Acid-Base Equilibrium

Dr. Ron Rusay

Introduction to Aqueous Acids

- *Acids: taste sour and cause certain dyes to change color.*

Introduction to
Aqueous Acids

Introduction to Aqueous Bases

- *Bases: taste bitter, feel soapy and cause certain dyes to turn color.*

Introduction to
Aqueous Bases

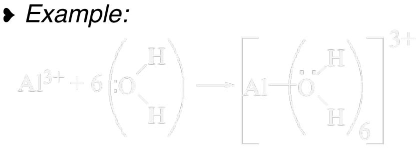
Models of Acids and Bases

- *Arrhenius: Acids produce H^+ & bases produce OH^- ion in aqueous solutions .*
- *Brønsted-Lowry: Acids are H^+ donors & bases are proton acceptors.*

- *$HCl + H_2O \rightarrow Cl^- + H_3O^+$*
  acid   base

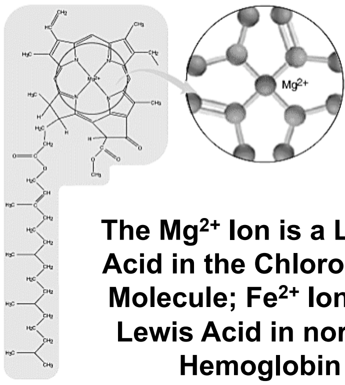
Lewis Acids and Bases

- ***Lewis Acid**: electron pair **acceptor***
- ***Lewis Base**: electron pair **donor***
- *Example:*



Lewis Acids and Bases

Lewis Acid-Base Theory



The Mg^{2+} Ion is a Lewis Acid in the Chlorophyll Molecule; Fe^{2+} Ion is a Lewis Acid in normal Hemoglobin

Conjugate Acid/Base Pairs

- *HA(aq) + H_2O(l) → H_3O^+(aq) + A^-(aq)*

acid 1	base 2	conj acid 2	conj base 1

- *conjugate acid: formed when the proton is transferred to the base.*
- *conjugate base: everything that remains of the acid molecule after a proton is lost.*

Click to reveal the conjugate acid and the conjugate base of each species.

Conjugate acid		Conjugate base
	NH_3	
	H_2O	
	$H_2PO_4^-$	
	OH^-	

Strong & Weak Acids: Dissociation Constant (K_a)

- HA(aq) + H_2O(l) ⇆ H_3O^+(aq) + A^-(aq)

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

- HA(aq) ⇆ H^+(aq) + A^-(aq)

Acid Strength

Strong Acid:

- *Equilibrium position lies far to the right. (HNO_3); Ka >> 1*
- *Produces a conjugate base. (NO_3^-) and a conjugate acid which are weaker than the starting acid and base (H_2O).*

Acid Strength

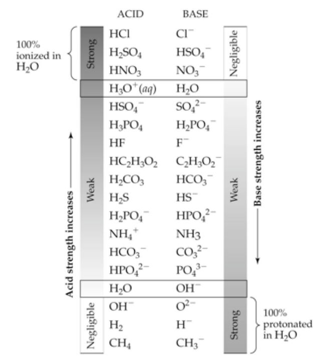
Strong Acids:

Strong Acid	Formula
Hydrochloric	HCl
Hydrobromic	HBr
Hydroiodic	HI
Nitric	HNO_3
Chloric	$HClO_3$
Perchloric	$HClO_4$
Sulfuric *	H_2SO_4

Acid Strength
(continued)

Weak Acid:

- *Equilibrium lies far to the left. (CH_3COOH); Ka < 1*
- *Yields a stronger (relatively strong) conjugate base than water. (CH_3COO^-)*



Weak Acids

- *Weak acids are only partially ionized in solution.*

$$HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)$$

$$HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$$

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

- ***K_a** is the acid dissociation constant.*

Percent Ionization

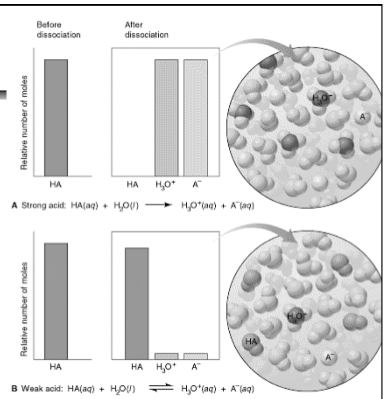
- *Percent ionization is a way to assess relative acid strengths.*
- *For the reaction*

$$HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)$$

$$\%\ \text{ionization} = \frac{[H^+]_{eqm}}{[HA]_0} \times 100$$

- *Percent ionization relates the* H_3O^+ ***(aq)*** *equilibrium concentration,* $[H^+]_{eqm}$*, to the initial* **HA(*aq*)** *concentration,* $[HA]_0$.

