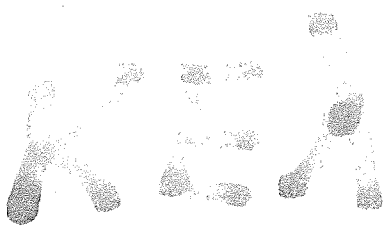
40S

Chemistry

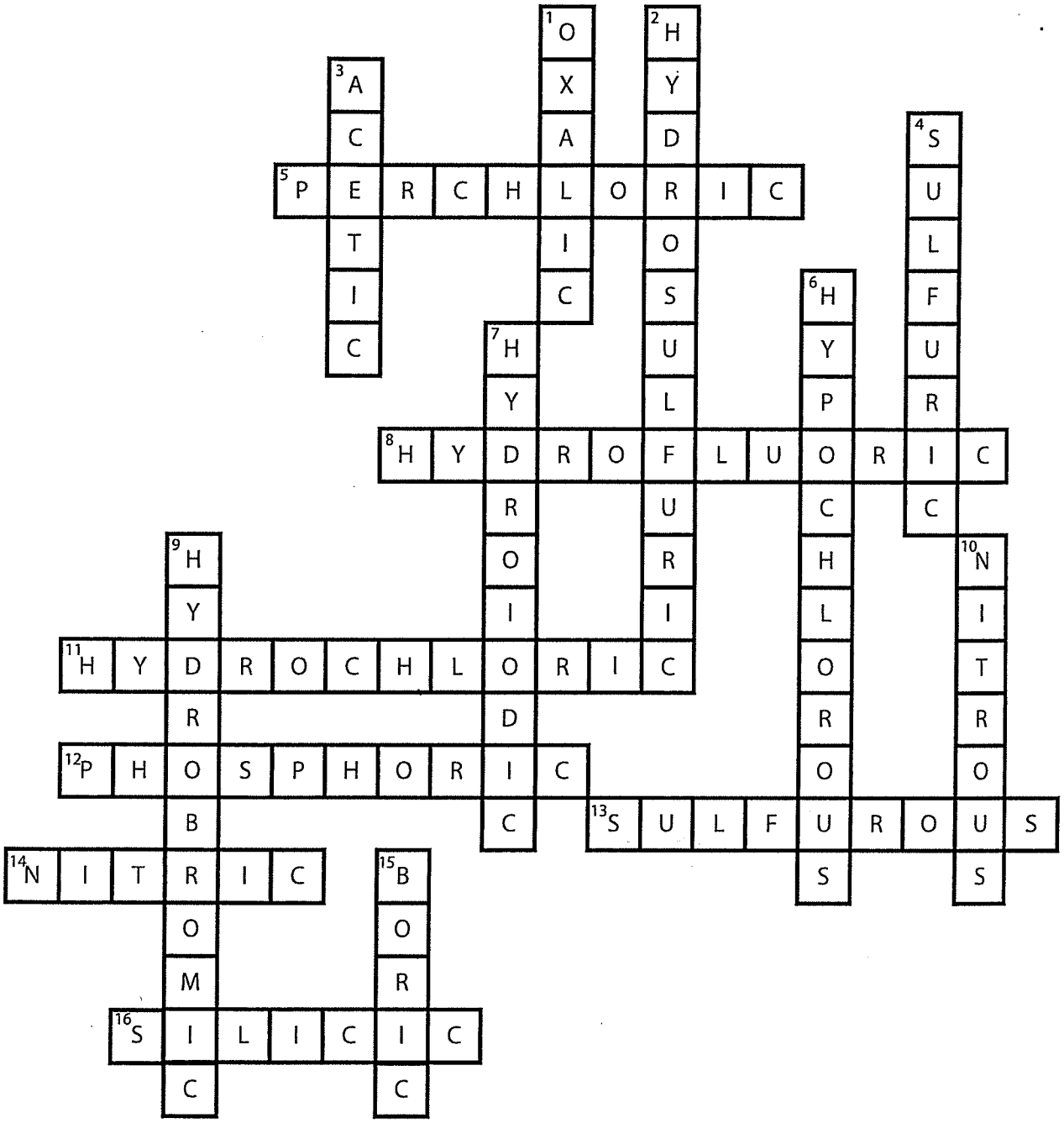
Acids and Base Equilibrium

Science Notebook

KEY



COMMON ACIDS CROSSWORD



Across

5. $HClO_4$
8. HF
11. HCl
12. H_3PO_4
13. H_3SO_4
14. HNO_3
16. H_2SiO_3

Down

1. $H_2C_2O_4$
2. H_2S
3. $HC_2H_3O_2$
4. H_2SO_4
6. $HClO_4$
7. HI
9. HBr
10. HNO_2
15. H_3BO_3

Chemistry 40S

Acids & Bases Assignment #1

Write the dissociation of each of the following in water. Predict whether each of the following will be an electrolyte or non-electrolyte.

