Aqueous Reactions

(Solutions/ Molarity)

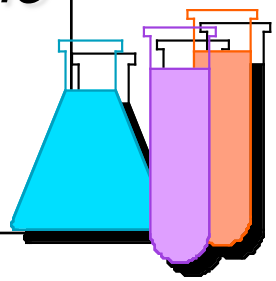
Electrolytes

Dr. Ron Rusay

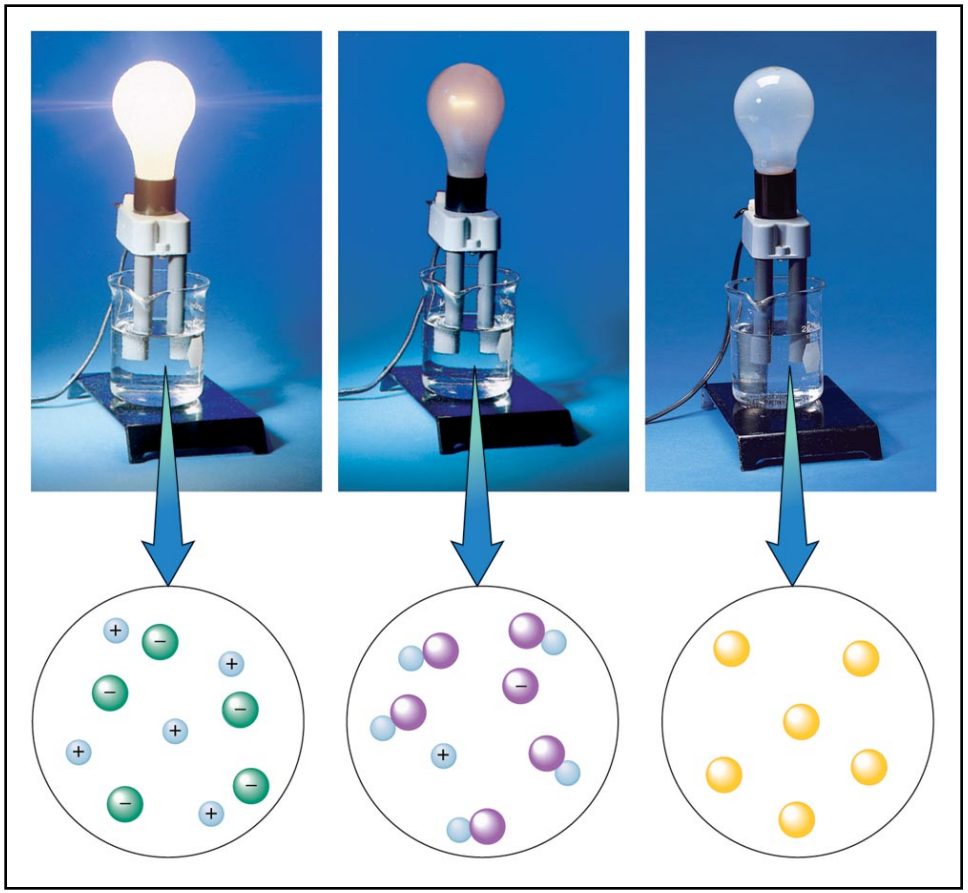
Electrolytes

Ions in an aqueous (water) solution

- ***Pure Water*** *does not conduct electricity.*
- *A water solution must have* ***ions*** *to conduct electricity.*
- *Aqueous solutions can be categorized into 3 types: non-electrolytes, strong electrolytes or weak electrolytes based on their ability to conduct electricity in a homogeneous aqueous solution (aq).*
- *Aqueous solutions can be tested for conductivity which will determine the degree of ionization of the solute, that is, the substance dissolved in water.*
- *It is possible to have full or partial ionization.*