The Extent of Dissociation for Strong and Weak Acids

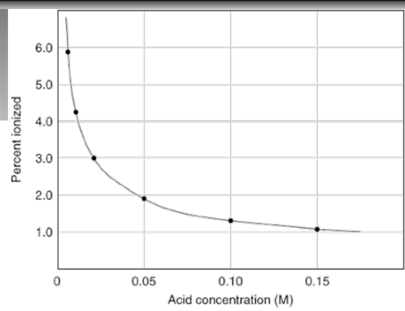


Weak Acids

- *The higher percent ionization, the stronger the acid.*
- *Percent ionization of a weak acid decreases as the molarity of the solution increases.*
- *For acetic acid, 0.05* M *solution is 2.0 % ionized whereas a 0.15* M *solution is 1.0 % ionized.*

Weak Acids

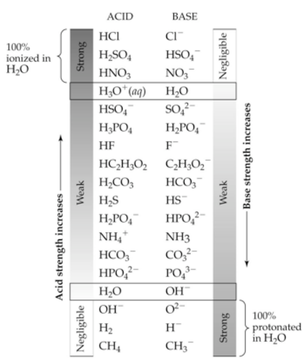
Percent Ionization



QUESTION

Nitric acid, HNO_3, is considered to be a strong acid whereas nitrous acid, HNO_2, is considered to be a weak acid. Which of the statements here is fully correct?

A. Nitric acid has an aqueous equilibrium that lies far to the right and NO_3^- is considered a weak conjugate base.
B. Nitric acid has a stronger conjugate base than nitrous acid.
C. The dissociation of nitrous acid compared to an equal concentration of nitric acid produces more H^+.
D. The equilibrium of nitrous acid lies far to the left and the conjugate base is weaker than the conjugate base of nitric acid.



Bases

- *"Strong" and "weak" are used in the same sense for bases as for acids.*
- *Strong = complete dissociation, K_b >> 1*

(concentration of hydroxide ion in solution)

$$NaOH(s) \rightarrow Na^+(aq) + OH^-(aq)$$

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

Bases

(continued)

- *Weak bases have very little dissociation, K_b < 1 (little ionization with water)*
- $CH_3NH_2(aq) + H_2O(l) \leftrightarrows CH_3NH_3^+(aq) + OH^-(aq)$
- *How conductive is NaOH(aq) vs morphine, $C_{17}H_{19}NO_3$ (aq)?*

QUESTION

Aniline, $C_6H_5NH_2$, was isolated in the 1800s and began immediate use in the dye industry. What is the formula of the conjugate acid of this base?

A. $C_6H_5NH_2^+$
B. $C_6H_5NH_3^+$
C. $C_6H_5NH^-$
D. $C_6H_5NH^+$

Acid-Base Strengths

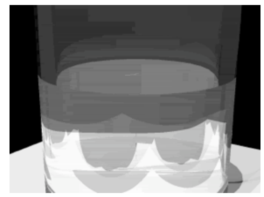
Strong Acid:

Strong Base:

Weak Acid:

Weak Base:

Water as an Acid and a Base
Self-ionization



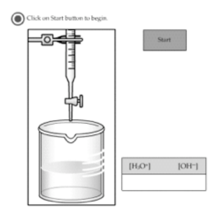
Water as an Acid and a Base

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

- *Water is amphoteric (it can behave either as an acid or a base).*
  - $H_2O + H_2O \leftrightarrows H_3O^+ + OH^-$

    acid 1 base 2 conj acid 2 conj base 1
  - $K_w = 1 \times 10^{-14}$ *at 25°C*

Water as an Acid and a Base
Self-ionization



The pH Scale

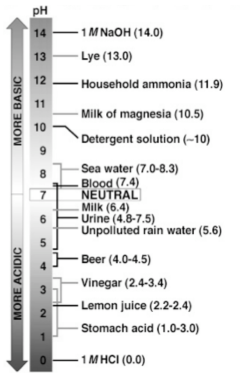
- $pH \approx -\log[H^+] \approx -\log[H_3O^+]$
- *pH in water ranges from 0 to 14.*

  $K_w = 1.00 \times 10^{-14} = [H^+][OH^-]$

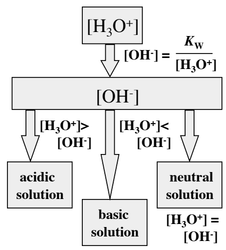
  $pK_w = 14.00 = pH + pOH$
- *As pH rises, pOH falls (sum = 14.00).*
- *There are no theoretical limits on the values of pH or pOH. (e.g. pH of 2.0 M HCl is -0.301)*

