Name: ______________________________ Block: ____________

IV. Acids & Bases (part 1)

IV.1 Arrhenius Acids & Bases

You will be able to:

- Define Arrhenius acids and bases
- Write balanced equations representing the neutralization of acids by bases in solution
- List general properties of acids and bases

ACID + BASE --> SALT + WATER

Arrhenius definitions:

ACID ____

BASE ____

SALT ____

All neutralization reactions are based on the fact that acids produce _____ and bases produce _____.

Net ionic equation: ____

Balancing A+B equations:

Example 1: Balance the neutralization equation of HCl and $Sn(OH)_4$

Step 1: Count the number of H's and OH's in the acid + base formula	
Step 2: Balance H's and OH's using coefficients	
Step 3: Write products as the number of H_2O molecules and formation of salt	

PROPERTIES

Acids (H^+)	**Bases (OH^-)**
a) b) c) d) e)	a) b) c) d) e)

IV.2 Common Acids & Bases

You will be able to:

- Write names and formulae of some common household acids and bases
- Outline some of the uses and commercial names of common household acids and bases

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ACIDS

Name	Formula	Properties	Uses
Sulphuric acid			
Hydrocholoric acid			
Nitric acid			
Acetic acid			

BASES

Name	Formula	Properties	Uses
Sodium hydroxide			
Potassium hydroxide			
Ammonia			

Do WS 4-1: Common Acids & Bases; Hebden set 21 p. 110 #2abef, 3, 4, 7, 9

IV.3 – IV.4 H^+ and Brønsted-Lowry Acids & Bases

You will be able to:

- Identify an H_3O^+ ion as a pronated H_2O molecule that can be represented in shortened form as H^+
- Define Brønsted-Lowry acids and bases and identify Brønsted-Lowry acids and bases in an equation
- Define amphiprotic
- Describe situations in which H_2O would act as an acid or base

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H^+ is very reactive: highly concentrated positive charge that is very attracted to any negative charge.

H^+	H_2O	$H^+ + H_2O \rightarrow H_3O^+$	
H^+ = _______________		H_3O^+ = ____________ or _________________	*Therefore, H^+ (aq) is actually H_3O^+(aq) when you write the IONIZATION of an acid.*

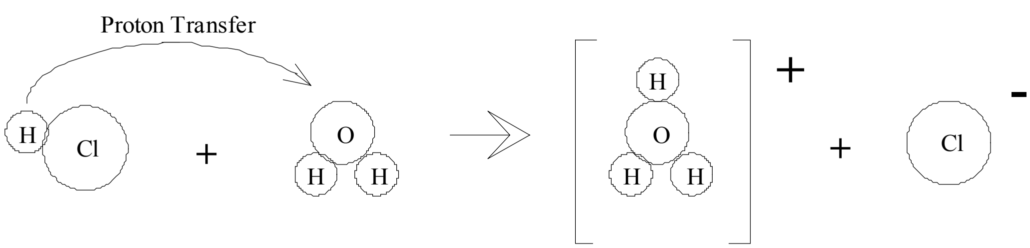
All acid solutions contain hydronium (H_3O^+) ions. It is the hydronium ion which gives all acids their properties (like sour taste, indicator colours, reactivity with metals etc.)

Writing the dissociation of acids in water:

Example 2: Write the ionization equation when $HCl_{(g)}$ is added to water to produce $HCl_{(aq)}$.

Previous way: ____

Ionization equation: ____



$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$

Brønsted-Lowry theory of acids and bases allows for ____.

Brønsted-Lowry definitions:

ACID ____

BASE ____

- When a substance ***loses a proton*** (_____________________), it turns into something with _________________________and _______________________________ (which means the same as one more (-) charge.)

- When a substance ***gains a proton*** (_____________________), it turns into something with _________________________and _______________________________ (which means the same as one less (-) charge.)

*According to Brønsted-Lowry definitions, **H_2O** can act ___________________________________.

