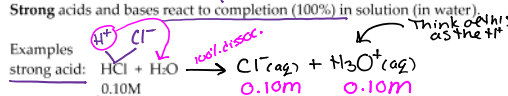


IV) Strong & Weak Acids & Bases

January 17, 2018 11:04 PM

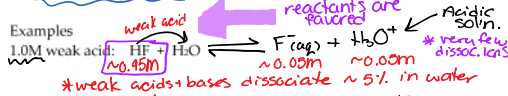
IV) Strong and Weak Acids and Bases

Strong acids and bases react to completion (100%) in solution (in water).



The OH^- produced is now ready to act as a base and accept H^+ .

Weak acids and bases do not react to completion in solution (in water). They create an equilibrium with reactants heavily favoured.



V) H^+ and H_3O^+

The most abundant hydrogen atom, by far, is hydrogen-1, which has an atomic weight of 1 amu, which means it must be made up of 1 proton, 0 neutron, and 1 electron.

H^+ has lost an electron, and thus it is simply a 'proton', which is what it is commonly called.

$\text{H}^+ \rightleftharpoons \text{'hydrogen proton'}$

When an acid such as HCl is put into solution, what happens?



* This form is listed in the A/B table

only H_2O is implied

* can be donated to a base

The equation suggests that HCl gives up a proton 100% in water. However, in the reaction above, no substance is accepting the proton, which is inaccurate. However, we use this reaction to show what HCl does in the presence of any base. If HCl is in solution and just water is present, HCl donates its proton to water, as shown below:



Both equations are commonly used, so H^+ is analogous to H_3O^+ (called hydronium ion).

VI) The Acid/Base Table (in aqueous solution)

Where are the acids on the table, and how are they arranged?

left side of table; strongest (top) \rightarrow weakest (bottom)

Strong Acids:

- top left shaded box
- all react fully (dissociate 100%)
- donate H^+
- NOT @ equilibrium \rightarrow single arrow

* All "strong acids" are the same relative strength donate all H^+ when here

Weak Acids:

- middle left region
- all weak acids donate H^+ ~5% or less
- ALL @ equilibrium \rightleftharpoons (2-way)
- ARE ranked: in terms of how much % of H^+ dissociate
- "strong weak acids" top eg. H_2SO_4
- "weak, weak acids" bottom eg. HPO_4^{2-}

Notice the table uses the 'simple' version of the two reactions described earlier. Ex. $\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$

This is because the acids or bases put into water only react with water if it's the only other substance present. If a base different than water is present, it will react with the base. So the reaction above is the 'general form'.

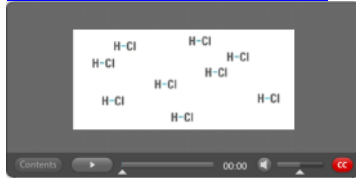
* Where are the bases on the acid/base table, and how are they arranged?

Right, weakest (top) \rightarrow strongest (bottom)

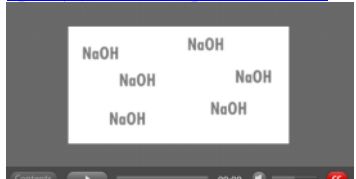
Strong Bases:

- bottom right shaded box (most are not listed, two OH^- bases are missing)
- react fully (100% dissociation) by accepting all H^+
- single arrow \leftarrow 1-way rxns.
- * all strong bases are equal 'relative' strength (react 100%)

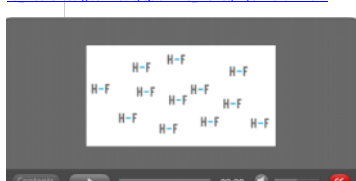
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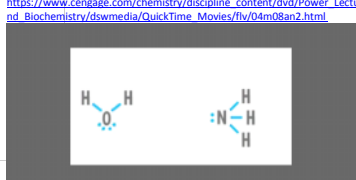
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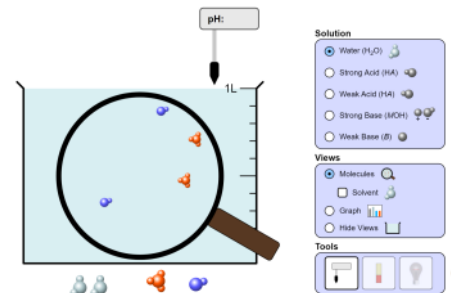
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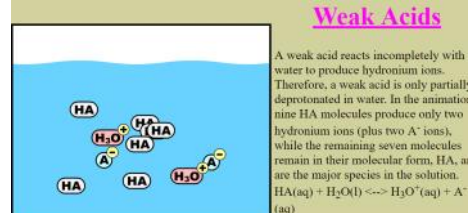
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https://phet.colorado.edu/sims/html/acid-base-solutions/latest/acid-base-solutions_en.html