The Relations Among $[H_3O^+]$, pH, $[OH^-]$, and pOH

	$[H_3O^+]$	pH	$[OH^-]$	pOH
MORE BASIC	1.0×10^{-15}	15.00	1.0×10^{1}	−1.00
	1.0×10^{-14}	14.00	1.0×10^{0}	0.00
	1.0×10^{-13}	13.00	1.0×10^{-1}	1.00
BASIC	1.0×10^{-12}	12.00	1.0×10^{-2}	2.00
	1.0×10^{-11}	11.00	1.0×10^{-3}	3.00
	1.0×10^{-10}	10.00	1.0×10^{-4}	4.00
	1.0×10^{-9}	9.00	1.0×10^{-5}	5.00
	1.0×10^{-8}	8.00	1.0×10^{-6}	6.00
NEUTRAL	1.0×10^{-7}	7.00	1.0×10^{-7}	7.00
	1.0×10^{-6}	6.00	1.0×10^{-8}	8.00
	1.0×10^{-5}	5.00	1.0×10^{-9}	9.00
	1.0×10^{-4}	4.00	1.0×10^{-10}	10.00
ACIDIC	1.0×10^{-3}	3.00	1.0×10^{-11}	11.00
	1.0×10^{-2}	2.00	1.0×10^{-12}	12.00
	1.0×10^{-1}	1.00	1.0×10^{-13}	13.00
	1.0×10^{0}	0.00	1.0×10^{-14}	14.00
MORE ACIDIC	1.0×10^{1}	−1.00	1.0×10^{-15}	15.00



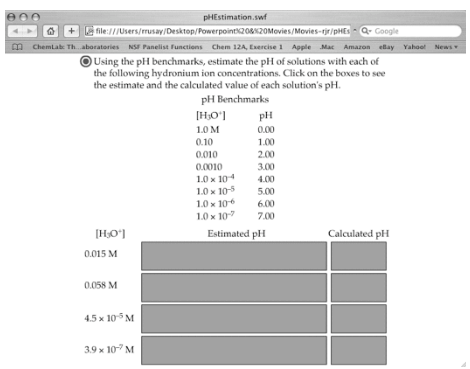
The pH Values of Some Familiar Aqueous Solutions



QUESTION

In a solution of water at a particular temperature the $[H^+]$ may be 1.2×10^{-6} M. What is the $[OH^-]$ in the same solution? Is the solution acidic, basic, or neutral?

A. 1.2×10^{-20} *M*; acidic
B. 1.2×10^{-20} *M*; basic
C. 8.3×10^{-9} *M*; basic
D. 8.3×10^{-9} *M*; acidic



QUESTION

An environmental chemist obtains a sample of rainwater near a large industrial city. The $[H^+]$ was determined to be 3.5×10^{-6} *M*. What is the pH, pOH, and $[OH^-]$ of the solution?

A. pH = 5.46 ; pOH = 8.54; $[OH^-] = 7.0 \times 10^{-6}$ *M*
B. pH = 5.46 ; pOH = 8.54; $[OH^-] = 2.9 \times 10^{-9}$ *M*
C. pH = 12.56 ; pOH =1.44 ; $[OH^-] = 3.6 \times 10^{-2}$ *M*
D. pH = 8.54; pOH = 5.46; $[OH^-] = 2.9 \times 10^{-9}$ *M*

Name: ____________________ Partner (if any): ____________________

The pH Scale

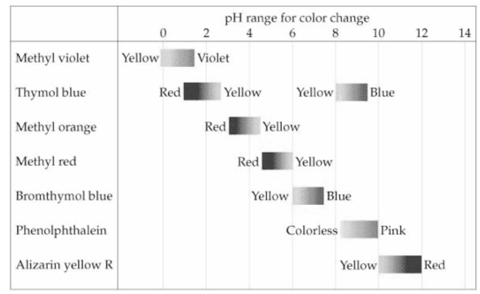
$[H^+]$	$[OH^-]$	pH	pOH	acidic or basic?
7.5×10^{-3} *M*				
	3.6×10^{-10} *M*			
		8.25		
			5.70	

The pH Scale

$[H^+]$	$[OH^-]$	pH	pOH	acidic or basic?
7.5×10^{-3} *M*	$1.3 x10^{-12}$	2.1	11.9	Acid
$2.8 x10^{-5}$	3.6×10^{-10} *M*	4.6	9.4	Acid
$5.62 x10^{-9}$	$1.78 x10^{-6}$	8.25	5.75	Base
$5.00 x10^{-9}$	$2.00 x10^{-6}$	8.30	5.70	Base

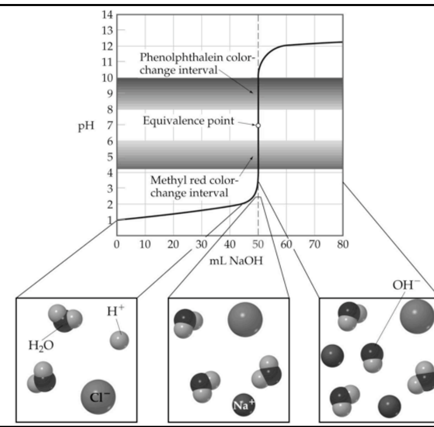
Indicators

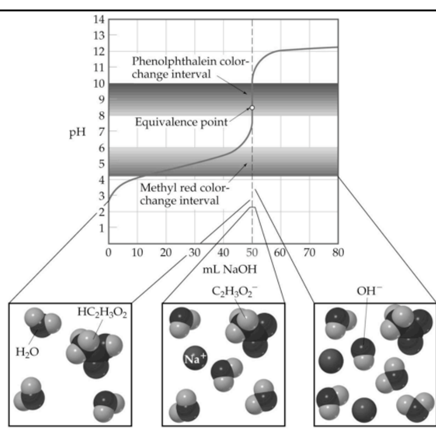
Acid-Base Indicators



Titrations: Indicators & (pH) Curves

- pH Curve is a plot of pH of the solution being analyzed as a function of the amount of titrant added.
- Equivalence (stoichiometric) point: Enough titrant has been added to react exactly with the solution being analyzed. An indicator provides a visible color change to determine an (end point) volume of titrant.

