UNIT 7

ACIDS & BASES

ANSWERS

Theories on Acids and Bases

(2) Bronsted-Lowry – more inclusive theory than that of Arrhenius

$$NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

ionic: $Na^+_{(aq)} + OH^-_{(aq)} + H^+_{(aq)} + Cl^-_{(aq)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)} + H_2O_{(l)}$

net ionic: $OH^-_{(aq)} + H^+_{(aq)} \rightarrow H_2O_{(l)}$

eg. b) $NH_{3(aq)} + H_2O_{(l)} \rightarrow NH_4^+_{(aq)} + OH^-_{(aq)}$
base acid conj. acid conj. base

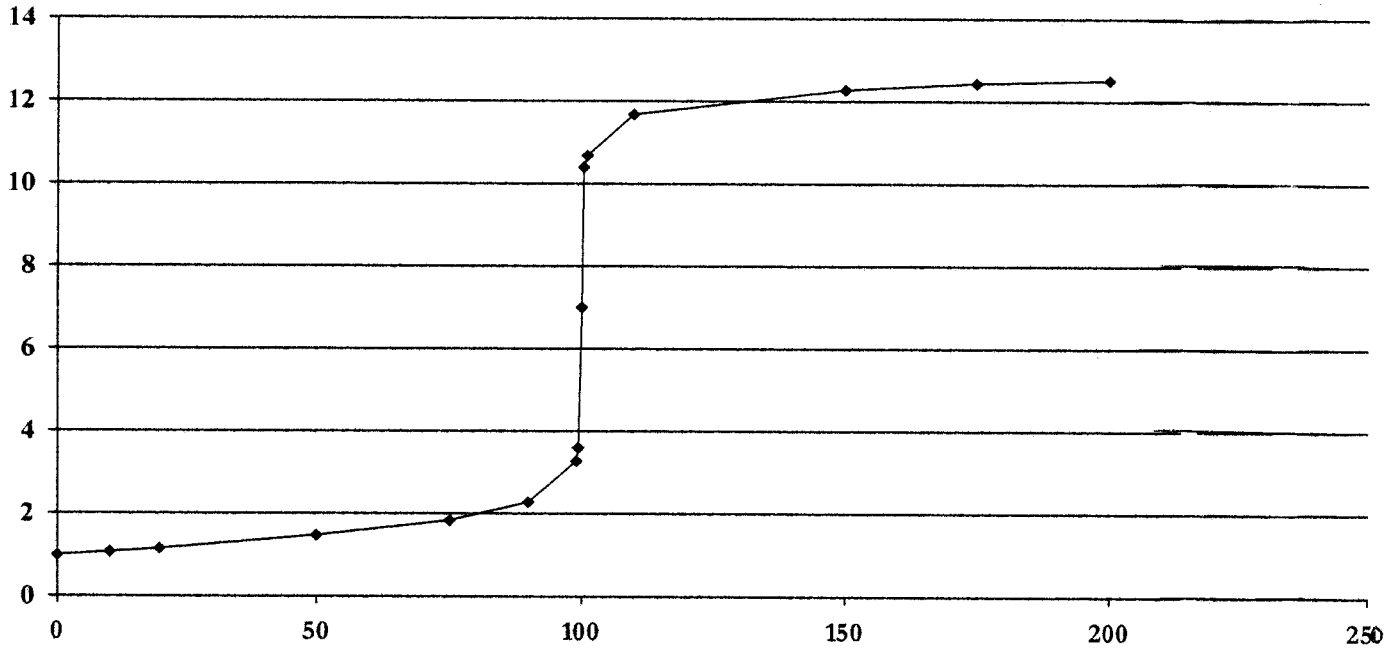
c) $CH_3COOH_{(aq)} + NH_{3(aq)} \rightarrow CH_3COO^-_{(aq)} + NH_4^+_{(aq)}$
acid base conj. base conj. acid

