COMMON ACIDS NOTES

lactic acetic phosphoric
citric malic

PROPERTIES OF ACIDS

1.

2.

3.

4.

5.

PROPERTIES OF BASES

1.

2.

3.

4.

5.

NAMING ACIDS NOTES

Binary acids (H + one element)

1. "hydro-"
2. root of name of second element
3. "-ic"

Practice:

- HF
- H_2S

Oxyacids (H + more than 1 element)

1. root of polyatomic ion
2. a. If negative ion ends with "-ate", use "-ic" ending
   b. If negative ion ends with "-ite", use "-ous" ending

- HNO_3
- $HClO_2$

BRONSTED-LOWRY ("B-L") THEORY OF ACIDS & BASES NOTES

~ Involve the transfer of a "proton". A proton is

Acid:

conjugate base (CB):

Base:

conjugate acid (CA):

How do you determine an acid's conjugate base and a base's conjugate acid?

~ An acid is a proton donor. So, conjugate base is the formula for the acid ________________________________
____.

** EXAMPLE: Acid = HCl; Conjugate Base (CB) =

~ A base is a proton acceptor/recipient. So, conjugate acid is the formula for the base ______________________ ____.

** EXAMPLE: Base = NO_3^{-1}; Conjugate Acid (CA) =

==

AMPHOTERISM NOTES

Example:

$HNO_3 + H_2O \leftrightarrow NO_3^- + H_3O^+$ Water acts as (acid / base)

$NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$ Water acts as (acid / base)

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BRONSTED - LOWRY ACIDS & BASES WORKSHEET

Label the Bronsted-Lowry acids (A), bases (B), conjugate acids (CA), and conjugate bases (CB) in the following reactions.

EXAMPLE: $H_2O + Cl^- \leftrightarrow OH^- + HCl$
A B CB CA

1. $C_6H_5NH_2 + H_2O \leftrightarrow C_6H_5NH_3^+ + OH^-$

2. $H_2SO_4 + OH^- \leftrightarrow HSO_4^- + H_2O$

3. $HSO_4^- + H_2O \leftrightarrow SO_4^{-2} + H_3O^+$

4. $HBr + OH^- \leftrightarrow H_2O + Br^-$

5. $NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$

CONJUGATE ACID-BASE PAIRS WORKSHEET

ACID	BASE
	HSO_4^-
H_3PO_4	
	F^-
	NO_3^-
$H_2PO_4^-$	
H_2O	

ACID	BASE
	SO_4^{-2}
HPO_4^{-2}	
NH_4^+	
	H_2O
	NO_2^-
NH_3	

ARRHENIUS THEORY OF ACIDS & BASES NOTES

Acids increase concentration of ______________________ ions in aqueous solution.
~ Acids have more ____ ions than ____ ions.
~ Formulas for acids begin with ____.
Bases increase concentration of ______________________ ions in aqueous solution.
~ Bases have more ____ ions than ____ ions.
~ Formulas for bases end with ____.

STRONG VS. WEAK ACIDS & BASES NOTES
Strong acid:

- The 6 strong acids are

Weak acid:

- any acid besides the 6 mentioned above

Strong base:

- Solution of strong base is called
- Strong bases contain any Group 1 or 2 metal (except Be) with OH^-

Weak base:
- any base other than ones mentioned above

~ Rule for strength of acids & bases (B-L theory):
**The stronger an acid is, the _____________ its conjugate base.
**The stronger a base is, the ___________ its conjugate acid.

Which is a weaker base, Cl^- or NO_2^-?

Which is a stronger base, HSO_4^- or $H_2PO_4^-$?

MONOPROTIC & POLYPROTIC ACIDS NOTES
~ How many hydrogens does each type contain?