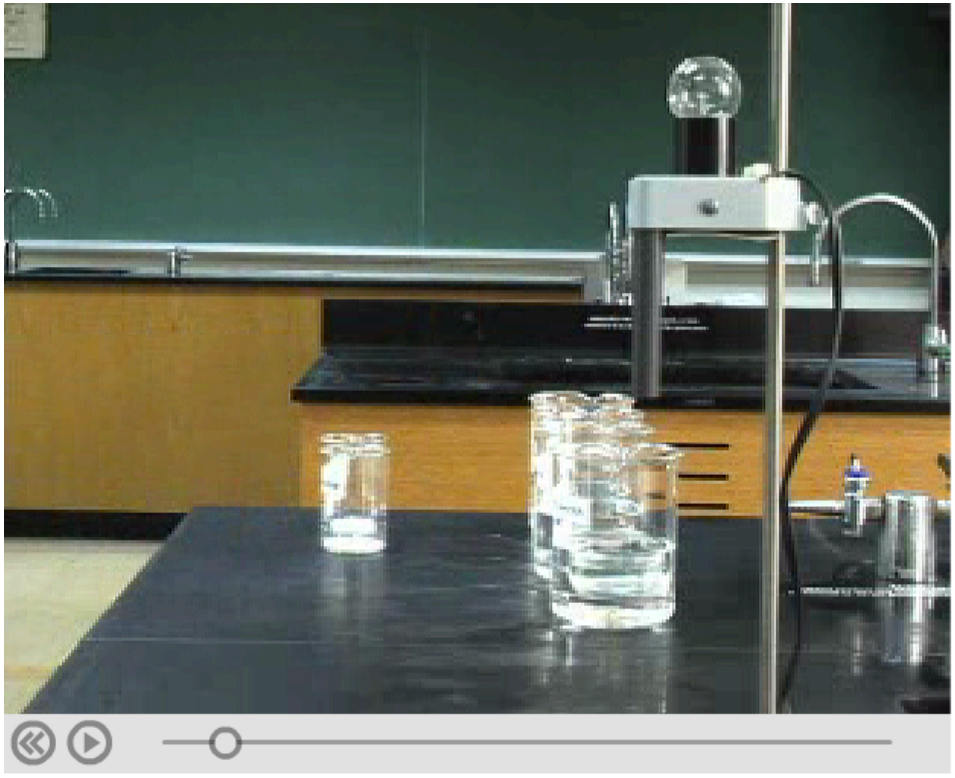
Solution Test Apparatus for Electrolytes (Ions)



strong *weak* *non-*

Conductivity depends on the amount of ions in solution

Conductivity



http://chemconnections.org/general/movies/html-swf/electrolytes.htm

Molarity (M) = moles solute / Liter solution

Electrolytes

- *Almost all ionic compounds and a few molecular compounds are strong electrolytes.*
- *Several molecular compounds are weak conductors, most are non-conductors.*
- *Conductivity is directly related to the amount of ionization, i.e. ions in solution. Table salt, sodium chloride, is completely ionized:*

$$NaCl_{(s)} + H_2O_{(l)} \longrightarrow NaCl_{(aq)} \longrightarrow$$

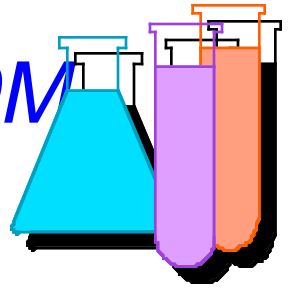
0.10M

$$Na^+_{(aq)} + Cl^-_{(aq)}$$

0.10M 0.10M

Add 5.8g of sodium chloride to water to make 1.0 L of solution = 0.10M = 0.10 mol/L

All of the sodium chloride ionizes to make 1.0 L of solution = 0.10M Na^+ and 0.10M Cl^-



Molarity (M) = moles solute / Liter solution

Electrolytes

- *Concentrations:*
- $CaCl_{2\,(s)} + H_2O_{(l)} \longrightarrow CaCl_{2(aq)}$ ——— *0.10M*

$$Ca^{2+}_{(aq)} + 2\ Cl^{-}_{(aq)}$$

0.10M *0.20M*

How many grams of calcium chloride (MM =111 g/mol) should be added to water to make 1.00 L of a 0.10M solution of calcium chloride?

