Acids and Bases

Dr.Gergens - SD Mesa College

- General Properties Periodic Trends
- Acid - Base (Strong versus Weak)
- Acid - Base Conjugates
- Reactions
- pH Scale
- Solution Stoichiometry and Titration
- Overall Review of Basic Principles

Acids

MOST acids in the world are Weak Organic Acids

- taste sour (vinegar, vitamin C, citric acid, folic acid)
- feel sticky

BLUE (litmus) to red … acid

- turn blue litmus indicator paper (acid) to red
- often have H listed first in their chemical formula

strong acid		car battery #1		stomach acid				Coke & Pepsi		vinegar
$HClO_4$	>	H_2SO_4	>	HCl	>	HNO_3	>>	H_3PO_4	>	$HC_2H_3O_2$
perchloric acid		sulfuric acid		hydrochloric acid		nitric acid		phosphoric acid		acetic acid

- often react with metals to produce hydrogen gas

$$1\ Mg\ (s) + 2\ HCl\ (aq) \longrightarrow 1\ MgCl_2\ (aq) + 1\ H_2\ (g)$$

1 Mg (s): atom metal (zero charge); 2 HCl (aq): strong acid; 1 $MgCl_2$ (aq): ionic salt; 1 H_2 (g): covalent

- strong acids react with strong base to give salt and water

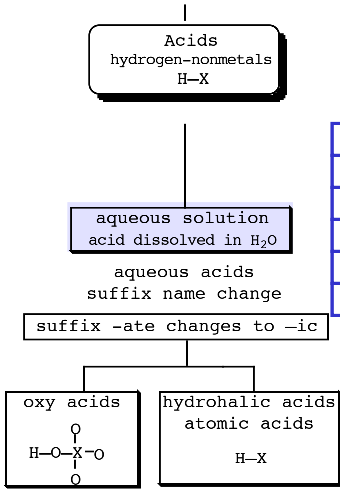
$$1\ NaOH\ (aq) + 1\ HCl\ (aq) \longrightarrow 1\ NaCl\ (aq) + 1\ H_2O\ (l)$$

1 NaOH (aq): ionic salt base (metal hydroxide); 1 HCl (aq): strong acid; 1 NaCl (aq): ionic salt; 1 H_2O (l): weak acid

Acids

$HClO_4$ > H_2SO_4 > HCl > HNO_3 >> H_3PO_4 > $HC_2H_3O_2$

hydrogen
listed first



as a gas	aqueous solution
hydrogen perchlorate	perchloric acid
dihydrogen sulfate	sulfuric acid
hydrogen chloride	hydrochloric acid
hydrogen nitrate	nitric acid
trihydrogen phosphate	phosphoric acid
hydrogen acetate	acetic acid

Bases

- taste bitter (shampoo, soap, baking soda, bleach)
- feel slippery (saponify the oils in your skin to form soap)
- turn red litmus to blue (base)
- sometimes have hydroxide ion OH^- given in their formula

$NaOH$ (drano), $Ca(OH)_2$ (added to orange juice), $Mg(OH)_2$ (milk of magnesia)

- weak bases react with water to form hydroxide ion at equilibrium

$$1\ NH_3\ (g) + 1\ H_2O\ (l) \rightleftharpoons 1\ NH_4^+\ (aq) + 1\ OH^-\ (aq)$$

covalent weak base; weak acid; ammonium ion; hydroxide ion

- strong acids react with strong base to give salt and water

$$1\ NaOH\ (aq) + 1\ HCl\ (aq) \rightarrow 1\ NaCl\ (aq) + 1\ H_2O\ (l)$$

strong base ionic salt; strong acid; ionic salt pH = 7; water

Acid-Base Trends, Conjugates, and Reactions
Dr. Gergens - SD Mesa College

Periodic Trend

ACIDS — acidity increases →

CH_4	NH_3	H_2O	H-F	
	PH_3	H_2S	H-Cl	↓ acidity increases
			H-Br	
			H-I	

conjugate bases — ← basicity increases

CH_3^-	NH_2^-	OH^-	F^-	↑ basicity increases
	PH_2^-	SH^-	Cl^-	
			Br^-	
			I^-	

Evaluating Acid-Base Reactions
(relative strength to produce weaker acid)

H–I + OH^- ______ I^- + H_2O

SH^- + H_2O ______ H_2S + OH^-

NH_3 + H-Cl ______ NH_4^+ + Cl^-

Predicting Proton-Transfer Products

CH_3^- + H_2O ______

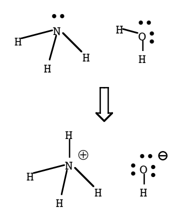
HO^- + H_2S ______

NH_2^- + HBr ______

NH_3 + HF ______

Definitions

	Arrhenius Theory	Bronsted-Lowry Theory
Acid	Give H^+ in water	Proton donor
Base	Gives OH^- in water	Proton acceptor
	limited to aqueous solutions	water may be a solvent, but it needn't be



Can you name all the ions on molecules on this handout?

