## CHEM 131

Name
Quiz 7 - October 30, 2019
Complete the following problems. Write your final answers in the blanks provided. You must show your work to receive full credit. Show your answers to the correct number of significant figures with the correct units.

1. Calculate the pH and pOH of an aqueous solution that is $0.0100 \mathrm{M} \mathrm{HNO}_{3}, 0.0150 \mathrm{M} \mathrm{HCl}$ and 0.0125 M $\mathrm{H}_{2} \mathrm{SO}_{4}$. Assume all of the solutes are strong acids. (8 points)

We have three sources of $\mathrm{H}^{+}$in solution, so the total $\left[\mathrm{H}^{+}\right]$must be the sum of the conrtributions from all three sources: $\left[\mathrm{H}^{+}\right]_{\text {otal }}=\left[\mathrm{H}^{+}\right]_{\mathrm{HNO} 3}+\left[\mathrm{H}^{+}\right]_{\mathrm{HCl}}+\left[\mathrm{H}^{+}\right]_{\mathrm{H} 2 \mathrm{SO} 4}$

These are all strong acids, so each of the dissociation reaction goes to completion. Given that:

$$
\begin{gathered}
{\left[\mathrm{H}^{+}\right]_{\mathrm{HNO} 3}=\frac{0.0100 \mathrm{~mol} \mathrm{HNO}_{3}}{1 \mathrm{~L}} \times \frac{1 \mathrm{~mol} \mathrm{H}^{+}}{1 \mathrm{~mol} \mathrm{HNO}_{3}}=0.0100 \mathrm{M}} \\
{\left[\mathrm{H}^{+}\right]_{\mathrm{HCl}}=\frac{0.0150 \mathrm{~mol} \mathrm{HCl}}{1 \mathrm{~L}} \times \frac{1 \mathrm{~mol} \mathrm{H}^{+}}{1 \mathrm{~mol} \mathrm{HCl}}=0.0150 \mathrm{M}} \\
{\left[\mathrm{H}^{+}\right]_{\mathrm{H} 2 \mathrm{SO} 4}=\frac{0.0125 \mathrm{~mol} \mathrm{H}_{2} \mathrm{SO}_{4}}{1 \mathrm{~L}} \times \frac{2 \mathrm{~mol} \mathrm{H}^{+}}{1 \mathrm{~mol} \mathrm{H}_{2} \mathrm{SO}_{4}}=0.0250 \mathrm{M}} \\
{\left[\mathrm{H}^{+}\right]_{\text {total }}=0.0100 \mathrm{M}+0.0150 \mathrm{M}+0.0250 \mathrm{M}=0.0500 \mathrm{M}} \\
\mathrm{pH}=-\log \left[\mathrm{H}^{+}\right]_{\text {total }}=-\log (0.0500 \mathrm{M})=1.30 \\
\mathrm{pOH}=14-\mathrm{pH}=12.70
\end{gathered}
$$

Answer___ $\mathrm{pH}=1.30 \mathrm{pOH}=12.70$ $\qquad$
2. Methylamine $\left(\mathrm{CH}_{3} \mathrm{NH}_{2}\right)$, is a monobasic weak base, which can accept a proton from water to form the methylammonium ion $\left(\mathrm{CH}_{2} \mathrm{NH}_{3}{ }^{+}\right)$and hydroxide. If the pH of a 0.00250 M solution of methylamine is 10.92 , what is the $\mathrm{K}_{\mathrm{b}}$ for methylamine? (8 points)

$$
\begin{array}{ccccccc} 
& \mathrm{CH}_{3} \mathrm{NH}_{2} & +\mathrm{H}_{2} \mathrm{O} \rightleftharpoons \mathrm{CH}_{2} \mathrm{NH}_{3}{ }^{+} & +\mathrm{OH}^{-} \\
\mathrm{I} & 0.00250 & -- & 0 & 0 & \mathrm{~K}_{\mathrm{b}}=\frac{\left[\mathrm{OH}^{-}\right]\left[\mathrm{CH}_{2} \mathrm{NH}_{3}{ }^{+}\right]}{\left[\mathrm{CH}_{2} \mathrm{NH}_{2}\right]}=\frac{(\mathrm{x})(\mathrm{x})}{0.00250-\mathrm{x}} \\
\mathrm{C} & -\mathrm{x} & -- & +\mathrm{x} & +\mathrm{x} \\
\mathrm{E} & 0.00250-\mathrm{x} & -- & \mathrm{x} & \mathrm{x} &
\end{array}
$$

