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

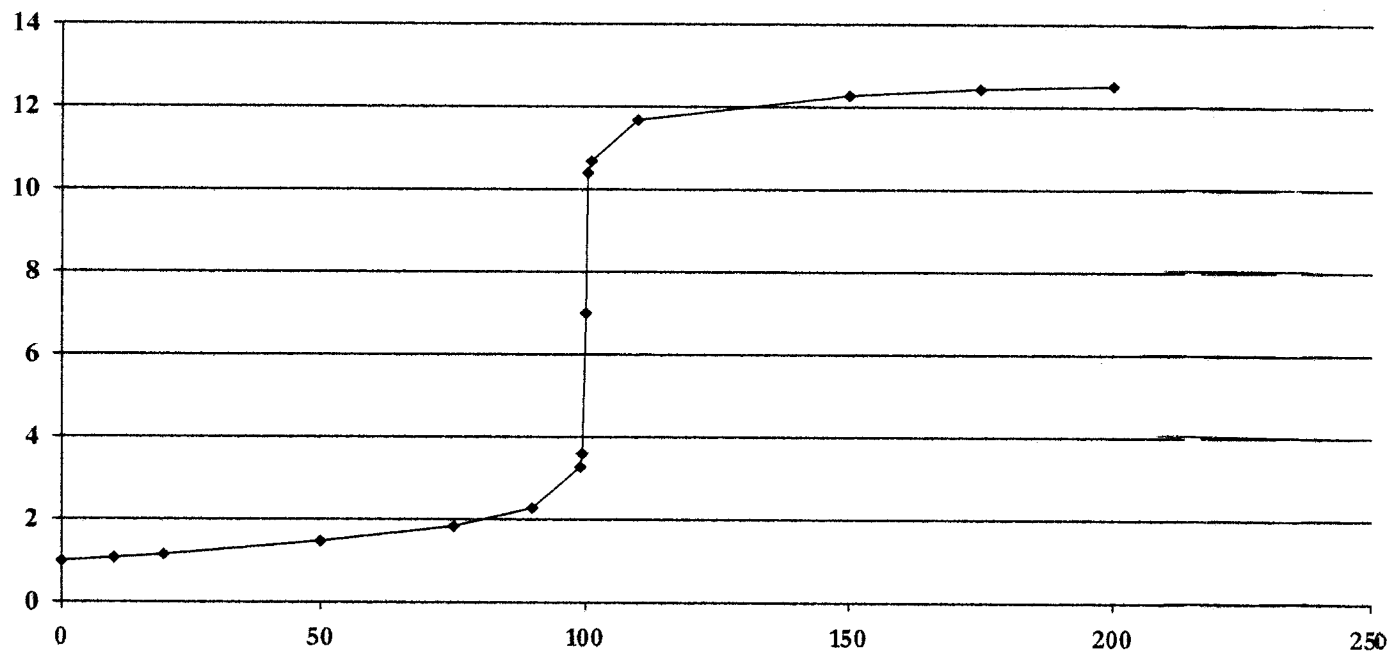
c) $CH_3COOH_{(aq)} + NH_{3(aq)} \rightarrow CH_3COO^-_{(aq)} + NH_4^+{}_{(aq)}$
acid base conj. base conj. acid

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 $V_{NaOH} = 10\,mL$:

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

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

$n_{left\ over} = 0.01 - 0.001 = 0.009$ 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 $V_{NaOH} = 20\,mL$:

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

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

$n_{left\ over} = 0.01 - 0.002 = 0.008$ 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 · 0.1 M
= 0.005 moles

n_{HCl} = 0.01 moles

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

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

pH = −log (0.333)
= 1.478

pH when V_{NaOH} = 75 mL:

n_{NaOH} = 0.075 × 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 × 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

$n_{NaCH} = 0.01$ 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.

$\therefore pH = 7$

<u>pH when V_{NaOH} = 100.5 mL:</u>

n_{NaOH} = 0.1 × 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

<u>pH when V_{NaOH} = 101 mL:</u>

n_{NaOH} = 0.1 × 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

<u>pH when V_{NaOH} = 110 mL:</u>

n_{NaOH} = 0.1 × 0.11
= 0.011

n_{HCl} = 0.01

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

n_{left} = 0.01 - 0.011 = 0.001 moles

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

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

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

$pH = 14 - pOH$
$= 12.3$

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

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

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

$pH = 14 - 1.56$
$= 12.44$

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.

$C_aV_a = C_bV_b$
$(0.05\ M)(30\ mL) = C_b(42\ mL)$
$C_b = 0.036\ M$

∴ the [NaOH] is 0.036 M

3.

$C_aV_a = C_bV_b$
$(0.03\ M)(0.025\ L) = C_b(2\ L)$
$C_b = 3.75 \times 10^{-4}\ M$

∴ 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.

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

$\therefore$ 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)

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

$\therefore$ the volume of NaOH is 4.8L

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

89% of 1850g is 1646.5 g

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

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

$\therefore$ the volume is 17.86 mL

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

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

$C_aV_a = C_bV_b$
$13.33\,V_a = 4\,M\,(100\,mL)$
$V_a = 30\,mL$

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

∴ 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 Ca of HCl

1.3 g/mL = 1300 g in one litre

35% of 1300g is 455 g

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

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

Find Va

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

∴ the volume is 60.2 L

$83\frac{1}{8}$

Problems Using K for Acids & Bases

1. $HNO_2 + H_2O \rightleftharpoons NO_2^- + H_3O^+$

	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. $H_3PO_4 + H_2O \rightleftharpoons H_2PO_4^- + H_3O^+$

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

$x = 8.1 \times 10^{-2}$

$$K_a = \frac{[H_2PO_4^-][H_3O^+]}{[H_3PO_4]} = \frac{(8.1 \times 10^{-2})^2}{(1-8.1 \times 10^{-2})} = 7.14 \times 10^{-3}$$

3.