* MONOPROTIC = ___ H's * DIPROTIC = ___ H's * TRIPROTIC = ___ H's

NEUTRALIZATION REACTIONS

~ ACID + BASE --> ___________ + _____________

~ salt:

pH and pOH NOTES

pH: the negative log of the hydrogen ion concentration $[H^+]$
pOH: the negative log of the hydroxide ion concentration $[OH^-]$

Self-Ionization of Water: $H_2O + H_2O \leftrightarrow H_3O^+ + OH^-$

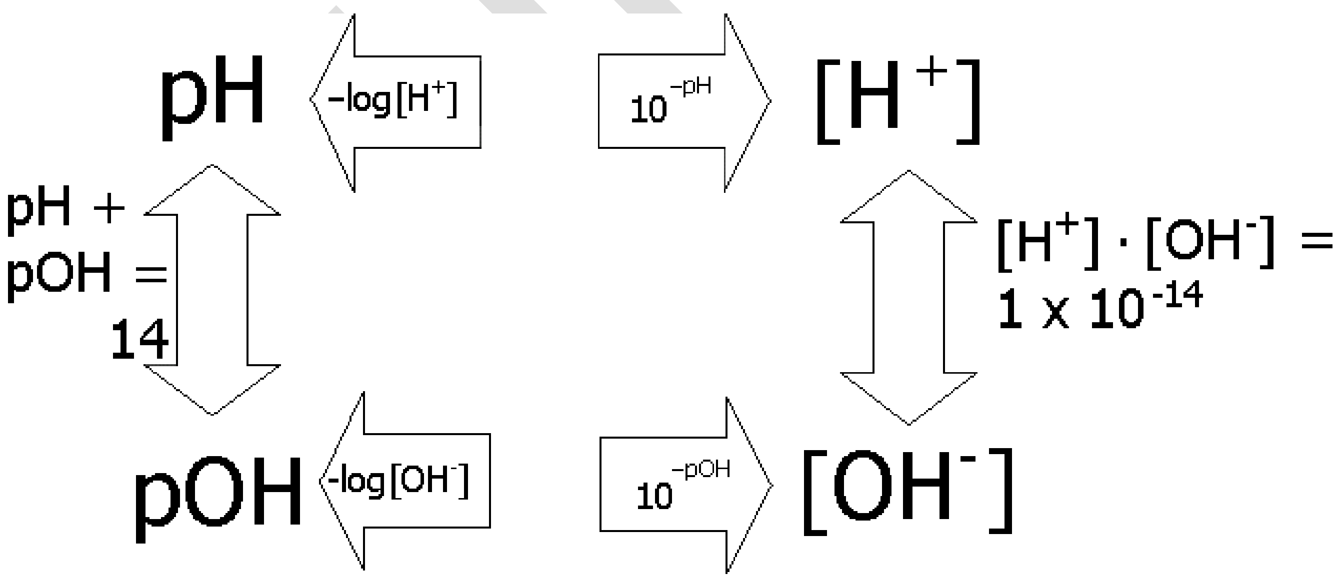
- Water molecules have the ability to self-ionize.
- This is a naturally-occurring phenomenon.
- In one liter of pure water at 25 °C,
  the concentration of H_3O^+ or simply H^+= 0.0000001 moles/liter
  the concentration of OH^- = 0.0000001 moles/liter
  or
  $[H_3O^+] = [H^+] = 1.0 \times 10^{-7}$ moles/L
  $[OH^-] = 1.0 \times 10^{-7}$ moles/L
- Solve for the pH of pure water:

$pH = -\log[H_3O^+]$	$pOH = -\log[OH^-]$
$pH = -\log[1.0 \times 10^{-7}]$	$pOH = -\log[1.0 \times 10^{-7}]$
pH = 7	pOH = 7

- Equations that will be helpful when solving pH and pOH problems:

$pH = -\log[H^+]$	$[H^+] = 10^{-pH}$
$pOH = -\log[OH^-]$	$[OH^-] = 10^{-pOH}$
$pH + pOH = 14$	
$K_w = [H^+] \cdot [OH^-] = 1 \times 10^{-14}$	

0 7 14
<------------------------------|------------------------------->
acids neutral bases



pH and pOH WORKSHEET

Part 1 - Calculate the pH and identify as acidic, basic, or neutral.

1.) $[H^+] = 1.0 \times 10^{-6}$ M pH = ____ A B N
2.) $[H^+] = 2.61 \times 10^{-2}$ M pH = ____ A B N
3.) $[H^+] = 4.0 \times 10^{-9}$ M pH = ____ A B N
4.) $[H^+] = 5.9 \times 10^{-12}$ M pH = ____ A B N
5.) $[H^+] = 1.0 \times 10^{-7}$ M pH = ____ A B N

Part 2 - Calculate the $[H^+]$ and identify as acidic, basic, or neutral.

