Review #2

A beaker contains 100 ml of a solution of hypochlorous acid, of unknown concentration.

1. The solution was titrated with 0.100 M NaOH and the equivalence point was reached when 40.0 ml of NaOH solution was added. What was the original concentration of the HOCl solution?
2. If the original HOCl solution had a pH of 4.46, what is the value of Ka for HOCl?
3. What percent of HOCl molecules were ionized in the original solution?
4. What is the concentration of OCl- in the solution at the equivalence point reached in 1.
5. What is the pH of the solution at the equivalence point?

A 100. Ml sample of 0.100 M NH_4Cl solution was added to 80 ml of a 0.200M solution of NH_3. Kb for ammonia is 1.79×10^{-5}

1. What is the value of pKb for ammonia?
2. What is the pH of the solution described in the question?
3. If 0.200 g of NaOH were added to the solution, what would be the new pH of the solution? (assume that the volume of the solution does not change)
4. If equal molar quantities of NH_3 and NH_4^+ were mixed in solution, what would be the pH of the solution?

A titration is completed where 0.100 M sodium hydroxide is slowly added to 50.0 mL of 0.100 M hydrochloric acid. Calculate the pH after the addition of:

a. 0.00 mL of 0.100 M sodium hydroxide

b. 25.00 mL of 0.100 M sodium hydroxide

c. 50.00 mL of 0.100 M sodium hydroxide

d. 75.00 mL of 0.100 M sodium hydroxide

e. 100.00 mL of 0.100 M sodium hydroxide

Sketch a graph of the change in pH as this strong acid is titrated with a strong base. Label the equivalence point in the titration.

A titration is completed where 0.200 M formic acid is slowly added to 25.0 mL of 0.100 M lithium hydroxide. Calculate the pH at the following points in the titration:

a. before the titration begins

b. at the half equivalence

c. at the equivalence

Review #2

problem 1

1) mmole NaOH = (0.100 M)(40.0 ml) = 4.00 mmol

$OH^- + HOCl \rightarrow H_2O + OCl^-$

$4.00\ \text{mmol}\ OH^- \frac{1\ \text{mmole}\ HOCl}{1\ \text{mmol}\ OH^-} = 4.00\ \text{mmol}\ HOCl$

$M = \frac{4.00\ \text{mmol}\ HOCl}{100.\ \text{ml}} = 0.0400\ M$

2)

	$HOCl$	$\rightleftarrows$	H^+	+	OCl^-
I	0.0400		0		0
C					
E					

$[H^+] = 10^{-4.46} = 3.47 \times 10^{-5}\ M$

$K_a = \frac{[H^+][OCl^-]}{[HOCl]} = \frac{(3.47 \times 10^{-5})^2}{0.0400}$

$K_a = 3.01 \times 10^{-8}$

3) $\frac{3.47 \times 10^{-5}}{0.0400} \times 100 = 0.087\ \%$

4) Na^+ $\underline{OH^-}$ H_2O $HOCl$

	OH^-	+	$HOCl$	$\rightarrow$	H_2O	+	OCl^-
I	4.00		4.00				0
C	-4.00		-4.00				+4.00
E	0		0				4.00

$[OCl^-] = \frac{4.00\ \text{mmol}}{100. + 40.0\ \text{ml}} = 0.0286\ M$

5) $OCl^- + H_2O \rightleftharpoons HOCl + OH^-$

	OCl^-	$HOCl$	OH^-
I	0.0286	0	0
C	$-x$	$+x$	$+x$
E	$0.0286 - x$	x	x

$$K_b = \frac{1 \times 10^{-14}}{3.01 \times 10^{-8}} = 3.32 \times 10^{-7} = \frac{[HOCl][OH^-]}{[OCl^-]}$$