How many grams of calcium chloride (MM =111 g/mol) should be added to water to make 1.00 L of a solution having 0.10M chloride ion?

QUESTION

If an antacid contains $Al(OH)_3$ it will form $AlCl_3$ upon neutralization of stomach acid. How many moles of Cl^- ions are in 100.0 mL of 0.010 M $AlCl_3$?

A.0.0010 mol
B.0.010 mol
C.0.0030 mol
D.0.030 mol

Molarity (M) = moles $AlCl_3$ / Liter solution

mol $AlCl_3$ = Molarity $AlCl_3$ x Volume solution (L)

$AlCl_3$ dissociates into 3 moles of Cl^-.

Calculations
*Reactant → **Product***

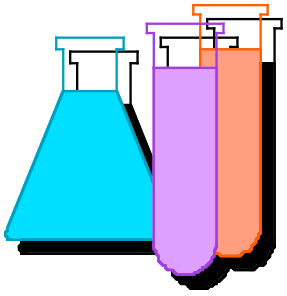
moles (Reactant) → **moles (Product)**

$AlCl_3$ dissociates into 3 moles of Cl^-.

$$AlCl_{3\,(aq)} \rightarrow Al^{3+}_{(aq)} + 3\ Cl^-_{(aq)}$$

(Volume) 1 L	**0.010 mol ($AlCl_3$)**	? mol **Cl -**	**100.0 mL ($AlCl_3$)**	= **? mol (Cl -)**
(Volume) 1000 mL	**1 L ($AlCl_3$)**	? mol **$AlCl_3$**		

"Gatekeepers" from Balanced reaction



Molarity (M) = moles solute / Liter solution

Electrolytes

- *Sugars like sucrose are non-ionic, molecular compounds that dissolve but produce no ions.*

$$C_{12}H_{22}O_{11\,(S)} + H_2O_{(l)} \longrightarrow C_{12}H_{22}O_{11\,(aq)}$$

- *Some molecular compounds like acetic acid ionize partially (dissociate) in water*

$$HC_2H_3O_{2\,(l)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + C_2H_3O_2^-{}_{(aq)}$$

$$0.1000M \qquad\qquad 0.09987M \rightleftharpoons 0.00013M$$

Acetic Acid ($HC_2H_3O_2$)