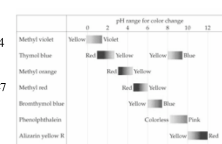




QUESTION

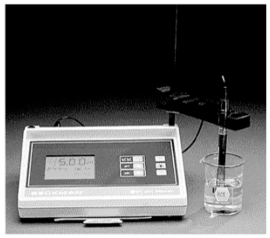
Most acid-base indicators are weak acids. In a titration of 0.50 *M* acetic acid (at 25°C, $K_a = 1.8 \times 10^{-5}$) with KOH, which indicator would best indicate the pH at the equivalence point? The approximate K_a for each choice is provided.

A. Bromophenol blue; $K_a \sim 1 \times 10^{-4}$
B. Methyl red; $K_a \sim 1 \times 10^{-5}$
C. Bromothymol blue; $K_a \sim 1 \times 10^{-7}$
D. Alizarin yellow; $K_a \sim 1 \times 10^{-10}$



Methods for Measuring the pH of an Aqueous Solution

(a) pH paper

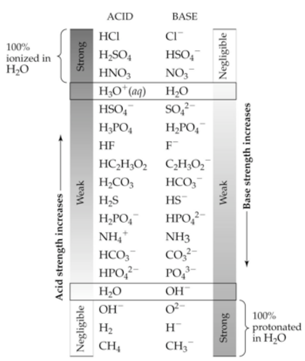


(b) Electrodes of a pH meter

QUESTION

The acid-base indicator bromocresol purple has an interesting yellow-to-purple color change. If the approximate K_a of this indicator is 1.0×10^{-6}, what would be the ratio of purple [A^-] to yellow [HA] at a pH of 4.0?

A. 100:1
B. 1:100
C. 1:1
D. This choice indicates that I don't know.



The Relations Among [H_3O^+], pH, [OH^-], and pOH

	[H_3O^+]	pH	[OH^-]	pOH
MORE BASIC	1.0×10^{-15}	15.00	1.0×10^{1}	−1.00
	1.0×10^{-14}	14.00	1.0×10^{0}	0.00
	1.0×10^{-13}	13.00	1.0×10^{-1}	1.00
BASIC	1.0×10^{-12}	12.00	1.0×10^{-2}	2.00
	1.0×10^{-11}	11.00	1.0×10^{-3}	3.00
	1.0×10^{-10}	10.00	1.0×10^{-4}	4.00
	1.0×10^{-9}	9.00	1.0×10^{-5}	5.00
	1.0×10^{-8}	8.00	1.0×10^{-6}	6.00
NEUTRAL	1.0×10^{-7}	7.00	1.0×10^{-7}	7.00
	1.0×10^{-6}	6.00	1.0×10^{-8}	8.00
	1.0×10^{-5}	5.00	1.0×10^{-9}	9.00
	1.0×10^{-4}	4.00	1.0×10^{-10}	10.00
ACIDIC	1.0×10^{-3}	3.00	1.0×10^{-11}	11.00
	1.0×10^{-2}	2.00	1.0×10^{-12}	12.00
	1.0×10^{-1}	1.00	1.0×10^{-13}	13.00
	1.0×10^{0}	0.00	1.0×10^{-14}	14.00
MORE ACIDIC	1.0×10^{1}	−1.00	1.0×10^{-15}	15.00

Conjugates

Some Conjugate Acid–Base Pairs

Acid	K_a	Base	K_b
HNO_3	(Strong acid)	NO_3^-	(Negligible basicity)
HF	6.8×10^{-4}	F^-	1.5×10^{-11}
$HC_2H_3O_2$	1.8×10^{-5}	$C_2H_3O_2^-$	5.6×10^{-10}
H_2CO_3	4.3×10^{-7}	HCO_3^-	2.3×10^{-8}
NH_4^+	5.6×10^{-10}	NH_3	1.8×10^{-5}
HCO_3^-	5.6×10^{-11}	CO_3^{2-}	1.8×10^{-4}
OH^-	(Negligible acidity)	O^{2-}	(Strong base)

$K_a \times K_b = ?$

$K_a \times K_b = K_w$

Conjugates

$K_a \times K_b = K_w$

HF

$K_a = 3.5 \times 10^{-4}$

Click to see conjugate base.

What do pK_a and pK_b refer to?

