ACIDS AND BASES REFERENCE SHEET

ACIDS
- Juices/Fruits
- Tart, sour, sharp taste
- They are electrolytes
  - Conduct electricity
- React with Metals
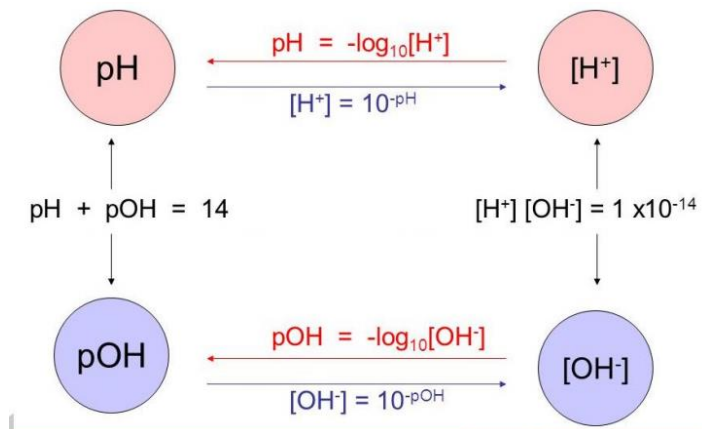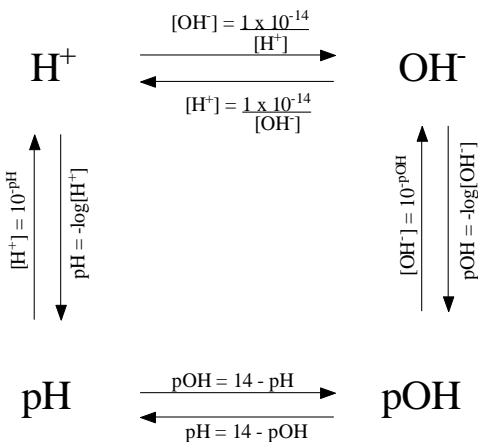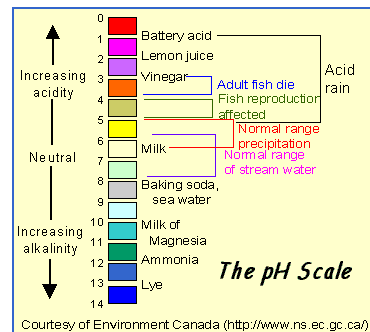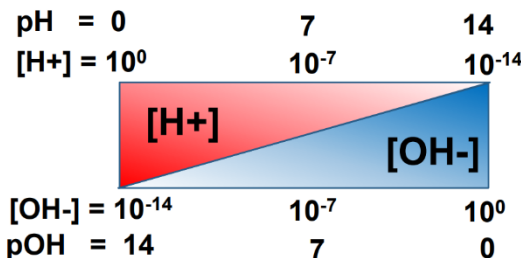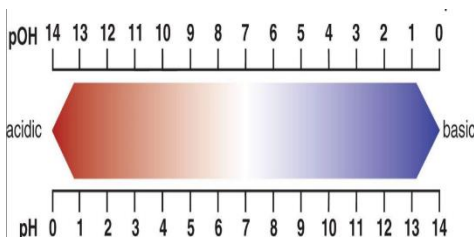- Common as aqueous and liquids

BASES
» Cleaning products
» Bitter tasting
» Slippery to the touch
» Common as Solids

7 Strong Acids (H^+) All other acids are weak		8 Strong Bases (OH^-) All other bases are weak	
Hydrochloric acid	HCl	Lithium hydroxide	LiOH
Hydrobromic acid	HBr	Sodium hydroxide	NaOH
Hydroiodic	HI	Potassium hydroxide	KOH
Perchloric acid	$HClO_4$	Rubidium hydroxide	RbOH
Chloric acid	$HClO_3$	Cesium hydroxide	CsOH
Nitric acid	HNO_3	Calcium hydroxide	$Ca(OH)_2$
Sulfuric acid	H_2SO_4	Strontium hydroxide	$Sr(OH)_2$
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Memorize these 15, ALL ELSE ARE considered WEAK

pOH 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

acidic — basic

pH 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

$pH = 0 \qquad 7 \qquad 14$
$[H+] = 10^0 \qquad 10^{-7} \qquad 10^{-14}$

[H+]   **[OH-]**

$[OH-] = 10^{-14} \qquad 10^{-7} \qquad 10^0$
$pOH = 14 \qquad 7 \qquad 0$

Increasing acidity
- 0 Battery acid
- 1
- 2 Lemon juice
- 3 Vinegar
- 4
- 5
- 6 Milk

