CHMG-142
"Recitation"

Name(s):________________________

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Dissociation constants of acids:

HOAc K_a=1.78x10^{-5}

H_2SO_4 K_{a1}=1x10^{7} K_{a2}=1.0x10^{-2}

HCNO K_a=2x10^{-4}

H_2CO_3 K_{a1}=4.3x10^{-7} K_{a2}=5.6x10^{-11}

H_2O K_a=1.0x10^{-14}

HIO K_a=2.3x10^{-11}

HIO_3 K_a = 1.7x10^{-4}

HCl K_a=1x10^{8}

HNO_3 K_a=1x10^{6}

HF K_a = 3.5x10^{-4}

$H_2C_2O_4$ K_{a1} = 6.0x10^{-2} K_{a2} = 6.1x10^{-5}

Dissociation constants of bases:

NH_3 K_b=1.76x10^{-5}

CH_3NH_2 K_b=4.4x10^{-4}

$HONH_2$ K_b=1.1x10^{-8}

$C_2H_5NH_2$ K_b = 5.6x10^{-4}

I mix together 50.0 mL of 0.100 M $NaIO_3$, 50.00 mL of 0.100 M NaOH, and 10.0 mL of 0.100 M HIO_3. What is the pH of the mixture?

Piece #1 What is HIO_3?

Acid

Piece #2 What is NaOH?

Base

Piece #3 What is $NaIO_3$?

Salt

Piece #4 Dissociate all of the salts into their ions.

$NaIO_3 = Na^+ + IO_3^-$
$NaOH = Na^+ + OH^-$

Piece #5 Make a list of all the acids.

HIO_3
Na^+
H_2O

Piece #6 Make a list of all the bases.

OH-
IO_3^-
H_2O

Major breakthrough #1. Write a balanced reaction for the reaction of EACH acid with EACH and every base.

$$HIO_3\ \ (aq) + OH^-\ (aq) \leftrightarrow\ IO_3^-(aq) + H_2O(aq)$$

$$HIO_3\ \ (aq) + H_2O\ (l) \leftrightarrow\ IO_3^-(aq) + H_3O^+(aq)$$

$$HIO_3\ (aq) + IO_3^-(aq)\ \leftrightarrow\ IO_3^-(aq) + HIO_3(aq)$$

$$H_2O\ (l) +\ OH^-(aq) \leftrightarrow\ OH^-(aq) + H_2O(l)$$

$$H_2O\ (l) + H_2O\ (l)\ \leftrightarrow\ OH^-(aq) + H_3O^+(aq)$$

$$H_2O\ (l) + IO_3^-(aq)\ \leftrightarrow\ OH^-(aq) + HIO_3(aq)$$

$$Na^+\ (aq) +\ OH^-(aq) + H_2O\ \leftrightarrow\ NaOH(aq) + H_2O(l)$$

$$Na^+\ (aq) + 2H_2O\ (l)\ \leftrightarrow\ NaOH(aq) + H_3O^+(aq)$$

$$Na^+\ (aq) + IO_3^-(aq) + H_2O\ (l) \leftrightarrow\ NaOH(aq) + HIO_3(aq$$

Really no perfect way to write the Na^+ equations. They borrow an H^+ from water by stealing the OH-. In the end, they don’t matter anyway because NaOH is a strong base!

Major Breakthrough #2 For each reaction you wrote, determine the equilibrium constant (K) or the relative value of it (SFB, FB, etc.)

Strong base with weak acid: K=SF B

$$HIO_3\ (aq) + OH^-\ (aq) \leftrightarrow IO_3^-(aq) + H_2O(aq)$$

Weak acid in water, just a K_a. $K_a = 1.7x10^{-4}$

$$HIO_3\ (aq) + H_2O\ (l) \leftrightarrow IO_3^-(aq) + H_3O^+(aq)$$

A weak acid with it's conjugate base. Nothing happens. K=0

$$HIO_3\ (aq) + IO_3^-(aq) \leftrightarrow IO_3^-(aq) + HIO_3(aq)$$

A strong base in water: K_b = FB

$$H_2O\ (l) + OH^-(aq) \leftrightarrow OH^-(aq) + H_2O(l)$$

Water and water; $K_w = 1.0x10^{-14}$

$$H_2O\ (l) + H_2O\ (l) \leftrightarrow OH^-(aq) + H_3O^+(aq)$$

Water and the conjugate base of HIO_3:

$$H_2O\ (l) + IO_3^-(aq) \leftrightarrow OH^-(aq) + HIO_3(aq)$$

$$K_aK_b = K_w = 1.0 \times 10^{-14}$$

$$K_b = \frac{1.0 \times 10^{-14}}{1.7 \times 10^{-4}} = 5.88 \times 10^{-11}$$

All the sodium reactions involve an infinitely weak acid (Na^+) which is the conjugate acid of a strong base (NaOH). So, effectively K=0

$$Na^+\ (aq) + OH^-(aq) + H_2O \leftrightarrow NaOH(aq) + H_2O(l)$$

$$Na^+\ (aq) + 2H_2O\ (l) \leftrightarrow NaOH(aq) + H_3O^+(aq)$$

$$Na^+\ (aq) + IO_3^-(aq) + H_2O\ (l) \leftrightarrow NaOH(aq) + HIO_3(aq$$

Finally, some math #1 Determine the DILUTED concentration of HIO_3 in the mixture before any acid/base reaction has occurred.