d) $NH_{3(g)} + HCl_{(g)} \rightarrow NH_4Cl_{(s)}$
base acid neutralization

Acid - Base Problems

Solution to Question 1

Titration Curve



Acid-Base Problems

Solutions

1. See previous page for graph.

Calculations required for graph:

pH when $V_{NaOH} = 0\ mL$:

$$pH = -\log[H_3O^+]$$
$$= -\log(0.1)$$
$$= 1$$

pH when $V_{NaOH} = 10\ mL$:

$$n_{NaOH} = C \cdot V$$
$$= 0.1 \times 0.01$$
$$= 0.001 \text{ moles}$$

$$n_{HCl} = C \cdot V$$
$$= 0.1 \cdot 0.1$$
$$= 0.01 \text{ moles}$$

$$n_{left\ over} = 0.01 - 0.001$$
$$= 0.009 \text{ moles}$$

$$C = \frac{n}{V}$$
$$= \frac{0.009 \text{ moles}}{(0.01\ L + 0.1\ L)}$$
$$= 0.08182\ M$$

$$pH = -\log(0.08182)$$
$$= 1.087$$

pH when $V_{NaOH} = 20\ mL$:

$$n_{NaOH} = 0.02 \cdot 0.1$$
$$= 0.002 \text{ moles}$$

$$n_{HCl} = 0.1 \cdot 0.1$$
$$= 0.01 \text{ moles}$$

$$n_{left\ over} = 0.01 - 0.002$$
$$= 0.008 \text{ moles}$$

$$C = \frac{n}{V}$$
$$= \frac{0.008 \text{ moles}}{(0.02\ L + 0.1\ L)}$$
$$= 0.067\ M$$

$$pH = -\log(0.067)$$
$$= 1.176$$

pH when V_{NaOH} = 50 mL:

$n_{NaOH} = 0.05\ L \cdot 0.1\ M$
$= 0.005$ moles

$n_{HCl} = 0.01$ moles

$n_{left\ over} = 0.01 - 0.005$
$= 0.005$ moles

$C = \frac{n}{V}$
$= \frac{0.005\ moles}{0.15\ L}$
$= 0.333\ M$

$pH = -\log(0.333)$
$= 1.478$

pH when V_{NaOH} = 75 mL:

$n_{NaOH} = 0.075 \times 0.1$
$= 0.0075$ moles

$n_{HCl} = 0.01$ moles

$n_{left\ over} = 0.01 - 0.0075$
$= 0.0025$ moles

$C = \frac{n}{V}$
$= \frac{0.0025}{0.175}$
$= 0.01429$

$pH = -\log(0.01429)$
$= 1.845$

pH when V_{NaOH} = 90 mL:

$n_{NaOH} = 0.09 \times 0.1$
$= 0.009$ moles

$n_{HCl} = 0.01$ moles

$n_{left\ over} = 0.01 - 0.009$
$= 0.001$ moles

$C = \frac{0.001}{0.19}$
$= 0.00526$

$pH = -\log(0.00526)$
$= 2.279$

Acid-Base Problems (Pg. 2)

pH when $V_{NaOH} = 99$ mL:

$n_{NaOH} = 0.099 \times 0.1$
$= 0.0099$ moles

$n_{HCl} = 0.01$ moles

$n_{left\ over} = 0.01 - 0.0099$
$= 0.0001$ moles

$C = \frac{0.0001}{0.199}$
$= 0.0005025$ M

$pH = -\log(0.0005025)$
$= 3.299$

pH when $V_{NaOH} = 99.5$ mL:

$n_{NaOH} = 0.00995 \times 0.1$
$= 0.000995$ moles

$n_{HCl} = 0.01$ moles

$n_{left\ over} = 0.01 - 0.000995$
$= 0.00005$ moles

$C = \frac{0.00005}{0.1995}$
$= 0.00025$ M

$pH = -\log(0.00025)$
$= 3.6$

pH when $V_{NaOH} = 100$ mL:

