HONORS CHEMISTRY: PROBLEMS AND SOLUTIONS DATE:_____

Objectives: **SWBAT. . .**
… review solution basics.
… explain how intermolecular forces affect solubility.

SOLUTION:

SOLVENT:

SOLUTE[S]:

AQUEOUS SOLUTIONS:

NOT ALL SOLUTIONS ARE AQUEOUS:

Mixture	Solution State of Matter	Solvent State of Matter	Solute State of Matter
Air			
Antifreeze mixture			
Brass			
Carbonated water			
Sugar water			

THE BASICS OF SOLUBILITY:

UNDERSTANDING SOLUBILITY COMES DOWN TO ONE, SIMPLE PHRASE:

Traditional solvents tend to be either…

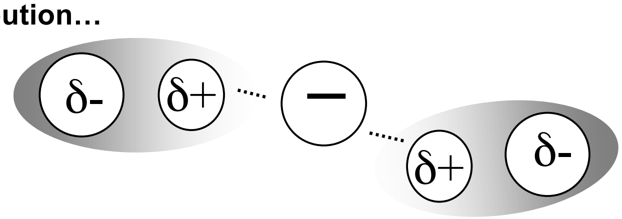
…

…

- Polar covalent solvents have an unequal charge distribution…

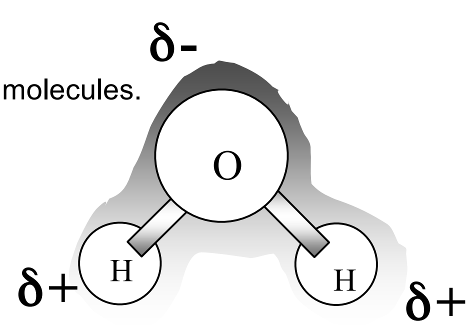
⑧

ex)



SOLVATION:

- As ions dissolve they spread out and become surrounded by solvent molecules.
  - The bigger the ion:
  - The higher the charge on the ion:
  - *HYDRATED:*

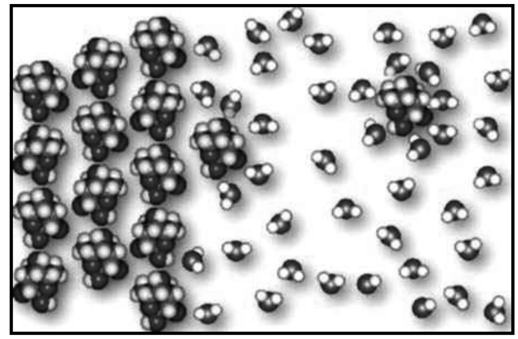


You don't need to be an ion to be dissolved in a polar solvent!

ex)

Which are the water molecules?

Which are the sugar molecules?



www.antoine.frostburg.edu

- Since non-polar covalent solvents have an equal charge distribution they…

…

…

…

ex) Dry cleaners use non-polar solvents to remove stains.

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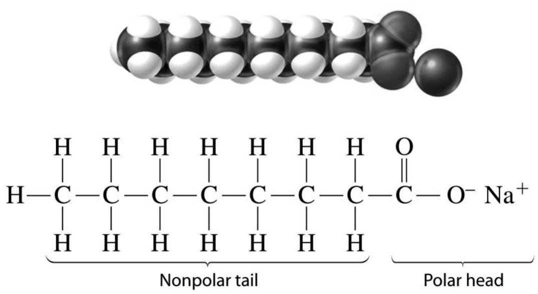


www. newark.rutgers.edu

Detergents work because they have…

…a non-polar part which will interact…

... and a polar part which will interact…

NOW THE CUTTING EDGE STUFF… IONIC LIQUIDS:

Normally ions pack closely into solid, crystalline structures due to…

What if bulky, asymmetrical cations were combined with smaller, evenly shaped anions?

- The ions don't pack well and remain disorganized. In other words, ________
  - Unlike typical organic solvents, tend not to give off fumes due to _____________
  - Potentially less hazardous and more convenient than current solvents.
  - Can easily extract chemicals from the ionic liquids, allowing…

Ionic liquids have the potential to redefine the entire field of chemistry.