6.) pH = 4.00 $[H^+]$ = __________ M A B N
7.) pH = 5.89 $[H^+]$ = __________ M A B N
8.) pH = 7.00 $[H^+]$ = __________ M A B N
9.) pH = 12.25 $[H^+]$ = __________ M A B N
10.) pH = 9.11 $[H^+]$ = __________ M A B N

Part 3 - Calculate the missing $[H^+]$ or $[OH^-]$ and identify as acidic, basic, or neutral.

11.) $[H^+] = 4.2 \times 10^{-6}$ M $[OH^-]$ = __________ M A B N
12.) $[H^+]$ = __________ M $[OH^-] = 4.3 \times 10^{-5}$ M A B N

Part 4 - Complete the following chart.

Solution	pH	pOH	$[H^+]$	$[OH^-]$
A	3.68			
B				8.60×10^{-5} M
C			1.80×10^{-9} M	
D		5.48		
E	10.84			
F			3.82×10^{-11} M	
G		2.85		

ACID - BASE TITRATION NOTES

TITRATION: process used in Chemistry lab to determine the concentration of an acid or a base; use a base or an acid with a known concentration to neutralize the acid or base with the unknown concentration

EQUATION TO USE FOR SOLVING TITRATION PROBLEMS: $n_A \cdot M_A \cdot V_A = n_B \cdot M_B \cdot V_B$

n_A = number of H's at the beginning of the formula for the acid

M_A = molarity of the acid V_A = volume of the acid

n_B = number of OH's in the formula for the base

M_B = molarity of the base V_B = volume of the base

EXAMPLE PROBLEM:

What is the molarity of a H_2SO_4 solution if 190 mL of the acid is needed to exactly neutralize 150 mL of a 2.5 M NaOH solution?

$n_A \cdot M_A \cdot V_A = n_B \cdot M_B \cdot V_B$

$2 \cdot M \cdot 190 \text{ mL} = 1 \cdot 2.5 \text{ M} \cdot 150 \text{ mL}$

380 M = 375
M = 0.99 M

What is the volume of a sample of 0.25 M HCl that requires 26.15 mL of 0.58 M NaOH to neutralize it?

ACID-BASE TITRATION WORKSHEET

1. A 25.0 mL sample of HCl was titrated to the endpoint with 15.0 mL of 2.0 M NaOH. What is the molarity of the HCl?

2. A 10.0 mL sample of H_2SO_4 was exactly neutralized by 13.5 mL of 1.0 M KOH. What is the molarity of the H_2SO_4?

3. How much 1.5 M NaOH is necessary to exactly neutralize 20.0 mL of 2.5 M H_3PO_4?

4. How much of 0.50 M HNO_3 is necessary to titrate 25.0 mL of 0.050 M $Ca(OH)_2$ solution to the endpoint?

5. What is the molarity of NaOH solution if 15.0 mL is exactly neutralized by 7.5 mL of a 0.020 M $HClO_3$ solution?

Acid Dissociation Constant (K_a) NOTES

$nA + mB \leftrightarrow eC + fD$ (general equilibrium rxn.)

Reminder #1 $K_{eq} = \dfrac{[C]^e\,[D]^f}{[A]^n\,[B]^m}$

Reminder #2 A weak acid does not completely dissociate (break into pos. & neg. ions); some remain together as molecules; "dissociation equation" for weak acids uses $\leftrightarrow$
Example of a dissociation equation for a weak acid, HNO_2:

How would we write the K_{eq} expression for this?

The K_{eq} gets renamed "K_a" because it is dealing with the dissociation of an acid.
The value for K_a for weak acids is very small because they do not dissociate very much.

EXAMPLE PROBLEM:
Nicotinic acid, $HC_2H_4NO_2$, is a B vitamin. It is also a weak acid with $K_a = 1.4 \times 10^{-5}$. What are the $[H^+]$ and pH of a 0.010 M solution of $HC_2H_4NO_2$?

To solve...
1.) Write a dissociation equation for the weak acid. $HC_2H_4NO_2 \leftrightarrow H^+ + C_2H_4NO_2^-$
2.) Write a K_a expression for the reaction in step 1. $K_a = \dfrac{[H^+]\,[C_2H_4NO_2^-]}{[HC_2H_4NO_2]}$

3.) (All of the weak acids we will study are monoprotic. That means that the acid will only lose 1 H. This means that the mole ratio between H^+ and the neg. ion in the equilibrium reaction will be 1:1. Therefore, the $[H^+]$ = [neg. ion$^-$].) Substituting in the values from the problem...