1. $NaOH(s) \rightarrow Na+(aq) + OH^-(aq)$

   electrolyte, ionic compound

2. $Na_2CO_3(s) \rightarrow 2\ Na^+(aq) + CO_3^{2-}(aq)$ electrolyte

3. $Mg(OH)_2(s) \rightarrow Mg^{2+}(aq) + 2\ OH^-(aq)$ electrolyte

4. $C_6H_{12}O_6(s) \rightarrow C_6H_{12}O_6(aq)$

   non-electrolyte, covalent compound

5. $HCl(g) \rightarrow H^+(aq) + Cl^-(aq)$ electrolyte

6. $K_3PO_4(s) \rightarrow 3\ K^+(aq) + PO_4^{3-}(aq)$ electrolyte

7. $H_2SO_4(aq) \rightarrow 2\ H^+(aq) + SO_4^{2-}(aq)$ electrolyte

8. $NaC_2H_3O_2(s) \rightarrow Na^+(aq) + C_2H_3O_2^-(aq)$ electrolyte

9. $(NH_4)_2SO_4(s) \rightarrow NH_4^+(aq) + SO_4^{2-}(aq)$ electrolyte

10. $C_2H_5OH(l) \rightarrow C_2H_5OH(aq)$ non-electrolyte

11. $H_3PO_4(aq) \rightarrow 3\ H^+(aq) + PO_4^{3-}(aq)$ electrolyte

12. $CaCl_2(s) \rightarrow Ca^{2+}(aq) + 2\ Cl^-(aq)$ electrolyte

Student Name: KEY Date: _____

Chemistry 40S

Acids and Bases

Conjugate Acid-Base Key

1. Identify the acid, base, conjugate acid and conjugate base for each of the following.

a) $HClO_4(aq) + H_2O(l) \Leftrightarrow H_3O^+(aq) + ClO_4^-(aq)$
acid base conj. acid conj. base

b) $H_2SO_3(aq) + H_2O(l) \Leftrightarrow H_3O^+(aq) + HSO_3^-(aq)$
acid base conj. acid conj. base

c) $HC_2H_3O_2(aq) + H_2O(l) \Leftrightarrow H_3O^+(aq) + C_2H_3O_2^-(aq)$
acid base conj. acid conj. base

d) $H_2S(g) + H_2O(l) \Leftrightarrow H_3O^+(aq) + HS^-(aq)$
acid base conj. acid conj. base

e) $HSO_3^-(aq) + H_2O(l) \Leftrightarrow H_3O^+(aq) + SO_3^{2-}(aq)$
acid base conj. acid conj. base

f) $NH_3(g) + H_2O(l) \Leftrightarrow NH_4^+ + OH^-(aq)$
base acid conj. acid conj. Base

g) $HF(aq) + HSO_3^-(aq) \Leftrightarrow F^-(aq) + H_2SO_3(aq)$
acid base conj. base conj. Acid

h) $HNO_2(aq) + HS^-(aq) \Leftrightarrow NO_2^-(aq) + H_2S(aq)$
acid base conj. base conj. acid

Ionic Equilibrium - pH Questions

1. $[OH^-] = 1.0 \times 10^{-3} \frac{mol}{L}$ $[H^+] = ?$

$K_W = [H^+][OH^-]$ $[H^+] = \frac{K_W}{[OH^-]} = \frac{1.0 \times 10^{-14}}{1.0 \times 10^{-3}} = 1.0 \times 10^{-11} \frac{mol}{L}$

the $[H^+]$ is $1.0 \times 10^{-11} \frac{mol}{L}$. The soln is basic (pH = 11)

2. Determine the pH of the following solutions:

a) $pH = -\log[H^+] = -\log(1 \times 10^{-6}) = 6.00$

b) $pH = -\log[H^+] = -\log(0.0001) = 4.00$

c) $K_W = [H^+][OH^-]$

$[H^+] = \frac{K_W}{[OH^-]} = \frac{1.0 \times 10^{-14}}{1 \times 10^{-2}} = 1 \times 10^{-12} \frac{mol}{L}$

$pH = -\log[H^+] = -\log(1 \times 10^{-12}) = 12.00$

d) $pOH = -\log[OH^-] = -\log(1 \times 10^{-11}) = 11.00$

$14.00 = pH + pOH$ $pH = 14.00 - pOH = 14.00 - 11.00 = 3.00$

OR

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

$[H^+] = \frac{K_W}{[OH^-]} = \frac{1.0 \times 10^{-14}}{1 \times 10^{-11}} = 1 \times 10^{-3} \frac{mol}{L}$

$pH = -\log[H^+] = -\log(1 \times 10^{-3}) = 3.00$

3. What are the $[H^+]$ for the following pH values:

a) $[H^+] = 10^{-pH} = 10^{-4.0} = 1.0 \times 10^{-4} \frac{mol}{L}$

b) $[H^+] = 10^{-pH} = 10^{-11.0} = 1.00 \times 10^{-11} \frac{mol}{L}$

c) $[H^+] = 10^{-pH} = 10^{-8.0} = 1.0 \times 10^{-8} \frac{mol}{L}$

4. What are the $[OH^-]$ for the following pH values:

a) $14.00 = pH + pOH$ $pOH = 14.00 - pH = 14.00 - 6.0 = 8.0$

$[OH^-] = 10^{-pOH} = 10^{-8.0} = 1.0 \times 10^{-8} \frac{mol}{L}$

c) $[H^+] = 10^{-pH} = 10^{-12.0} = 1.00 \times 10^{-12} \frac{mol}{L}$

$K_W = [H^+][OH^-]$ $[OH^-] = \frac{K_W}{[H^+]} = \frac{1.0 \times 10^{-14}}{1.00 \times 10^{-12}} = 1.00 \times 10^{-2} \frac{mol}{L}$

