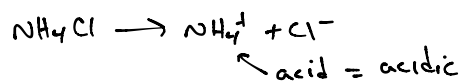
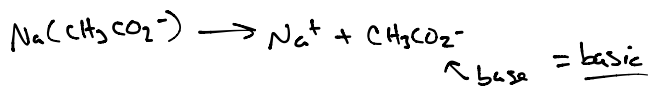


$\text{pK}_a > \text{pK}_b$  ... acidic



2. a.  $\boxed{\text{HCl}}$  vs HF weak vs. strong

b.  $\text{HNO}_2$  vs.  $\boxed{\text{HNO}_3}$  weak vs. strong

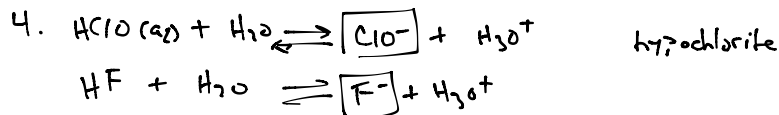
c.  $\boxed{\text{H}_2\text{SO}_4}$  vs. HCl  $\text{H}_2\text{SO}_4 = \text{diprotic}$  (so more than 10mM  $\text{H}_3\text{O}^+$  produced)

d.  $\boxed{\text{H}_3\text{PO}_4}$  vs. HF  $\text{H}_3\text{PO}_4 = \text{polyprotic}$  (1<sup>st</sup>  $\text{pK}_a$  is more acidic than HF)

e.  $\boxed{10 \text{ mM HNO}_2}$  vs. 20 mM  $\text{HNO}_2$  higher concentration

f. 10 mM  $\text{H}_2\text{SO}_4$  vs  $\boxed{0.2 \text{ M H}_2\text{SO}_4}$  higher concentration

3. a.  $\text{HClO}$   $\text{p}K_a = 7.53$   $K_a = 10^{-7.53} = 2.95 \times 10^{-8}$   
 b.  $\text{HF}$   $\text{p}K_a = 3.2$   $K_a = 10^{-3.2} = 6.31 \times 10^{-4}$



5.  $\text{HClO}$ :  $\text{p}K_b = 14 - 7.53 = 6.47$   $K_b = 10^{-6.47} = 3.39 \times 10^{-7}$   
 $\text{HF}$   $\text{p}K_b = 14 - 3.2 = 10.8$   $K_b = 10^{-10.8} = 1.58 \times 10^{-11}$

6. a.  $\text{pH} = -\log 1.5 \times 10^{-6} = 5.82$

b.  $[\text{OH}^-] = 1.5 \times 10^{-6}$   $\text{pOH} = 5.82$   $\text{pH} = 14 - 5.82 = 8.18$

c.  $\text{pOH} = 5$   $\text{pH} = 14 - 5 = 9$

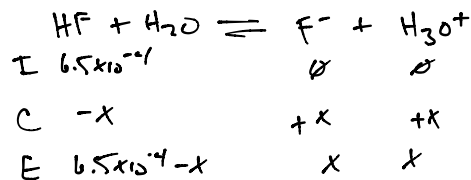
d.  $\text{pH} = -\log 4.59 \times 10^{-3} = 2.31$

e.  $[\text{OH}^-] = 18.6 \times 10^{-6} \text{ M}$   $\text{pOH} = 4.73$   $\text{pH} = 14 - 4.73 = 9.27$