$n_{NaOH} = 0.1 \times 0.1$
$= 0.01$ moles

$n_{NaOH} = 0.01$ moles

$n_{left\ over} = 0.01 - 0.01$
$= 0$ moles

Since all of the moles of NaOH & HCl cancel out, water is the only thing that contributes to pH. The pH of water is 7.
$\therefore pH = 7$

pH when $V_{NaOH} = 100.5$ mL:

$n_{NaOH} = 0.1 \times 0.1005$
$= 0.01005$ moles

$n_{HCl} = 0.01$ moles

$n_{left} = 0.01005 - 0.01$
$= 0.00005$ moles

$C = \frac{0.00005}{0.2005}$
$= 0.00025$ M

$pOH = -\log(0.00025)$
$pOH = 3.6$

$pH = 14 - pOH$
$= 14 - 3.6$
$= 10.4$

pH when $V_{NaOH} = 101$ mL:

$n_{NaOH} = 0.1 \times 0.101$
$= 0.0101$

$n_{HCl} = 0.01$ moles

$n_{left} = 0.0101 - 0.01$
$= 0.0001$ moles

$C = \frac{0.0001}{0.201}$
$= 0.00048$ M

$pOH = -\log(0.00048)$
$= 3.322$

$pH = 14 - pOH$
$= 14 - 3.322$
$= 10.7$

pH when $V_{NaOH} = 110$mL:

$n_{NaOH} = 0.1 \times 0.11$
$= 0.011$

$n_{HCl} = 0.01$

$n_{left} = 0.01 - 0.011 = 0.001$ moles

$C = \frac{0.001 \text{ moles}}{0.21}$
$= 0.00476$ M

$pOH = -\log(0.00476) = 2.32$
$pH = 14 - 2.32 = 11.68$

Acid - Base Problems (Pg. 3)

pH when $V_{NaOH} = 150$ mL:

$n_{NaOH} = 0.1 \times 0.15$
$= 0.015$ moles

$n_{HCl} = 0.01$ moles

$n_{left} = 0.015 - 0.01$
$= 0.005$ moles

$C = \frac{0.005 \text{ moles}}{0.25 \text{ L}}$
$= 0.02 \text{ M}$

$pOH = -\log(0.02)$
$= 1.56$

$pH = 14 - pOH$
$= 12.3$

pH when $V_{NaOH} = 175$ mL.

$n_{NaOH} = 0.1 \times 0.175$
$= 0.0175$ moles

$n_{HCl} = 0.01$ moles

$n_{left} = 0.0175 - 0.01$
$= 0.0075$ moles

$C = \frac{0.0075}{0.275}$
$= 0.0273 \text{ M}$

$pOH = -\log(0.0273)$
$= 1.56$

$pH = 14 - 1.56$
$= 12.44$

pH when $V_{NaOH} = 200$ mL:

$n_{NaOH} = 0.1 \times 0.2$
$= 0.02$ moles

$n_{HCl} = 0.01$ moles

$n_{left} = 0.02 - 0.01$
$= 0.01$ moles

$C = \frac{0.01}{0.3}$
$= 0.0333$

$pOH = -\log(0.0333)$
$= 1.477$

$pH = 14 - pOH$
$= 12.52$

Using all of the pH values create the graph! (see computer graph)

2.

$C_a V_a = C_b V_b$
$(0.05\ M)(30\ mL) = C_b(42\ mL)$
$C_b = 0.036\ M$

∴ the [NaOH] is 0.036 M

3.

$C_a V_a = C_b V_b$
$(0.03\ M)(0.025\ L) = C_b(2\ L)$
$C_b = 3.75 \times 10^{-4}\ M$

∴ the [nitric acid] is 3.75×10^{-4} M.