b) $14.00 = pH + pOH$ $pOH = 14.00 - pH = 14.00 - 9.0 = 5.0$

$[OH^-] = 10^{-pOH} = 10^{-5.0} = 1.0 \times 10^{-5} \frac{mol}{L}$

5. Calculate the pH of the following:

a) $pH = -\log[H^+] = -\log(1\times10^{-4}) = 4.00$

b) $pH = -\log[H^+] = -\log(0.001) = 3.00$

c) $pH = -\log[H^+] = -\log(1\times10^{-9}) = 9.00$

d) $pH = -\log[H^+] = -\log(100\times10^{-12}) = 10.00$

6. Calculate pH for each soln:

a) $pH = -\log[H^+] = -\log(5.0\times10^{-6}) = 5.30$

b) $pH = -\log[H^+] = -\log(8.3\times10^{-10}) = 9.08$

c) $pOH = -\log[OH^-] = -\log(2.0\times10^{-5}) = 4.70$

$14.00 = pH + pOH$ $\quad pH = 14.00 - pOH = 14.00 - 4.70 = 9.30$

d) $K_W = [H^+][OH^-]$ $\quad [H^+] = \frac{K_W}{[OH^-]} = \frac{1.0\times10^{-14}}{4.5\times10^{-11}} = 2.22\times10^{-4}\ \frac{mol}{L}$

$pH = -\log[H^+] = -\log(2.22\times10^{-4}) = 3.65$

7. Calculate $[H^+]$ for each soln:

a) $[H^+] = 10^{-pH} = 10^{-5.0} = 1.0 \times 10^{-5} \frac{mol}{L}$

b) $[H^+] = 10^{-pH} = 10^{-5.80} = 1.58 \times 10^{-6} \frac{mol}{L}$

c) $[H^+] = 10^{-pH} = 10^{-12.20} = 6.310 \times 10^{-13} \frac{mol}{L}$

d) $[H^+] = 10^{-pH} = 10^{-2.64} = 2.29 \times 10^{-3} \frac{mol}{L}$

Student Name:_____ Date: _____

Chemistry 40S

Acids and Bases

Kw Problems

Answer all questions in your Chemistry notebook. Show all work.

1. $[OH^-] = \frac{K_W}{[H_3O^+]} = \frac{1.0\times10^{-14}}{6.80\times10^{-10}} = 1.47\times10^{-5}$ mol/L OH^-

2. $[H_3O^+] = \frac{K_W}{[OH^-]} = \frac{1.0\times10^{-14}}{5.67\times10^{-3}} = 1.76\times10^{-12}$ mol/L H_3O^+

3. HNO_3 is a strong acid, so $[H_3O^+] = 0.0020$ mol/L

   $[OH^-] = \frac{K_W}{[H_3O^+]} = \frac{1.0\times10^{-14}}{0.0020} = 5.0\times10^{-12}$ mol/L OH^-

4. $[H_3O^+] = \frac{K_W}{[OH^-]} = \frac{1.0\times10^{-14}}{0.050} = 2.0\times10^{-13}$ mol/L H_3O^+

5. $HCl(g) + H_2O(l)$ qe $H_3O^+(aq) + Cl^-(aq)$

   $[HCl] = \frac{n}{V} = \frac{0.25 \text{ moles}}{2.0 \text{ L}} = 0.125$ mol/L

   HCl is a strong acid so $[H_3O^+] = 0.125$ mol/L

   $[OH^-] = \frac{K_W}{[H_3O^+]} = \frac{1.0\times10^{-14}}{0.125} = 8.0\times10^{-14}$ mol/L OH^-

6. $LiOH \rightleftharpoons Li^+ + OH^-$

$LiOH = 23.9$ g/mol

$$\text{moles LiOH} = \frac{m}{M} = \frac{10.0\text{ g}}{23.9\text{ g/mol}} = 0.4184\text{ moles LiOH}$$

$$C = \frac{n}{V} = \frac{0.4184\text{ mol}}{0.75\text{ L}} = 0.5579\text{ mol/L}$$

$[OH^-] = [LiOH] = \mathbf{0.558\ mol\ L}$

$$[H_3O^+] = \frac{K_W}{[OH^-]} = \frac{1.0\times10^{-14}}{0.5579} = 1.79\times10^{-14}\text{ mol/L } H_3O^+$$

7. $Ca(OH)_2(s) \rightleftharpoons Ca^{2+}(aq) + 2\ OH^-(aq)$

$Ca(OH)_2 = 74.1$ g/mol

$$\text{moles } Ca(OH)_2 = \frac{m}{M} = \frac{10.0\text{ g}}{74.1\text{ g/mol}} = 0.135\text{ moles } \cancel{LiOH}\ Ca(OH)_2$$

$$C_{Ca(OH)_2} = \frac{n}{V} = \frac{0.135\text{ mol}}{0.400\text{ L}} = 0.3375\text{ mol/L}$$

$[OH^-] = 2 \times [Ca(OH)_2] = 2 \times 0.3375\text{ mol/L} = \mathbf{0.675\ mol/L\ OH^-}$

$$[H_3O^+] = \frac{K_W}{[OH^-]} = \frac{1.0\times10^{-14}}{0.675} = 1.48\times10^{-14}\text{ mol/L } H_3O^+$$

