AP CHEMISTRY

TOPIC 7: ACIDS & BASES, REVIEW PART IV – DO THIS !!! Day 84:

1. List ALL the STRONG ACIDS and STRONG BASES – Use ONLY your periodic table to answer this question!

Acids:

HCl

HBr

HI

HNO_3

$HClO_4$

H_2SO_4 (Only the first dissociation is strong!)

Bases:

LiOH

NaOH

KOH

RbOH

CsOH

FrOH

$Ca(OH)_2$ (Both OH^{-1} will dissociate)

$Sr(OH)_2$ (Both OH^{-1} will dissociate)

$Ba(OH)_2$ (Both OH^{-1} will dissociate)

2. What is the:

Conjugate Acid for:	***Base for:***	***Conjugate Base for:***	***Acid for:***
$HB_4O_7^{-1}$: ***$H_2B_4O_7$***	HPO_4^{-2} : ***PO_4^{-3}***	$HB_4O_7^{-1}$: ***$B_4O_7^{-2}$***	HPO_4^{-2} : ***$H_2PO_4^{-1}$***
$HCrO_4^{-1}$: **H_2CrO_4**	$H_2PO_4^{-1}$: **HPO_4^{-2}**	$HCrO_4^{-1}$: **CrO_4^{-2}**	$H_2PO_4^{-1}$: **H_3PO_4**
$HC_2O_4^{-1}$: **$H_2C_2O_4$**	$HSCN^{-1}$: **SCN^{-2}**	$HC_2O_4^{-1}$: **$C_2O_4^{-2}$**	$HSCN^{-1}$: **H_2SCN**
$HCr_2O_7^{-1}$: **$H_2Cr_2O_7$**	$H_2SiO_4^{-2}$: **$HSiO_4^{-3}$**	$HCr_2O_7^{-1}$: **$Cr_2O_7^{-2}$**	$H_2SiO_4^{-1}$: **H_3SiO_4**
HWO_4^{-1} : **H_2WO_4**	HSO_3^{-1} : **SO_3^{-2}**	HWO_4^{-1} : **WO_4^{-2}**	HSO_3^{-1} : **H_2SO_3**

3. Write the dissociation reaction for each of the following salts when placed in water and determine if the solution will become acidic, basic or remain neutral – THEN identify "the thing" that causes the solution to become this way.

Salt:	***Reaction that causes the solution to become…***	***Acidic, Basic or Remain Neutral***
$NaC_3H_7O_2$	$NaC_3H_7O_2 \rightarrow \mathbf{Na^{+1}} + \mathbf{C_3H_7O_2^{-1}}$; $C_3H_7O_2^{-1} + H_2O \leftrightarrow HC_3H_7O_2 + OH^{-1}$	Basic
	Conjugates of Strong Bases (cation) do nothing to change the pH of a solution, conjugates of weak acids (anion) behave as a base.	
$C_4H_4O_2HI$	$C_4H_4O_2HI \rightarrow \mathbf{C_4H_4O_2H^{+1}} + I^{-1}$; $C_4H_4O_2H^{+1} \leftrightarrow C_4H_4O_2 + H^{+1}$	Acidic
	Conjugates of Strong Acids (anion) do nothing to change the pH of a solution, conjugates of weak bases (cation) behave as an acid.	
Cs_2SO_4	$Cs_2SO_4 \rightarrow 2\ \mathbf{Cs^{+1}} + \mathbf{SO_4^{-2}}$; $SO_4^{-2} + HOH \leftrightarrow HSO_4^{-1} + OH^{-1}$	Basic
	Conjugates of Strong Bases (cation) do nothing to change the pH of a solution, conjugates of weak acids (anion) behave as a base.	
$CH_3N_2HNO_3$	$CH_3N_2HNO_3 \rightarrow \mathbf{CH_3N_2H^{+1}} + NO_3^{-1}$; $CH_3N_2H^{+1} \leftrightarrow CH_3N_2 + H^{+1}$	Acidic
	Conjugates of Strong Acids (anion) do nothing to change the pH of a solution, conjugates of weak bases (cation) behave as an acid.	
RbF	$RbF \rightarrow \mathbf{Rb^{+1}} + \mathbf{F^{-1}}$; $F^{-1} + H_2O \leftrightarrow HF + OH^{-1}$	Basic
	Conjugates of Strong Bases (cation) do nothing to change the pH of a solution, conjugates of weak acids (anion) behave as a base..	
$HNNH_2Br$	$HNNH_2Br \rightarrow \mathbf{HNNH_2^{+1}} + Br^{-1}$; $HNNH_2^{+1} \leftrightarrow HNNH + H^{+1}$	Acidic
	Conjugates of Strong Acids (anion) do nothing to change the pH of a solution, conjugates of weak bases (cation) behave as an acid.	
$Ba(C_2H_3O_2)_2$	$Ba(C_2H_3O_2)_2 \rightarrow \mathbf{Ba^{+2}} + 2\ \mathbf{C_2H_3O_2^{-1}}$; $C_2H_3O_2^{-1} + H_2O \leftrightarrow HC_2H_3O_2 + OH^{-1}$	Basic
	Conjugates of Strong Bases (cation) do nothing to change the pH of a solution, conjugates of weak acids (anion) behave as a base.	
$C_5H_3N_3HCl$	$C_5H_3N_3HCl \rightarrow \mathbf{C_5H_3N_3H^{+1}} + Cl^{-1}$; $C_5H_3N_3H^{+1} \leftrightarrow C_5H_3N_3 + H^{+1}$	Acidic
	Conjugates of Strong Acids (anion) do nothing to change the pH of a solution, conjugates of weak bases (cation) behave as an acid.	
RbCl	$RbCl \rightarrow \mathbf{Rb^{+1}} + \mathbf{Cl^{-1}}$	Neutral !
	Conjugates of Strong Acids and Strong Bases do nothing to change the pH of a solution	

