

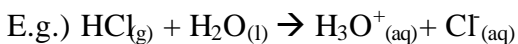
## Chem 12- Notes on Acids & Bases

After Tutorial 14 & Workbook Questions 10-19 p. 115-121

Do demo of Conductivity 1 M HCl, 1 M CH<sub>3</sub>COOH

### Strong & Weak Acids & Bases

**Strong Acid**- *An acid which is 100% ionized in a water solution.*



Single arrow (goes to completion)  
 = Strong acid

Question: What is the [HCl<sub>(g)</sub>] in 1 M HCl?

Answer:

Question: What is [H<sub>3</sub>O<sup>+</sup>] in 0.20 M HCl

Answer:

Important:

In a **Strong Acid** [H<sub>3</sub>O<sup>+</sup>] = [Acid] (to Start with)

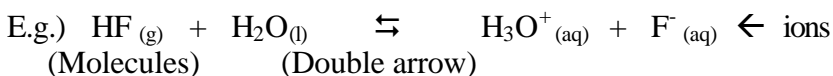
E.g.) What is [H<sub>3</sub>O<sup>+</sup>] in 0.60 M HNO<sub>3</sub>

Answer:

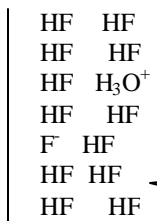
**Weak Acid**: *An Acid which is less than 100% ionized in solution.*

(In Chem 12 WA's are usually significantly less than 100% ionized.)  
 (Usually < 5% ionized)

- In a solution of a **weak acid**, most of the molecules don't ionize.



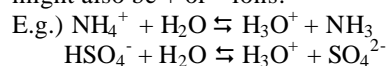
[H<sub>3</sub>O<sup>+</sup>] is only a small fraction of [HF]



← H<sub>2</sub>O is omitted in diagram

A beaker containing aqueous HF

NOTE: WA's can be molecules but they might also be + or - ions.



- Any acid (weak or strong) could have high or low *concentration*.

**Weak & Strong** → refers to % ionization.

**Concentration** → the moles of acid dissolved per litre.

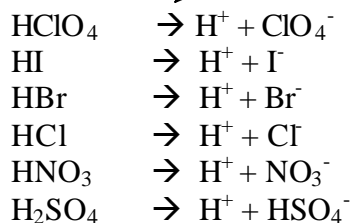
Eg.) 10.0 M HCl → conc. and strong  $[\text{H}_3\text{O}^+] = 10.0 \text{ M}$   
 0.001 M HCl → dilute and strong  $[\text{H}_3\text{O}^+] = 0.001 \text{ M}$   
 10.0 M HF → conc. and weak  $[\text{H}_3\text{O}^+] = \text{low}$   
 0.001 M HF → dilute and weak  $[\text{H}_3\text{O}^+] = \text{very low}$

Concentration of ions would determine conductivity

### The Acid Table

#### Strong Acids

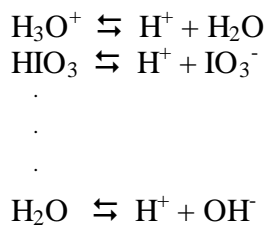
Notice single arrows for all SA's



\*Note  $\text{H}_2\text{SO}_4$  is a SA but diprotic

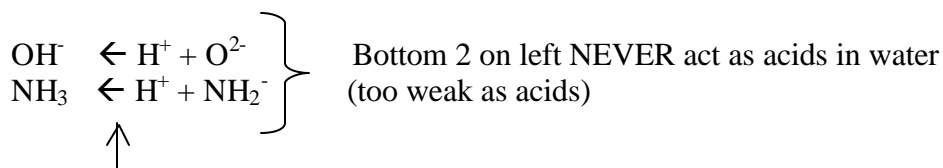
- The first ionization is 100% =  $\text{H}_2\text{SO}_4 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{HSO}_4^-$
- The second ionization is <100%  $\text{HSO}_4^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{SO}_4^{2-}$

#### Weak Acids



Most act as weak acids in water

Double arrow



↑  
Single arrows going backwards  
( $\text{O}^{2-}$  and  $\text{H}^+$  can form  $\text{OH}^-$  but  $\text{OH}^-$  cannot form  $\text{H}^+$  and  $\text{O}^{2-}$  in water solution.)