f.  $\text{pOH} = 11$   $\text{pH} = 14 - 11 = 3$

7. a.  $650 \mu\text{M HF} = 6.5 \times 10^{-4} \text{ M}$

$\text{p}K_a = 3.20$   
 $K_a = 6.31 \times 10^{-4}$



$$6.31 \times 10^{-4} = \frac{x^2}{6.5 \times 10^{-4} - x}$$

$a = 1$   
 $b = 6.31 \times 10^{-4}$   
 $c = -4.1 \times 10^{-7}$

$x = 3.98 \times 10^{-4} = [\text{H}_3\text{O}^+]$

$\text{pH} = 3.4$

b.  $175 \mu\text{M HClO} = 1.75 \times 10^{-4} \text{ M}$

$\text{p}K_a = 7.53$   
 $K_a = 2.95 \times 10^{-8}$

ICE Table as above

$a = 1$   
 $b = 2.95 \times 10^{-8}$   
 $c = -5.16 \times 10^{-12}$

$x = 2.26 \times 10^{-6} = [\text{H}_3\text{O}^+]$

$\text{pH} = 5.65$

c. Strong acid



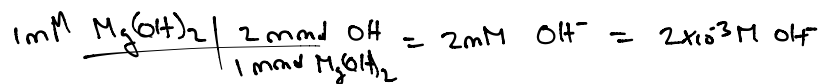
$$-\log 6.5 \times 10^{-4} = 3.19$$

d. Strong acid



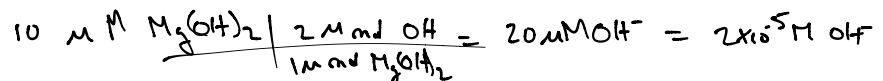
$$-\log 1.75 \times 10^{-4} = 3.76$$

e. strong base

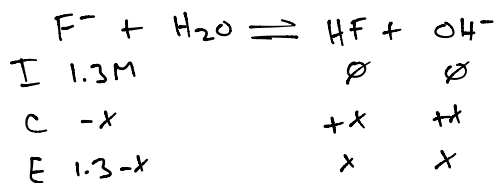
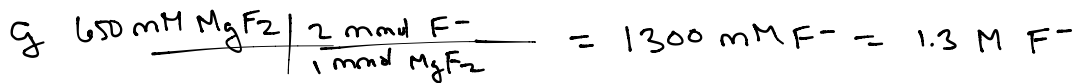


$$\text{pOH} = -\log 2 \times 10^{-3} = 2.70 \quad \text{pH} = 14 - 2.70 = 11.30$$

f. strong base



$$\text{pOH} = -\log 2 \times 10^{-5} = 4.70 \quad \text{pH} = 14 - 4.70 = 9.30$$



$$K_b = 1.58 \times 10^{-11} = \frac{x^2}{1.3-x}$$

assume:  $x \ll 1.3$

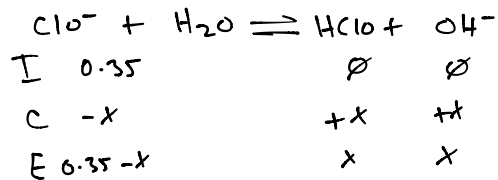
$$1.58 \times 10^{-11} = \frac{x^2}{1.3} \quad x^2 = 2.054 \times 10^{-11}$$

$$\text{pOH} = -\log 4.5 \times 10^{-6} = 5.34$$

$$\text{pH} = 14 - 5.34 = 8.66$$

$$x = 4.5 \times 10^{-6} = [\text{OH}^-]$$

$$h. \frac{175 \text{ mM Ca(ClO)}_2}{1 \text{ mmol Ca(ClO)}_2} \cdot \frac{2 \text{ mmol ClO}^-}{1 \text{ mmol Ca(ClO)}_2} = 350 \text{ mM ClO}^- = 0.35 \text{ M ClO}^-$$



$$K_b = 3.39 \times 10^{-7} = \frac{x^2}{1.3-x}$$

assume:  $x \ll 0.35$

$$3.39 \times 10^{-7} = \frac{x^2}{0.35}$$

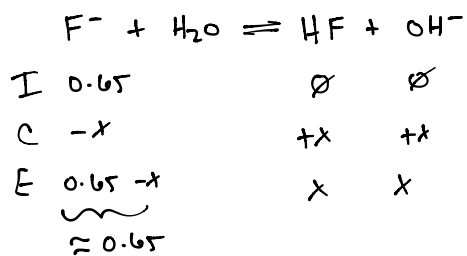
$$x^2 = 1.17 \times 10^{-7}$$

$$x = 3.4 \times 10^{-4} \text{ M} = [\text{OH}^-]$$

$$\text{pOH} = -\log 3.4 \times 10^{-4} = 3.47$$

$$\text{pH} = 14 - 3.47 = 10.53$$

$$8. a. 650 \text{ mM NaF} = 650 \text{ mM F}^- = 0.65 \text{ M F}^-$$



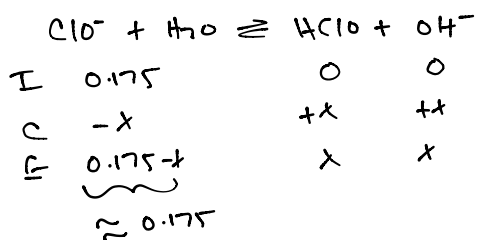
$$1.58 \times 10^{-11} = \frac{x^2}{0.65}$$