8. $Ba(OH)_2(s) \rightleftharpoons Ba^{2+}(aq) + 2\ OH^-(aq)$

$$[OH^-] = \frac{K_W}{[H_3O^+]} = \frac{1.0\times10^{-14}}{1.0\times10^{-13}} = 0.10\text{ mol/L } OH^-$$

$$C_{Ba(OH)_2} = \frac{[OH\text{-}]}{2} = \frac{0.100\text{ mol/L}}{2} = 0.050\text{ mol/L } Ba(OH)_2$$

moles $Ba(OH)_2 = C \cdot V = (0.050\text{ mol/L})(1.0\text{ L}) = 0.050$ moles $Ba(OH)_2$

mass $= n \cdot M = (0.050\text{ moles})(171.3\text{ g/mol}) = \mathbf{8.6\ g\ Ba(OH)_2}$

9. $Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2\,OH^-(aq)$

$$[H_3O^+] = \frac{K_W}{[OH^-]} = \frac{1.0\times10^{-14}}{1.43\times10^{-4}} = \mathbf{6.99\times10^{-11}\ mol/L\ H_3O^+}$$

10. $HB(g) + H_2O(l) \rightleftharpoons H_3O^+(aq) + B^-(aq)$

$$[H_3O^+] = \frac{K_W}{[OH^-]} = \frac{1.0\times10^{-14}}{4.5\times10^{-10}} = \mathbf{2.22\times10^{-5}\ mol/L\ H_3O^+}$$

$$[H_3O^+] = [B^-] = 2.22\times10^{-5}\ mol/L$$

$$K_a = \frac{[H_3O^+][B^-]}{[HB]} = \frac{(2.22\times10^{-5})(2.22\times10^{-5})}{0.800} = \mathbf{6.2\times10^{-10}}$$

Percent of Ionization Questions (Kq)

KEY

1. $[H_3O^+] = 1.27 \times 10^{-4}\ M$
   $[HC_2H_3O_2] = 0.00100\ M$

$$\%\text{ of ionization} = \frac{[H^+]}{[HA]} \times 100\% = \frac{1.27 \times 10^{-4}\ M}{0.00100\ M} \times 100\% = 12.7\%$$

2. $[H_3O^+] = 7.85 \times 10^{-6}\ M$
   $[HCl] = 0.100\ M$

$$\%\text{ of ionization} = \frac{[H_3O^+]}{[HCl]} \times 100\% = \frac{7.85 \times 10^{-6}\ M}{0.100\ M} \times 100\% = 7.85 \times 10^{-3}\%$$

3. $[H_3O^+] = 0.40\ M$
   $[HA] = 10.4\ M$

$$\%\text{ of ionization} = \frac{[H_3O^+]}{[HA]} \times 100\% = \frac{0.40\ M}{10.4\ M} \times 100\% = 3.8\%$$

4. $[H_3O^+] = 1.82 \times 10^{-5}\ M$
   $[HX] = 5.50\ M$

0.18%

$$\%\text{ of Ionization} = \frac{[H_3O^+]}{[HX]} \times 100\% = \frac{1.82 \times 10^{-5}\ M}{5.50\ M} \times 100\% = 3.31 \times 10^{-4}\%$$

5. $[H_3O^+] = 3.98 \times 10^{-4}\ M$
   $[HC_2H_3O_2] = 0.00100\ M$

2.63×10^{-4}

$$\%\text{ of ionization} = \frac{[H_3O^+]}{[HC_2H_3O_2]} \times 100\% = \frac{3.98 \times 10^{-4}\ M}{0.00100\ M} \times 100\% = 39.8\%$$

6. $[H_3O^+] = 1.12 \times 10^{-2}\ M$
   $[HX] = 0.300\ M$

$$\%\text{ of ionization} = \frac{[H_3O^+]}{[HX]} \times 100\% = \frac{1.12 \times 10^{-2}\ M}{0.300\ M} \times 100\% = 3.73\%$$

7. $[OH^-] = 3.46 \times 10^{-4} M$
$[NH_3] = 0.00700 M$

$$\% \text{ of Ionization} = \frac{[OH^-]}{[NH_3]} \times 100\% = \frac{3.46 \times 10^{-4} M}{0.00700 M} \times 100\% = 4.94\%$$

8. $[H_3O^+] = 2.00 \times 10^{-5} M$
$[HA] = 0.670 M$

$$\% \text{ of ionization} = \frac{[H_3O^+]}{[HA]} \times 100\% = \frac{2.00 \times 10^{-5} M}{0.670 M} \times 100\% = 2.99 \times 10^{-3}\%$$

9. $[H_3O^+] = 3.16 \times 10^{-3} M$
$[HA] = 0.16 M$

$$\% \text{ ionization} = \frac{[H_3O^+]}{[HA]} \times 100\% = \frac{3.16 \times 10^{-3} M}{0.16 M} \times 100\% = 1.98\%$$

10. $[H_3O^+] = 2.40 \times 10^{-6} \frac{mol}{L}$ $\quad pH = 5.62$

Ka Problems

✓ 1. M = 0.00100M

$[H^+] = 1.27 \times 10^{-4} M$

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

$= -\log (1.27 \times 10^{-4})$

$= -(\log 1.27 + \log 10^{-4})$

$= 3.896 = 3.90$

$K_a = \dfrac{[H^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$

$= \dfrac{(1.27 \times 10^{-4})(1.27 \times 10^{-4})}{0.00100 - 1.27 \times 10^{-4}}$