### Strong Base

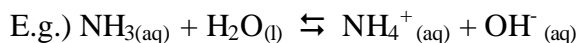
A substance (base) which (ionizes) or dissociates 100% in solution

Forms ions from molecules or atoms

Ions in an ionic solid separate and dissolve in water

### Weak Base

*A base which is less than 100% ionized in solution.*



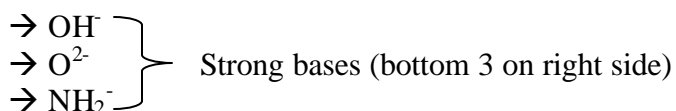
A neutral molecule

- Consists of mostly  $\text{H}_2\text{O}$  and  $\text{NH}_3$  molecules with a few  $\text{NH}_4^+$  and  $\text{OH}^-$  ions.

### Using Acid Table & Periodic Table

Bases on Right Side

### Strong Bases



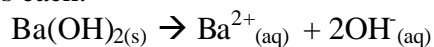
- Any substance which dissociates completely to produce  $\text{OH}^-$ ,  $\text{O}^{2-}$  or  $\text{NH}_2^-$  is a Strong Base

### Alkali Metal Hydroxides (Group 1)

$\text{LiOH}$ ,  $\text{NaOH}$ ,  $\text{KOH}$ ,  $\text{RbOH}$ ,  $\text{CsOH}$  are all highly (100%) soluble and form  $\text{OH}^-$ , so they are all strong bases.

### (Alkaline Earth) Hydroxides (Group 2)

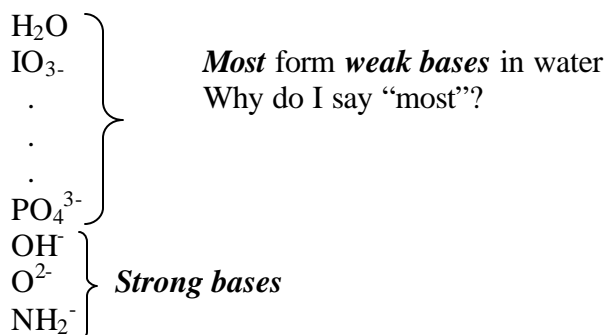
$\text{Mg}(\text{OH})_2$ ,  $\text{Ba}(\text{OH})_2$ ,  $\text{Sr}(\text{OH})_2$  are designated as Strong Bases (even though  $\text{Sr}(\text{OH})_2$  is the only one called “Soluble” on the Solubility Table. They dissociate to form 2  $\text{OH}^-$  s each:



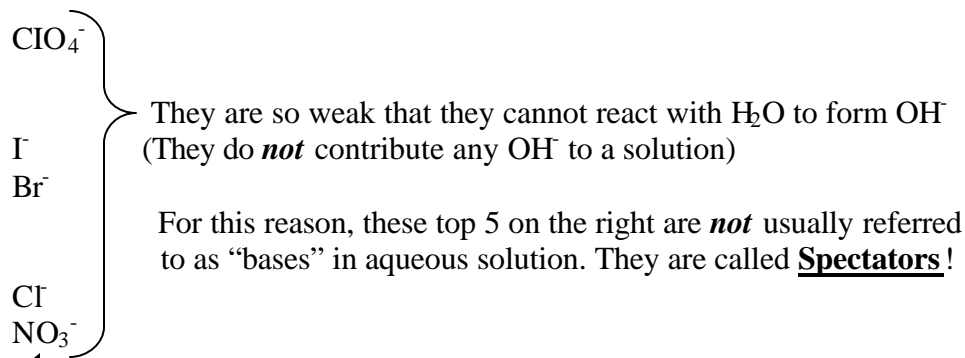


**Weak Bases**

Found above OH<sup>-</sup> on right side of Table.

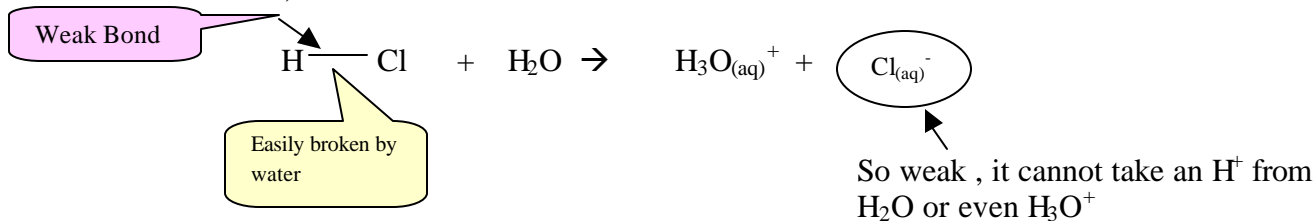
**Very Weak (non-hydrolyzing Bases) or Spectators**

These are the **top 5** (not 6) “bases” on the **right**.