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

	CH_3COOH	H_2O	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	H_2O	F^-	H_3O^+
I	y	—	0	0
C	$-x$		$+x$	$+x$
E	$y-x$		x	x

$x = [H_3O^+] = 10^{-2.5}$

$= 3.16\times10^{-3}$ mol/L

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

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

$y = 1.83\times10^{-2}$ mol/L

$83 - \frac{3}{8}$

5. $HNO_2 + H_2O \rightleftharpoons NO_2^- + H_3O^+$

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

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

$pOH = 14 - 1.8$
$= 12.2$

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

6

	$HCOOH$	+ H_2O ⇌	$COOH^-$	+ H_3O^+
I	0.2	—	0	0
C	$-x$		$+x$	$+x$
E	$0.2-x$		x	x

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

$$1.8\times10^{-4} = \frac{x^2}{0.2-x}$$

assume x is small

$x = 6\times10^{-3}$ mol/L

validate assumption

$$\frac{6\times10^{-3}}{0.2}\times 100 = 3\%$$

$pH = -\log(6\times10^{-3})$

$= 2.22$

7

	NH_3	+ H_2O ⇌	NH_4^+	+ OH^-
I	0.15	—	0	0
C	$-x$		$+x$	$+x$
E	$0.15-x$		x	x

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

$$1.8\times10^{-5} = \frac{x^2}{0.15-x}$$

assume x is small

$x = 1.64\times10^{-3}$ mol/L

validate assumption

$\frac{1.64\times10^{-3}}{0.15}\times100 = 1.1\%$

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

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

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

$x = (0.03)(0.2)$
$= 0.006$ mol/L

$$K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]}$$
$$= \frac{(0.006)^2}{(0.2-0.006)}$$
$$= 1.856\times10^{-4}$$

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

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

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

$$1.8\times10^{-5} = \frac{x^2}{0.025-x}$$

assume x is small

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

validate assumption

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

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

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

10. $C_6H_5COOH + H_2O \rightleftharpoons C_6H_5COO^- + H_3O^+$

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

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

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

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

$y = 0.921$ mol/L

11 $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

	NH_3	H_2O	NH_4^+	OH^-
I	0.3	–	0	0
C	−x		+x	+x
E	0.3 − x		x	x

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

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

$83 = \frac{7}{8}$

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	$+ H_2O$	$\rightleftharpoons$	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

$$K_a = \frac{[X^-][H_3O^+]}{[HX]}$$
$$= \frac{(3.89 \times 10^{-4})^2}{0.1 - 3.89 \times 10^{-4}}$$
$$= 1.52 \times 10^{-6}$$

83 − $\frac{8}{8}$

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

	CN^-	$+ H_2O$	$\rightleftharpoons HCN$	$+ OH^-$
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.) $HNO_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + NO_2^-(aq)$

	HNO_2	H_3O^+	NO_2^-
I	1.0×10^{-2}	Ø	Ø
C	-6.09%	$+6.09\%$	$+6.09\%$
E	$1.0\times10^{-2} - (6.09\times10^{-4})$	6.09×10^{-4}	6.09×10^{-4}

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

$$= \frac{(6.09 \times 10^{-4})^2}{(1\times10^{-2} - 6.09\times10^{-4})}$$

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

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

	H_3PO_4	H_3O^+	$H_2PO_4^-$
I	1.00	Ø	Ø
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.) $CH_3COOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CH_3COO^-(aq)$

	CH_3COOH	H_3O^+	CH_3COO^-
I	0.10	Ø	Ø
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) $HF + H_2O \rightleftharpoons H_3O^+ + F^{-1}$

pH = 2.50

$\therefore [H_3O^+]_{eq} = 10^{-2.50}$ mol/L
$= 3.16 \times 10^{-3}$ mol/L

	HF	H_3O^+	F^{-1}
I	x	$\varnothing$	$\varnothing$
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}

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

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

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

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

$$x = 0.0317$$

$\therefore [HF] = 0.0317$

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

$\therefore$ 0.0317 moles of HF must be present

(5.) $HNO_2 + H_2O \rightleftharpoons H_3O^+ + NO_2^-$

	HNO_2	H_3O^+	NO_2^-
I	0.35	$\varnothing$	$\varnothing$
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) $HCOOH + H_2O \rightleftharpoons H_3O^+ + HCOO^-$

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

	NH_3	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.)

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

	CH_3COOH	H_3O^+	CH_3COO^-
I	0.0200	Ø	Ø
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.)

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

	CH_3COOH	H_3O^+	CH_3COO^-
I	0.025	Ø	Ø
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.) $H_{benz} + H_2O \rightleftharpoons H_3O^+ + Benz^{-1}$

	H_{benz}	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.) $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

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

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

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

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

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

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

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

PUK #6

(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

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

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

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

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

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

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

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

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

$$pOH = -\log(3.19 \times 10^{-3})$$
$$= 2.50$$
$$pH = 14 - 2.50$$
$$= 11.50$$