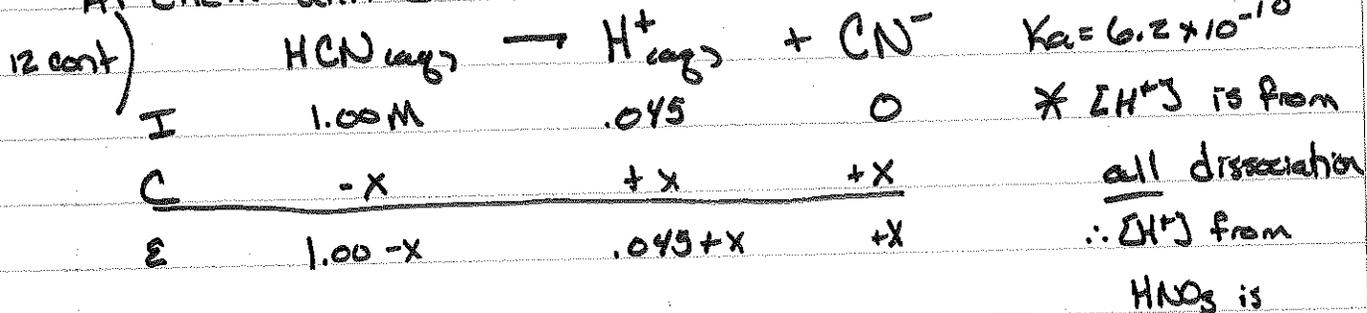
⑥ Check 5% Rule

$$\frac{x}{[\text{HNO}_2]_0} \times 100 \Rightarrow \frac{0.045}{5.00 \times 100} = .90\% \quad \text{good!}$$

$$\text{PH} = -\log [\text{H}^+] = -\log [0.045]$$

$$\boxed{\text{PH} = 1.35}$$

AP Chem - Unit 10 - Nmat A+B

Assume x is negligible due to small  $K_a$ 

$$K_a = \frac{[\text{H}^+][\text{CN}^-]}{[\text{HCN}]}$$

$$[\text{CN}^-] = \frac{K_a [\text{HCN}]}{[\text{H}^+]} = \frac{(6.2 \times 10^{-10})(1.00)}{(0.045)}$$

$$[\text{CN}^-] = 1.4 \times 10^{-8} \text{ M}$$

13) A) 1.00 M  $\text{HC}_2\text{H}_3\text{O}_2$  ?% dissociation  $K_a = 1.8 \times 10^{-5}$  $\text{HC}_2\text{H}_3\text{O}_2$  will be dominate  $[\text{H}^+]$  in equilibrium

I	1.00	0	0
C	-x	x	x
E	1.00 - x	x	x

Assume x to small compared to due to  $K_a$ 

$$K_a = \frac{[\text{H}^+][\text{C}_2\text{H}_3\text{O}_2^-]}{[\text{HC}_2\text{H}_3\text{O}_2]} \Rightarrow \frac{(x)(x)}{1.00} = 1.8 \times 10^{-5}$$

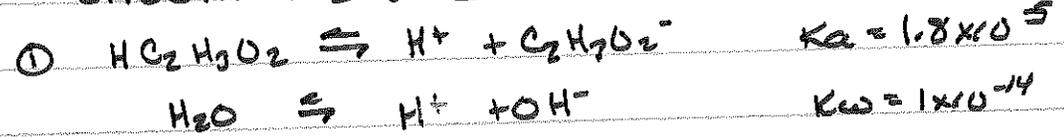
$$x = 4.2 \times 10^{-3} = [\text{H}^+]$$

$$\% \text{ dissociation } = \frac{[\text{H}^+]}{[\text{HC}_2\text{H}_3\text{O}_2]} \times 100 \Rightarrow \frac{4.2 \times 10^{-3}}{1.00} \times 100 = \boxed{.42\%}$$

AP Chem - Unit 10 - NMSE - A+B

13 cont)

B) 0.100 M HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>    K<sub>a</sub> = 1.8 x 10<sup>-5</sup>



HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub> will be dominate [H<sup>+</sup>] in equilibrium