Since we are given pH , we can calculate the $\left[\mathrm{OH}^{-}\right]$, which is x in our $\mathrm{K}_{\mathrm{b}}$ expression:

$$
\begin{gathered}
\mathrm{pOH}=14-\mathrm{pH}=3.08 \\
{\left[\mathrm{OH}^{-}\right]=10^{-\mathrm{pOH}}=10^{-3.08}=8.318 \times 10^{-4} \mathrm{M}=\mathrm{x}}
\end{gathered}
$$

Inserting this for x in our $\mathrm{K}_{\mathrm{b}}$ expression gives

$$
\mathrm{K}_{\mathrm{b}}=\frac{\left[\mathrm{OH}^{-}\right]\left[\mathrm{CH}_{2} \mathrm{NH}_{3}{ }^{+}\right]}{\left[\mathrm{CH}_{2} \mathrm{NH}_{2}\right]}=\frac{\left(8.318 \times 10^{-4}\right)^{2}}{0.00250-8.318 \times 10^{-4}}=4.15 \times 10^{-4}
$$

Answer $\qquad$ $K_{b}=4.15 \times 10^{-4}$ $\qquad$
3. Nitrous acid $\left(\mathrm{HNO}_{2}\right)$ is a monoprotic weak acid with a $\mathrm{pK}_{\mathrm{a}}$ of 3.15 . What is the pH of a 0.035 M solution of nitrous acid? (8 points)

$$
\mathrm{K}_{\mathrm{a}}=10^{-\mathrm{pKa}}=10^{-3.15}=7.08 \times 10^{-4}
$$

$$
\begin{array}{ccccc} 
& \mathrm{HNO}_{2} & \rightleftharpoons & \mathrm{H}^{+} & + \\
\mathrm{NO}_{2}^{-} \\
\mathrm{I} & 0.0350 & 0 & 0 \\
\mathrm{C} & -\mathrm{x} & +\mathrm{x} & +\mathrm{x} \\
\mathrm{E} & 0.0350-\mathrm{x} & \mathrm{x} & \mathrm{x}
\end{array} \quad \mathrm{~K}_{\mathrm{a}}=\frac{\left[\mathrm{H}^{+}\right]\left[\mathrm{NO}_{2}^{-}\right]}{\left[\mathrm{HNO}_{2}\right]}=\frac{(\mathrm{x})(\mathrm{x})}{0.0350-\mathrm{x}}
$$

$$
\begin{gathered}
\mathrm{K}_{\mathrm{a}}(0.0350-\mathrm{x})=\mathrm{x}^{2} \\
0.0350 \mathrm{~K}_{\mathrm{a}}-\mathrm{xK}_{\mathrm{a}}=\mathrm{x}^{2} \\
\mathrm{x}^{2}+\mathrm{xK} \mathrm{~K}_{\mathrm{a}}-0.0350 \mathrm{~K}_{\mathrm{a}}=0
\end{gathered}
$$

Solving the quadratic gives $\mathrm{x}=4.64 \times 10^{-3}$ or $-5.35 \times 10^{-3}$. Since a negative concentration doesn't make any chemical sense, the reasonable result is $\mathrm{x}=\left[\mathrm{H}^{+}\right]=4.64 \times 10^{-3} \mathrm{M}$

$$
\mathrm{pH}=-\log \left(4.64 \times 10^{-3} \mathrm{M}\right)=2.33
$$

You may attempt to simplify the calculation by assuming $\mathrm{x} \ll 0.0350$ so that $0.0350-\mathrm{x} \approx 0.0350$. In doing so, the math becomes:

$$
\begin{gathered}
{\left[\mathrm{H}^{+}\right]=\left(0.0350 \mathrm{~K}_{\mathrm{a}}\right)^{1 / 2}=0.00498 \mathrm{M} .} \\
\mathrm{pH}=2.30
\end{gathered}
$$

In this case the assumption isn't very good since $0.0350-0.00498=0.0300$ which is significantly different than 0.0350 !
+1 free point to make 25
Answer__ $\mathrm{pH}=2.33$ $\qquad$
$\mathrm{pH}+\mathrm{pOH}=14$

$$
\mathrm{K}_{\mathrm{a}} \mathrm{~K}_{\mathrm{b}}=\mathrm{K}_{\mathrm{w}}=1.00 \times 10^{-14}
$$