Periodic Trend for increasing Acid Strength (across a period)

Periodic Trend

ACIDS — acidity increases →

CH_4	NH_3	H_2O	H-F	Electronegativity increases within a row
	PH_3	H_2S	H-Cl	Electronegativity increases within a row
			H-Br	↓ acidity increases
			H-I	

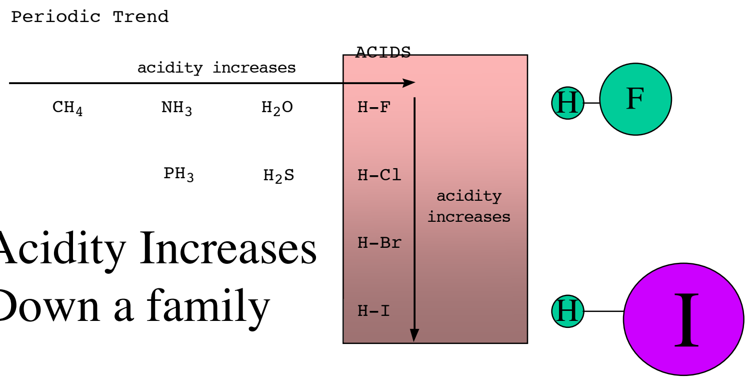
The more electronegative atom produces a <u>more</u> <u>polar</u> H-X bond

Electronegativity Trend

F > O > N > Cl > Br > I > S > C > H

Foncl Brisch

Periodic Trend for increasing Acid Strength (down a family)



Acidity Increases
Down a family

Atom size increases going down a family with in “n” shells.
A larger atoms afford longer H–X bond.
Longer covalent bonds are more easily broken.

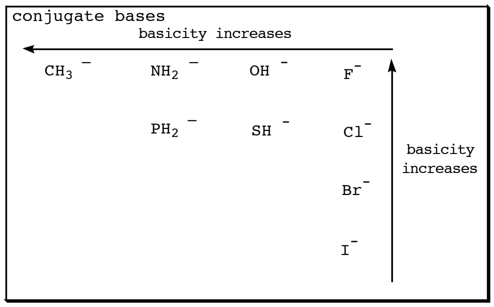
Use the Periodic Trend for increasing acid strength to make your prediction

Which is the stronger acid and why?

HCl	or	HI	I is a larger atom with a more easily broken H-I bond
H_2O	or	H_2S	S is a larger atom with a more easily broken H-S bond
H_2S	or	HCl	Cl is a more electronegative atom; more polar bond

Periodic Trend for increasing conjugate base strength

For every Acid, there is a conjugate base
To draw a conjugate base, just remove a H^+ from its acid formula



ACID		Conjugate base
H-I	becomes	I^-
H-Br	becomes	Br^-
H-Cl	becomes	Cl^-
H-F	becomes	F^-
H_2O	becomes	OH^-
NH_3	becomes	NH_2^-
CH_4	becomes	CH_3^-
weakest acid		strongest base

Note: basicity for these conjugate base is the reverse of the acidity trend

Use the Periodic Trend for increasing conjugate base strength to make your prediction

Which is the stronger base?

Cl^- or I^-

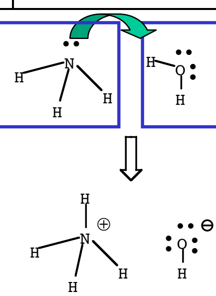
HO^- or HS^-

HS^- or Cl^-

Definitions **Know these definitions!!!**

	Arrhenius Theory	Bronsted-Lowry Theory
Acid	Give H^+ in water	Proton donor
Base	Gives OH^- in water	Proton acceptor
	limited to aqueous solutions	water may be a solvent, but it needn't be

Bronsted-Lowry proton acceptor



Bronsted-Lorwy proton donor

Which definition best describes the reaction on the right?

