Answers to Chapter 16

(1) only choice B has H_3O^+ as one of the products so thats Ka

(2) ↑ Ka ↑ strength of weak acid

$HC_2H_3O_2$ < HOCN < HF strongest weak acid

(3)

R:	$HC_2H_3O_2$	+ H_2O ⟷	H_3O^+	+	$C_2H_3O_2^-$
I	1.3		0		0
C	$-x$		$+x$		$+x$
E	$1.3-x$		x		x

$$Ka = \frac{[H_3O^+][C_2H_3O_2^-]}{[HC_2H_3O]} = 1.8\times10^{-5} = \frac{(x)(x)}{1.3-x} \approx 1.3$$

$\frac{1.3}{1.8\times10^{-5}} > 1000$ so $1.3-x \approx 1.3$

$$(1.8\times10^{-5})(1.3) = x^2$$

$$2.4\times10^{-5} = x^2$$

$$\sqrt{2.4\times10^{-5}} = x = 4.9\times10^{-3}$$

$$\%\text{ ionized} = \frac{x}{[HA]_i}\times100 = \frac{4.9\times10^{-3}}{1.3}\times100 = 0.38\%$$

0.37% closest among choices

(4)

R	HA	⟷	H^+	+	A^-
I	0.20		0		0
C	$-x$		$+x$		$+x$
E	$0.20-x$		x		x

$x = 0.20\times0.0020 = 4.0\times10^{-4}$ ↑ obtained from 0.20%

$$Ka = \frac{(4.0\times10^{-4})(4.0\times10^{-4})}{0.20-4.0\times10^{-4}} = 8.0\times10^{-7}$$

(5)

R	HA	⟷	H^+	+	A^-
I	0.020		0		0
C	$-x$		$+x$		$+x$
E	$0.020-x$		x		x

$x = [H^+] = 10^{-pH}$

$5.1\times10^{-4} = 10^{-3.29}$

$$Ka = \frac{(5.1\times10^{-4})(5.1\times10^{-4})}{0.020-x} = 1.3\times10^{-5}$$

(6)

R	HA	⟷	H^+	+	A^-
I	0.035		0		0
C	$-x$		$+x$		$+x$
E	$0.035-x$		x		x

$$Ka = \frac{(x)(x)}{0.035-x}$$

$$6.3\times10^{-5} = \frac{(x)(x)}{0.035}$$

$$(6.3\times10^{-5})(0.035) = x^2$$

$$2.2\times10^{-6} = x^2$$

$$x = \sqrt{2.2\times10^{-6}}$$

$x = 1.5\times10^{-3} = [H^+]$

$pH = -\log 1.5\times10^{-3} = 2.83$

(7) $HOOCCH_2CH_2COOH \underset{Ka_1}{\overset{H_2O}{\rightleftharpoons}} H_3O^+ + HOOCCH_2CH_2COO^-$

$HOOCCH_2CH_2COO^- \underset{Ka_2}{\overset{H_2O}{\rightleftharpoons}} H_3O^+ + {}^-OOCCH_2CH_2COO^-$

since Ka values are so small only small amount dissociated so the species present in highest concentration is $HOOCCH_2CH_2COOH$.

(8) For K_b, find the reaction that has OH^- as one of the products.

9)

R	B	+ H_2O ⟷	BH^+	+	OH^-
I	0.19 M		0		0
C	$-x$		$+x$		$+x$
E	$0.19-x$		x		x

$$K_b = \frac{(x)(x)}{0.19-x} = 1.4\times10^{-9}$$

$$x^2 = (0.19)(1.4\times10^{-9})$$

$$x = \sqrt{2.66\times10^{-10}}$$

$[OH^-] = x = 1.6\times10^{-5}$

$pOH = -\log 1.6\times10^{-5}$

$= 4.79$

(10)

	NH_3	+ H_2O ⟷	NH_4^+	+ OH^-
I	0.26		0	0
C	$-x$		$+x$	$+x$
E	$0.26-x$		x	x

$K_b = \frac{(x)(x)}{0.26-x}$

$1.8\times10^{-5} = \frac{x^2}{0.26}$

$x^2 = (1.8\times10^{-5})(0.26)$

$x^2 = 4.7\times10^{-6}$

$x = \sqrt{4.7\times10^{-6}}$

$[NH_4^+] = [OH^-] = x = 2.2\times10^{-3}$

(11)

	B	+ H_2O ⟷	BH^+	+ OH^-
I	0.0868		0	0
C	$-x$		x	x
E	$0.0868-x$		x	x

$K_b = \frac{(1.1\times10^{-5})(1.1\times10^{-5})}{(0.0868-1.1\times10^{-5})}$

$= 1.4\times10^{-9}$ so its pyridine

Given pH = 9.04

$[H_3O^+] = 10^{-9.04}$

$[H_3O^+] = 9.1\times10^{-10}$

$[OH^-] = \frac{Kw}{[H_3O^+]}$

$1.1\times10^{-5} = [OH^-] = \frac{1\times10^{-14}}{9.1\times10^{-10}}$

(12) The one that hydrolyses are conjugate base of weak acid and conjugate acid of week base. The ions are NH_4^+ and Cl^- so only NH_4^+ will hydrolyze. The Cl^- will not hydrolyze since its conjugate base of a strong acid

$NH_4^+ + H_2O \longleftrightarrow NH_3 + H_3O^+$

13) The correct choice here is the one with the conjugate base coming from weak acid. All choices have conjugate base from strong acids except D.