HC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>	→	H <sup>+</sup>	+	C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> <sup>-</sup>
.100 M		0		0
-x		x		x
.100 - x		x		x

x is small due to small K<sub>a</sub>

$$K_a = \frac{[\text{H}^+][\text{C}_2\text{H}_3\text{O}_2^-]}{[\text{HC}_2\text{H}_3\text{O}_2]}$$

$$\% \text{ dissociation} = \frac{[\text{H}^+]}{[\text{HC}_2\text{H}_3\text{O}_2]} \times 100$$

$$= \frac{1.3 \times 10^{-3}}{.10} \times 100$$

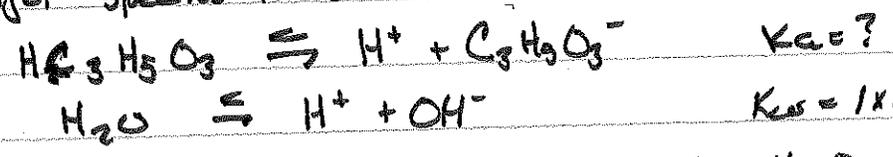
$$1.8 \times 10^{-5} = \frac{(x)(x)}{.100}$$

$$x = [\text{H}^+] = 1.3 \times 10^{-3} \text{ M}$$

$$= 1.3\%$$

14) HC<sub>3</sub>H<sub>5</sub>O<sub>3</sub>, 0.100 M, 3.7% dissociated, K<sub>a</sub> = ?

① major species in soln



HC<sub>3</sub>H<sub>5</sub>O<sub>3</sub> is weak acid, But stronger than H<sub>2</sub>O

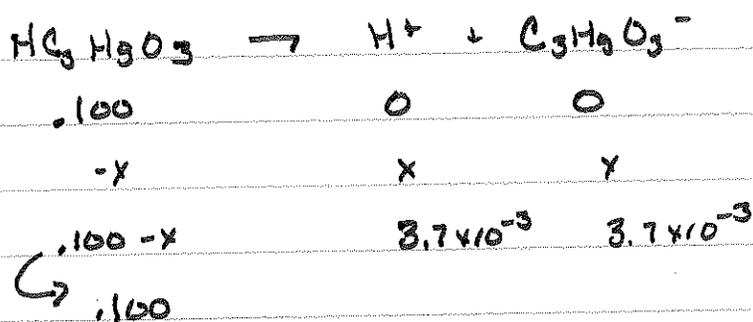
∴ dominate source of [H<sup>+</sup>] in equilibrium

$$K_a = \frac{[\text{H}^+][\text{C}_3\text{H}_5\text{O}_3^-]}{[\text{HC}_3\text{H}_5\text{O}_3]}$$

$$\% \text{ dissociation} = \frac{[\text{H}^+]}{[\text{HC}_3\text{H}_5\text{O}_3]} \times 100$$

$$3.7 = \frac{[\text{H}^+]}{(.100)} \times 100$$

14 cont)  $[H^+] = 3.7 \times 10^{-3} M$



$$K_a = \frac{[H^+][C_3H_5O_3^-]}{[HC_3H_5O_3]} = \frac{(3.7 \times 10^{-3})(3.7 \times 10^{-3})}{.100}$$

$$K_a = 1.4 \times 10^{-4}$$

15)  $NH_3$   $K_b = 1.8 \times 10^{-5}$  15.0 M, pH?

① main species



$NH_3$   $[OH^-]$  will dominate  $K_b \gg K_w$



$$I \quad 15.0 M \quad 0 \quad 0$$

$$C \quad -x \quad x \quad x$$

$$\Sigma \quad 15.0 - x \quad x \quad x$$

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]} = \frac{(x)(x)}{15.0} = 1.8 \times 10^{-5}$$

Assume 5%

$$x = .016$$

Check 5%

$$\frac{[OH^-]}{[NH_3]_0} \times 100 = \frac{.016}{[15.00]} \times 100$$

$$.11\% \therefore \underline{\underline{OK}}$$

15 cont)  $pOH = -\log [OH^-] = -\log [0.016]$   
 $= 1.80$

$pH = 14 - pOH$   
 $pH = 12.20$

16) methylamine  $NH_2CH_3$   $K_b = 4.38 \times 10^{-4}$  1.0M pH = ?

① main species

	$NH_2CH_3$	$H_2O$	neglect $H_2O$	$K_b \gg K_w$
	$H_2O + NH_2CH_3 \rightleftharpoons CH_3NH_3^+ + OH^-$			
I	1.0	0	0	
C	-x	x	x	
E	<u>1.0 - x</u>	<u>x</u>	<u>x</u>	

assume 5%

$K_b = \frac{[CH_3NH_3^+][OH^-]}{[NH_2CH_3]} \Rightarrow \frac{(x)(x)}{1.0} = 4.38 \times 10^{-4}$

$x = .021$

check 5%

$\frac{x}{[NH_2CH_3]_0} \times 100$   
 $\frac{.021}{1.03} \times 100 = 2.1\% \text{ OK}$