$$x^2 = 1.03 \times 10^{-11}$$

$$x = [\text{OH}^-] = 3.2 \times 10^{-6}$$

$$\text{pOH} = -\log \rightarrow 5.49$$

$$b. 175 \text{ mM NaClO} = 0.175 \text{ M ClO}^-$$



$$3.39 \times 10^{-7} = \frac{x^2}{0.175}$$

$$x^2 = 5.9 \times 10^{-8}$$

$$x = [\text{OH}^-] = 2.4 \times 10^{-4}$$

9. a. HCl pH=5.5

strong acid, so  $[H_3O^+] = [HCl] = 10^{-5.5} = 3.16 \times 10^{-6} M = 3.16 \mu M$

b.  $HNO_3$  Same as HCl!  $3.16 \mu M$

c.  $NH_4Cl \rightarrow NH_4^+ + Cl^-$

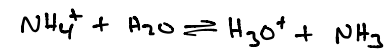
$pK_a = 9.25$

$K_a = 10^{-9.25}$

$X = [H_3O^+] = 3.16 \times 10^{-6} M$

(because pH=5.5)

$$10^{-9.25} = \frac{(3.16 \times 10^{-6})^2}{I - 3.16 \times 10^{-6}}$$



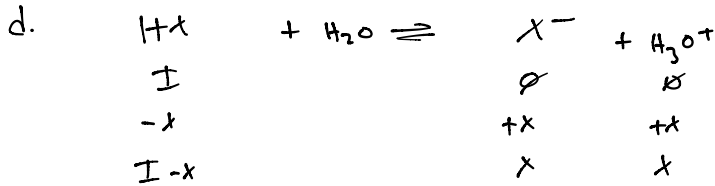
I	0	0
-x	+x	+x
I-x	x	x

$$10^{-9.25} I - 1.77 \times 10^{-15} = 9.99 \times 10^{-12}$$

$$10^{-9.25} I = 9.987 \times 10^{-12}$$

$$I = 0.0178 M$$

$$I = 17,800 \mu M$$



$X = [H_3O^+] = 3.16 \times 10^{-6} M$

(because pH=5.5)

$$10^{-2.87} = \frac{(3.16 \times 10^{-6})^2}{I - 3.16 \times 10^{-6}}$$

$$10^{-2.87} I - 4.26 \times 10^{-9} = 9.99 \times 10^{-12}$$

$$10^{-2.87} I = 4.27 \times 10^{-9}$$

$$I = 3.165 \times 10^{-6} M$$

$$I = 3.17 \mu M$$

10. a. hypochlorous acid  $pK_a = 7.40$  buffer range:  $6.4 \rightarrow 8.4$   
 b. boric acid  $pK_a = 9.27$  buffer range  $8.27 \rightarrow 10.27$   
 c. formic acid  $pK_a = 3.75$  buffer range  $2.75 \rightarrow 4.75$

11.  $pK_a = 5.75$   $pH = 4.5$   $pH = pK_a + \log \frac{A^-}{HA}$   
 $4.5 = 5.75 + \log \frac{A^-}{HA}$   $-1.25 = \log \frac{A^-}{HA}$   $\frac{A^-}{HA} = 0.056$

more HA

b.  $pK_a = 3.75$   $pH = 4.5$  more  $A^-$   $pH > pK_a$

c.  $pH = pK_a$   $[HA] = [A^-]$

d.  $pK_a = 7.1$   $pH = 7.2$  more  $A^-$   $pH > pK_a$

12.  $[HA] = 0.15M$   $[A^-] = 0.25M$   $pK_a = 4.74$

$pH = 4.74 + \log \frac{0.25}{0.15} = 4.96$

b.  $[HA] = 1.38M$   $pK_a = 3.2$   $pH = 3.2 + \log \frac{1.25}{1.38} = 3.16$   
 $[A^-] = 1.25M$

13. a.  $7.0 = 7.4 + \log \frac{x}{100mM}$   
 $-0.4 = \log \frac{x}{100}$   
 $10^{-0.4} = \frac{x}{100}$