Acid - Base Problems (Pg. 4)

4. H_2SO_4 is a diprotic acid. Therefore, every one mole of H_2SO_4 will react with 2 moles of NaOH. For this reason, C_AV_A must be multiplied by 2.

$$2(C_aV_a) = C_bV_b$$
$$2(C_a \cdot 30\ mL) = 3M \cdot 20\ mL$$
$$\therefore C_a = 1\ M$$

∴ the $[H_2SO_4]$ is 1 M

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5. C_aV_a must be multiplied by 2. (see explanation in question 4)

$$2(C_aV_a) = C_bV_b$$
$$2(0.02\ mL \cdot 12\ M) = 0.1\ M \cdot V_b$$
$$\therefore V_b = 4.8\ L$$

∴ the volume of NaOH is 4.8 L

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6. 1.85 g/mL = 1850 g in one litre

89% of 1850 g is 1646.5 g

$$n_{H_2SO_4} = \frac{m}{mm}$$
$$= \frac{1646.5\ g}{98.06\ g/mole}$$
$$= 16.79\ moles$$

$$C_{H_2SO_4} = n/V$$
$$= 16.79\ moles / 1\ L$$
$$= 16.79\ M$$

$$2(C_aV_a) = C_bV_b$$
$$2(16.75\ M \cdot V_a) = 0.6\ moles$$
$$\therefore V_a = 17.86\ mL$$

∴ the volume is 17.86 mL

7. 1.20 g/mL = 1200 g in one litre

70% of 1200 g is 840 g

$n = m/mm$
$= 840\,g / 63.01\,g/mol$
$= 13.33$ moles

$C = n/V$
$= 13.33\,moles / 1\,L$
$= 13.33\,M$

$C_a V_a = C_b V_b$
$13.33\,V_a = 4\,M\,(100\,mL)$
$V_a = 30\,mL$

∴ the volume is 30 mL.

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8. HCl: $n = C \cdot V$
$= 0.67\,M \cdot 0.25\,L$
$= 0.1675$ mol
∴ the number of moles is 0.1675 moles.

H_2SO_4: $n = (C \cdot V)2$
$= (0.25\,L \cdot 0.67\,M)2$
$= 0.335$ moles.
∴ the number of moles is 0.335 mol.

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9 HCl:

$n_{HCl} = n_{KOH}$
$0.1675 = m/mm$
$0.1675 = \frac{m}{56.1}$
$m = 9.4\,g$
∴ the mass is 9.4 g

H_2SO_4:

$n_{H_2SO_4} = n_{KOH}$
$0.335 = m/mm$
$0.335 = \frac{m}{56.1}$
$m = 18.8\,g$
∴ the mass is 18.8 g

Acid-Base Problems (pg 5)

10 Find n of NaOH

$$n = \frac{m}{mm}$$
$$= \frac{30\ g}{40\ g/mol}$$
$$= 0.75\ mol$$

Find C_a of HCl

1.3 g/mL = 1300 g in one litre

35% of 1300 g is 455 g

$$n = m/mm$$
$$= 455\ g / 36.45\ g/mol$$
$$= 12.48\ mol.$$

$$C_a = n/V$$
$$= 12.48\ moles/1\ L$$
$$= 12.48\ M$$

Find V_a

$$n_{HCl} = n_{NaOH}$$
$$(12.48\ M \cdot V_a) = 0.75\ mol.$$
$$V_a = 60.2\ L$$

∴ the volume is 60.2 L

Problems Using K for Acids & Bases

1.

	HNO_2	+ H_2O	⇌	NO_2^-	+	H_3O^+
I	1	—		0		0
C	$-x$			$+x$		$+x$
E	$1-x$			x		x

$x = (0.0609)(1)$

$= 0.0609$ mol/L

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

$$= \frac{(0.0609)^2}{(1-0.0609)}$$

$$= 3.95 \times 10^{-3}$$

2.