<http://www.chembio.uguelph.ca/educmat/chm19104/chemtoons/chemtoons4.html>



Weak Acids

A weak acid reacts incompletely with water to produce hydronium ions. Therefore, a weak acid is only partially deprotonated in water. In the animation nine HA molecules produce only two hydronium ions (plus two A^- ions), while the remaining seven molecules remain in their molecular form, HA, and are the major species in the solution. $\text{HA}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{A}^-(\text{aq})$

The animation also shows the dynamic nature of the equilibrium (\rightleftharpoons); proton transfer is always taking place between HA, A^- , H_3O^+ and water. The value of K_a for a weak acid is small because the ratio $[\text{H}_3\text{O}^+][\text{A}^-]/[\text{HA}]$ is small. Typically, weak acids have K_a values about 10^{-3} to 10^{-10} .

RELATIVE STRENGTHS OF BRONSTED-LOWRY ACIDS AND BASES

in aqueous solution at room temperature

Name of Acid	Acid	Base	K_a
Perchloric	HClO_4	ClO_4^-	very large
Hydroiodic	HI	I^-	very large
Hydrobromic	HBr	Br^-	very large
Hydrochloric	HCl	Cl^-	very large
Nitric	HNO_3	NO_3^-	very large
Sulphuric	H_2SO_4	HSO_4^-	very large
Hydronium ion	H_3O^+	H_2O	1×10^{-14}
Iodic	HIO_3	IO_3^-	5.9×10^{-2}
Oxalic	$\text{H}_2\text{C}_2\text{O}_4$	HC_2O_4^-	5.9×10^{-2}
Sulphurous ($\text{SO}_2 + \text{H}_2\text{O}$)	H_2SO_3	HSO_3^-	1.5×10^{-2}
Hydrogen sulphate ion	HSO_4^-	SO_4^{2-}	1.2×10^{-2}
Phosphoric	H_3PO_4	H_2PO_4^-	7.5×10^{-3}
Hexaquoiron ion, iron(III) ion	$\text{Fe}(\text{H}_2\text{O})_6^{3+}$	$\text{Fe}(\text{H}_2\text{O})_5(\text{OH})^{2+}$	6.0×10^{-3}
Citric	$\text{H}_3\text{C}_6\text{H}_5\text{O}_7$	$\text{H}_2\text{C}_6\text{H}_5\text{O}_7^-$	7.1×10^{-4}
Nitrous	HNO_2	NO_2^-	4.6×10^{-4}
Hydrofluoric	HF	F^-	3.5×10^{-4}
Methanoic, formic	HCOOH	HCOO^-	1.8×10^{-4}
Hexaquoaluminum ion, chromium(III) ion	$\text{Cr}(\text{H}_2\text{O})_6^{3+}$	$\text{Cr}(\text{H}_2\text{O})_5(\text{OH})^{2+}$	1.5×10^{-4}
Benzoic	$\text{C}_6\text{H}_5\text{COOH}$	$\text{C}_6\text{H}_5\text{COO}^-$	6.5×10^{-5}
Hydrogen oxalate ion	HC_2O_4^-	$\text{C}_2\text{O}_4^{2-}$	6.4×10^{-5}
Ethanoic, acetic	CH_3COOH	CH_3COO^-	1.8×10^{-5}
Dihydrogen citrate ion	$\text{H}_2\text{C}_6\text{H}_5\text{O}_7^-$	$\text{HC}_6\text{H}_5\text{O}_7^{2-}$	1.7×10^{-5}
Hexaquoaluminum ion, aluminum ion	$\text{Al}(\text{H}_2\text{O})_6^{3+}$	$\text{Al}(\text{H}_2\text{O})_5(\text{OH})^{2+}$	1.4×10^{-5}
Carbonic ($\text{CO}_2 + \text{H}_2\text{O}$)	H_2CO_3	HCO_3^-	4.3×10^{-7}
Monohydrogen citrate ion	$\text{HC}_6\text{H}_5\text{O}_7^-$	$\text{C}_6\text{H}_5\text{O}_7^{2-}$	4.1×10^{-7}
Hydrogen sulphite ion	HSO_3^-	SO_3^{2-}	1.0×10^{-7}
Hydrogen sulphide	H_2S	HS^-	9.1×10^{-8}
Dihydrogen phosphate ion	H_2PO_4^-	HPO_4^{2-}	6.2×10^{-8}
Boric	H_3BO_3	H_2BO_3^-	7.3×10^{-10}
Ammonium ion	NH_4^+	NH_3	5.6×10^{-10}
Hydrocyanic	HCN	CN^-	4.9×10^{-10}
Phenol	$\text{C}_6\text{H}_5\text{OH}$	$\text{C}_6\text{H}_5\text{O}^-$	1.3×10^{-10}
Hydrogen carbonate ion	HCO_3^-	CO_3^{2-}	5.6×10^{-11}
Hydrogen peroxide	H_2O_2	HO_2^-	2.4×10^{-11}
Monohydrogen phosphate ion	HPO_4^{2-}	PO_4^{3-}	2.2×10^{-13}
Water	H_2O	OH^-	1.0×10^{-14}
Hydroxide ion	OH^-	H^+	very small
Ammonia	NH_3	H^+	very small