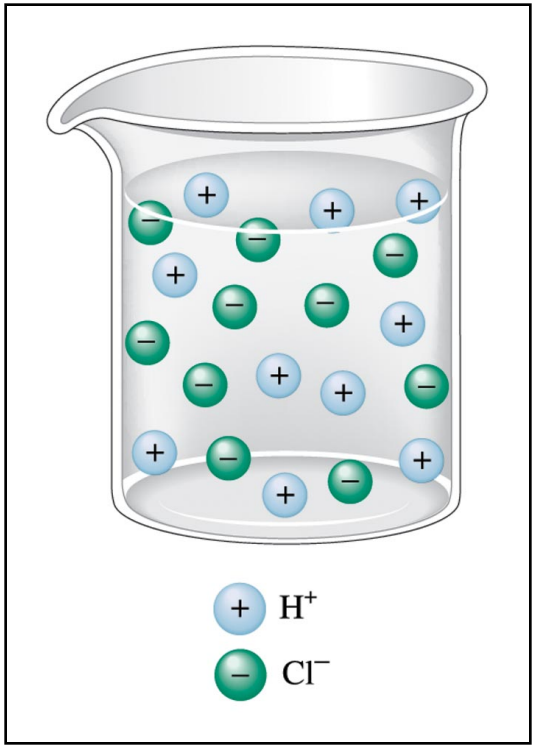
NOT *Completely Ionized*

Example of equilibrium

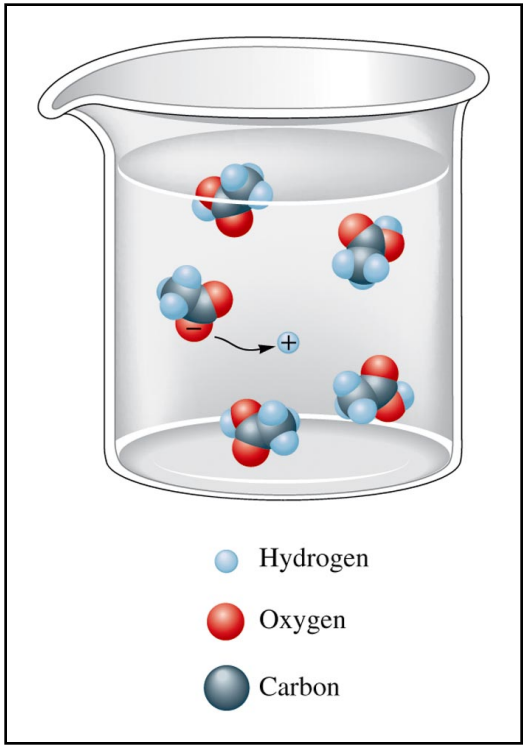
Conductivity

Which of these solutions will have highest conductivity?

A	B	C
0.1 M $KCl_{(aq)}$	0.2 M $HCl_{(aq)}$	0.3 M $HC_2H_3O_{2(aq)}$



HCl
Completely
Ionized



Acetic Acid
($HC_2H_3O_2$)

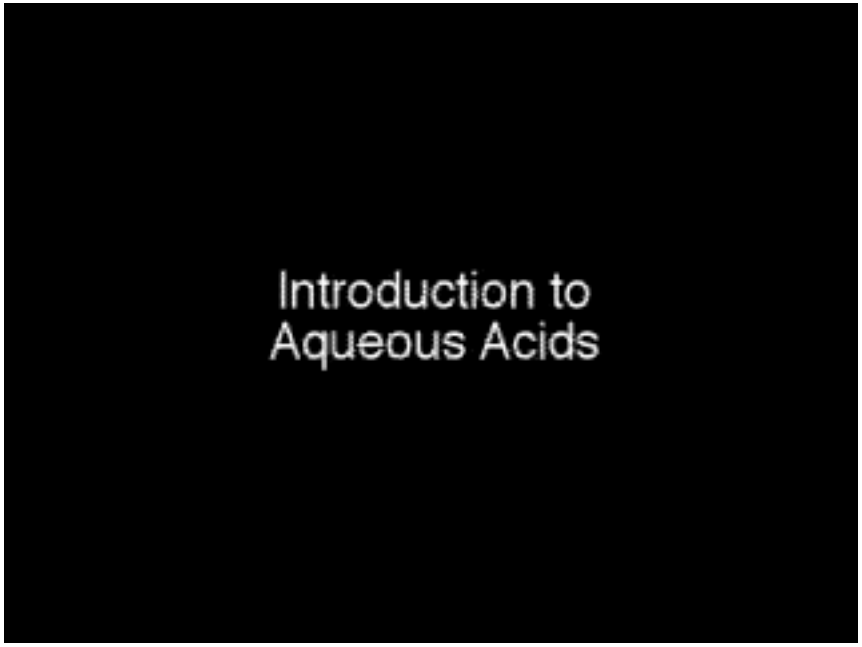
Conductivity

Which of these solutions will have highest conductivity?