4. Calculate the pH of a 0.677 *M* $RbC_3H_3N_2$ solution. K_a value for $HC_3H_3N_2$ is 8.65×10^{-4}.

Answer:

$RbC_3H_3N_2$ is a SALT !!! $RbC_3H_3N_2 \rightarrow Rb^{+1} + \mathbf{C_3H_3N_2^{-1}}$

Rb^{+1} is the conjugate of a strong BASE and will do nothing to change the pH. However, the ***$C_3H_3N_2^{-1}$*** *is the conjugate of a weak acid – and this will behave as a BASE !!!*

	[$C_3H_3N_2^{-1}$]	+	[H_2O]	↔	[$HC_3H_3N_2$]	+	[OH^{-1}]
I	0.677 *M*		-		0		0
C	- x		-		+ x		+ x
E	0.677 - x		-		x		x

$$K_b = \frac{\left[\ HC_3H_3N_2\ \right]\left[\ OH^{-1}\ \right]}{\left[\ C_3H_3N_2^{-1}\ \right]}$$

Be sure to notice (recognize) that you CANNOT have [H^{+1}] in your expression if you are solving for K_b.

$$K_b = \frac{K_w}{K_a} = \frac{1.00 \times 10^{-14}}{8.65 \times 10^{-4}} = 1.16 \times 10^{-11}$$

$$K_b = 1.16 \times 10^{-11} = \frac{\left[\ HC_3H_3N_2\ \right]\left[\ OH^{-1}\ \right]}{\left[\ C_3H_3N_2^{-1}\ \right]} = \frac{(x)(x)}{0.677 - x} = \frac{x^2}{0.677}$$

$$K_b = 1.16 \times 10^{-11} = \frac{x^2}{0.677}$$

$$\left(\ 1.16 \times 10^{-11}\ \right)\left(\ 0.677\ \right) = x^2$$

$$x = \sqrt{7.83 \times 10^{-12}} = 2.80 \times 10^{-6}\ M = \left[\ OH^{-1}\ \right]$$

pOH = - log (2.80×10^{-6}) = **5.55**

pH = 14 – pOH = 14 – 5.55 = 8.45

5. Find the pH of a solution that has 44.5 grams of rubidium hydroxide dissolved in 4.75 liters of water.

Answer:

RbOH is a STRONG BASE !!! $RbOH \rightarrow Rb^{+1} + OH^{-1}$ *(100% dissociation (ionization))*

Therefore, the (calculated) concentration is for the rubidium hydroxide is the same concentration (at the end of the reaction) for the Rb^{+1} *AND* OH^{-1} *!!!*

So, let's calculate the concentration of the RbOH that we initially begin with…

$$\frac{44.5\ g\ RbOH}{} \times \frac{1\ mole\ RbOH}{102.478\ g} = 0.434\ mole\ RbOH$$

$$M = \frac{0.434\ mole\ RbOH}{4.75\ L} = 0.0914\ M$$

Okay, now that we know the initial concentration for the RbOH, we can assume that the concentration for the OH^{-1} *at the end of the reaction (dissociation of the RbOH – recall, this is NOT an equilibrium reaction)*

$$\left[OH^{-1}\right] = 0.0914\ M$$

$$pOH = -\log\left[OH^{-1}\right] = -\log\ 0.0914 = 1.04$$

$$\mathbf{pH} = 14 - pOH = 14 - 1.04 = \mathbf{12.96}$$

6. Calculate the pH of a 3.44 *M* $HC_7H_7ClO_4$ solution. K_b value for HC_7H_6 is 2.11 x 10^{-3}.

Answer:

$HC_7H_7ClO_4$ is a SALT !!! $HC_7H_7ClO_4 \rightarrow \mathbf{HC_7H_7^{+1}} + ClO_4^{-1}$

$HC_7H_7^{+1}$ is the conjugate of a weak BASE and will behave as an ACID. The ClO_4^{-1} is the conjugate of a STRONG acid and this will do nothing to change the pH. This salt causes the solution to become more acidic !!!