Conj. Bases of strong acids---- In acid-base reactions they are **SPECTATORS**

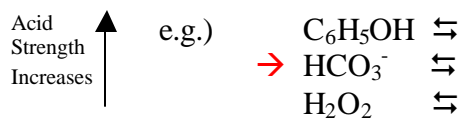
In a SA, the bond to H<sup>+</sup> is weak



SA's have non-hydrolyzing (**spectator**) ions for conj. Bases.

**Amphiprotic Species (ions or molecules)**

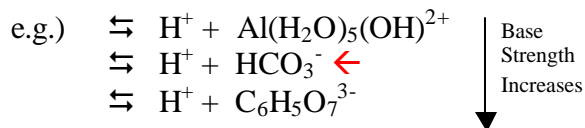
- are found on **both** sides of the table e.g.)  $\text{HSO}_4^-$
- can act as acids (donate  $\text{H}^+$ 's) or as bases (accept  $\text{H}^+$ 's)
- to look at an amphiprotic species as an **acid**, you must find it on the **left** side:



$\text{HCO}_3^-$  is a \_\_\_\_\_er acid than  $\text{C}_6\text{H}_5\text{OH}$

$\text{HCO}_3^-$  is a \_\_\_\_\_er acid than  $\text{H}_2\text{O}_2$

- to look at an amphiprotic species as a **base**, you must find it on the **right** side:  
for  $\text{HCO}_3^-$  as a **base**:



$\text{HCO}_3^-$  is a \_\_\_\_\_er base than  $\text{C}_6\text{H}_5\text{O}_7^{3-}$

$\text{HCO}_3^-$  is a \_\_\_\_\_er base than  $\text{Al}(\text{H}_2\text{O})_5(\text{OH})^{2+}$

$\text{HSO}_4^-$  in shaded region on top right will **not** act as a base in water (Too weak of a base)

- However, it is **not** a spectator! (like  $\text{NO}_3^-$  is) Why not?

( $\text{HSO}_4^-$  is also found on the left side quite a way up, it is a relatively “strong” weak *acid*.)

**The Leveling Effect for Acids**

What is  $[\text{H}_3\text{O}^+]$  in 1.0 M  $\text{H}_3\text{O}^+$  ? \_\_\_\_\_

What is  $[\text{H}_3\text{O}^+]$  in 1.0 M  $\text{HNO}_3$ ? \_\_\_\_\_

What is  $[\text{H}_3\text{O}^+]$  in 1.0 M  $\text{HCl}$  ? \_\_\_\_\_

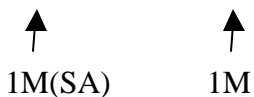
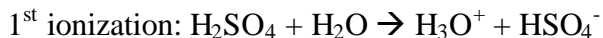
Acids from  $\text{HClO}_4$  to  $\text{H}_2\text{SO}_4$  are 100% ionized in water

only solvent used in Chem 12 (and most Chemistry)

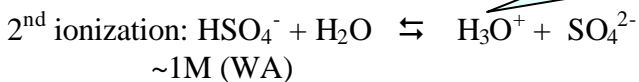
- so even though  $\text{HClO}_4$  is above  $\text{HCl}$  on the chart, it is no more acidic in a water solution.

***$\text{H}_3\text{O}^+$  is the strongest acid that can exist in an undissociated form in water solution.***  
***- all stronger acids ionize to form  $\text{H}_3\text{O}^+$***

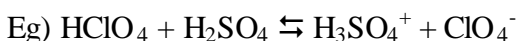
(NOTE: although  $\text{H}_2\text{SO}_4$  is diprotic, the  $\text{H}_3\text{O}^+$  produced from the second ionization is very little compared to that from the first)



A very small amount of  $\text{H}_3\text{O}^+$



The only way you can tell which strong acid is “stronger” is to react them in a non-aqueous (not  $\text{H}_2\text{O}$ ) solvent.