$pK_a + pK_b = ?$

$pK_a + pK_b = pK_w$

QUESTION

Values of K_a for Some Common Monoprotic Acids

Formula	Name	Value of K_a*
HSO_4^-	Hydrogen sulfate ion	1.2×10^{-2}
$HClO_2$	Chlorous acid	1.2×10^{-2}
$HC_2H_2ClO_2$	Monochloracetic acid	1.35×10^{-3}
HF	Hydrofluoric acid	7.2×10^{-4}
HNO_2	Nitrous acid	4.0×10^{-4}
$HC_2H_3O_2$	Acetic acid	1.8×10^{-5}
$[Al(H_2O)_6]^{3+}$	Hydrated aluminum(III) ion	1.4×10^{-5}
HOCl	Hypochlorous acid	3.5×10^{-8}
HCN	Hydrocyanic acid	6.2×10^{-10}
NH_4^+	Ammonium ion	5.6×10^{-10}
HOC_6H_5	Phenol	1.6×10^{-10}

↑ Increasing acid strength

Use information on this table to determine which of the following bases would have the weakest conjugate acid:

$OC_6H_5^-$; $C_2H_3O_2^-$; OCl^-; NH_3

A. $OC_6H_5^-$
B. $C_2H_3O_2^-$
C. OCl^-
D. NH_3

Strong vs.Weak Acids
pH Estimations/ Calculations

What are the respective pH values for a 0.100M solution of HCl ($K_a = \infty$) and a 0.100M solution of HF ($K_a = 3.53 \times 10^{-4}$)?

- *What are the respective equilibrium concentrations of* H^+ (H_3O^+)?
- *pH is calculated from the equilibrium concentration of* H^+ (H_3O)
- *Using* K_a*, and the starting molarity of acid, the equilibrium concentration of* H^+ (H_3O^+) *can be estimated and then pH*); Strong acids 100%, ***pH=1.00***, Weak: less than 100%

Strong vs.Weak Acids
pH Estimations/ Calculations

What are the respective pH values for a 0.100M solution of HCl ($K_a = \infty$) and a 0.100M solution of HF ($K_a = 3.53 \times 10^{-4}$)?

- *Using* K_a*, and the starting molarity of the weak acid, the equilibrium concentration of* H^+ (H_3O^+) *can be estimated using an ICE approach and then the pH.*

$$K_a = [H^+][A^-] / [HA - x] = x^2/(0.100\ M - x)$$

$3.53 \times 10^{-4} = x^2/0.100$; estimate @ $\boldsymbol{x} \cong (10^{-5})^{1/2}$ representing the $[H^+]$, taking –log yields a *pH* >2 and <3.

QUESTION

Which of the following correctly compares strength of acids, pH, and concentrations?

A. A weak acid, at the same concentration of a strong acid, will have a lower pH.
B. A weak acid, at the same concentration of a strong acid, will have the same pH.
C. A weak acid, at a high enough concentration more than a strong acid, could have a lower pH than the strong acid.
D. A weak acid, at a concentration below a strong acid, could have a lower pH than a strong acid.

Weak Acids
K_a and Calculating pH

- *Write the balanced chemical equation clearly showing the equilibrium.*
- *Write the equilibrium expression. Use the value for* K_a
- *Let* x = $[H^+]$; *substitute into the equilibrium constant expression and solve.*
- *Convert* $[H^+]$ *to pH.*

Equilibrium Concentration Calculations pH from Initial Concentrations and K_a

What is the pH value for a 0.100M solution of HF ($K_a = 3.53 \times 10^{-4}$)?

$$HF_{(aq)} \rightleftharpoons H^+_{(aq)} + F^-_{(aq)}$$

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

Equilibrium Concentration Calculations

$HF_{(aq)} \leftrightarrows H^+_{(aq)} + F^-_{(aq)}$

Concentration (M)	HF	H^+	F^-
Initial	0.100	0	0
Change	0.100-x	+x	+x
Final	0.100-x	x	x

$$K_c = \frac{[H^+][F^-]}{[HF]} = 3.53 \times 10^{-4} = \frac{x^2}{(0.100 - x)}$$

$3.53 \times 10^{-4}(0.100 - x) = x^2$

Quadratic:

$0 = x^2 + 3.53 \times 10^{-4}x - 3.53 \times 10^{-5}$

x=[H$^+$] = 0.00805 *M; pH= 2.09*

Simplified:

$$3.53 \times 10^{-4} = \frac{x^2}{(0.100)}$$

$3.53 \times 10^{-4}(0.100) = x^2$

$x = [3.53 \times 10^{-4}(0.100)]^{1/2}$

x=[H$^+$] = 0.00594 *M; pH= 2.23*

QUESTION

Butyric acid is a weak acid that can be found in spoiled butter. The compound has many uses in synthesizing other flavors. The K_a of $HC_4H_7O_2$ at typical room temperatures is 1.5×10^{-5}. What is the pH of a 0.20 *M* solution of the acid?