	H_3PO_4	+ H_2O	⇌	$H_2PO_4^-$	+	H_3O^+
I	1	—		0		0
C	$-x$			$+x$		$+x$
E	$1-x$			x		x

$x = 9.1 \times 10^{-2}$

$$K_a = \frac{[H_2PO_4^-][H_3O^+]}{[H_3PO_4]}$$

$$= \frac{(9.1 \times 10^{-2})^2}{(1-9.1 \times 10^{-2})}$$

$$= 7.14 \times 10^{-3}$$

3. $CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$

	CH_3COOH		CH_3COO^-	H_3O^+
I	0.1	−	0	0
C	$-x$		$+x$	$+x$
E	$0.1-x$		x	x

$$K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]}$$

$$1.8\times10^{-5} = \frac{x^2}{0.1-x}$$

assume x is small

$x = 1.34\times10^{-3}$ mol / L

validate assumption

$$\frac{1.34\times10^{-3}}{0.1}\times100 = 1.34\ \%$$

$$pH = -\log(1.34\times10^{-3})$$
$$= 2.87$$

4. $HF + H_2O \rightleftharpoons F^- + H_3O^+$

	HF		F^-	H_3O^+
I	y	−	0	0
C	$-x$		$+x$	$+x$
E	$y-x$		x	x

$$x = [H_3O^+] = 10^{-2.5}$$
$$= 3.16\times10^{-3}\ \text{mol/L}$$

$$K_a = \frac{[F^-][H_3O^+]}{[HF]}$$

$$6.6\times10^{-4} = \frac{(3.16\times10^{-3})^2}{y-3.16\times10^{-3}}$$

$y = 1.53\times10^{-2}$ mol / L

5.

	HNO_2	+ H_2O ⇌	NO_2^-	+ H_3O^+
I	0.35	—	0	0
C	$-x$		$+x$	$+x$
E	$0.35-x$		x	x

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

$$7.2\times10^{-4} = \frac{x^2}{0.35-x}$$

assume x is small

$x = 1.587\times10^{-2}$ mol/L

validate assumption

$$\frac{1.587\times10^{-2}}{0.35}\times100 = 4.53\%$$

$$pH = -\log(1.587\times10^{-2})$$
$$= 1.8$$

$$pOH = 14 - 1.8$$
$$= 12.2$$

$$[OH^-] = 10^{-12.2}$$
$$= 6.31\times10^{-13} \text{ mol/L}$$

6

$HCOOH + H_2O \rightleftharpoons COOH^- + H_3O^+$

	$HCOOH$		$COOH^-$	H_3O^+
I	0.2	—	0	0
C	$-x$		$+x$	$+x$
E	$0.2 - x$		x	x

$$K_a = \frac{[COOH^-][H_3O^+]}{[HCOOH]}$$

$$1.8 \times 10^{-4} = \frac{x^2}{0.2 - x}$$

assume x is small

$x = 6 \times 10^{-3}$ mol/L

validate assumption

$$\frac{6 \times 10^{-3}}{0.2} \times 100 = 3\ \%$$

$$pH = -\log(6 \times 10^{-3})$$

$$= 2.22$$

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$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

	NH_3		NH_4^+	OH^-
I	0.15	—	0	0
C	$-x$		$+x$	$+x$
E	$0.15 - x$		x	x

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

$$1.8 \times 10^{-5} = \frac{x^2}{0.15 - x}$$

assume x is small

$x = 1.64 \times 10^{-3}$ mol/L

validate assumption

$\frac{1.64\times10^{-3}}{0.15} \times 100 = 1.1\%$

$[OH^-] = 1.64\times10^{-3}$ mol/L

8.

	CH_3COOH	+ H_2O	= CH_3COO^-	+ H_3O^+
I	0.2	-	0	0
C	$-x$		$+x$	$+x$
E	$0.2-x$		x	x

$x = (0.003)(0.2)$

$= 0.0006$ mol/L

$K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]}$

$= \frac{(0.0006)^2}{(0.2-0.0006)}$

$= 1.856\times10^{-6}$

9.