A	B	C
0.1 M $HCl_{(aq)}$	0.1 M $CaCl_{2\,(aq)}$	0.2 M $HC_2H_3O_{2(aq)}$

Aqueous Acids

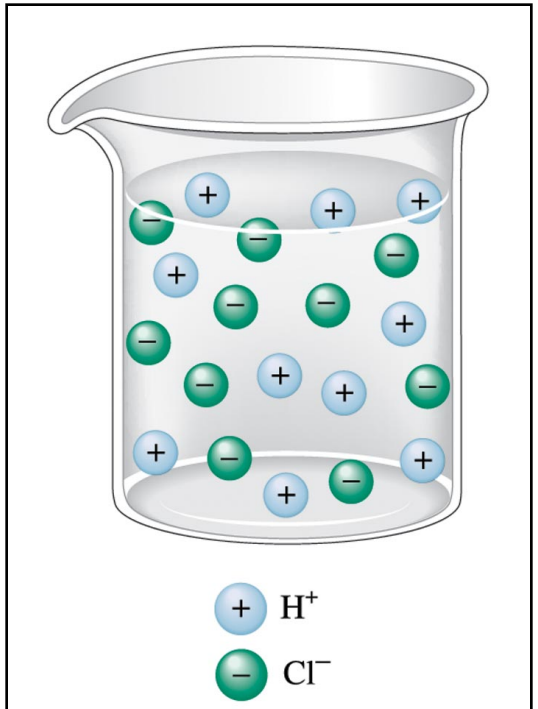
- *Any compound that provides a proton can be considered an acid. Strong acids are sulfuric acid, nitric acid, perchloric acid, HI, HBr and HCl.*