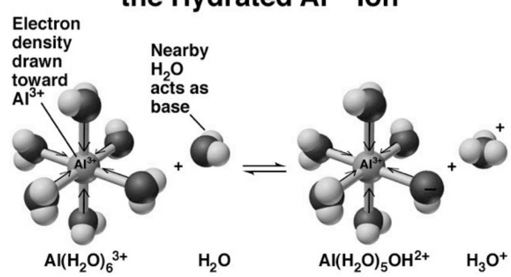
A. 5.52
B. 4.82
C. 2.76
D. –0.70

QUESTION

A 0.35 *M* solution of an unknown acid is brought into a lab. The pH of the solution is found to be 2.67. From this data, what is the K_a value of the acid?

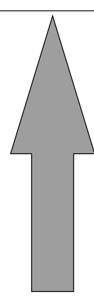
A. 6.1×10^{-3}
B. 1.3×10^{-5}
C. 7.5×10^{-4}
D. 2.1×10^{-3}

Acidic Behavior of the Hydrated Al^{3+} Ion



K_a Values of Some Hydrated Metal Ions at 25ºC

Ion	K_a
Fe^{3+} (aq)	6×10^{-3}
Sn^{2+} (aq)	4×10^{-4}
Cr^{3+} (aq)	1×10^{-4}
Al^{3+} (aq)	1×10^{-5}
Be^{2+} (aq)	4×10^{-6}
Cu^{2+} (aq)	3×10^{-8}
Pb^{2+} (aq)	3×10^{-8}
Zn^{2+} (aq)	1×10^{-9}
Co^{2+} (aq)	2×10^{-10}
Ni^{2+} (aq)	1×10^{-10}



Oxides

- *Acidic Oxides (Acid Anhydrides):*
  - *O–X bond is strong and covalent.*

    SO_2, NO_2, CrO_3
- *Basic Oxides (Basic Anhydrides):*
  - *O–X bond is ionic.*

    K_2O, CaO

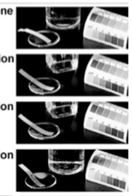
Structure and Acid-Base Properties

- *Two important factors that effect acidity in **binary** compounds, eg. HCl (aq):*
  - *Bond Polarity (smaller e.n. differences favor higher acidities)*
  - *Bond Strength (weak bonds favor higher acidity: more protons [hydronium ions] in solution)*
  - *Select & explain which is the stronger acid: HBr vs. HF.*

Behavior of Salts in Water

The Behavior of Salts in Water

Salt Solution (Examples)	pH	Nature of Ions	Ion That Reacts with Water
Neutral [NaCl, KBr, $Ba(NO_3)_2$]	7.0	Cation of strong base Anion of strong acid	None
Acidic [NH_4Cl, NH_4NO_3, CH_3NH_3Br]	<7.0	Cation of weak base Anion of strong acid	Cation
Acidic [$Al(NO_3)_3$, $CrCl_3$, $FeBr_3$]	<7.0	Small, highly charged cation Anion of strong acid	Cation
Basic [CH_3COONa, KF, Na_2CO_3]	>7.0	Cation of strong base Anion of weak acid	Anion



$LiNO_2$ NH_4Cl $Ca(NO_3)_2$

$MgSO_4$ $AgClO_3$ CsCN

QUESTION

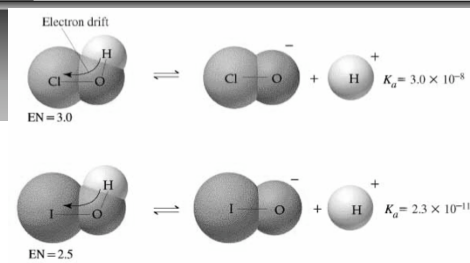
The following salts were all placed in separate solutions at the same temperature so that their concentrations were all equal. Arrange them in order from lowest pH to highest pH.

NaCl; NH_4NO_3; $Ca(C_2H_3O_2)_2$; $AlCl_3$

Additional information: K_b for $NH_3 = 1.8 \times 10^{-5}$; K_a for $HC_2H_3O_2 = 1.8 \times 10^{-5}$; K_a for $Al(H_2O)^{3+} = 1.4 \times 10^{-5}$.

A. NaCl; NH_4NO_3; $Ca(C_2H_3O_2)_2$; $AlCl_3$
B. $AlCl_3$; NaCl; NH_4NO_3; $Ca(C_2H_3O_2)_2$
C. $AlCl_3$; NH_4NO_3; NaCl; $Ca(C_2H_3O_2)_2$
D. NH_4NO_3; $AlCl_3$; NaCl; $Ca(C_2H_3O_2)_2$

Strength of Oxyacids



Strength of Oxyacids

- Name the acids:
  - *HBrO* , $K_a = 2.1 \times 10^{-8}$
  - *HIO* , $K_a = 2.3 \times 10^{-11}$
  - *HClO* , $K_a = 3.0 \times 10^{-8}$
  - *$HClO_2$* , $K_a = 1.2 \times 10^{-2}$

Is *$HBrO_3$* stronger or weaker than *$HClO_3$?*
A) stronger or B) weaker

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Is *$HBrO_3$* stronger or weaker than *$HClO_3$?*
A) stronger or **B) weaker**

QUESTION

- Rank 1.0M solutions of *HBrO, HIO* and *HClO* in order of increasing acidity.

