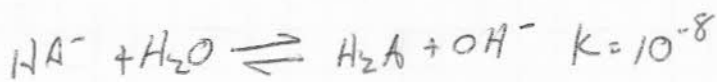
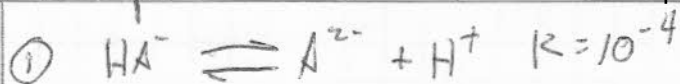
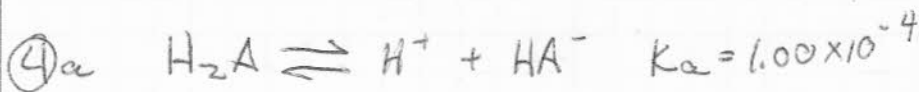


# or Chapter 9



The  $\text{H}^+$  in the first reaction reacts with  $\text{OH}^-$  from the second reaction driving the second reaction further towards products than expected.

②  $^+\text{H}_3\text{N}-\underset{\text{R}}{\text{CH}}-\text{CO}_2^-$  all amino acids are diprotic (2 pKas) and some have an additional acid group on their side chain.



$$\frac{[\text{H}^+][\text{HA}^-]}{[\text{H}_2\text{A}]} = 1.00 \times 10^{-4}$$

$$\frac{x^2}{0.100 - x} = 1.00 \times 10^{-4}$$

$$x^2 + 1.00 \times 10^{-4} - 1.00 \times 10^{-5} = 0$$

$$x = 3.11 \times 10^{-3} = [\text{H}^+]$$

$$\frac{[\text{H}^+][\text{A}^{2-}]}{[\text{HA}^-]} = 1.00 \times 10^{-8}$$

$$[\text{A}^{2-}] = 1.00 \times 10^{-8}$$

	$\text{H}_2\text{A}$	$\text{H}^+$	$\text{HA}^-$
T	0.100	-	-
C	-x	+x	+x
E	0.100 - x	x	x

$\text{pH} = 2.51$

$[\text{H}_2\text{A}] = 9.69 \times 10^{-2} \text{ M}$

$[\text{HA}^-] = 3.11 \times 10^{-3} \text{ M}$

$[\text{A}^{2-}] = 1.00 \times 10^{-8} \text{ M}$

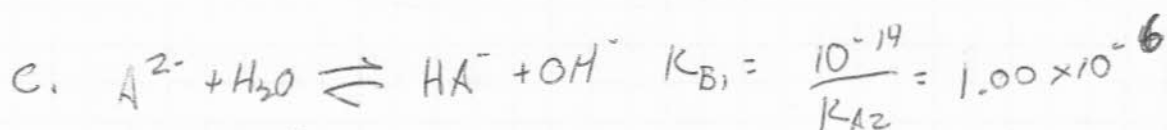
$$4) [H^+] = \sqrt{\frac{(1.00 \times 10^{-4})(1.00 \times 10^{-8})(0.100) + (1.00 \times 10^{-4})(1.00 \times 10^{-14})}{1.00 \times 10^{-4} + 0.100}}$$

$$= 1.00 \times 10^{-6} \Rightarrow \text{pH} = 6$$

$$\text{E}_{H_2} [H_2A] = \frac{[H^+][HA^-]}{1.00 \times 10^{-4}} = \frac{(1.00 \times 10^{-6})(0.100)}{1.00 \times 10^{-4}} = 1.00 \times 10^{-3} \text{ M}$$

$$[HA^-] = F = 0.100 \text{ M}$$

$$[A^{2-}] = \frac{[HA^-](1.00 \times 10^{-8})}{[H^+]} = \frac{(0.100)(1.00 \times 10^{-8})}{1.00 \times 10^{-6}} = 1.00 \times 10^{-3} \text{ M}$$