$pOH = -\log [OH^-] = -\log [0.021]$   
 $= 1.679$

$pH = 14 - pOH$   
 $pH = 12.32$

17)  $\text{pH} = ?$  5.0 M  $\text{H}_3\text{PO}_4$   $[\text{H}_3\text{PO}_4], [\text{H}_2\text{PO}_4^-], [\text{HPO}_4^{2-}] = ?$

major species



$\text{H}_3\text{PO}_4 \text{ } K_{a1} = 7.5 \times 10^{-3}$

$K_a \gg K_w$

Neglect  $\text{H}_2\text{O}$

$[\text{PO}_4^{3-}]$



I	5.0 M	0	0
C	-x	x	x
E	5.0 - x	x	x

Assume 5%

$K_a = \frac{[\text{H}^+][\text{H}_2\text{PO}_4^-]}{[\text{H}_3\text{PO}_4]} \quad 7.5 \times 10^{-3} = \frac{(x)(x)}{5.0}$

$\text{pH} = -\log [\text{H}^+] = -\log (.19)$

$x = .19 \text{ M}$

$\text{pH} = .72$

5% check  $\frac{.19}{5.0} \times 100$

= 3.8% OK

$[\text{H}_3\text{PO}_4] = 5.0 - .19$

$[\text{H}_3\text{PO}_4] = 4.28 \text{ M}$

$[\text{H}_2\text{PO}_4^-] = .19 \text{ M}$



I	.19 M	.19 M	0
C	-x	x	x
E	.19 - x	.19 + x	x

$K_{a2} = 6.2 \times 10^{-8}$

$K_{a2} = \frac{[\text{H}^+][\text{HPO}_4^{2-}]}{[\text{H}_2\text{PO}_4^-]}$

Assume 5%

$6.2 \times 10^{-8} = \frac{[.19][\text{HPO}_4^{2-}]}{[.19]}$

$[\text{HPO}_4^{2-}] = 6.2 \times 10^{-8} \text{ M}$

5% check

easy less than 5% OK

$.19 \gg 6.2 \times 10^{-8}$   
C

17 cont)

	$\text{HPO}_4^{-2} \rightleftharpoons \text{H}^+ + \text{PO}_4^{-3}$	
I	$6.2 \times 10^{-8} \text{ M}$	$.19 \text{ M}$
C	$-x$	$x$
E	$6.2 \times 10^{-8} - x$	$.19 - x$

$K_{a3} = 4.8 \times 10^{-13}$

Assume 5%

$$K_{a3} = \frac{[\text{H}^+][\text{PO}_4^{-3}]}{[\text{HPO}_4^{-2}]}$$

$$4.8 \times 10^{-13} = \frac{[.19][\text{PO}_4^{-3}]}{6.2 \times 10^{-8}}$$

$[\text{PO}_4^{-3}] = 1.6 \times 10^{-19} \text{ M}$

18)  $\text{pH} = ?$  1.0 M  $\text{H}_2\text{SO}_4$   
major species



$\text{H}_2\text{SO}_4$  will dissociate  $2x \therefore 2x[\text{H}^+]$ .  $\text{HSO}_4^-$  1<sup>st</sup> product,  
But will 2<sup>nd</sup> dissociation increase  $[\text{H}^+]_{\text{total}}$  concentration

	$\text{HSO}_4^- \rightarrow \text{H}^+ + \text{SO}_4^{-2}$
I	1.0 M      1.0 M      0
C	$-x$ $x$ $x$
E	$1.0 - x$ $1.0 + x$ $x$

Table 14H  $K_{a2} = 1.2 \times 10^{-2}$   
 $\text{H}^+$  is 1.0 M since strong  
acid complete dissociation

Assume 5%

$$K_{a2} = \frac{[\text{H}^+][\text{SO}_4^{-2}]}{[\text{HSO}_4^-]}$$

$$1.2 \times 10^{-2} = \frac{[1.0][x]}{[1.0]}$$

$x = 1.2 \times 10^{-2}$

AP Chem - Unit 9 - NMSI - A+B

18) cont

5% check

$$\frac{[H^+]}{[HSO_4^-]_0} = \frac{1.2 \times 10^{-2}}{1.0} \times 100 = 1.2\% \quad \underline{OK}$$

$$[H^+] = 1.0 + .012$$

$$[H^+] = 1.0$$

$$pH = -\log[H^+] = -\log[1.0]$$

$$\boxed{pH = 0.0}$$

$\therefore$  The dissociation of  $HSO_4^-$  does not make a significant contribution to  $[H^+]$

AP Chem - Unit 10 - NMSI A+B

20)