HBrO , $K_a = 2.1 \times 10^{-8}$
HIO , $K_a = 2.3 \times 10^{-11}$
HClO , $K_a = 3.0 \times 10^{-8}$

A) HBrO < HIO < HClO *B) HIO < HBrO < HClO*

C) HClO < HBrO < HIO *D) HIO < HClO < HBrO*

ANSWER: B) HIO < HBrO < HClO
(Increasing Ka values)

QUESTION

- Rank 1.0M solutions of *HBrO, HIO* and *HClO* in order of increasing pH.

HBrO , $K_a = 2.1 \times 10^{-8}$
HIO , $K_a = 2.3 \times 10^{-11}$
HClO , $K_a = 3.0 \times 10^{-8}$

A) HBrO < HIO < HClO *B) HIO < HBrO < HClO*

C) HClO < HBrO < HIO *D) HIO < HClO < HBrO*

ANSWER: C) HClO < HBrO < HIO
(pH ~ -log Ka values)

Strength of Acids

Acid	Formula	K_a (25°C)
Acetic	CH_3COOH	1.8×10^{-5}
Chloroacetic	$CH_2ClCOOH$	1.4×10^{-3}
Dichloroacetic	$CHCl_2COOH$	3.3×10^{-2}
Trichloroacetic	CCl_3COOH	2×10^{-1}

Strength of Acids

Br-CH_2COOH, I-CH_2COOH, CH_3COOH

- *pKa=2.69 pKa=3.12 pKa=4.75*

1) Is chloroacetic acid more or less acidic than bromoacetic acid?
2) Will its pKa be higher or lower than bromoacetic acid?

A) 1.more 2.higher B) 1.less 2.lower C) 1.less 2.higher D) 1.more 2.lower

Strength of Acids

Br-CH_2COOH, I-CH_2COOH, CH_3COOH

- *pKa=2.69 pKa=3.12 pKa=4.75*

1) Is chloroacetic acid more or less acidic than bromoacetic acid?
2) Will its pKa be higher or lower than bromoacetic acid?

D) 1.more 2.lower

QUESTION

- *Rank the following acids in order of decreasing acidity.*

1) Br-CH_2COOH, 2) I-CH_3COOH, 3) CH_3COOH
pKa= 2.69 pKa=3.12 pKa=4.75

A) 1 > 2 > 3 B) 3 > 2 > 1 C) 2 > 3 > 1

ANSWER: B) 3 > 2 > 1; LOWER pKa HIGHER Acidity

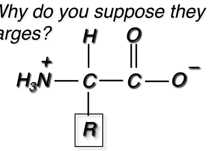
QUESTION

Ascorbic acid, also known as vitamin C, has two hydrogen atoms that ionize from the acid. $Ka_1 = 7.9 \times 10^{-5}$; $Ka_2 = 1.6 \times 10^{-12}$. What is the pH, and $C_6H_6O_6^{2-}$ concentration of a 0.10 *M* solution of $H_2C_6H_6O_6$?

A. 2.55; $[C_6H_6O_6^{2-}] = 0.050\ M$
B. 2.55; $[C_6H_6O_6^{2-}] = 1.6 \times 10^{-12}\ M$
C. 1.00; $[C_6H_6O_6^{2-}] = 1.6 \times 10^{-12}\ M$
D. 5.10; $[C_6H_6O_6^{2-}] = 0.050\ M$

Amino Acids

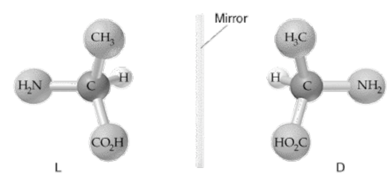
- *More than 700 amino acids occur naturally, but 20 (22?) of them are especially important.*
- *These 20 amino acids are the building blocks of proteins in humans and developed organisms*
- *They differ in respect to the group attached to the α carbon. Why do you suppose they are written with + and – charges?*



Amino Acids

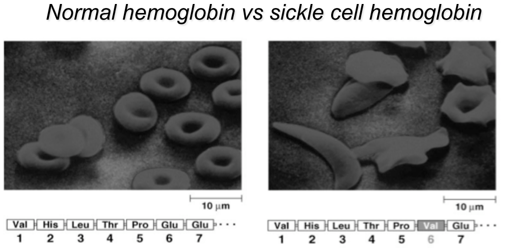
- *Our bodies can synthesize about 10 amino acids.*
- *Essential amino acids are the other 10 amino acids, which have to be ingested.*
- *The α-carbon in all amino acids except glycine is chiral (has 4 different groups attached to it).*
- *Chiral molecules exist as two non-superimposable mirror images called enantiomers.*
- *L-amino acids are the common natural enantiomers.*

Amino Acids



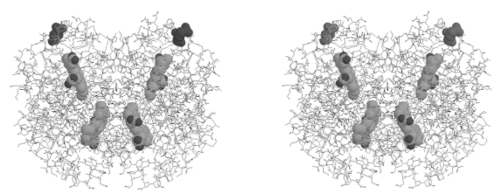
- *L-amino acids are the common natural enantiomers, eg. Alanine above.*