$= 1.847 \times 10^{-5}$

$= 1.85 \times 10^{-5}$

√2. [HCl] = 0.100M

$[H^+] = 7.85 \times 10^{-6} M$

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

$= -\log (7.85 \times 10^{-6})$

$= -(\log 7.85 + \log 10^{-6})$

$= -(0.8949 + (-6))$

$= 5.105$

$= 5.11$

$K_a = \dfrac{[H^+][Cl^-]}{[HCl]}$

$= \dfrac{(7.85 \times 10^{-6})(7.85 \times 10^{-6})}{0.100 - 7.85 \times 10^{-6}}$

$= 6.162 \times 10^{-10}$

$= 6.16 \times 10^{-10}$

3. $[H^+] = 0.40\,M$

$[acid] = 10.4\,M$

$$K_a = \frac{[H^+][X^-]}{[HX]}$$

$$= \frac{(0.40)(0.40)}{10.4 - 0.40}$$

$$= 0.016$$

$$= 1.6 \times 10^{-2}$$

4. $[HX] = 5.50\,M$

$pH = 2.00$

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

$\log[H^+] = -pH = -2.00$

$[H^+] = 1.00 \times 10^{-2}\,M$

$$K_a = \frac{[H^+][X^-]}{[HX]}$$

$$= \frac{(1.00 \times 10^{-2})(1.00 \times 10^{-2})}{5.50 - (1.00 \times 10^{-2})}$$

$$= 1.821 \times 10^{-5}$$

$$= 1.82 \times 10^{-5}$$

5. $pH = 3.40$

$[HC_2H_3O_2] = 0.00100\,M$

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

$\log[H^+] = -pH = -3.40$

$= (-3.40 + 4.00) - 4.00$

$= 0.60 - 4.00$

$[H^+] = 10^{(0.60 - 4.00)}$

$= 10^{0.6} \times 10^{-4}$

$= 3.98 \times 10^{-4}\,M$

$$K_a = \frac{[H^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$$

$$= \frac{(3.98 \times 10^{-4})(3.98 \times 10^{-4})}{0.00100 - (3.98 \times 10^{-4})}$$

$$= 2.63 \times 10^{-4}$$

6. $[HX] = 0.300M$

$pH = 1.95$

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

$\log[H^+] = -pH = -1.95$

$= (-1.95 + 2) - 2$

$= 0.05 - 2$

$= 10^{0.05} \times 10^{-2}$

$= 1.122 \times 10^{-2}$

$= 1.12 \times 10^{-2} M$

$K_a = \dfrac{[H^+][X^-]}{[HX]}$

$= \dfrac{(1.12 \times 10^{-2})(1.12 \times 10^{-2})}{0.300 - (1.12 \times 10^{-2})}$

$= 4.34 \times 10^{-4}$

7. $[Soln] = 0.00700M$

$[OH^-] = 3.46 \times 10^{-4}$

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

$= -\log(2.89 \times 10^{-11})$

$= -(\log 2.89 + \log 10^{-11})$

$= -(0.4608) - (-11)$

$= -0.4608 + 11$

$= 10.54$

$K_w = [H^+] \times [OH^-]$

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

$[H^+] = \dfrac{1.0 \times 10^{-14}}{3.46 \times 10^{-4}}$

$= 2.89 \times 10^{-11}$

$K_b = \dfrac{[NH_4^+][OH^-]}{[NH_3]}$

$= \dfrac{(3.46 \times 10^{-4})(3.46 \times 10^{-4})}{0.00700 - (3.46 \times 10^{-4})}$

$= 1.799 \times 10^{-5}$

$= 1.80 \times 10^{-5}$

✓ 8. [Sol'n] = 0.670 M

$[H^+] = 2.0 \times 10^{-5}$ M

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

$= -\log (2.0 \times 10^{-5})$

$= -(\log 2.0 \times 10^{-5})$

$= -((0.3010) + (-5))$

$= -0.3010 + 5$

$= 4.6989$

$= 4.7$

$K_a = \frac{[H^+][X^-]}{[HX]}$

$= \frac{(2.0 \times 10^{-5})(2.0 \times 10^{-5})}{(0.670) - (2.0 \times 10^{-5})}$

$= 5.97 \times 10^{-10}$

✓ 9. [Sol'n] = 0.16 M

pH = 2.50

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

$\log [H^+] = -pH = -2.50$

$= (-2.50 + 3) - 3$

$= (0.5) - 3$

$[H^+] = 10^{0.5 - 3}$

$= 10^{0.5} \times 10^{-3}$

$= 3.16 \times 10^{-3}$

$K_a = \frac{[H^+][B^-]}{[HB]}$

$= \frac{(3.16 \times 10^{-3})^2}{(0.16 - 3.16 \times 10^{-3})}$

$= 6.3376 \times 10^{-5}$

$= 6.34 \times 10^{-5}$

$= 6.38 \times 10^{-5}$

10. $[HB] = 0.0100\,M$ $\quad HB \rightarrow H^+ + B^-$

$$K_b = \frac{[H^+][B^-]}{[HB]} = \frac{x^2}{0.0100 - x} \quad \text{small } K_a \text{ value}$$