(14) Find the salt that will give acidic soln. This will be the one that has a conjugate base from a strong acid and conjugate acid from a weak base. NH_4Cl

(15) $K_aK_b = Kw$ $K_a = \frac{Kw}{K_b} = \frac{1\times10^{-14}}{1.8\times10^{-5}} = 5.6\times10^{-10}$

(16) Just like #15 $K_b = \frac{Kw}{Ka} = \frac{1\times10^{-14}}{5.0\times10^{-4}} = 2.0\times10^{-11}$

(17)

	$NaC_3H_5O_2$	⟶	Na^+	+	$C_3H_5O_2^-$
I	0.26		0.26		0.26

	$C_3H_5O_2^-$	+ H_2O ⟷	$C_3H_5O_2H$	+ OH^-
I	0.26		0	0
C	$-x$		$+x$	$+x$
E	$0.26-x$		x	x

$K_b = \frac{(x)(x)}{0.26-x} = \frac{1\times10^{-14}}{1.3\times10^{-5}} = \frac{x^2}{0.26-x} \approx 0.26$

$7.7\times10^{-10} = \frac{x^2}{0.26}$ $(7.7\times10^{-10})(0.26) = x^2$

$2.0\times10^{-10} = x^2$

$[OH^-] = \sqrt{2.0\times10^{-10}} = x$

$= 1.4\times10^{-5}$

pOH = $-\log 1.4\times10^{-5}$

$= 4.8$

pH = $14 - 4.2$

$= 9.2$

(18) $NH_4Br = \frac{0.799}{97.94\,g/mol} = 0.0466\ M$

$\frac{175\,mL}{1000\,mL/L}$

$NH_4Br \rightarrow NH_4^+ + Br^-$

	NH_4^+	+ H_2O ⟷	NH_3	+ H_3O^+
I	0.0466		0	0
C	$-x$		x	x
E	$0.0466-x$		x	x

$K_a = \frac{(x)(x)}{0.0466-x} = \frac{Kw}{K_b}$

$\frac{1\times10^{-14}}{1.8\times10^{-5}} = \frac{x^2}{0.0466}$

$pH = -\log(5.1\times10^{-6})$

$= 5.29$

$pOH = 14 - 5.29$

$= 8.71$

$x^2 = (5.6\times10^{-10})(0.0466)$

$x^2 = 2.6\times10^{-11}$

$x = 5.1\times10^{-6} = [H_3O^+]$

(19) $NH_3 + H_2O \longleftrightarrow NH_4^+ + OH^-$

Adding NaOH will increase $[OH^-]$. This common ion will favor backward rxn causing the percent ionization of ammonia to decrease.

(20) $HCN \xrightleftharpoons{H_2O} H_3O^+ + CN^-$

$pH = pKa + \log \frac{CN^-}{HCN}$

$= pKa + \log \frac{[CN^-]}{[HCN]}$ if $[CN^-] = [HCN]$

Only choice B is false.

(21) Find the pKa of acid in buffer system closest to the pH.

Choice D pKa is closest to pH 4.45.

(22) Buffer is made up of weak acid and its conjugate base or weak base and its conjugate acid. Only choice D fulfill this definition of a buffer.

(23) $HF \longleftrightarrow H^+ + F^-$

after addn of H^+ $H^+ + F^- \longrightarrow HF$

F^- will react with added H^+ from HCl

(24) $HCHO_2 + H_2O \longrightarrow CHO_2^- + H_3O^+$

$OH^- + HCHO_2 \longrightarrow CHO_2^- + H_2O$

NaOH will dissociate to Na^+ & OH^- and OH^- reacts with acid component of the buffer

(25) $pH = pKa + \log \frac{[base]}{[acid]}$

$= -\log 1.8\times10^{-5} + \log \frac{0.032}{0.032}$

$pH = 4.74 + \log 1$

$[H^+] = 10^{-4.74} = 1.8 \times 10^{-5}$

(26) $HCl + NaOH \longrightarrow H_2O + NaCl$

$(0.18\ M)\left(\frac{700\ mL}{1000\ mL/L}\right) = 0.126\ mol\ H^+$

$(0.51M)\left(\frac{300\ mL}{1000\ mL/L}\right) = 0.153\ mol\ OH^-$

$\frac{0.027\ mol\ OH^-\ left}{1.0\ L} = 0.026M$

$pOH = -\log 0.027 = 1.57$

$[OH^-] = 10^{-pOH} = 0.027$

$[H^+] = \frac{1\times10^{-14}}{0.027} = 3.7 \times 10^{-13}$

(27) Only choice D is true where at equivalence point, the solution is composed of the conjugate base of the weak acid.

(28) For indicator choices, look at the pH region being analyzed. The indicator whose transition range is close to the pH region being analyzed is the best indicator.

For the question, a weak acid is titrated with strong base and since equivalence point is higher than 7 = pH, choice D is the most appropriate.

(29) The equivalence point is the steepest point so correct choice is C or III.

(30) $mol\ OH^- = (0.125\ \frac{mol}{L})\left(\frac{41.36\ mL}{1000\ mL/L}\right) = 5.17\times10^{-3}$

$mol = CV$

$C = \frac{mol}{V} = \frac{5.17\times10^{-3}\ mol}{\frac{25.00\ mL}{1000\ mL/L}} = 0.2068\ M$ original concn of propionic acid

$HA + OH^- \longleftrightarrow H_2O + A^-$

5.17×10^{-3} 5.17×10^{-3} 5.17×10^{-3}

$[A^-] = \frac{5.17\times10^{-3}}{\left(\frac{41.36 + 25.00\ mL}{1000\ mL/L}\right)}$

$= 0.0779\ M$ = concentration of propionate ion at the equivalence point