Sickle Cell Anemia
Normal hemoglobin vs sickle cell hemoglobin



(a) Normal red blood cells and the primary structure of normal hemoglobin
(b) Sickled red blood cells and the primary structure of sickle-cell hemoglobin

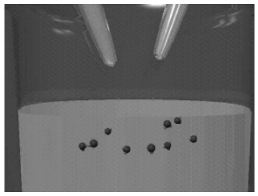
Sickle Cell Anemia
Normal hemoglobin vs sickle cell hemoglobin



Valine replaces Glutamate

http://chemconnections.org/Presentations/Columbia/slide9-3.html

Neutralization Reactions



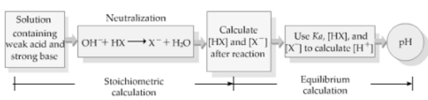
Would there be a difference in the reaction of HF versus HCl?

Neutralizations / Titrations

Are there differences in the titration of HF versus HCl? ….1) mass wise? …. 2) pH wise?

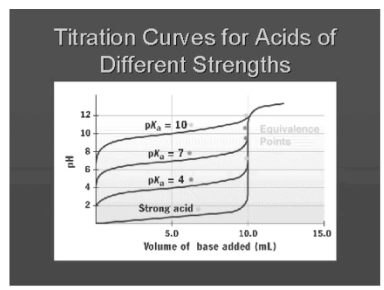
A) 1.NO 2.NO B) 1.YES 2.YES C) 1.YES 2.NO D) 1.NO 2.YES

Neutralizations / Titrations



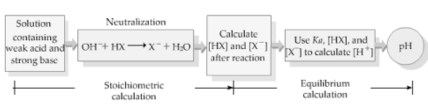
Are there differences in the titration of HF versus HCl? ….1) mass wise? …. 2) pH wise?

D) 1.NO 2.YES



QUESTION

What is the pH of a solution made from adding 500. mL of 2.00 M $HOAc_{(aq)}$ (Ka = 1,8 x 10^{-5}) to 100. mL of 5.100M $NaOH_{(aq)}$?
(This question relates to the titration of acetic acid.)



A) 4.74 B) 4.76 C) 9.24 D) 9.26

QUESTION

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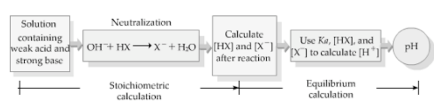
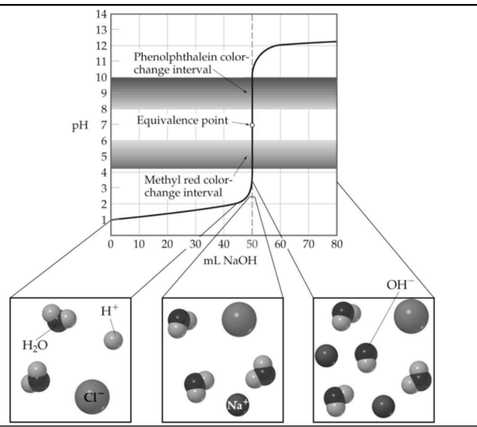
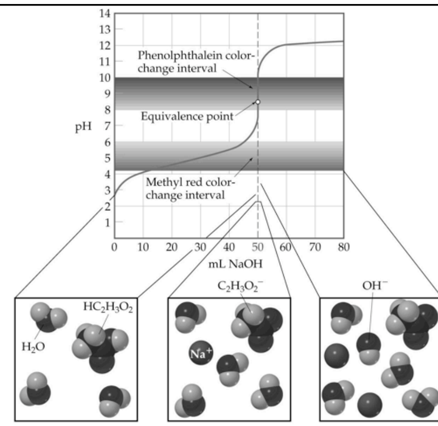


A) 4.74 **B) 4.76** C) 9.24 D) 9.26

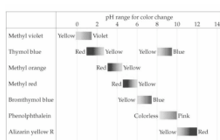




QUESTION

Most acid-base indicators are weak acids. In a titration of 0.50 *M* acetic acid (at 25°C, $K_a = 1.8 \times 10^{-5}$) with KOH, which indicator would best indicate the pH at the equivalence point? The approximate K_a for each choice is provided.

A. Bromophenol blue; $K_a \sim 1 \times 10^{-4}$
B. Methyl red; $K_a \sim 1 \times 10^{-5}$
C. Bromothymol blue; $K_a \sim 1 \times 10^{-7}$
D. Alizarin yellow; $K_a \sim 1 \times 10^{-10}$



QUESTION

The acid-base indicator bromocresol purple has an interesting yellow-to-purple color change. If the approximate K_a of this indicator is 1.0×10^{-6}, what would be the ratio of purple $[A^-]$ to yellow [HA] at a pH of 4.0?

A. 100:1
B. 1:100
C. 1:1
D. This choice indicates that I don't know.