Evaluating Acid-Base Reactions

(relative strength to produce weaker acid)

H–I	+	OH^-	———	I^-	+	H_2O
Acid		Base		conjBase		conjAcid
SH^-	+	H_2O	———	H_2S	+	OH^-
Base		Acid		conjAcid		conjBase
NH_3	+	H-Cl	———	NH_4^+	+	Cl^-
Base		Acid		conjAcid		conjBase

1) The first questions to ask in evaluating the preferred side of a proton transfer reaction:

A) Which is the Acid? (acids generally have H listed first in their formula), and are the proton donor on the left side of the equation.

B) Which is the Base? (bases can be anions or ionic salts, NaSH, KOH, $LiCH_3$), and are the proton acceptor on the left side of the equation, including ammonia, NH_3

2) The second question to ask in :

Where is the conjugate base? The conjugate base shown on the right hand side of the reaction is the species formed from the Acid with a hydrogen ion missing.

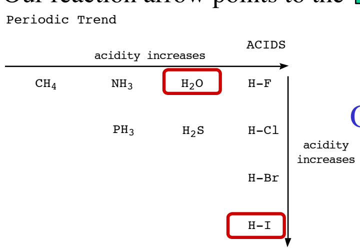
Where is the conjugate acid? the conjugate acid shown on the right hand side of the reaction is the species formed from the Base with a hydrogen ion added.

Evaluating Acid-Base Reactions
(relative strength to produce weaker acid)

H—I (Acid) + OH^- (Base) → I^- (conjBase) + H_2O (conjAcid)

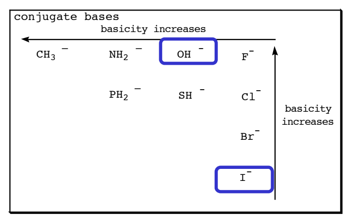
3) Using our period trend for **acidity and conjugate base strength**, we can make an educated decisions regarding relative strength for our acids and bases in each reaction.

4) Our reaction arrow points to the → weaker side of equilibrium.



$HI > H_2O$

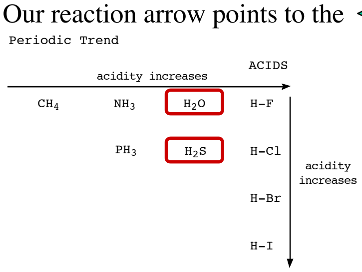
$OH^- > I^-$



Evaluating Acid-Base Reactions
(relative strength to produce weaker acid)

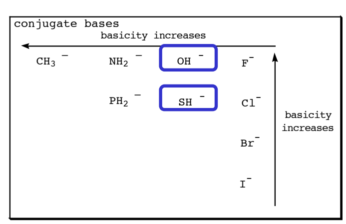
SH^- (Base) + H_2O (Acid) ← H_2S (conjAcid) + OH^- (conjBase)

Our reaction arrow points to the ← weaker side of equilibrium.



$H_2S > H_2O$

$OH^- > SH^-$



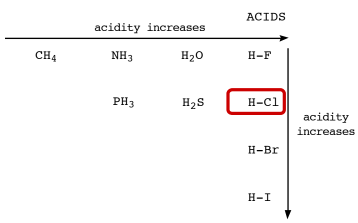
Evaluating Acid-Base Reactions
(relative strength to produce weaker acid)

Demonstrated in class
An ionic salt formed!!!!!
It appeared as smoke.

NH_3	+	H-Cl	→	NH_4^+	+	Cl^-
Base		Acid		conjAcid		conjBase

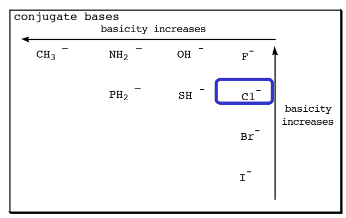
Our reaction arrow points to the → weaker side of equilibrium.

Periodic Trend



$HCl > NH_4^+$

$NH_3 > Cl^-$



Predicting Proton-Transfer Products

CH_3^-	+	H_2O	——	CH_4	+	HO^-
Base		Acid		conj Acid		conj Base
HO^-	+	H_2S	——	H_2O	+	HS^-
Base		Acid		conj Acid		conj Base
NH_2^-	+	HBr	——	NH_3	+	Br^-
Base		Acid		conj Acid		conj Base
$:NH_3$	+	HF	——	NH_4^+	+	F^-
Base		Acid		conj Acid		conj Base

Let me demonstrate the ionic salt formed!!!!!