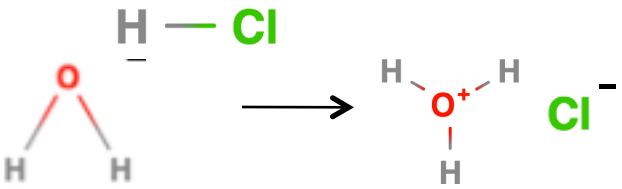


Electrolytes

- *How would the conductivity of acetic acid compare to hydrochloric acid?*

strong

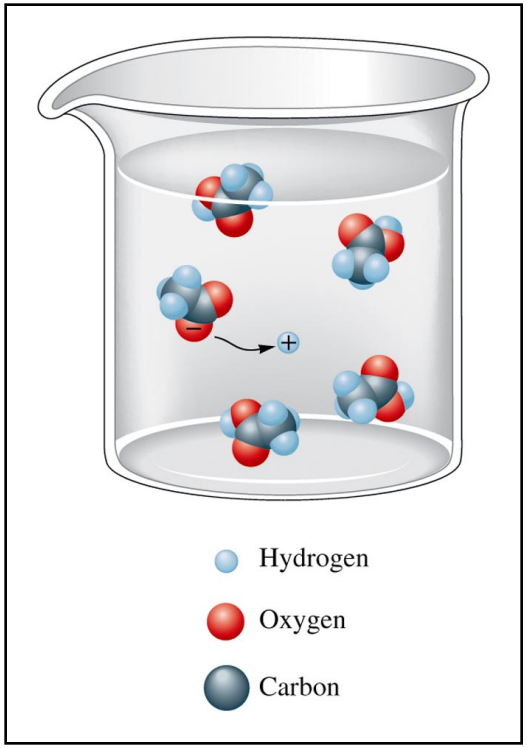


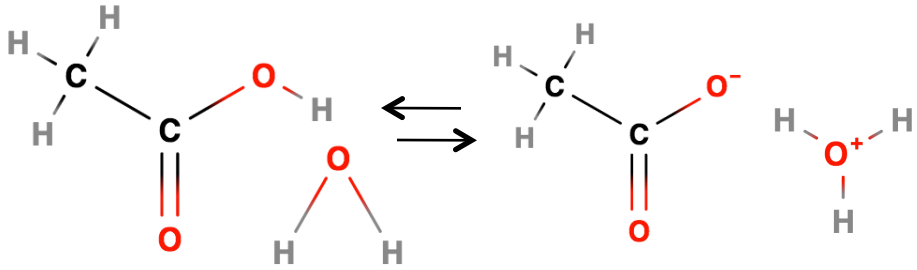


HCl

Completely Ionized

weak





Acetic Acid $(HC_2H_3O_2)$

NOT *Completely Ionized*

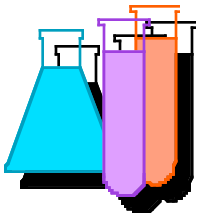
Example of equilibrium

Aqueous Bases

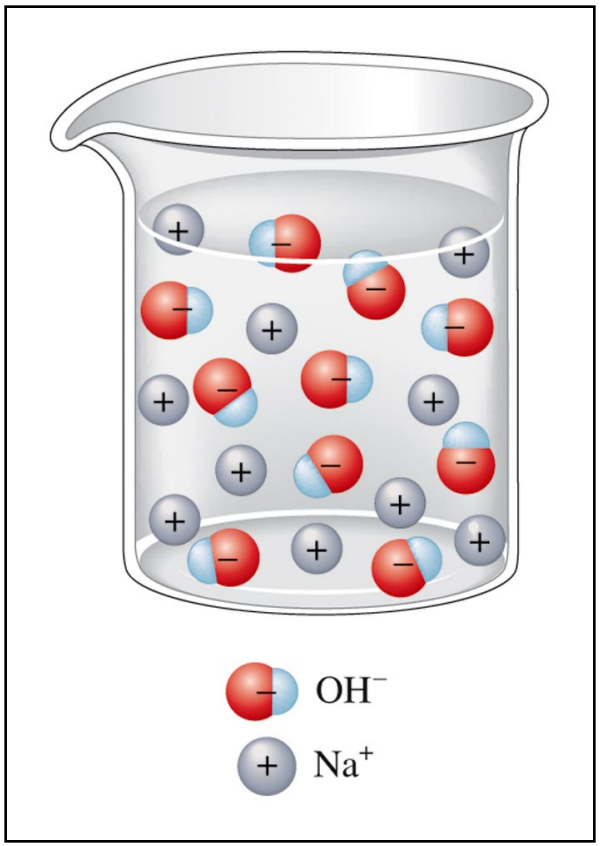
- *Any compound that accepts a proton is a base.*
- *The common bases are group IA & IIA metal hydroxide compounds. They are strong bases, dissociating completely in water.*
- *An example of a weak base is ammonia.*

$$NH_{3\,(g)} + H_2O_{(l)} \rightleftharpoons NH_{3\,(aq)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$$

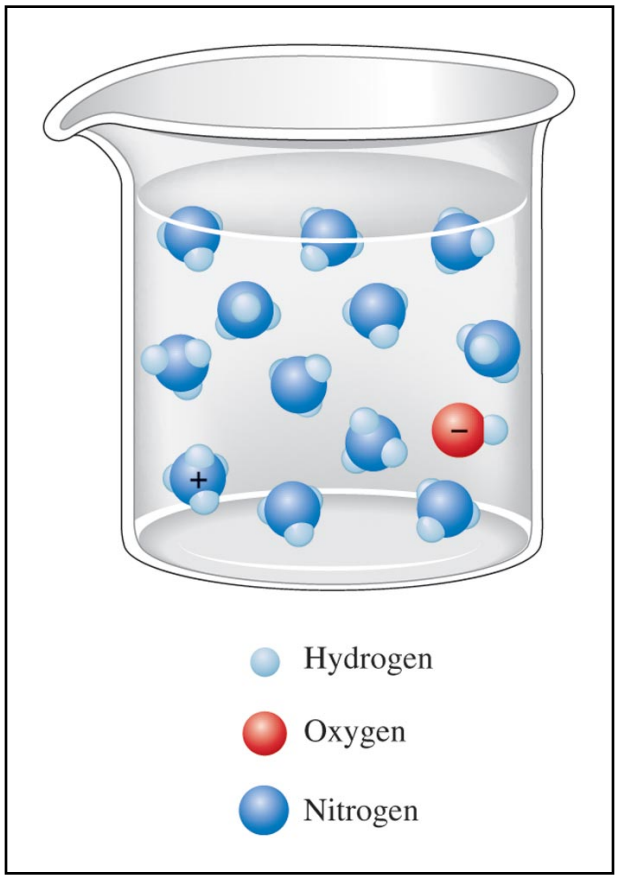
Consider that aqueous ammonia is in equilibrium with ammonium hydroxide. The names have often been used interchangeably.