"Ideas are the factors that lift civilization. They create revolutions. There is more dynamite in an idea than in many bombs." ~ Bishop Vincent

HONORS CHEMISTRY
SOLUTIONS INTRO

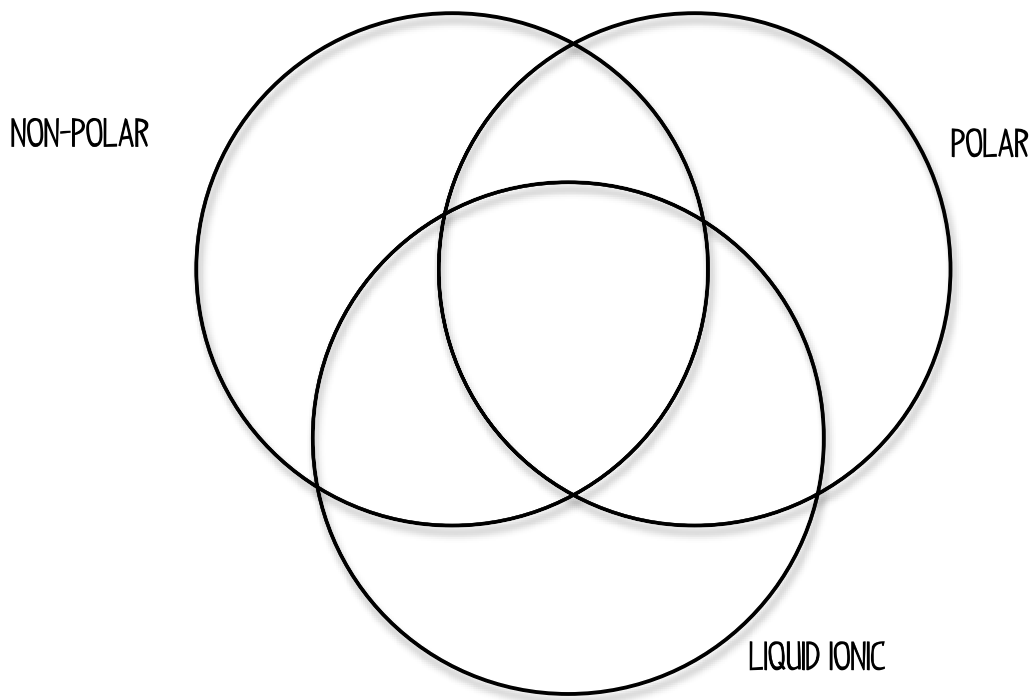
NAME _________________

See if you can come up with new examples for each of the following. Do not reuse the ones from the video!

Mixture	Solution State of Matter	Solvent State of Matter	Solute State of Matter
	Gas	Gas	Gas
	Liquid	Liquid	Liquid
	Solid	Solid	Solid
	Liquid	Liquid	Gas
	Liquid	Liquid	Solid

What is necessary for a detergent to work?

Venn Diagram Time! Compare and contrast these different types of solvents. Feel free to add drawings to help.



"Be a first rate version of yourself, not a second rate version of someone else." - Judy Garland

HONORS CHEMISTRY: DEFINING SOLUTION STRENGTH **DATE:_____**

Learning Activities: **SWBAT. . .**

…describe solution strength through both qualitative and quantitative means.

QUALITATIVE DESCRIPTIONS OF SOLUTION STRENGTH:

Concentrated:

Dilute:

Unsaturated:

Saturated:

Supersaturated:

- Usually due to changes in temperature.

As a general rule of thumb,

The solubility of solids tends to ________________ with increasing temperature.

The solubility of gases tends to ________________ with increasing temperatures.

QUANTITATIVE DESCRIPTIONS OF SOLUTION STRENGTH:

MOLARITY [M] =

- Molarity is the most common unit of concentration used.

Try this… 50.0 grams of sodium hydroxide is dissolved in a 0.500 liter volumetric flask. What is the molarity of the solution?