	HB	$+ B^-$	$\rightarrow HB$
I	0	0	0.0100
C	$+x$	$+x$	$-x$
E	x	x	$0.0100 - x$

$$\sqrt{(5.75\times10^{-7})(0.0100)} = x$$

$$\sqrt{5.75\times10^{-12}} = x$$

$$2.397\times10^{-6} = x$$

$[H^+] = [B^-] = x = 2.40\times10^{-6}$ mol/L

$[HB] = 0.0100 - x = 0.0100 - 2.397\times10^{-6} = 0.009997 = 0.0100$ mol/L

$$pH = -\log[H_3O^+] = -\log[2.397\times10^{-6}] = 5.620 = 5.62$$

11. $H^+ + Y^- \rightarrow HY$

	H^+	$+ Y^-$	$\rightarrow HY$
I	0	0	0.153
C	$+x$	$+x$	$-x$
E	x	x	$0.153 - x$

$$K_a = \frac{[H^+][Y^-]}{[HY]}$$

$$3.20\times10^{-8} = \frac{x^2}{0.153} \quad K_a \text{ is small } \therefore \text{negligible}$$

$$\sqrt{(3.20\times10^{-8})(0.153)} = x$$

$[H^+] = [Y^-] = x = 7.00\times10^{-5}$ mol/L

$[HY] = 0.153 - 7.00\times10^{-5}$

$= 0.1529 = 0.153$ mol/L

$$\sqrt{4.896\times10^{-9}} = x =$$

$$6.997\times10^{-5} = x$$

$$7.00\times10^{-5} = x$$

$pH = -\log[H_3O^+]$

$= -\log[7.00\times10^{-5}]$

$= 4.15$

12. $[HNO_2] = 1.20$

$$HNO_2 + H_2O \rightleftharpoons H_3O^+ + NO_2^-$$

	HNO_2		H_3O^+	NO_2^-
I	1.20	–	0	0
C	$-x$	–	$+x$	$+x$
E	$1.20 - x$	–	x	x

$$K_a = \frac{[H_3O^+][NO_2^-]}{[HNO_2]}$$

$$4.00 \times 10^{-4} = \frac{x^2}{1.20 - x}$$ K_a is small... negligible

$$\sqrt{(4.00 \times 10^{-4})(1.20)} = x$$

$$\sqrt{4.8 \times 10^{-4}} = x$$

$$0.0219 = x$$

$[H_3O^+] = [NO_2^-] = x = 0.0219 \text{ mol/L}$

$[HNO_2] = 1.20 - x = 1.20 - 2.19 \times 10^{-2}$
$= 1.1781 = 1.18 \text{ mol/L}$

$$pH = -\log[H_3O^+] = -\log(2.19 \times 10^{-2}) = 1.66$$

13. $$HC_2H_3O_2 + H_2O \rightleftharpoons H_3O^+ + C_2H_3O_2^-$$

	$HC_2H_3O_2$		H_3O^+	$C_2H_3O_2^-$
I	0.0500	–	0	0
C	$-x$	–	$+x$	$+x$
E	$0.0500 - x$	–	x	x

$$K_a = \frac{[H_3O^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$$

$$1.80 \times 10^{-5} = \frac{x^2}{0.0500 - x}$$ K_a is very small

$$\sqrt{(1.80 \times 10^{-5})(0.0500)} = x$$

$$9.49 \times 10^{-4} = x$$

$[H_3O^+] = [C_2H_3O_2^-] = x = 9.49 \times 10^{-4} \text{ mol/L}$

$$pH = -\log[H_3O^+]$$
$$= -\log(9.49 \times 10^{-4})$$
$$= 3.02$$

14. $HX + H_2O \rightleftharpoons H_3O^+ + X^-$

I	4.00	0	0
C	-x	+x	+x
E	4.00 - x	x	x

$K_a = \frac{[H_3O^+][X^-]}{[HX]}$

$3.60 \times 10^{-4} = \frac{x^2}{4.00}$ (-x) K_a is very small

$\sqrt{(3.60 \times 10^{-4})(4.00)} = x$

$3.79 \times 10^{-2} = x$

$[H_3O^+] = [X^-] = x = 3.79 \times 10^{-2}$ mol/L

$pH = -\log[H_3O^+]$

$pH = -\log[3.79 \times 10^{-2}]$

$pH = 1.42$

15. $HX + H_2O \rightleftharpoons H_3O^+ + X^-$

I	0.200	0	0
C	-x	+x	+x
E	0.200 - x	x	x

$K_a = \frac{[H_3O^+][X^-]}{HX}$

$1.50 \times 10^{-4} = \frac{x^2}{0.200}$ (-x) K_a is small

$\sqrt{(1.50 \times 10^{-4})(0.200)} = x$

$5.48 \times 10^{-3} = x$

$[H_3O^+] = [X^-] = x = 5.48 \times 10^{-3}$ mol/L

$pH = -\log[H_3O^+]$

$pH = -\log(5.48 \times 10^{-3})$

$pH = 2.26$

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Chemistry 40S

Ionic Equilibrium

Acid-Base Calculations

Answer all questions in the space provided in your Chemistry notebook. Show all work.

1. HNO_3 is a strong acid. It dissociates 100%.

$$HNO_3 + H_2O \rightarrow H_3O^+ + NO_3^-$$

$[H_3O^+] = [NO_3^-] = 0.70$ mol/L
$[HNO_3] = 0$ mol/L

2.