A)  $\text{NaC}_2\text{H}_3\text{O}_2$

1)  $\text{HC}_2\text{H}_3\text{O}_2$  - weak acid

$\rightarrow$  Basic

Strong is spectator

2)  $\text{NaOH}$  - strong Acid

~~$\text{NaC}_2\text{H}_3\text{O}_2$~~



Basic

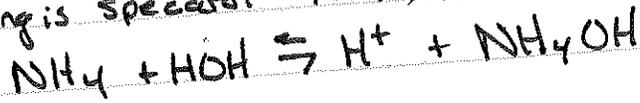
B)  $\text{NH}_4\text{NO}_3$

1)  $\text{NH}_4\text{OH}$  - weak Base

$\rightarrow$  Acidic

2)  $\text{HNO}_3$  - strong Acid

Strong is spectator  ~~$\text{NH}_4\text{NO}_3$~~



Acidic

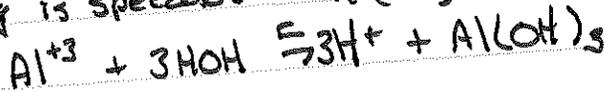
C)  $\text{Al}_2(\text{SO}_4)_3$

1)  $\text{Al}(\text{OH})_3$  - weak Base

$\rightarrow$  Acidic

2)  $\text{H}_2\text{SO}_4$  - strong Acid

Strong is spectator  ~~$\text{Al}_2(\text{SO}_4)_3$~~



Acidic

AP Chem - Unit 10 - NMSI - A+B

21)  $\text{pH} = ?$  0.30 M NaF,  $K_a = 7.2 \times 10^{-4}$  for HF

NaF

1) HF weak acid



2) NaOH strong Base

I .30M - 0 0

~~NaF~~ strong is spectator C

Assume 5%

$$K_b = \frac{[\text{OH}^-][\text{HF}]}{[\text{F}^-]}$$

 $K_b = ??$ 

$$K_a K_b = K_w$$

$$K_b = \frac{K_w}{K_a} = \frac{1 \times 10^{-14}}{7.2 \times 10^{-4}}$$

$$K_b = 1.4 \times 10^{-11}$$

$$1.4 \times 10^{-11} = \frac{(x)(x)}{.30}$$

$$x = 2.0 \times 10^{-6}$$

$$[\text{OH}^-] = x$$

$$\text{pOH} = -\log[\text{OH}^-]$$

$$\text{pOH} = 5.7$$

$$\text{pH} = 14 - \text{pOH}$$

$$\boxed{\text{pH} = 8.3}$$

$$\frac{5\% \text{ check}}{2.0 \times 10^{-6}} \times 100 = .00067\%$$

OK

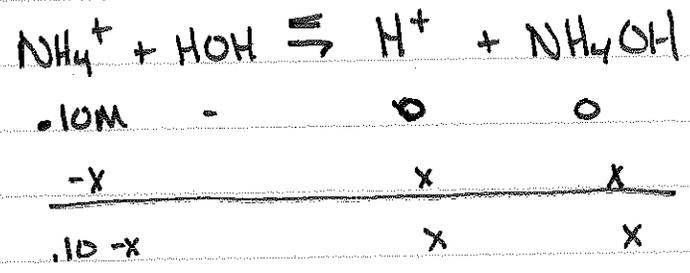
22) pH? of 0.10M  $\text{NH}_4\text{Cl}$ .  $K_b = 1.8 \times 10^{-5}$  for  $\text{NH}_3$

$\text{NH}_4\text{Cl}$

1)  $\text{NH}_4\text{OH}$  weak Base

2)  $\text{HCl}$  strong Acid

$\text{NH}_4\text{Cl}$  strong is spectator



$$K_a = \frac{[\text{H}^+][\text{NH}_4\text{OH}]}{[\text{NH}_4^+]}$$

Assume 5%

$K_a = ?$

$$K_a K_b = K_w$$

$$K_a = \frac{K_w}{K_b} = \frac{1 \times 10^{-14}}{1.8 \times 10^{-5}}$$

$$= 5.6 \times 10^{-10}$$

5% check

$$\frac{x}{[\text{NH}_4^+]_0} = \frac{7.5 \times 10^{-6}}{.10} \times 100 = .0075\%$$

PK

$$5.6 \times 10^{-10} = \frac{(x)(x)}{.10}$$

$$x = 7.5 \times 10^{-6}$$

$$[\text{H}^+] = x = 7.5 \times 10^{-6}$$

$$\text{pH} = -\log[\text{H}^+]$$

$\text{pH} = 5.1$