	CH_3COOH	+ H_2O	= CH_3COO^-	+ H_3O^+
I	0.025	-	0	0
C	$-x$		$+x$	$+x$
E	$0.025-x$		x	x

$K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]}$

$1.8\times10^{-5} = \frac{x^2}{0.25\ x}$

assume x is small

$x = 6.71\times10^{-4}$ mol/L

validate assumption

$$\frac{6.71\times10^{-4}}{0.25}\times100 = 2.68\%$$

$$[H_3O^+] = 6.71\times10^{-4}\ \text{mol/L}$$

$$pH = -\log(6.71\times10^{-4})$$
$$= 3.17$$

10.

	C_6H_5COOH	+ H_2O	= $C_6H_5COO^-$	+ H_3O^+
I	y		0	0
C	$-x$		$+x$	$+x$
E	$y-x$		x	x

$$x = [H_3O^+] = 10^{-2.12}$$
$$= 7.586\times10^{-3}\ \text{mol/L}$$

$$K_a = \frac{[C_6H_5COO^-][H_3O^+]}{[C_6H_5COOH]}$$

$$6.3\times10^{-5} = \frac{(7.586\times10^{-3})^2}{y - 7.586\times10^{-3}}$$

$$y = 0.921\ \text{mol/L}$$

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	NH_3	+ H_2O	= NH_4^+	+ OH^-
I	0.3		0	0
C	$-x$		$+x$	$+x$
E	$0.3-x$		x	x

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

$$1.8\times10^{-5} = \frac{x^2}{0.3-x}$$

assume x is small

$x = 2.32 \times 10^{-3}$ mol/L

validate assumption

$\frac{2.32 \times 10^{-3}}{0.3} \times 100 = 0.77\%$

$pOH = -\log(2.32 \times 10^{-3})$

$= 2.63$

$pH = 14 - 2.63$

$= 11.37$

12.

	HX	+ H_2O	⇌	X^-	+ H_3O^+
I	0.1	—		0	0
C	$-x$			$+x$	$+x$
E	$0.1-x$			x	x

$pH = 14 - 10.59$

$= 3.41$

$x = [H_3O^+] = 10^{-3.41}$

$= 3.89 \times 10^{-4}$ mol/L

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

$= \frac{(3.89 \times 10^{-4})^2}{0.1 - 3.89 \times 10^{-4}}$

$= 1.52 \times 10^{-6}$

13 $NaCN \rightarrow Na^+ + CN^-$

$CN^- + H_2O \rightleftharpoons HCN + OH^-$

	CN^-		HCN	OH^-
I	0.5	–	0	0
C	$-x$		$+x$	$+x$
E	$0.5-x$		x	x

$$K_b = \frac{1\times10^{-14}}{6.2\times10^{-10}} = 1.61\times10^{-5}$$

$$K_b = \frac{[HCN][OH]}{[CN^-]}$$

$$1.61\times10^{-5} = \frac{x^2}{0.5-x}$$

assume x is small

$x = 2.84\times10^{-3}$ mol/L

validate assumption

$\frac{2.84\times10^{-3}}{0.5}\times100 = 0.57\%$

$pOH = -\log(2.84\times10^{-3})$

$= 2.55$

$pH = 14 - 2.55$

$= 11.45$

Problems Using K for Acids and Bases

(1.)

$HNO_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + NO_2^-(aq)$

I	1.0×10^{-2}	$\emptyset$	$\emptyset$
C	-6.09%	$+6.09\%$	$+6.09\%$
E	$1.0 \times 10^{-2} - (6.09 \times 10^{-4})$	6.09×10^{-4}	6.09×10^{-4}

$$K_a = \frac{[H_3O^+][NO_2^-]}{1 \times 10^{-2}}$$

$$= \frac{(6.09 \times 10^{-4})^2}{(1 \times 10^{-2} - 6.09 \times 10^{-4})}$$

$$= 3.95 \times 10^{-5}$$

(2.)