$x = [ClO^-] = 39.81mM$

$\frac{250mL}{1mL} \cdot \frac{L}{L} \cdot \frac{39.81mM}{L} \cdot \frac{10^3mol}{1mmol} \cdot \frac{90.57g}{mol}$

$0.901g KClO$

$$b. \quad 3.8 = 3.25 + \log \frac{x}{75}$$

$$0.55 = \log \frac{x}{75}$$

$$10^{0.55} = \frac{x}{75}$$

$$x = 266 \text{ mM} = 0.266 \text{ M}$$

$$\frac{0.5 \text{ L} \cdot 0.266 \text{ mol/L}}{1} \cdot \frac{69.02 \text{ g/mol}}{1} = 9.18 \text{ g NaNO}_2$$

14. a. (1) Stoichiometry step: 0.005 mol HCl added to the buffer

$$\text{HCl: } 10 \text{ mL} \rightarrow \frac{0.01 \text{ L} \cdot 0.5 \text{ mol HCl}}{1} = 0.005 \text{ mol HCl}$$

(HCl is L.R.)

$$\text{A}^-: \frac{1.8 \text{ L} \cdot 14.73 \text{ mmol/L}}{1} = 25.614 \text{ mmol} \rightarrow 0.025614 \text{ mol A}^-$$

$$\text{HA: } \frac{1.8 \text{ L} \cdot 35.77 \text{ mmol/L}}{1} = 64.39 \text{ mmol} \rightarrow 0.06439 \text{ mol}$$

	A <sup>-</sup>	+ HCl	→	HA	+ Cl <sup>-</sup>
I <sub>mol</sub>	0.025614	0.005 mol		0.06439	
C <sub>mol</sub>	-0.005	-0.005		+0.005	
F <sub>mol</sub>	0.020614	0		0.06939	

(2) Equilibrium step (Henderson-Hasselbalch)

$$\text{pH} = 7.4 + \log \frac{0.020614}{0.06939}$$

$$\text{pH} = 6.873$$

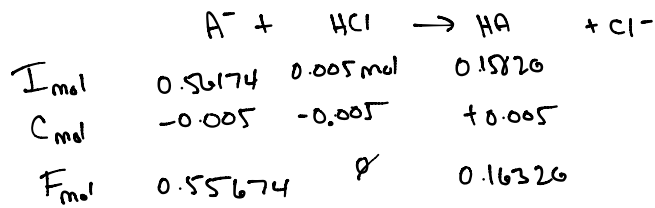
b. (1) Stoichiometry step: 0.005 mol HCl added to the buffer

$$\text{HCl: } 10 \text{ mL} \rightarrow \frac{0.01 \text{ L} \cdot 0.5 \text{ mol HCl}}{1} = 0.005 \text{ mol HCl}$$

(HCl is L.R.)

$$\text{A}^-: \frac{3.6 \text{ L} \cdot 156.04 \text{ mmol/L}}{1} = 561.74 \text{ mmol} \rightarrow 0.56174 \text{ mol A}^-$$

$$\text{HA: } \frac{3.6 \text{ L} \cdot 43.96 \text{ mmol/L}}{1} = 158.26 \text{ mmol} \rightarrow 0.15826 \text{ mol}$$



② Equilibrium step (Henderson-Hasselbalch)

$$pH = 3.257 + \log \frac{0.55674}{0.16326}$$

$$pH = 3.78$$

15. a. 1.00 M HA  $pK_a = 4.74$   $pH = 5.3$

$$5.3 = 4.74 + \log \frac{[A^-]}{1.00 M} \quad 0.56 = \log \frac{[A^-]}{1.00 M} \quad [A^-] = 3.63 M$$

need 3.63 M acetate  $\rightarrow$  moles?

Sodium acetate  
 $NaCH_3CO_2$   
 $MW = 82.04 \text{ g/mol}$

$$\frac{0.5 L | 3.63 \text{ mol}}{L} = \frac{1.81 \text{ mol} | 82.04 \text{ g}}{\text{mol}} = 148.49 \text{ g}$$

b.  $5.3 = 4.74 + \log \frac{[A^-]}{0.385 M}$

$$\frac{[A^-]}{0.385 M} = 3.63 \quad [A^-] = 1.398 M$$

$$\frac{0.5 L | 1.389 \text{ mol} | 82.04 \text{ g}}{L \quad \text{mol}} = 57.34 \text{ g}$$