$$3.32 \times 10^{-7} = \frac{x^2}{0.0286 - x}$$

$x = 9.75 \times 10^{-5} M = [OH^-]$

5% $\frac{9.75 \times 10^{-5}}{0.0286} \times 100 = 0.34\%$

$pOH = -\log(9.75 \times 10^{-5}) = 4.01$

$pH = 9.99$

Problem 2

1) $pK_b = -\log(1.79 \times 10^{-5}) = 4.75$

2) * it's a buffer

$pH = pK_a + \log \frac{B}{A}$

$K_a = \frac{1 \times 10^{-14}}{1.79 \times 10^{-5}} = 5.59 \times 10^{-10}$

mmole NH_4^+ = (0.100 M)(100. mL) = 10.0 mmol

mmole NH_3 = (0.200 M)(80 mL) = 16.0 mmol

$pH = -\log(5.59 \times 10^{-10}) + \log \frac{16}{10}$

$pH = 9.46$

3) 0.200 g NaOH $\frac{1\ mole}{40.00\ g}$ = 8.00 mmole OH^-

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

	OH^-	NH_4^+	NH_3
I	8.00	10.0	16.0
C	-8.00	-8.00	+8.0
F	0	2.0	24.0

$pH = pK_a + \log \frac{B}{A}$

$= -\log(5.59 \times 10^{-10}) + \log \frac{24.0}{2.0} = 10.33$

4) @ equivalence

$pH = pK_a + \log \frac{B}{A}$

$pH = pK_a = -\log(5.59 \times 10^{-10})$

$pH = 9.25$

problem 3

$H^+ + OH^- \longrightarrow H_2O$

a)

mmole H^+ = (0.100 M)(50.0 ml) = 5.00 mmole

pH = −log(0.100) = 1.00

b)

mmole OH^- = (0.100 M)(25.00 ml) = 2.50 mmol

	H^+	+	OH^-	$\longrightarrow$	H_2O
I	5.00		2.50		
C	−2.50		−2.50		
E	2.50		0		

$[H^+] = \frac{2.50\ mmol}{50.0 + 25.0\ ml} = 0.033\ M$

pH = −log(0.033) = 1.48

c)

mmole OH^- = (0.100 M)(50.00 ml) = 5.00 mmol

	H^+	+	OH^-	$\longrightarrow$	H_2O
I	5.00		5.00		
C	−5.00		−5.00		
E	0		0		

@ equivalence pH = 7

d)

mmole OH^- = (0.100 M)(75.00 ml) = 7.50 mmol

	H^+	+	OH^-	$\longrightarrow$	H_2O
I	5.00		7.50		
C	−5.00		−5.00		
E	0		2.50		

$[OH^-] = \frac{2.50\ mmol}{50.0 + 75.0\ ml} = 0.0200\ M$

pOH = −log(0.0200) = 1.70

pH = 12.30

e)

mmol OH^- = (0.100 M)(100.0 ml) = 10.0 mmol

$H^+ + OH^- \rightarrow H_2O$

	H^+	OH^-
mmol I	5.00	10.0
mmol C	−5.00	−5.00
mmol F	0	5.00

$[OH^-] = \frac{5.00 \text{ mmol}}{50.00 + 100.00 \text{ ml}} = 0.033 M$

$pOH = -\log(0.033) = 1.48$

$pH = 14 - 1.48 = 12.52$

problem 4

Li^+ OH^- H_2O $HCOOH$

0.100 M 0.200 M

25.0 mL

a) $HCOOH \rightleftharpoons H^+ + COOH^-$

	$HCOOH$	H^+	$COOH^-$
I	0.200	0	0
C	$-x$	$+x$	$+x$
E	$0.200 - x$	x	x

$K_a = 1.77 \times 10^{-4} = \frac{[H^+][COOH^-]}{[HCOOH]}$

$1.77 \times 10^{-4} = \frac{x^2}{0.200 - x}$

$x = 5.95 \times 10^{-3}\ M = [H^+]$

$5\% \quad \frac{5.95 \times 10^{-3}}{0.200} \times 100 = 2.97\%$ ✓

$pH = -\log(5.95 \times 10^{-3}) = 2.23$

b) $\frac{1}{2}$ equivalence

$pH = pK_a = -\log(1.77 \times 10^{-4})$

$= 3.75$

b) $OH^- + HCOOH \rightarrow H_2O + COOH^-$

mmole OH^- = (0.100 M)(25.00 ml) = 2.50 mmol

@ equivalence 2.50 mmol HCOOH

Volume HCOOH = $\frac{2.50 \text{ mmol}}{0.200 \text{ M}}$ = 12.5 ml

	OH^-	+	HCOOH	→	H_2O	+	$COOH^-$
I	2.50		2.50				0
C	−2.50		−2.50				+2.50
E	0		0				2.50

$[COOH^-] = \frac{2.50 \text{ mmol}}{25.0 + 12.5 \text{ ml}} = 0.0667 \text{ M}$

	$COOH^-$	+	H_2O	⇌	HCOOH	+	OH^-
I	0.0667				0		0
C	−x				+x		+x
E	0.0667 − x				x		x

$K_a = 1.77 \times 10^{-4} = \frac{x^2}{0.0667 - x}$

x = 3.44×10^{-3} M = $[OH^-]$

5% $\frac{3.44 \times 10^{-3}}{0.0667} \times 100 = 5.15$:(

oops! let's assume less than 5%

↓

you will not need quadratic on test!

pOH = −log (3.44×10^{-3})

pOH = 2.46

pH = 11.54