Neutral
- 7

Increasing alkalinity
- 8 Baking soda, sea water
- 9
- 10 Milk of Magnesia
- 11 Ammonia
- 12
- 13 Lye
- 14

Adult fish die
Fish reproduction affected
Normal range precipitation
Normal range of stream water
Acid rain

The pH Scale

Courtesy of Environment Canada (http://www.ns.ec.gc.ca/)

H^+ $\xrightarrow{[OH^-] = \frac{1 \times 10^{-14}}{[H^+]}}$ $\xleftarrow{[H^+] = \frac{1 \times 10^{-14}}{[OH^-]}}$ OH^-

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

$[OH^-] = 10^{-pOH}$ $pOH = -\log[OH^-]$

pH $\xrightarrow{pOH = 14 - pH}$ $\xleftarrow{pH = 14 - pOH}$ pOH

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

pH + pOH = 14

$[H^+][OH^-] = 1 \times 10^{-14}$

pOH $\xleftarrow{pOH = -\log_{10}[OH^-]}$ $\xrightarrow{[OH^-] = 10^{-pOH}}$ [OH-]

Arrhenius
» Acids make H^+ ions in aqueous solutions
» Bases make OH^- ions in solution

Bronsted-Lowry
» Acids donate protons
» Bases accept protons

Lewis
» Acids accept electron pairs
» Bases donate electron pairs

Lewis: A ← :B
Brønsted-Lowry: H^+ ← :B
Arrhenius: H^+ ← $:OH^-$

CONJUGATES

NH_3 (Base) + HBr (Acid) → NH_4^+ (Conjugate Acid) + Br^- (Conjugate Base)

wanna play catch? Sure! sounds fun

ACID   BASE

R-44

STRONG ACIDS			
Acid	Formula	Conj. Base	K_a
Perchloric	$HClO_4$	ClO_4^-	Very large
Hydriodic	HI	I^-	Very large
Hydrobromic	HBr	Br^-	Very large
Hydrochloric	HCl	Cl^-	Very large
Nitric	HNO_3	NO_3^-	Very large
Sulfuric	H_2SO_4	HSO_4^-	Very large
Hydronium ion	H_3O^+	H_2O	1.0

COMMON WEAK ACIDS			
Acid	Formula	Conj.Base	K_a
Iodic	HIO_3	IO_3^-	1.7×10^{-1}
Oxalic	$H_2C_2O_4$	$HC_2O_4^-$	5.9×10^{-2}
Sulfurous	H_2SO_3	HSO_3^-	1.5×10^{-2}
Phosphoric	H_3PO_4	$H_2PO_4^-$	7.5×10^{-3}
Citric	$H_3C_6H_5O_7$	$H_2C_6H_5O_7^-$	7.1×10^{-4}
Nitrous	HNO_2	NO_2^-	4.6×10^{-4}
Hydrofluoric	HF	F^-	3.5×10^{-4}
Formic	$HCOOH$	$HCOO^-$	1.8×10^{-4}
Benzoic	C_6H_5COOH	$C_6H_5COO^-$	6.5×10^{-5}
Acetic	CH_3COOH	CH_3COO^-	1.8×10^{-5}
Carbonic	H_2CO_3	HCO_3^-	4.3×10^{-7}
Hypochlorous	$HClO$	ClO^-	3.0×10^{-8}
Hydrocyanic	HCN	CN^-	4.9×10^{-10}