$$M_1V_1 = M_2V_2$$

$$0.100\ M\ \times 10.0\ mL = M_2(110.0\ mL)$$

$$M_2 = 0.009091\ M$$

Finally, some math #2 Determine the DILUTED concentration of Na^+ in the mixture before any acid/base reaction has occurred.

$$M_1V_1 = M_2V_2$$

$$0.100\ M\ \times 50.0\ mL = M_2(110.0\ mL)$$

$$M_2 = 0.04545\ M$$

Finally, some math #3 Determine the DILUTED concentration of IO_3^- in the mixture before any acid/base reaction has occurred.

$$M_1V_1 = M_2V_2$$

$$0.100\ M \times 50.0\ mL = M_2(110.0\ mL)$$

$$M_2 = 0.04545\ M$$

Finally, some math #4 Determine the DILUTED concentration of OH- in the mixture before any acid/base reaction has occurred.

$$M_1V_1 = M_2V_2$$

$$0.100\ M \times 50.0\ mL = M_2(110.0\ mL)$$

$$M_2 = 0.04545\ M$$

Let's make a picture #1 For the reaction with the BIGGEST K, construct an ICE chart.

Biggest would be the SFB one!

	HIO_3 (aq) +	OH- (aq)	↔	IO_3^- (aq) +	H_2O (l)
I	$0.009091\ M$	$0.04545\ M$		0.04545	$lots$
C	-x	-x		+x	+x
E	$0.009091 - x$	$0.04545 - x$		$0.04545 + x$	$lots$

LET'S DO IT! #1 Solve the ICE chart for the reaction with the BIGGEST K.

	HIO_3 (aq) +	OH- (aq)	↔	IO_3^- (aq) +	H_2O (l)
I	$0.009091\ M$	$0.04545\ M$		0.04545	$lots$
C	-x	-x		+x	+x
E	0, limiting	$0.04545 - x$		$0.04545 + x$	$lots$

0.009091-x=0
X=0.009091

	HIO_3 (aq) +	OH- (aq)	↔	IO_3^- (aq) +	H_2O (l)
I	0.009091 M	0.04545 M		0.04545	$lots$
C	-x	-0.009091		+0.009091	+x
E	0, limiting	0.03636		0.05454	$lots$

Let's make a picture #2 For the reaction with the second BIGGEST K, construct an ICE chart using the concentrations as they exist AFTER the first reaction is over.

LET'S DO IT! #2 Solve the ICE chart for the reaction with the second BIGGEST K.

Next is just the FB one, but it doesn't really do anything

	OH- (aq) +	H_2O (l)	↔	OH^- (aq) +	H_2O (l)
I	0.03636	LOTS		0	0
C	-x	-x		+x	+x
E	0	LOTS		0.03636	x

Repeat until the ICE charts stop yielding any significant change.
Next would be:

$$HIO_3\ (aq) + H_2O\ (l) \leftrightarrow IO_3^-(aq) + H_3O^+(aq)$$

But I don't have any HIO_3 left, so I can't do it.

That leaves me with only one other meaningful reaction (K_w is insignificant here);

$$H_2O\ (l) + IO_3^-(aq)\ \leftrightarrow\ OH^-(aq) + HIO_3(aq)$$

$$K_aK_b = K_w = 1.0 \times 10^{-14}$$
$$K_b = \frac{1.0 \times 10^{-14}}{1.7 \times 10^{-4}} = 5.88 \times 10^{-11}$$

	IO_3^- (aq) +	H_2O (l)	↔	HIO_3 (aq)	+ OH^- (aq)
I	0.05454			0.0	0.03636
C	-x	-x		+x	+x
E	0.05454-x			x	0.03636+x

$$K_b = 5.88 \times 10^{-11} = \frac{(x)(0.03636 + x)}{0.05454 - x}$$

Assume x<<0.0125

$$5.88 \times 10^{-11} = \frac{(x)(0.03636 + x)}{0.05454 - x} \approx \frac{(x)(0.03636)}{(0.05454)}$$
$$x = 8.82 \times 10^{-11}$$

	IO_3^- (aq) +	H_2O (l)	↔	HIO_3 (aq)	+ OH^- (aq)
I	0.05454			0.0	0.03636
C	-8.82×10^{-11}	-8.82×10^{-11}		$+8.82 \times 10^{-11}$	$+8.82 \times 10^{-11}$
E	0.05454			8.82×10^{-11}	0.03636

DONE! DONE! DONE! #1

I mix together 50.0 mL of 0.100 M $NaIO_3$, 50.00 mL of 0.100 M NaOH, and 10.0 mL of 0.100 M HIO_3. What is the pH of the mixture?

$$pOH = -\log(0.03636) = 1.44$$
$$pH = 14 - pOH = 14 - 1.44 = 12.56$$