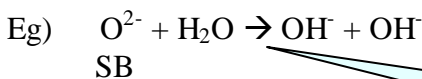


(it is found that  $\text{HClO}_4$  donates a proton to  $\text{H}_2\text{SO}_4$ , not the other way around, so  $\text{HClO}_4$  is a stronger acid than  $\text{H}_2\text{SO}_4$ ) ***This is not important in Chemistry 12.***

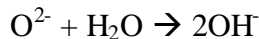
This would not happen in a water solution.  
(In  $\text{H}_2\text{O}$ , they would **both** form  $\text{H}_3\text{O}^+$ )

### Leveling Affects of Bases

***The strongest base which can exist in high concentrations in water solution is OH***  
***The two stronger bases below it will react with water completely to form OH.***



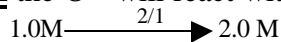
Or



Single  
Arrow

What is the final  $[\text{O}^{2-}]$  in 1.0 M  $\text{Na}_2\text{O}$ ? Answer: 0 M

- **All** the  $\text{O}^{2-}$  will react with water to form  $\text{OH}^-$



Write an equation for  $\text{NH}_2^-$  reacting with  $\text{H}_2\text{O}$ .

Answer: \_\_\_\_\_

- Do Ex. 21-27 Pg.125-126 S.W.

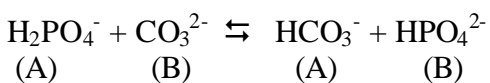
### Acid-Base Equilibria & Relative Strengths of Acids & Bases

- Take out your acid table
- Mix some  $\text{H}_2\text{PO}_4^-$  and some  $\text{CO}_3^{2-}$

Amphiprotic  
can donate or  
accept an  $\text{H}^+$

Can only act as a base  
(accept an  $\text{H}^+$ ) (doesn't  
have an  $\text{H}^+$  to give)

So, in this case  $\text{CO}_3^{2-}$  will play the role of base (take  $\text{H}^+$ ) and  $\text{H}_2\text{PO}_4^-$  will play the role of acid (donate an  $\text{H}^+$ ).



Consider the 2 acids  $\text{H}_2\text{PO}_4^-$  and  $\text{HCO}_3^-$

Question: At equilibrium, which will be favoured, reactants or products?

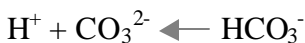
They both “want” to donate protons.

- look them both up on the left side

Strength  
as acid

$\text{H}_2\text{PO}_4^-$  is *above*  $\text{HCO}_3^-$  on LEFT, so  $\text{H}_2\text{PO}_4^-$  is a *stronger* acid than  $\text{HCO}_3^-$ .

Strong  
“push” to  
donate a  
proton

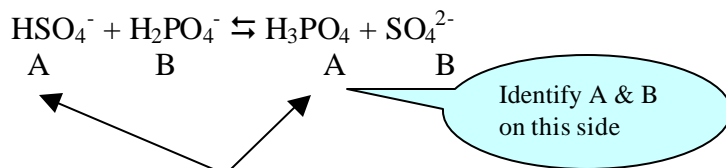


Weaker  
“push” to  
donate a  
proton





- Complete the equation: (making  $\text{HSO}_4^-$  act as the acid.)



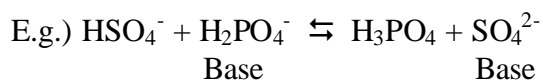
Now compare the 2 conjugate acids (Look for them both on the LEFT side of chart.)  
 $\text{HSO}_4^-$  is slightly ABOVE  $\text{H}_3\text{PO}_4$  on the left side so  $\text{HSO}_4^-$  is the SrA and  $\text{H}_3\text{PO}_4$  is the WrA.

$\text{HSO}_4^- + \text{H}_2\text{PO}_4^- \rightleftharpoons \text{H}_3\text{PO}_4 + \text{SO}_4^{2-}$  so the products (with WrA,) are favoured!

**SrA**

**WrA**

- Comparing relative strengths of bases.



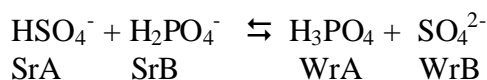
Base

Base

Compare these on the **RIGHT** side of table

$\text{H}_2\text{PO}_4^-$  is lower on the right side (stronger base) than  $\text{SO}_4^{2-}$

So see:



-Since this equilibrium favoured products ( $\text{H}_3\text{PO}_4$  is WrA), we can say that equilibrium favours the side with the weaker conjugate base.