$1.4 \times 10^{-5} = \frac{[x]\,[x]}{0.010^*}$ $\qquad$ $1.4 \times 10^{-7} = x^2$

$x = 3.74 \times 10^{-4}\ M = [H^+]$

* We assume that $[HC_2H_4NO_2]$ = 0.010 M because only a small amount dissociates. When the amount that actually dissociates is subtracted from the original concentration, the difference will be negligible.

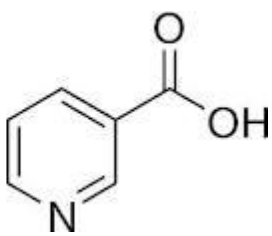
4.) To get the pH... $\qquad$ $pH = -\log[H^+]$ $\qquad$ $pH = -\log[3.74 \times 10^{-4}] = 3.43$

Example on your own... Calculate the pH of a 1.00 M HF solution. The K_a for HF is 7.2×10^{-4}.

<u>Weak Acids & Ka WORKSHEET</u> (taken from *Chemistry – The Central Science*)

Before solving the problem, write out the dissociation equation for the weak acid. Then, write the K_{eq} expression for each. (This K_{eq} expression gets renamed K_a when used with acids.)

1. A student prepared a 0.10 M solution of formic acid, $HCHO_2$ (monoprotic), and measured its pH at 25^oC to be 2.38. Calculate the K_a for formic acid at this temperature.
2. Niacin, one of the B vitamins, has the following molecular structure: (When writing the dissociation equation for niacin, use "H-Nia" as the formula for niacin.)



A 0.020 M solution of niacin has a pH of 3.26. What is the acid dissociation constant, K_a, for the ionizable proton?

3. The K_a value for acetic acid at 25^oC is 1.8×10^{-5}. What is the pH of a 0.30 M acetic acid solution at 25^oC?
4. Calculate the pH of a 0.20 M solution of HCN. (The K_a for HCN is 4.9×10^{-10}.)
5. The K_a for niacin is 1.5×10^{-5}. What is the pH of a 0.010 M solution of niacin?
6. Lactic acid, $HC_3H_5O_3$, has one acidic hydrogen. A 0.10 M solution of lactic acid has a pH of 2.44. Calculate the K_a for lactic acid.

Answers:

1. $K_a = 1.8 \times 10^{-4}$, 2. $K_a = 1.5 \times 10^{-5}$, 3. pH = 2.64, 4. pH = 5.00, 5. pH = 3.41, 6. $K_a = 1.4 \times 10^{-4}$

UNIT 14 REVIEW WORKSHEET

Part 1 – Tell whether each of the following properties describes an acid (A), a base (B), or both (AB).

____ 1. taste bitter

____ 2. lose a proton (B-L Theory)

____ 3. feel slippery

____ 4. change color of indicators

____ 5. 2nd part of formula is usually OH

____ 6. 1st element in formula is usually H

____ 7. conduct electricity

____ 8. taste sour

____ 9. gain a proton (B-L Theory)

____ 10. react with metals to form H_2 gas

Part 2 – Acid Nomenclature – Write the name or the formula for the following acids.

11. HI
12. HNO_2
13. H_3PO_4
14. hydrobromic acid
15. carbonic acid
16. sulfurous acid

Part 3 – Answer the following questions.

17. According to the Arrhenius theory, acids increase ____ ion concentration in aqueous solution.

    Bases increase ____ ion concentration
18. List the six (6) strong acids.
19. How do you know if a base is strong or weak (in Arrhenius theory)?
20. Define conjugate acid.
21. Define conjugate base.
22. The stronger an acid is, the _________ its conjugate base.
23. Which is a stronger base, ClO_4^{-1} or S^{-2}?
24. Which is a weaker base, I^{-1} or SO_4^{-2}?
25. What does it mean if a compound is said to be amphoteric?
26. Can SO_4^{-2} be amphoteric? Why or why not?
27. What is the conjugate base of…
    (A) NH_3 (B) H_2SO_4 (C) $H_2PO_4^-$
28. What is the conjugate acid of…
    (A) $H_2PO_4^-$ (B) HSO_4^- (C) HCO_3^-
29. When an acid and a base react with each other, what are the two (2) products?