AMPHIPROTIC = ____
Examples: H_2O, $H_2PO_4^-$, HS^-, HCO_3^-

*__In every Brønsted-Lowry reaction, there is an acid and a base on BOTH sides of the equation.__**

Example 3ab: Determine which substances are acids and bases in the following B-L equations:

Step 1: Determine which reactant gains or loses a proton	Ex. A $CH_3COOH + H_2O \leftrightarrows CH_3COO^- + H_3O^+$	Ex. B $NH_3 + H_2O \leftrightarrows NH_4^+ + OH^-$
Step 2: Determine the opposite substance on the products side (conjugate pair)		
Step 3: Each side must have BOTH and acid and a base		

Do Hebden set 22: p. 115-119 #10, 11, 13, 14

IV.5 Conjuagte Acids & Bases

You will be able to:
- Define conjugate acid-base pair
- Identify the conjugate of a given acid or base
- Show than in any Brønsted-Lowry acid-base equation there are two conjugate pairs present

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ACID A + BASE B $\leftrightarrows$ BASE A + ACID B

- A Bronsted-Lowry acid-base reaction just involves an equilibrium proton transfer.
- If a proton is transferred during the ***forward*** reaction, we can also assume there will be a proton transfer in the ***reverse*** reaction.

CONJUGATE ACID-BASE PAIR (or **CONJUGATE PAIR**) = ____________________ ____
CONJUGATE ACID is ____
CONJUGATE BASE is ____

In the equilibrium reaction, $NH4^+ + H_2O \rightleftarrows NH3 + H_3O^+$, there are two conjugate pairs.

Conjugate pair	Conjugate acid	Conjugate base

Example 4: Identify the conjugate acid-base pairs in each of the following reactions:

a) $NH_3 + CH_3COOH \rightleftarrows NH_4^+ + CH_3COO^-$

Pair 1: (acid) ________________________ (base) ________________________

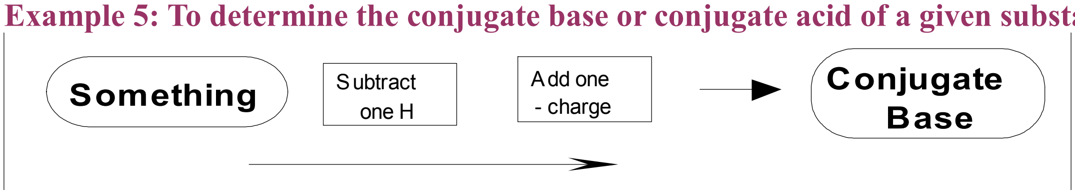
Pair 2: (acid) ________________________ (base) ________________________

b) $H_2SO_3 + H_2PO_4^- \rightleftarrows H_3PO_4 + HSO_3^-$

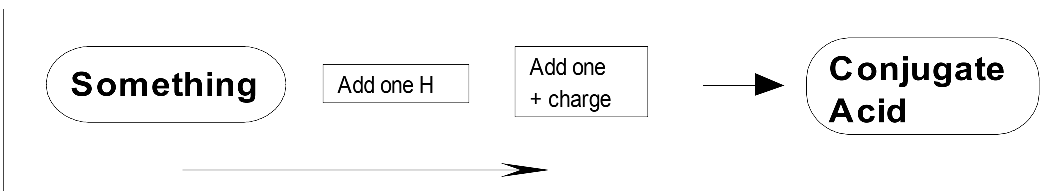
Pair 1: (acid) ________________________ (base) ________________________

Pair 2: (acid) ________________________ (base) ________________________

Example 5: To determine the conjugate base or conjugate acid of a given substance,



Example: Give the conjugate base of $H_2PO_4^-$ ____________________



Example: Give the conjugate acid of HSO_4^- ____________________

Do Hebden set 23: p. 121 #16-19

<u>IV.6 "Strong and Weak" Acids & Bases</u>

You will be able to:

- Relate electrical conductivity in a solution to the total concentration of ions in a solution
- Define and give several examples for the following terms: strong acid, strong base, weak acid, weak base
- Write equations to show what happens when strong and weak acids and bases are dissolved in water
- Compare the relative strengths of acids or bases by using a table of relative acid strengths
- Predict whether products or reactants are favoured in an acid-base equilibrium by comparing the strength of the two acids (or two bases)
- Compare the relative concentrations of H_3O^- (or OH^-) between two acids (or between two bases) using their relative positions on an acid strength table

----

- WEAK and STRONG refer to ____.
- DILUTE and CONCENTRATED refer to ____.

A <u>STRONG</u> ACID or BASE is ____

A <u>WEAK</u> ACID or BASE is ____

See Data table, "Relative Strengths of Bronsted-Lowry Acids and Bases" (p. 334 Hebden)

- Equilibrium (double arrow) reactions involve ***weak*** acids and bases, NOT *strong* acids and bases.