$$\frac{[HA^-][OH^-]}{[A^{2-}]} = 1.00 \times 10^{-6}$$

$$\frac{x^2}{0.100 - x} = 1.00 \times 10^{-6}$$

$$x = 3.16 \times 10^{-4} \text{ M}$$

	A <sup>2-</sup>	OH <sup>-</sup>	HA <sup>-</sup>
I	0.100	-	-
C	-x	+x	+x
E	0.100 - x	x	x

$$\text{pH} = -\log \frac{10^{-14}}{3.16 \times 10^{-4}} = 10.5$$

$$[HA^-] = 3.16 \times 10^{-4} \text{ M}$$

$$[A^{2-}] = 0.0997 \text{ M}$$

$$[H_2A] = K_{B2} = 1.00 \times 10^{-10} \text{ M}$$

$$5) a. K_{a1} = 1.42 \times 10^{-3}$$

$$K_{a2} = 2.01 \times 10^{-6}$$

$$\frac{x^2}{0.100 - x} = 1.42 \times 10^{-3}$$

$$x^2 + 1.42 \times 10^{-3}x - 1.42 \times 10^{-4} = 0$$

$$x = 1.12 \times 10^{-2} = [H^+]$$

$$\text{pH} = 1.95$$

$$[H_2A] = 0.089 \text{ M}$$

$$[HA^-] = 1.12 \times 10^{-2} \text{ M}$$

$$[A^{2-}] = 2.01 \times 10^{-6} \text{ M}$$

$$5b. [H^+] = \sqrt{\frac{(1.42 \times 10^{-3})(2.01 \times 10^{-6})(0.100) + (1.42 \times 10^{-3})(10^{-14})}{1.42 \times 10^{-3} + 0.100}}$$

$$[H^+] = 5.30 \times 10^{-5}$$

$$[H_2A] = \frac{[H^+][HA^-]}{K_{a1}} = \frac{(5.30 \times 10^{-5})(0.100)}{1.42 \times 10^{-3}} = 3.7 \times 10^{-3}$$

$$[A^{2-}] = \frac{K_{a2}[HA^-]}{[H^+]} = \frac{(2.01 \times 10^{-6})(0.100)}{5.30 \times 10^{-5}} = 3.79 \times 10^{-3}$$

$$pH = 4.28$$

$$[HA^-] = 0.100 M$$

$$[H_2A] = 3.7 \times 10^{-3} M$$

$$[A^{2-}] = 3.8 \times 10^{-3} M$$

$$c. \frac{x^2}{0.100 - x} = K_{B1} = \frac{10^{-14}}{K_{a2}} = 4.98 \times 10^{-9}$$

$$x = 2.23 \times 10^{-5} = [OH^-]$$

$$pH = -\log \frac{10^{-14}}{[OH^-]} = 9.35$$

$$pH = 9.35$$

$$A^{2-} = 0.100 M$$

$$HA^- = 2.23 \times 10^{-5} M$$

$$H_2A = K_{B2} = 2.04 \times 10^{-12} M$$

$$6. K_{a1} = 4.65 \times 10^{-6}$$

$$K_{a2} = 1.86 \times 10^{-10}$$

$$K_{B1} = 10^{-14} / 1.86 \times 10^{-10} = 5.38 \times 10^{-5}$$

$$K_{B2} = 10^{-14} / 4.65 \times 10^{-6} = 2.15 \times 10^{-9}$$

$$\frac{x^2}{0.300 - x} = 5.38 \times 10^{-5}$$

$$x = 4.02 \times 10^{-3} = [OH^-]$$

$$pH = -\log \left( \frac{10^{-14}}{[OH^-]} \right) =$$

$$[BH_2^{2+}] = \frac{K_{B2}[BH^+]}{[OH^-]} = 2.15 \times 10^{-9}$$

$$pH = 11.6$$

$$[B] = 0.296 M$$

$$[BH^+] = 4.02 \times 10^{-3} M$$

$$[BH_2^{2+}] = 2.15 \times 10^{-9} M$$