	$[HC_7H_7^{-1}]$	$\leftrightarrow$	$[HC_7H_6]$	+	$[H^{+1}]$
I	3.44 *M*		0		0
C	- *x*		+ *x*		+ *x*
E	3.44 - *x*		*x*		*x*

$$K_a = \frac{\left[HC_7H_6 \right]\left[H^{+1} \right]}{\left[HC_7H_7^{-1} \right]}$$

Be sure to notice (recognize) that you CANNOT have [H^{+1}] in your expression if you are solving for K_b.

$$K_a = \frac{K_w}{K_b} = \frac{1.00 \times 10^{-14}}{2.11 \times 10^{-3}} = 4.74 \times 10^{-12}$$

$$K_a = 4.74 \times 10^{-12} = \frac{\left[HC_7H_6 \right]\left[H^{+1} \right]}{\left[HC_7H_7^{-1} \right]} = \frac{(x)(x)}{3.44 - x} = \frac{x^2}{3.44}$$

$$K_a = 4.74 \times 10^{-12} = \frac{x^2}{3.44}$$

$$\left(4.74 \times 10^{-12} \right) \left(3.44 \right) = x^2$$

$$x = \sqrt{1.63 \times 10^{-11}} = 4.04 \times 10^{-6} \ M = \left[H^{+1} \right]$$

pH = - log (4.04 x 10^{-6}) = **5.39**

7. a) Calculate the equilibrium constant, *K*, at a certain temperature for the reaction:

$$HC_3H_5O_3 \leftrightarrow H^{+1} + C_3H_5O_3^{-1}$$

if the initial concentration of lactic acid, $HC_3H_5O_3$, was 4.33 *M*. When the reaction reaches equilibrium it is discovered that the lactic acid dissociated 0.677 %.

Answer:

Lactic acid, $HC_3H_5O_3$, is a weak acid and will only have 0.677% of the original concentration will dissociate (or ionize) when the reaction reaches equilibrium.

$$\mathbf{x = (4.33\ M)(0.00677) = 0.0293\ M}$$

	$[HC_3H_5O_3]$	$\leftrightarrow$	$[C_3H_5O_3^{-1}]$	+	$[H^{+1}]$
I	*4.33 M*		0		0
C	*- x = - 0.0293 M*		*+ x = + 0.0293 M*		*+ x = + 0.0293 M*
E	*4.33 - 0.0293 = 4.30*		*0.0293*		*0.0293*

$$K_a = \frac{[C_3H_5O_3^{-1}][H^{+1}]}{[HC_3H_5O_3]} = \frac{(0.0293)^2}{(4.33-0.0293)} = 0.0001996$$

b) Calculate the pH of a solution formed by dissolving 123 grams of solid francium lactate, $FrC_3H_5O_3$, in 1734 mL of the ***initial*** concentration of $HC_3H_5O_3$ (from part (a)). Assume that volume change is negligible.

Answer:

Francium lactate, $FrC_3H_5O_3$, is a SALT !!! $FrC_3H_5O_3 \rightarrow Fr^{+1} + C_3H_5O_3^{-1}$

Fr^{+1} is the conjugate of a STRONG base and will do nothing to change the pH of the solution.

The $C_3H_5O_3^{-1}$ is the conjugate of a weak acid and this will behave as a BASE and cause the solution to become more basic !!!

Calculate the concentration of the salt:

$$\frac{123\ g\ FrC_3H_5O_3}{} \times \frac{1\ mole\ FrC_3H_5O_3}{312.07\ g} = 0.394\ mole\ FrC_3H_5O_3$$

$$M = \frac{0.394\ mole\ FrC_3H_5O_3}{1.734\ L} = 0.227\ M$$

	$[HC_3H_5O_3]$	$\leftrightarrow$	$[C_3H_5O_3^{-1}]$	+	$[H^{+1}]$
I	*4.33 M*		*0.227 M*		~ 0
C	*+ x*		*- x*		*- x*
E	*4.33 + x*		*0.227 - x*		$[H^{+1}]$

$$K_a = \frac{[C_3H_5O_3^{-1}][H^{+1}]}{[HC_3H_5O_3]} = \frac{(0.227 - x)[H^{+1}]}{(4.33 + x)} = \frac{(0.227)[H^{+1}]}{(4.33)} = 0.0001996$$

$$[H^{+1}] = \frac{(4.33)(0.0001996)}{(0.227)} = 0.00381$$

pH = - log (0.00381) = **2.42**

8. Fill in the missing information in the following table:

pH	pOH	[H^{+1}]	[OH^{-1}]	acid, base or neutral
10.56	3.44	**2.75×10^{-11}**	**3.63×10^{-4}**	**Basic**
3.57	**10.43**	2.70×10^{-4}	**3.70×10^{-11}**	**Acidic**
7.39	**6.61**	**4.07×10^{-8}**	**2.45×10^{-7}**	**Basic**
6.89	**7.11**	**1.28×10^{-7}**	7.84×10^{-8}	**Acidic**