<table>
<tr><th>Strong acids</th><th>Weak acids (left)</th><th>Weak bases (right)</th><th>Strong bases</th></tr>
<tr>
<td>100% ionization
one-way arrows
high K_a
<u>Examples:</u>
$HClO_4$,HI, HBr, HCl, HNO_3, H_2SO_4

In a Strong Acid,
$[H_3O^+] = [Acid]$</td>
<td colspan="2">Less than 100% ionization (usually < 5% ionized)
double arrows (equilibrium)
K_a = 1.0 to 1.0 x 10^{-14}

Amphiprotic compounds can be on both sides
(left acting as an acid, on the right acting as a base.)

Ex.) $H_2PO_4^- \leftrightarrows H^+ + HPO_4^{2-}$
Ex.) $H_3PO_4 \leftrightarrows H^+ + H_2PO_4^-$</td>
<td>100% ionization
one-way arrows
low K_a
<u>Examples:</u>
O^{2-} and NH_2^-
metal hydroxides: NaOH, KOH, $Mg(OH)_2$, $Ca(OH)_2$, $Fe(OH)_3$, $Zn(OH)_2$

In a Strong Base,
[OH-] = [Base] x # of OH's in formula</td>
</tr>
</table>

The stronger the ACID, the a)____,

b) ____,

c) ____.

The stronger the BASE, the a)____,

b) ____,

c) ____.

Example 6: What is $[H_3O^+]$ in 0.20 M HCl?

Step 1: Write out ionization of HCl in H_2O	
Step 2: Use molar ratio to determine [ ]	

Example 7: What is the $[H_3O^+]$ in 0.40 M sulphuric acid?

Step 1: Write out ionization of acid in H_2O	
Step 2: Use molar ratio to determine [ ]	
Note: The STRONG acids all have the same strengths in aqueous solutions. [H30+] = [acid]	

Example 8: What is the $[OH^-]$ in 0.10 M $Ba(OH)_2$?

Step 1: Write out ionization of $Ba(OH)_2$ in H_2O	
Step 2: Use molar ratio to determine [ ]	

The strongest base which can exist in high concentrations in water solution is OH^-
H_3O^+ is the strongest acid that can exist in an undissociated form in water solution.
****Concentration of ions determines its electrial conductivity.****

Acid-Base Equilibria & Relative Strengths of Acids & Bases

- *Equilibrium favors the side with the weaker conjugate acid and the weaker conjugate base.*

"only as strong as weakest link" or "strong push the weak"

Example 9: Consider the mixing of $H_2PO_4^-$ and some CO_3^{2-} At equilibrium, which will be favoured, reactants or products?

Step 1: Determine which reactant acts as the acid and base	
Step 2: Write out ionization equation	
Step 3: Determine which is the stronger of the 2 acids	
Step 4: Equilibrium favours the side of the weaker acid	

Example 10: Complete the reaction of HSO_4^- + $H_2PO_4^-$. At equilibrium, which will be favoured, reactants or products?

Step 1: Determine which reactant acts as the acid and base (both are amphiprotic)	
Step 2: Write out ionization equation	
Step 3: Compare the two conjugate acids	
Step 4: Equilibrium favours the side of the weaker acid	

Example 11: Complete the net ionic reaction between two salts, $NaHSO_3$ and K_2HPO_4 ,and state whether equilibrium favors reactants or products.

Step 1: Write the dissociation equation for each reactant. Discard spectators of A-B reactions*	
Step 2: Determine which reactant acts as the acid and base	
Step 3: Write out ionization equation	
Step 4: Compare the two conjugate acids	
Step 5: Equilibrium favours the side of the weaker acid	

NOTE:** All alkali ions Na^+, K^+, Li^+ …etc….. are ***spectators in Acid-Base reactions. Also top five ions right side of acid chart (ClO_4^-, I^-, Br^-, Cl^-, NO_3^-) are ***spectators*** in Acid-Base reactions.

Relating K_{eq} to acid-base equilibrium

If products are favored K_{eq} is large (>1)

If reactants are favored K_{eq} is small (<1)

Do Hebden set 24: p. 125 # 21-23, 24abcd, 26, 27