Chemistry 12

Weak Bases:

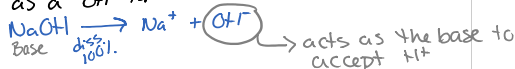
- middle RIGHT
- react much less < 5% by accepting H^+
- all @ equilibrium \rightleftharpoons

* ARE RANKED: in terms of how much H^+ they can accept

- "weak weak bases" (top) eg. H_2O
- "strongest weak base" (bottom) eg. PO_4^{3-}

What strong bases are missing from the acid/base table?
How do these types of strong bases behave in water?

The arrhenius bases, strong OH bases are missing.
These are group 1 + 2 bases: $NaOH$, $LiOH$, KOH , $Ca(OH)_2$, $Mg(OH)_2$ etc....
Behave as a OH^- ion in terms of the table.



How are weak acids/bases different from strong acids/bases, and how does this affect their conductivity?

- strong acids + bases dissociate 100% into ions
- \therefore 4 ions in solution = 4 conductivity.
- weak acids + bases dissociate < 5% into ions
- \therefore 1 ions in solution = 1 conductivity.

Which substances listed as bases are not bases at all?

- the bases listed in the top right (opp. strong acids) are NOT bases because they can NOT accept H^+ .
- these are not reversible rxns.

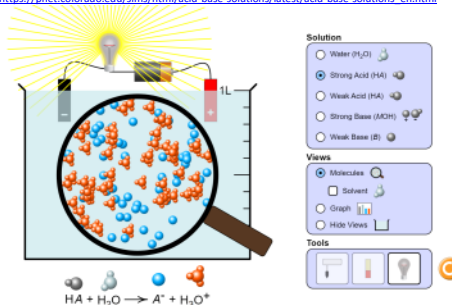
Which substances listed as acids are not acids at all?

- the "acids" in the bottom left (opp strong bases) cannot donate a H^+ (these are 1-way rxns).

Water	H_2O	$H^+ + OH^-$	1.0×10^{-14}
Hydroxide ion	OH^-	$H^+ + O^{2-}$	very small
Ammonia	NH_3	$H^+ + NH_4^+$	very small

Acids: Bases

https://phet.colorado.edu/sims/html/acid-base-solutions/latest/acid-base-solutions_en.html



Where can water be found on the table?

- H_2O is the weakest acid and also the weakest base.

Water is the weakest of the weak bases, so any other base present in solution will react with any acid put into the solution before water will.
Water is the weakest of the weak acids, so any other acid present in solution will react with any base put into the solution before water will.

VI Bronsted-Lowry Acids and Bases Part 2

Define the following terms:

Monoprotic Acid (H_1A): an acid with only 1 H^+ to donate

Diprotic Acid (H_2A): an acid with 2 H^+ to donate

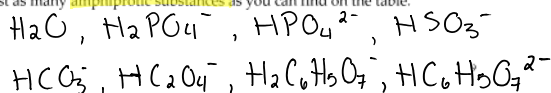
Polyprotic Acid (H_nA): an acid with 2+ H^+ to donate.

* Amphiprotic substance: can act as an acid (donate H^+) or as a base (accept H^+) ... dependant on the other substance in sol'n.

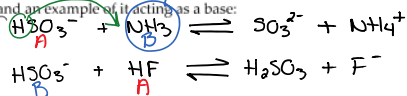
How can you tell if a substance is amphiprotic using the acid/base

table? substance will appear on both sides of table.

List as many amphiprotic substances as you can find on the table.



For one of those substances, give an example of that substance acting as an acid, and an example of it acting as a base:



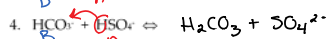
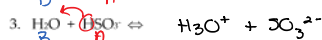
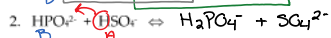
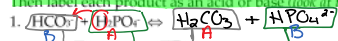
Notice that all amphiprotic substances (except for H_2O), are polyatomic groups that contain at least one proton and are negatively charged.

* In a reaction between ^{one or} two amphiprotic substances in aqueous solution, how can you use your table to find out which substance will act as the acid and which will act as the base?

- Look for both substances on the LEFT (as an acid)
- whichever is the "stronger" weak acid, will BE the acid \Rightarrow it will give up a H^+

Practice: Using your table, label each reactant as an acid or base, and determine the products.

Then label each product as an acid or base (look at the reverse reaction).



Look up products on the LEFT.... which is the 'stronger' weak acid?

reverse rxn

* Assignment 3: Hebden p.117 #12 & read p.117 & 118 & do p.119 #13, 14