$H_3PO_4(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + H_2PO_4^-(aq)$

I	1.00	$\emptyset$	$\emptyset$
C	-8.1×10^{-2}	$+8.1 \times 10^{-2}$	$+8.1 \times 10^{-2}$
E	0.919	8.1×10^{-2}	8.1×10^{-2}

$$K_a = \frac{[H_3O^+][H_2PO_4^-]}{[H_3PO_4]}$$

$$= \frac{(8.1 \times 10^{-2})^2}{0.919}$$

$$= 7.14 \times 10^{-3}$$

(3.)

$CH_3COOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CH_3COO^-(aq)$

I	0.10	$\emptyset$	$\emptyset$
C	$-x$	$+x$	$+x$
E	$0.10 - x$	x	x

$$K_a = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]}$$

$$1.8 \times 10^{-5} = \frac{x^2}{0.10}$$

$$x = 1.34 \times 10^{-3}$$

$x = [H_3O^+] = 1.34 \times 10^{-3}$

$pH = -\log(1.34 \times 10^{-3})$

$pH = 2.87$

(4)

	HF	$+ H_2O \rightleftharpoons$	H_3O^+	$+ F^{-1}$
I	x		$\emptyset$	$\emptyset$
C	-3.16×10^{-3}		$+3.16 \times 10^{-3}$	$+3.16 \times 10^{-3}$
E	$x - 3.16 \times 10^{-3}$		3.16×10^{-3}	3.16×10^{-3}

$pH = 2.50$

$\therefore [H_3O^+]_{eq} = 10^{-2.50}$ mol/L

$= 3.16 \times 10^{-3}$ mol/L

$$K_a = \frac{[H_3O^+][F^-]}{[HF]}$$

$$3.5 \times 10^{-4} = \frac{(3.16 \times 10^{-3})^2}{x - 3.16 \times 10^{-3}}$$

$$x - 3.16 \times 10^{-3} = \frac{(3.16 \times 10^{-3})^2}{3.5 \times 10^{-4}}$$

$x - 3.16 \times 10^{-3} = 0.0286$

$x = 0.0317$

$\therefore [HF] = 0.0317$

$n_{HF} = 0.0317 \text{ mol/L} * 1.00 \text{ L}$

$= 0.0317$ mol

$\therefore$ 0.0317 moles of HF must be present

(5.)

	HNO_2	$+ H_2O \rightleftharpoons$	H_3O^+	$+ NO_2^-$
I	0.35		$\emptyset$	$\emptyset$
C	$-x$		$+x$	$+x$
E	$0.35 - x$		x	x

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

$$4.6 \times 10^{-4} = \frac{x^2}{0.35}$$

$x = 0.0127$

$x = [H_3O^+] = 0.0127$

$pH = -\log(0.0127)$

$= 1.90$

$pOH = 14 - 1.90 = 12.10$

$[OH^-] = 10^{-12.10}$

$= 7.87 \times 10^{-13}$

(6)

	$HCOOH$	+ H_2O	⇌	H_3O^+	+	$HCOO^-$
I	0.200			∅		∅
C	$-x$			$+x$		$+x$
E	$0.200 - x$			x		x

$$K_a = \frac{[H_3O^+][HCOO^-]}{[HCOOH]}$$

$$1.76 \times 10^{-4} = \frac{x^2}{0.200}$$

$$x = 5.93 \times 10^{-3}$$

$$x = [H_3O^+] = 5.93 \times 10^{-3}$$

$$pH = -\log(5.93 \times 10^{-3})$$
$$= 2.23$$

(7)

	NH_3	+ H_2O	⇌	NH_4^+	+	OH^-
I	0.15			∅		∅
C	$-x$			$+x$		$+x$
E	$0.15 - x$			x		x

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

$$1.8 \times 10^{-5} = \frac{x^2}{0.15}$$

$$x = 1.64 \times 10^{-3}$$

$$x = [OH^-] = 1.64 \times 10^{-3}$$

(8.)

	CH_3COOH	+ H_2O ⇌	H_3O^+	+ CH_3COO^-
I	0.0300		∅	∅
C	−3.0%		+3.0%	+3.0%
E	0.0194		6×10^{-4}	$6. \times 10^{-4}$

$$K_a = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]}$$

$$= \frac{(6.0 \times 10^{-4})^2}{0.0194}$$

$$= 1.86 \times 10^{-5}$$

(9.)