COMMON WEAK BASES			
Base	Formula	Conj. Acid	K_b
Ammonia	NH_3	NH_4^+	1.8×10^{-5}
Methylamine	CH_3NH_2	$CH_3NH_3^+$	4.38×10^{-4}
Ethylamine	$C_2H_5NH_2$	$C_2H_5NH_3^+$	5.6×10^{-4}
Diethylamine	$(C_2H_5)_2NH$	$(C_2H_5)_2NH_2^+$	1.3×10^{-3}
Triethylamine	$(C_2H_5)_3N$	$(C_2H_5)_3NH^+$	4.0×10^{-4}
Hydroxylamine	$HONH_2$	$HONH_3^+$	1.1×10^{-8}
Hydrazine	H_2NNH_2	$H_2NNH_3^+$	3.0×10^{-6}
Aniline	$C_6H_5NH_2$	$C_6H_5NH_3^+$	3.8×10^{-10}
Pyridine	C_5H_5N	$C_5H_5NH^+$	1.7×10^{-9}

Strong Acid

HA Before Dissociation

H^+ A^- After Dissociation, at Equilibrium

Weak Acid

HA Before Dissociation

HA $\rightleftharpoons$ H^+ A^- After Dissociation, at Equilibrium

You can convert back and forth from Ka to Kb using this equation:

Kw = Ka x Kb

Strong Acid $\xrightarrow{\text{makes a}}$ Weak Conj. Base
Large Ka   Small Kb

Weak Acid $\xrightarrow{\text{makes a}}$ Strong Conj. Base
Small Ka   Large Kb

Strong Base $\xrightarrow{\text{makes a}}$ Weak Conj. Acid
Large Kb   Small Ka

Weak Base $\xrightarrow{\text{makes a}}$ Strong Conj. Acid
Small Kb   Large Ka

Increase in ACID strength — K_a and $[H_3O^+]$ increase — pH decreases

Increase in BASE strength — K_b and pH increase — $[H_3O^+]$ decreases

WEAK ACIDS AND BASES CALCULATIONS

- Dissociation is a reversible reaction!
- So use Equilibrium Expressions, K values, and Ice Tables to find [ ]'s before doing pH type calculations
- Equilibrium Expression still $\frac{Products}{Reactants}$ which will be $\frac{[Dissociated\ Ions]}{[Undissociated\ Molecule]}$
- To find pH (or pOH) of something you first have to know the $[H_3O_+]$ (or $[OH^-]$)
    - For weak acids/bases you need to do the following steps to find those [ ]'s
        - Step 1 – ICE Table
        - Step 2 – Write a Ka expression (or Kb depending on the problem)
        - Step 3 – Solve for x using either quadratic or 5% rule
        - Step 4 – put x back into ICE Table to find the actual [ ] answers
        - Step 5 – use your $[H_3O^+]$ (or $[OH^-]$) to find the pH (or pOH)

MONOPROTIC VS. POLYPROTIC – HOW MANY IONS COME OFF?

- Monoprotic acids/bases → only have one H^+ or OH^-
- Diprotic acids/bases → have two H^+ or OH^-
- Triprotic acids/bases → have three H^+ or OH^-

- <u>Strong Bases</u>
    - all OH^- come off
        - Take that into account with your stoichiometry when finding the $[OH^-]$
            - 1 M $Ca(OH)_2$ = 2 M of OH^- ions

- <u>Strong Acids</u>
    - The first H^+ comes off and it would be a normal strong acid type pH calculation
        - No Ka value needed
        - No ICE Table needed.
    - The second/third/etc H^+ might come off <u>BUT</u>
        - That would be a weak reaction and you would need:
            - Ka value for that second H^+ coming off
            - Would need to do an ICE table
            - Then add the $[H^+]$ from the ICE Table calculation to the $[H^+]$ you found from the first H^+ coming off.
    - Example: H_2SO_4 → H^+ + HSO_4^-
      Only assume one H^+ comes off unless given Ka value for HSO_4^- → H^+ + SO_4^{2-}

- <u>Weak Acids/Bases</u>
    - For the given Ka or Kb value assume only one H^+/OH^- comes off.
    - You would need a second Ka or Kb value to do a second ICE Table for the second H^+/OH^- coming off, and then would need to add your [ ]'s from each ICE Table calculation.