Make Smoke?!?!?!?!?!?!

Acidic Oxides (nonmetal oxide molecules)

nonmetal oxide molecules

nonmetal oxide molecules		acids
CO_2	The reaction of the oxides on the left added to water produces these acids on the right →	H_2CO_3
SO_3		H_2SO_4
NO		HNO_3

Can you draw the Lewis dot structures for all of these compounds?
Begin by counting valence electrons.
Remember, acids containing oxygen have an H attached to an O

make a table

```
2H x 1 =  2
4O x 6 = 24
1S x 6 =  6
-----------
         32 VE
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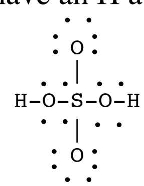
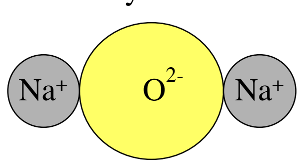
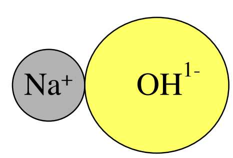


Basic Oxides (metal oxides ionic salts - nonmolecules)

metal oxide nonmolecules		bases
Na_2O	The reaction of the oxides on the left added to water produces these ionic base salts on the right →	$NaOH$
MgO		$Mg(OH)_2$
CaO		$Ca(OH)_2$

Can you draw the visual representation for all these compounds?





Acid-Base reactions of Carbonates

ionic carbonate salts

$NaHCO_3$

$MgCO_3$