	H_2S	+ H_2O	$\rightleftharpoons$	H_3O^+	+	HS^-
I	0.90			0		0
C	$-x$			$+x$		$+x$
E	$0.90 - x$			x		x

$$K_a = \frac{[H_3O^+][HS^-]}{[H_2S]}$$

$$1.0\times10^{-7} = \frac{x^2}{0.90 - x}$$ K_a is very small assume x to be negligible

$$(1.0\times10^{-7})(0.90) = \left(\frac{x^2}{0.90}\right)(0.90)$$

$$\sqrt{9.0\times10^{-8}} = \sqrt{x^2}$$

$$3.0\times10^{-4} = x$$

$[H_3O^+] = x = 3.0 \times 10^{-4}$ mol/L

3. NaOH is a strong base, therefore complete dissociation.

$$NaOH \rightarrow Na^+ + OH^-$$

$[Na^+] = [OH^-] = 0.10$ mol/L
$[NaOH] = 0$ mol/L

4.

	NH_3	+ H_2O	qe	NH_4^+	+ OH^-
I	0.65			0	0
C	$-x$			$+x$	$+x$
E	$0.65-x$			x	x

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$$

$$1.0\times10^{-5} = \frac{x^2}{0.65-x} \quad K_b \text{ is very small assume x to be negligible}$$

$$(1.0\times10^{-5})(0.65) = \left(\frac{x^2}{0.65}\right)(0.65)$$

$$\sqrt{6.5\times10^{-6}} = \sqrt{x^2}$$

$$2.55\times10^{-4} = x$$

$$[NH_4^+] = [OH^-] = x = 2.6 \times 10^{-4} \text{ mol/L}$$

$$[NH_3] = 0.65 - x$$
$$= 0.65 - 2.6 \times 10^{-4} \text{ mol/L}$$
$$= 0.6497 \text{ mol/L}$$

$$[NH_3] = 0.65 \text{ mol/L} \quad \text{(this rounds to 0.65 so our assumption was correct)}$$

5.

	H_2O_2	+ H_2O	qe	H_3O^+	+ HO_2^-
I	0.86			0	0
C	$-x$			$+x$	$+x$
E	$0.86-x$			x	x

$$K_a = \frac{[H_3O^+][HO_2^-]}{[H_2O_2]}$$

$$2.4\times10^{-12} = \frac{x^2}{0.86-x} \quad K_a \text{ is very small assume x to be negligible}$$

$$(2.4\times10^{-12})(0.86) = \left(\frac{x^2}{0.86}\right)(0.86)$$

$$\sqrt{2.064\times10^{-12}} = \sqrt{x^2}$$

$$1.44\times10^{-6} = x$$

$$[H_3O^+] = x = 1.4 \times 10^{-6} \text{ mol/L}$$

6. $$\%\text{dissociation} = \frac{[\text{ionized}]}{[\text{acid}]} \times 100\%$$

$$= \frac{[H_3O^+]}{[HX]} \times 100\%$$

$$= \frac{4.5 \times 10^{-4}}{0.45} \times 100\%$$

$$= \mathbf{1.0 \times 10^{-3}\%}$$

7.

	HPO_4^{2-}	+ H_2O	$\rightleftharpoons$	$H_2PO_4^-$	+ OH^-
I	0.87			0	0
C	$-x$			$+x$	$+x$
E	$0.87 - x$			x	x

$$K_b = \frac{[H_2PO_4^-][OH^-]}{[HPO_4^{2-}]}$$

$$1.6 \times 10^{-7} = \frac{x^2}{0.87 - x}$$ K_b is very small assume x to be negligible

$$(1.6 \times 10^{-7})(0.87) = \left(\frac{x^2}{0.87}\right)(0.87)$$

$$\sqrt{1.392 \times 10^{-7}} = \sqrt{x^2}$$

$$3.73 \times 10^{-4} = x$$

$[OH^-] = 3.73 \times 10^{-4}$ mol/L

$$\%\text{dissociation} = \frac{[OH^-]}{[HPO_4^{2-}]} \times 100\%$$

$$= \frac{3.73 \times 10^{-4}}{0.87} \times 100\%$$

$$= \mathbf{0.043\% dissociated}$$

8. $[H_3O^+] = \frac{(\%diss)[acid]}{100\%}$ Rearrange the equation to solve for $[H_3O^+]$

$$= \frac{(0.12\%)(0.38 mol/L)}{100\%}$$

$$\mathbf{[H_3O^+] = 4.56 \times 10^{-4} mol/L}$$

9. $HA + H_2O \rightleftharpoons H_3O^+ + A^-$

$$[H_3O^+] = \frac{(\%diss)[HA]}{100\%}$$

$$= \frac{(0.025\%)(0.45 mol/L)}{100\%}$$

$$= 0.01125 \text{ mol/L}$$

$$[H_3O^+] = [A^-] = 0.01125 \text{ mol/L}$$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

$$= \frac{(0.01125)(0.01125)}{0.45}$$

$$\mathbf{K_a = 2.8 \times 10^{-4}}$$

10. $C_2H_3O_2^- + H_2O \rightleftharpoons OH^- + HC_2H_3O_2$

$$[OH^-] = [HC_2H_3O_2] = 1.5 \times 10^{-5} \text{ mol/L}$$

$$K_b = \frac{[OH^-][HC_2H_3O_2]}{[C_2H_3O_2^-]}$$

$$[C_2H_3O_2^-] = \frac{[OH^-][HC_2H_3O_2]}{K_b}$$

$$= \frac{(1.5 \times 10^{-5})(1.5 \times 10^{-5})}{5.6 \times 10^{-10}}$$

$$\mathbf{[C_2H_3O_2^-] = 0.40 mol/L}$$

11.

