Chem 12 Acid Base Worksheet #7

1.

	$HB + H_2O \rightleftharpoons$	$H_3O^+ +$	B^-
I	$[HB]$	0	0
C	$-x$	$+x$	$+x$
E	$[HB]-x$	x	x

$\approx [HB]$ if x is small

$K_a = \frac{[H_3O^+][B^-]}{[HB]} = \frac{x^2}{[HB]}$

$x^2 = K_a[HB]$

$x = \sqrt{K_a[HB]}$

$x = [H_3O^+]$

2. $H_2SO_3 \rightleftharpoons H^+ + HSO_3^-$ $K_{a_1} = 1.5\times10^{-2} = \frac{[H^+][HSO_3^-]}{[H_2SO_3]}$

$HSO_3^- \rightleftharpoons H^+ + SO_3^{2-}$ $K_{a_2} = 1.0\times10^{-7} = \frac{[H^+][SO_3^{2-}]}{[HSO_3^-]}$

$K_{a_1} \times K_{a_2} = \frac{[H^+][HSO_3^-]}{[H_2SO_3]} \times \frac{[H^+][SO_3^{2-}]}{[HSO_3^-]} = \frac{[H^+]^2[SO_3^{2-}]}{[H_2SO_3]}$

$H_2SO_3 \rightleftharpoons 2H^+ + SO_3^{2-}$ $K_a = \frac{[H^+]^2[SO_3^{2-}]}{[H_2SO_3]}$ ← same

so $K_a = K_{a_1} \times K_{a_2}$

$K_a = (1.5\times10^{-2})(1.0\times10^{-7}) = 1.5\times10^{-9}$

3a) $CH_3CH_2CH_2COOH + H_2O \rightleftharpoons H_3O^+ + CH_3CH_2CH_2COO^-$ $K_a = 1.54\times10^{-5}$

b)

I	0.010 M	0	0	$1.54\times10^{-5} = \frac{[H_3O^+][CH_3CH_2CH_2COO^-]}{[CH_3CH_2CH_2COOH]}$
C	$-x$	$+x$	$+x$	
E	$0.010-x$	x	x	$= \frac{x^2}{0.010}$

≈ 0.010 if x is small

$[H_3O^+] = x = \sqrt{(1.54\times10^{-5})(0.010)}$

$= 3.92428\ldots\times10^{-4}$

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

$= -\log(3.92428\ldots\times10^{-4}) = 3.41$

c) $CH_3CH_2CH_2COOH + NaOH \rightarrow H_2O + NaCH_3CH_2CH_2COO$

moles of $CH_3CH_2CH_2COOH = M\times V = (0.010\ M)(0.100\ L) = 0.0010$ mol

moles of $NaOH = 0.00100$ mol $CH_3CH_2CH_2COOH \times \frac{1\text{ mol } NaOH}{1\text{ mol } CH_3CH_2CH_2COOH} = 0.00100$ mol

$M = \frac{n}{V}$ so $V = \frac{n}{M} = (0.00100\text{ mol}) \div 0.35\ M = 2.9\times10^{-3}$ L

d) H_2O water $NaCH_3CH_2CH_2COO$ sodium butanoate

4. Total moles of H_2SO_4 present $= M_1V_1 + M_2V_2$

$= (0.50M)(0.050L) + (0.25M)(0.100L) = 0.050$ mol

Total volume $= 0.050L + 0.100L = 0.150L$

$[acid] = \frac{n}{V} = 0.050\text{ mol} \div 0.150L = 0.33\ M$

5. $HA + H_2O \rightleftharpoons H_3O^+ + A^-$ $NaOH \rightarrow Na^+ + OH^-$

↑ reacts to form H_2O ↑

$[H_3O^+]$ ↓

eqm shifts → and so $[HA]$ ↓ ($HA_{(s)} \rightleftharpoons HA_{(aq)}$)

↓ shifts →

so HA solids dissolves

6. $CH_3CH_2OH + O_2 \longrightarrow CH_3COOH + H_2O$

ethanol (in wine) — ethanoic acid (also called acetic acid)

$pH = 2.80 \rightarrow [H_3O^+] = 10^{-pH} = 10^{-2.80} = 1.584893\ldots \times 10^{-3}\ M$ (2 s.f.) $= x$

R	CH_3COOH	+ H_2O	$\rightleftharpoons$ H_3O^+	+ CH_3COO^-
I	?		0	0
C	$-x$		$+x$	$+x$
E	$[CH_3COOH]_{initial} - x$		x	x

$$K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]} \qquad 1.8 \times 10^{-5} = \frac{x^2}{[CH_3COOH]_{initial} - x}$$

$$1.8 \times 10^{-5} = \frac{(1.584893\ldots \times 10^{-3})^2}{[CH_3COOH]_i - (1.584893\ldots \times 10^{-3})}$$

$$1.8 \times 10^{-5}\left([CH_3COOH]_i - 1.584893\ldots \times 10^{-3}\right) = (1.584893\ldots \times 10^{-3})^2$$

$$(1.8 \times 10^{-5})[CH_3COOH]_i - (1.8 \times 10^{-5})(1.584893\ldots \times 10^{-3}) = (1.584893\ldots \times 10^{-3})^2$$

$$[CH_3COOH]_i = \frac{(1.584893\ldots \times 10^{-3})^2 + (1.8 \times 10^{-5})(1.584893\ldots \times 10^{-3})}{(1.8 \times 10^{-5})}$$

$$= 0.14113413\ldots\ M$$

moles of $CH_3COOH = M \times V = (0.141\ldots\ M)(1\ L) = 0.141\ldots\ mol$

moles of ethanol $CH_3CH_2OH = 0.141\ldots\ mol\ CH_3COOH \times \frac{1\ mol\ CH_3CH_2OH}{1\ mol\ CH_3COOH}$

$= 0.141\ldots\ mol$

molar mass of ethanol $= 2(12.0) + 6(1.0) + 16.0\ g/mol$

$= 46.0\ g/mol$

mass of ethanol $= 0.141\ldots\ mol \times \frac{46.0\ g}{1\ mol} = 6.5\ g$