$CaCO_{3\ (marble)}$

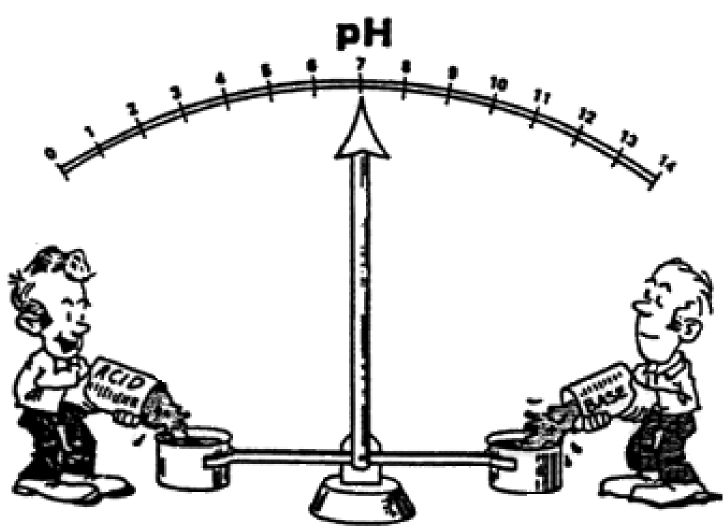
The reaction of these carbonates on the left added to acid produces carbon dioxide gas and H_2O → CO_2 & H_2O

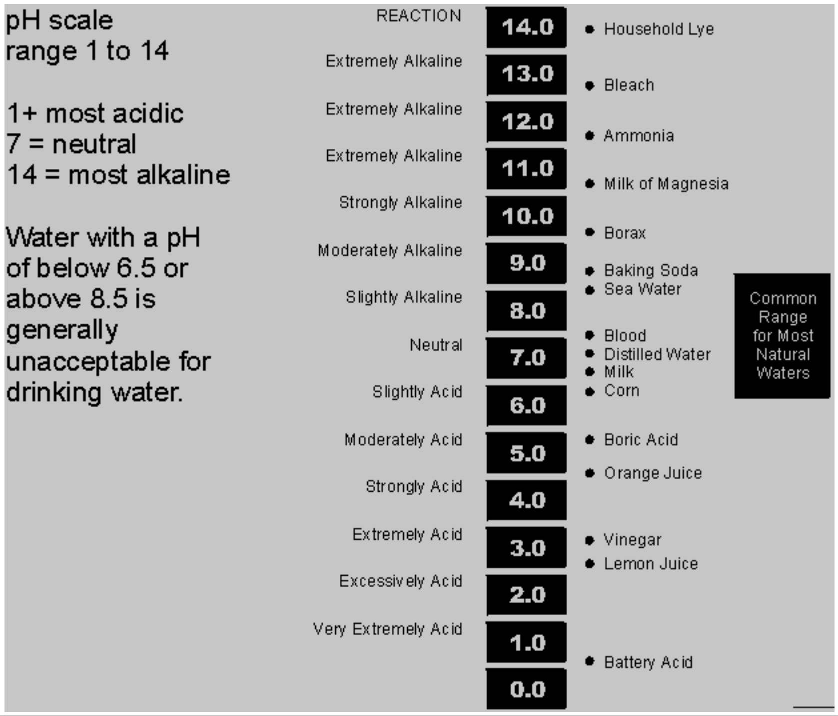
Predict the products of these reactions and balance the reaction:

$1\,NaHCO_3 + 1\,HCl$ ----------> $1\,NaCl + 1\,H_2O + 1\,CO_2$

$1\,MgCO_3 + 1\,H_2SO_4$ ----------> $1\,MgSO_4 + 1\,H_2O + 1\,CO_2$

$1\,CaCO_{3\ (marble)} + 2\,HNO_3$ ----------> $1\,Ca(NO_3)_2 + 1\,H_2O + 1\,CO_2$



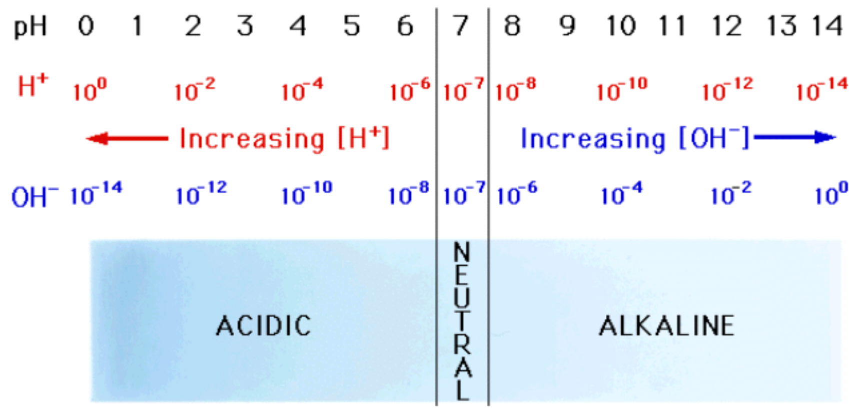


$$[H^+] = 10^{-(\text{pH value})}$$

$$\text{pH value} = -\log_{10} [H^+]$$

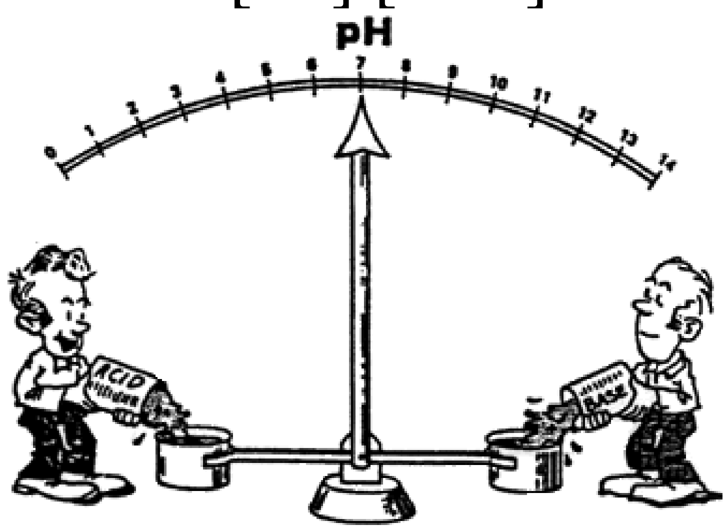
$$Kw = [H^+]\,[OH^-]$$

$[H^+] = 10^{-(\text{pH value})}$

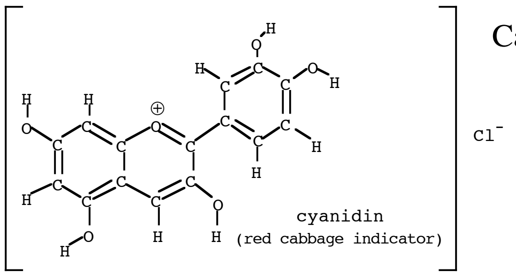


pH value = $-\log_{10} [H^+]$

Kw = $[H^+] [OH^-]$



Kw = 1 EE -14



cyanidin
(red cabbage indicator)

Cabbage Juice as a pH indicator

Demonstration

Stoichiometry & Titration

Watch the video on titration linked below

http://homework.sdmesa.edu/dgergens/chem100L/titration/titration.html