strong



weak



An Aqueous Solution of Sodium Hydroxide

$$NaOH_{(aq)} \longrightarrow Na^+_{(aq)} + OH^-_{(aq)}$$

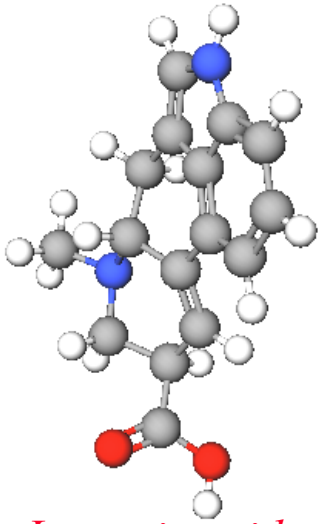
Completely Ionized

An Aqueous Solution of Ammonia

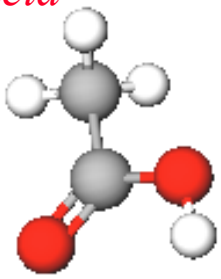
$$NH_{3\,(aq)} \rightleftarrows NH_4^+{}_{(aq)} + OH^-_{(aq)}$$

NOT *Completely Ionized*

Example of equilibrium



Lysergic acid



Acetic acid

Selected Acids and Bases

Acids

Strong

Hydrochloric acid, HCl
Hydrobromic acid, HBr
Hydriodic acid, HI
Nitric acid, HNO_3
Sulfuric acid, H_2SO_4
Perchloric acid, $HClO_4$

Weak

Hydrofluoric acid, HF
Phosphoric acid, H_3PO_4
Acetic acid, CH_3COOH
(or $HC_2H_3O_2$)

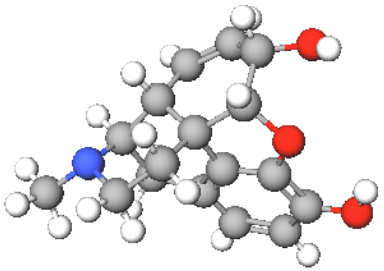
Bases

Strong

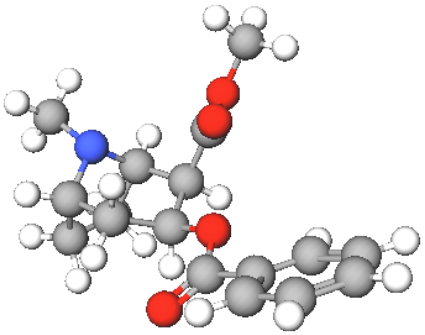
Sodium hydroxide, NaOH
Potassium hydroxide, KOH
Calcium hydroxide, $Ca(OH)_2$
Strontium hydroxide, $Sr(OH)_2$
Barium hydroxide, $Ba(OH)_2$

Weak

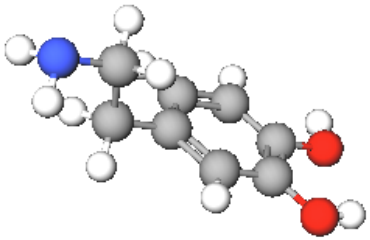
Ammonia, NH_3



Morphine



Cocaine



Dopamine

QUESTION

All of the following are weak acids *except*:

A) HCNO.
B) HBr.
C) HF.
D) HNO_2.
E) HCN.