$$C_6H_5NH_2 + H_2O \rightleftharpoons C_6H_5NH_3^+ + OH^-$$

	$C_6H_5NH_2$		$C_6H_5NH_3^+$	OH^-
I	0.60		0	0
C	$-x$		$+x$	$+x$
E	$0.60-x$		x	x

$$K_b = \frac{[OH^-][C_6H_5NH_3^+]}{[C_6H_5NH_2]}$$

$$3.8\times10^{-10} = \frac{x^2}{0.60-x} \quad K_b \text{ is very small assume x to be negligible}$$

$$(3.8\times10^{-10})(0.60) = \left(\frac{x^2}{0.60}\right)(0.60)$$

$$\sqrt{2.28\times10^{-10}} = \sqrt{x^2}$$

$$1.51\times10^{-5} = x$$

$[OH^-] = x = 1.51 \times 10^{-5}$ mol/L

$$\%\,\text{dissociation} = \frac{[OH^-]}{[C_6H_5NH_2]}\times100\%$$

$$= \frac{1.51\times10^{-5}}{0.60}\times100\%$$

$$= \mathbf{2.5\times10^{-3}\ \%\ dissociated}$$

12. $$HA + H_2O \rightleftharpoons H_3O^+ + A^-$$

You must find the $[H_3O^+]$ and $[A^-]$ first:

$$[H_3O^+] = \frac{(\%\text{diss})[HA]}{100\%}$$

$$= \frac{(0.015\%)(0.750\ \text{mol/L})}{100\%}$$

$$= 1.125\times10^{-4}\ \text{mol/L}$$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

$$= \frac{(1.125\times10^{-4})(1.125\times10^{-4})}{0.750}$$

$$\mathbf{K_a = 1.7\times10^{-8}}$$

13. $Mg(OH)_2$ is a strong base, so it dissociates completely:

$$Mg(OH)_2(s) \rightarrow Mg^{2+}(aq) + 2OH^-(aq)$$

$[Mg^{2+}] = 0.75$ mol/L
$[OH^-] = 2 \times [Mg^{2+}] = 1.5$ mol/L
$[Mg(OH)_2] = 0$ mol/L

14. $$HB + H_2O \rightleftharpoons H_3O^+ + B^-$$

$$K_a = \frac{[H_3O^+][B^-]}{[HB]}$$

$$= \frac{(4.5\times10^{-10})(4.5\times10^{-10})}{0.80}$$

$$\mathbf{K_a = 2.5\times10^{-19}}$$

Student Name: Key Date: _____

Chemistry 40S

Acids and Bases

Neutralization Reactions

Write a complete balanced equation for each of these acid-base reactions. Give the names of the salts produced. An example is completed for you. (20 marks)

example: HNO_3 with KOH:

$HNO_3 + KOH \rightarrow KNO_3 + H_2O$ already balanced salt: potassium nitrate

1. HCl with $Mg(OH)_2$:

$2HCl_{(aq)} + Mg(OH)_2 \rightarrow MgCl_{2(aq)} + 2H_2O_{(l)}$ Magnesium chloride

2. H_2SO_4 with NH_4OH:

$H_2SO_{4(aq)} + 2NH_4OH_{(aq)} \rightarrow (NH_4)_2SO_{4(aq)} + 2H_2O_{(l)}$ Ammonium Sulfate

3. HCl with NH_4OH:

$HCl_{(aq)} + NH_4OH_{(aq)} \rightarrow NH_4Cl_{(aq)} + H_2O_{(l)}$ Ammonium chloride

4. H_2SO_4 with NaOH:

$H_2SO_{4(aq)} + 2NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$ Sodium Sulfate

5. H_3PO_4 with $Ca(OH)_2$:

$2H_3PO_{4(aq)} + 3Ca(OH)_{2(aq)} \rightarrow Ca_3(PO_4)_{2(aq)} + 6H_2O_{(l)}$ Calcium phosphate

6. HNO_3 with $Mg(OH)_2$:

$2HNO_{3(aq)} + Mg(OH)_{2(aq)} \rightarrow Mg(NO_3)_{2(aq)} + 2H_2O_{(l)}$ Magnesium Nitrate

7. NaOH with HNO_3:

$NaOH_{(aq)} + HNO_{3(aq)} \rightarrow NaNO_{3(aq)} + H_2O_{(l)}$ Sodium Nitrate

8. HBr with $Ca(OH)_2$:

$2HBr_{(aq)} + Ca(OH)_{2(aq)} \rightarrow CaBr_{2(aq)} + 2H_2O_{(l)}$ Calcium Bromide

9. $Mg(OH)_2$ with HCl:

$Mg(OH)_{2(aq)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + 2H_2O_{(l)}$ Magnesium Chloride

10. H_3PO_4 with NaOH:

$H_3PO_{4(aq)} + 3NaOH_{(aq)} \rightarrow Na_3PO_{4(aq)} + 3H_2O_{(l)}$ Sodium phosphate