	CH_3COOH	+ H_2O ⇌	H_3O^+	+ CH_3COO^-
I	0.025		∅	∅
C	$-x$		$+x$	$+x$
E	$0.025 - x$		x	x

$$K_a = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]}$$

$$1.8 \times 10^{-5} = \frac{x^2}{0.025}$$

$$x = 6.71 \times 10^{-4}$$

$$x = [H_3O^+] = 6.71 \times 10^{-4}$$

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

$$= -\log(6.71 \times 10^{-4})$$

$$= 3.17$$

(10.)

	H_{benz}	+ H_2O ⇌	H_3O^+	+ $Benz^{-1}$
I	x		$\emptyset$	$\emptyset$
C	-7.59×10^{-3}		$+7.59 \times 10^{-3}$	$+7.59 \times 10^{-3}$
E	$x - 7.59 \times 10^{-3}$		7.59×10^{-3}	7.59×10^{-3}

$pH = 2.12$

$[H_3O^+] = 10^{-2.12}$

$= 7.59 \times 10^{-3}$

$$K_a = \frac{[H_3O^+][Benz^-]}{[HBenz]}$$

$$6.5 \times 10^{-5} = \frac{(7.59 \times 10^{-3})^2}{x}$$

$$x = 0.886$$

$$x = [HBenz]_i = 0.886 \text{ mol/L}$$

(11.)

	NH_3	+ H_2O ⇌	NH_4^+	+ OH^-
I	0.30		$\emptyset$	$\emptyset$
C	$-x$		$+x$	$+x$
E	$0.30 - x$		x	x

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

$$1.8 \times 10^{-5} = \frac{x^2}{0.3}$$

$$x = 2.32 \times 10^{-3}$$

$$x = [OH^-] = 2.32 \times 10^{-3}$$

$$pOH = -\log[OH^-]$$
$$= -\log(2.32 \times 10^{-3})$$
$$= 2.63$$

$$pH = 14 - 2.63$$
$$= 11.37$$

(12)

	HA	+ H_2O	$\rightleftharpoons$	H_3O^+	+	A^-
I	0.100			$\emptyset$		$\emptyset$
C	-3.89×10^{-4}			$+3.89 \times 10^{-4}$		$+3.89 \times 10^{-4}$
E	$0.100 - 3.89 \times 10^{-4}$			3.89×10^{-4}		3.89×10^{-4}

$pOH = 10.59$

$pH = 14 - 10.59$

$= 3.41$

$[H_3O^+] = 10^{-3.41}$

$= 3.89 \times 10^{-4}$

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

$$= \frac{(3.89 \times 10^{-4})^2}{0.0996}$$

$$= 1.52 \times 10^{-6}$$

(13)

$$NaCN \longrightarrow Na^+ + CN^-$$

	CN^-	+ H_2O	$\rightleftharpoons$	HCN	+	OH^-
I	0.5			$\emptyset$		$\emptyset$
C	$-x$			$+x$		$+x$
E	$0.5 - x$			x		x

$K_a(HCN) = 4.9 \times 10^{-10}$

$$\therefore K_b = \frac{K_w}{K_a}$$

$$= \frac{1.0 \times 10^{-14}}{4.9 \times 10^{-10}}$$

$$= 2.04 \times 10^{-5}$$

$$K_b = 2.04 \times 10^{-5} = \frac{[HCN][OH^-]}{[CN^-]}$$

$$2.04 \times 10^{-5} = \frac{x^2}{0.5}$$

$$x = 3.19 \times 10^{-3}$$

$$x = [OH^-] = 3.19 \times 10^{-3}$$

$$pOH = -\log(3.19 \times 10^{-3})$$

$$= 2.50$$

$$pH = 14 - 2.50$$

$$= 11.50$$