Part 4 – Draw lines between the conjugate acid-base pairs and label the acid (A), base (B), conjugate acid (CA), and conjugate base (CB).

30. $H_2SO_4 + H_2O \leftrightarrow HSO_4^- + H_3O^+$

31. $NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$

32. HPO_4^{-2} + H_2O ←→ H_3O^+ + PO_4^{-3}

Part 5 - Solve the following problems.

33. What is the pH of a solution whose $[OH^-]$ is 3.08×10^{-3} M?

34. What is the $[OH^-]$ of a solution whose $[H^+]$ is 5.92×10^{-2} M?

35. What is the concentration (molarity) of NaOH if 15.3 mL are needed to completely neutralize 20.4 mL of 2.50 M H_2SO_4?

36. What volume of 1.50 M $Ca(OH)_2$ is needed to reach the endpoint of a titration using 17.2 mL of 3.00 M H_3PO_4?

37. At 25°C, a 0.025 M solution of formic acid, HCOOH, is found to have a hydrogen ion concentration of 2.03×10^{-3} M. Calculate the ionization constant of formic acid at 25^oC.

Part 6 – Fill in the following chart.

pOH	pH	$[OH^-]$	$[H^+]$	A, B, or N
4.63				
	11.75			
		2.96×10^{-8} M		
			5.27×10^{-9} M	

ACID – BASE TITRATION LAB

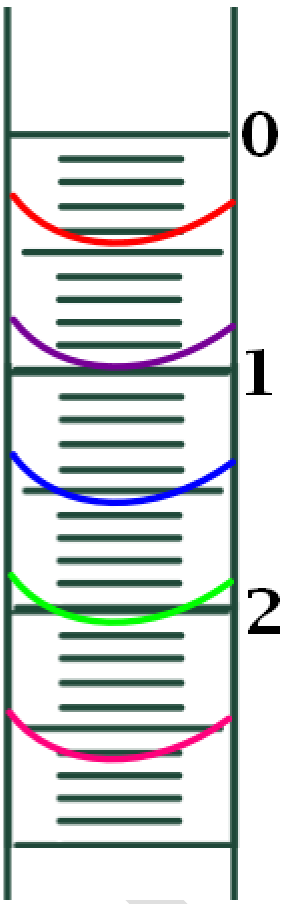
PURPOSE: - to determine the molarity of an aqueous solution of hydrochloric acid (HCl)
- to learn and practice the technique for titration

MATERIALS:

EQUIPMENT
- 2 burets (labeled "A" and "B")
- double buret clamp
- ring stand
- Erlenmeyer flask

CHEMICALS
- _________ M NaOH
- phenolphthalein
- ? M HCl

READING A BURET:



PROCEDURE:

1.) Obtain approximately 10 mL of HCl from the buret labeled "A" for acid in the Erlenmeyer flask. (It is not necessary to have EXACTLY 10.00 mL. However, the volume of the HCl should be measured to the nearest hundredth.)

2.) Add 3 or 4 drops of phenolphthalein. (Only a few drops are needed. Adding more than 3 or 4 drops will not make the reaction any bigger or better.)

3.) Add NaOH from the buret labeled "B" for base SLOWLY until the solution changes color. (When the solution changes color, the acid is neutralized. Ideally, the solution in the flask should be a very faint shade of the color.)

DATA TABLE:

		TRIAL 1	TRIAL 2	TRIAL 3
1	Reading of HCl (at start)	mL	mL	mL
2	Reading of HCl (at end)	mL	mL	mL
3	Volume of HCl used	mL	mL	mL
4	Reading of NaOH (at start)	mL	mL	mL
5	Reading of NaOH (at end)	mL	mL	mL
6	Volume of NaOH used	mL	mL	mL

QUESTIONS AND CALCULATIONS:

1.) Write a balanced equation for the neutralization reaction that occurs between hydrochloric acid (HCl) and sodium hydroxide (NaOH).

2.) What is the mole ratio between HCl and NaOH in the balanced equation?

3.) What volume of HCl was used in TRIAL 1? Show how you determined this volume.

4.) What volume of NaOH was used in TRIAL 1? Show how you determined this volume.

5.) The NaOH had a concentration of __________ M. Using your data, what is the concentration (molarity) of the hydrochloric acid? (CLEARLY and LEGIBLY show your calculations in detail!)

6.) If your group was able to do more than one trial, what was the average molarity?