NOTICE: The SrA is on the same side as the SrB. [the SrA has the weaker conj. Base]  
 The WrA is on the same side as the WrB

(Birds of a feather flock together)

or

(The weakies hang out together and survive better than the “strongies”.)

- So we could compare conj. Acids or conj. Bases. **Equilibrium favors the side with the weaker conj. Acid and the weaker conj. Base.**

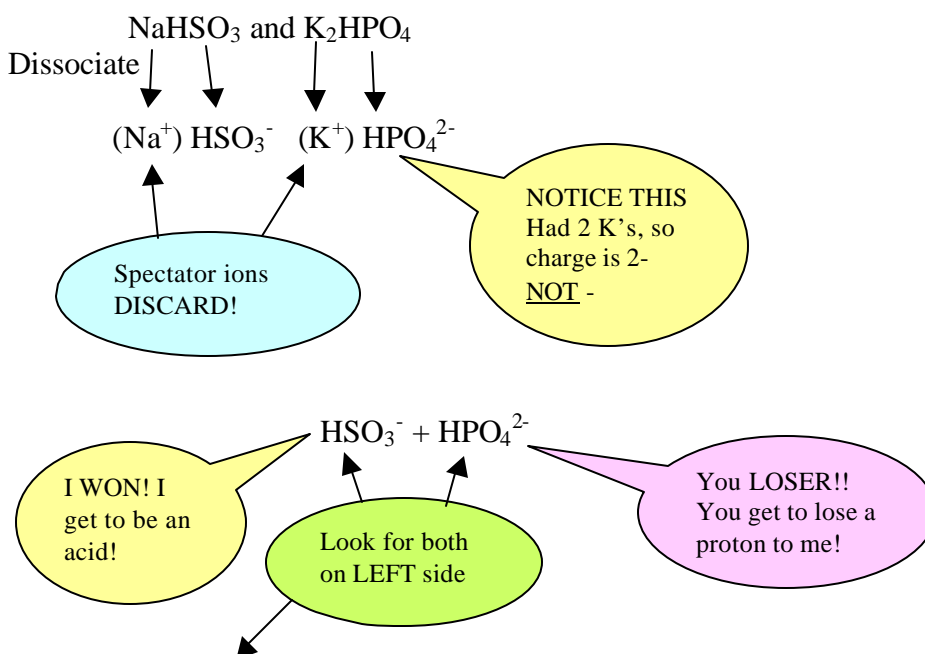
## Starting with “Salts”

The amphiprotic ions are often products of the *dissociation* of salts.

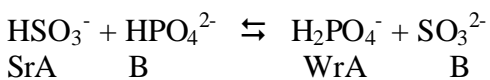
- Spectator ions must be discarded.

NOTE: All alkali ions  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Li}^+$  ...etc..... are *spectators* in Acid-Base reactions. Also top five ions right side of acid chart ( $\text{ClO}_4^-$ ,  $\text{I}^-$ ,  $\text{Br}^-$ ,  $\text{Cl}^-$ ,  $\text{NO}_3^-$ ) are *spectators* in Acid-Base reactions.

E.g.) complete the net ionic reaction between and state whether equilm favors reactants or products



$\text{HSO}_3^-$  is higher, so it will play the role of the **acid**.



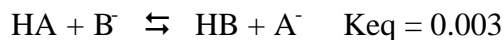
$\text{HSO}_3^-$  is a stronger acid than  $\text{H}_2\text{PO}_4^-$ , so equilm favors the side with the *weaker* acid ( $\text{H}_2\text{PO}_4^-$ ) so **products** are favored!

**Relating The Keq to A-B equilibria**

If products are favored Keq is large (>1)

If reactants are favored Keq is small (<1)

Eg.) Given:



Which acid is stronger, HA or HB?

Keq is **small** so **reactant** side is favored.

Since **equilibrium favors side with weaker acid**, HA must be the weaker acid, so HB would be the stronger acid.

- Which is the stronger base?                      Ans. \_\_\_\_\_

(the SrB is on the same side as the SrA)

or

( the weaker acid (HA) has the stronger conj. Base (A<sup>-</sup>))

-Do Ex. 38 - 46 P. 133 of SW.