$$
x=\frac{-b \pm \sqrt{b^{2}-4 a c}}{2 a}
$$

| ${ }_{1}^{1 A}$ |  | Periodic Table of the Elements |  |  |  |  |  |  |  |  |  |  |  |  |  |  | $\mathrm{vma}_{\text {si }}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\underset{\substack{1 \\ \text { Hutuen } \\ \text { Himese }}}{ }$ |  |  |  |  |  |  |  |  |  |  |  | $\begin{gathered} 13 \\ \substack{13 \\ 3 A \\ \hline} \end{gathered}$ | $\begin{gathered} 14 \\ \left.\begin{array}{c} 14 \\ 4 A \end{array}\right) \end{gathered}$ | $\begin{aligned} & 150 \\ & \substack{15 \\ 5 A \\ \hline} \end{aligned}$ |  | , 17 | He |
| Li | Be <br> Ben |  |  |  |  |  |  |  |  |  |  |  | $\left.\right\|_{\substack{\text { cinen } \\ \text { nein }}} ^{\text {c }}$ | $\underset{\substack{\text { cuesem } \\ \text { Nueo }}}{\mathbf{N}}$ | ${ }^{8}$ |  |  |
|  |  |  | $\underset{\substack{\text { UE } \\ 48}}{\text { ¢ }}$ | $\underbrace{\text { chem }}_{\substack{\text { ve } \\ 58}}$ | $\underbrace{\text { cher }}_{\substack{\text { vib } \\ 68}}$ | $\begin{gathered} 7 \\ v_{7 B}^{7} \end{gathered}$ | $i_{8}$ | $\frac{\mathrm{vim}}{-\frac{8}{8}}$ | $\underbrace{10}$ | $\begin{aligned} & 11 \\ & \substack{18 \\ 18 \\ \hline} \end{aligned}$ | $\begin{gathered} 12 \\ \begin{array}{c} 12 \\ 28 \end{array} \\ \hline 18 \end{gathered}$ | ${ }^{13} \mathbf{A l}$ |  | ${ }_{\substack{\text { mempous } \\ \text { apas }}}^{15}$ | S <br> Sulfur 32.066 |  |  |
| ${ }^{19} \mathbf{K}$ | Ca $\qquad$ |  | $\begin{aligned} & 2220 \\ & \hline \end{aligned}$ | ${ }^{230} \mathbf{V}$ | ${ }_{\substack{\text { coincom } \\ \text { cisem }}}^{24}$ |  | Fe $\underset{\substack{\text { tum } \\ \text { sises }}}{ }$ | Co | ${ }_{\substack{\text { stices } \\ \text { sices }}}^{28}$ |  |  |  | ${ }_{\substack{\text { a }}}^{32}{ }^{\text {chen }}$ | ${ }^{33} \text { As }$ | Se 78.971 |  |  |
| $\underset{\substack{\text { Rbbum } \\ \hline \text { buck }}}{ }$ | Sr <br> Saticn | ${ }^{39} \mathbf{y}$ | ${ }^{40} \mathbf{Z r}$ |  |  | ${ }_{\substack{\text { a }}}^{\text {a }}$ | ${ }_{\substack{\text { Ratumem } \\ \text { Rutior }}}^{44}$ | Rh <br>  | ${ }^{46} \mathbf{P d}$ | $\mathrm{Ag}$ | ${ }^{48} \mathbf{C d}$ | ${ }^{49} \text { In }$ | Sn <br>  | Sb $\square$ | ${ }^{52} \mathbf{T e}$ | $53$ | ${ }_{\substack{\text { a }}}^{54}$ |
| Cs <br> ${ }^{\text {cisizem }}$ | ${ }^{56}$ Ba <br> Bat | ${ }^{57-71}$ |  | ${ }_{\substack{\text { a }}}^{73}$ | ${ }^{74} \mathrm{~W}$ | ${ }^{75}$ | ${ }^{76}$ |  | ${ }_{\substack{\text { Sut } \\ \text { pisiose }}}^{78}$ | Au <br> cos |  |  | $\underbrace{82}_{\substack{\text { cout } \\ \text { bunt }}}$ | Bi <br> Bismuth 208.980 |  |  |  |
| Fr <br> Francium 223.020 | ${ }^{88} \mathrm{Ra}$ | ${ }^{89.103}$ |  |  | $\int_{\text {seng }}^{\substack{1060}}$ |  |  |  | ${ }_{\substack{\text { a }}}^{10}$ Ds | ${ }^{11} \mathrm{Rg}$ |  |  | ${ }_{\substack{\text { factiom } \\ \text { capl }}}^{14}$ |  | ${ }^{116}$ Lv | Ts |  |


|  |  |  |  |  |  |  | Eu |  |  |  |  |  |  |  |  |
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