AS NOTED EARLIER, MOLARITY IS BY FAR THE MOST COMMON MEASUREMENT OF CONCENTRATION, BUT CERTAIN PROFESSIONS USE DIFFERENT UNITS OF CONCENTRATION THAT ARE MORE USEFUL TO THEIR WORK.

MASS PERCENT:

$$\text{Mass Percent} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100\% = \frac{\text{mass of \_\_\_\_\_\_}}{\text{mass of \_\_\_\_\_\_} + \text{mass of \_\_\_\_\_\_}} \times 100\%$$

Try this… 50.0 grams of sodium hydroxide is dissolved in a 0.500 liters of water. What is the mass percent of NaOH? Density of water = 1.0 g/mL

MOLALITY [m]:

- Since volume can change at different temperatures,
- Since molality uses mass, not volume, it's independent of temp. changes ⑧
- Even with the advantages of molality, many chemists prefer the ease of using molarity for conc.

Try this… 50.0 grams of sodium hydroxide is dissolved in a 0.500 liters of water. What is the molality of NaOH given that the density of water at that temperature is 1.0 g/mL?

"Don't go around saying the world owes you a living. The world owes you nothing. It was here first." ~ Mark Twain (1835 - 1910)

HONORS CHEMISTRY SOLUTIONS UNITS

NAME _________________

Treat these like test problems! List all relevant information, write out the blank equation, manipulate for the appropriate variables, show all work, show all units, and watch you sig figs!

Mr. Anticole wants to make 2.5 liters of 0.125 M strontium nitrate. How many grams of strontium nitrate does he have to measure out?

55 cmoles of sodium hypochlorite is dissolved in 1.00 liters of water (density 1.00 g/mL). What is the mass percent of sodium hypochlorite in that bleach solution?

Determine the molalities of the solutions in the two previous problems.

"The true measure of a man is how he treats someone who can do him absolutely no good."
-Samuel Johnson

HONORS CHEMISTRY: DILUTION IS THE SOLUTION! DATE:_____

Learning Activities: **SWBAT. . .**

…solve dilution problems and calculate new concentrations.

DILUTION: *A method of lowering the concentration of a solution by adding water.*

- The key to understanding dilution is that you ARE NOT changing the amount of solute.
- The moles if solute remain ___________________.
- What will change is ________________________ hence the concentration will also change.

Can set up the equation : $$M_iV_i = M_fV_f$$

Where **M_i =** **V_i =**

M_f = **V_f =**

Think about the units…

That should make sense…

Try this… 1000.0 mL of water is added to 300.0 mL of 5.00 M H_3PO_4. Determine the new conc.

"There are more of them than us." ~ Herb Caen

HONORS CHEMISTRY
DILUTION

NAME ________________

Treat these like exam problems. List relevant information & show all relevant work.

How much 0.50 M HCl can be made by diluting 250 mL of 10.0 M HCl?

If you add water to 100.0 mL of a 0.15 M NaOH solution until the final volume is 150.0 mL, what will molarity of the diluted solution be?

How much water would you need to add 500 mL of a 2.4 M KCl solution to make a 1.0 M solution?

"It takes a great deal of courage to stand up to your enemies, but even more to stand up to your friends." - J. K. Rowling

HONORS CHEMISTRY: Stoichiometry in Solutions **DATE:_____**

Learning Activities: **SWBAT. . .**
…apply stoichiometric principles to solutions.

MANY IMPORTANT CHEMICAL REACTIONS TAKE PLACE IN AQUEOUS ENVIRONMENTS.

- Stoichiometry is needed to predict mass and mole amounts between reactants and products.
- Often multiple ways to approach a problem. Be sure to have a game plan before starting.
- Take the time to plan and organize your work. No credit for work that cannot be followed!

HOW TO RECOGNIZE SOLUTION STOICHIOMETRY PROBLEMS:

- Involve a complete chemical reaction in a solution (i.e. both products and reactants.)
- You'll be given info. about one chemical and be expected to determine information about another.
- This will require that you use mole-mole ratios at some point.

THESE PROBLEMS OFTEN REQUIRE:

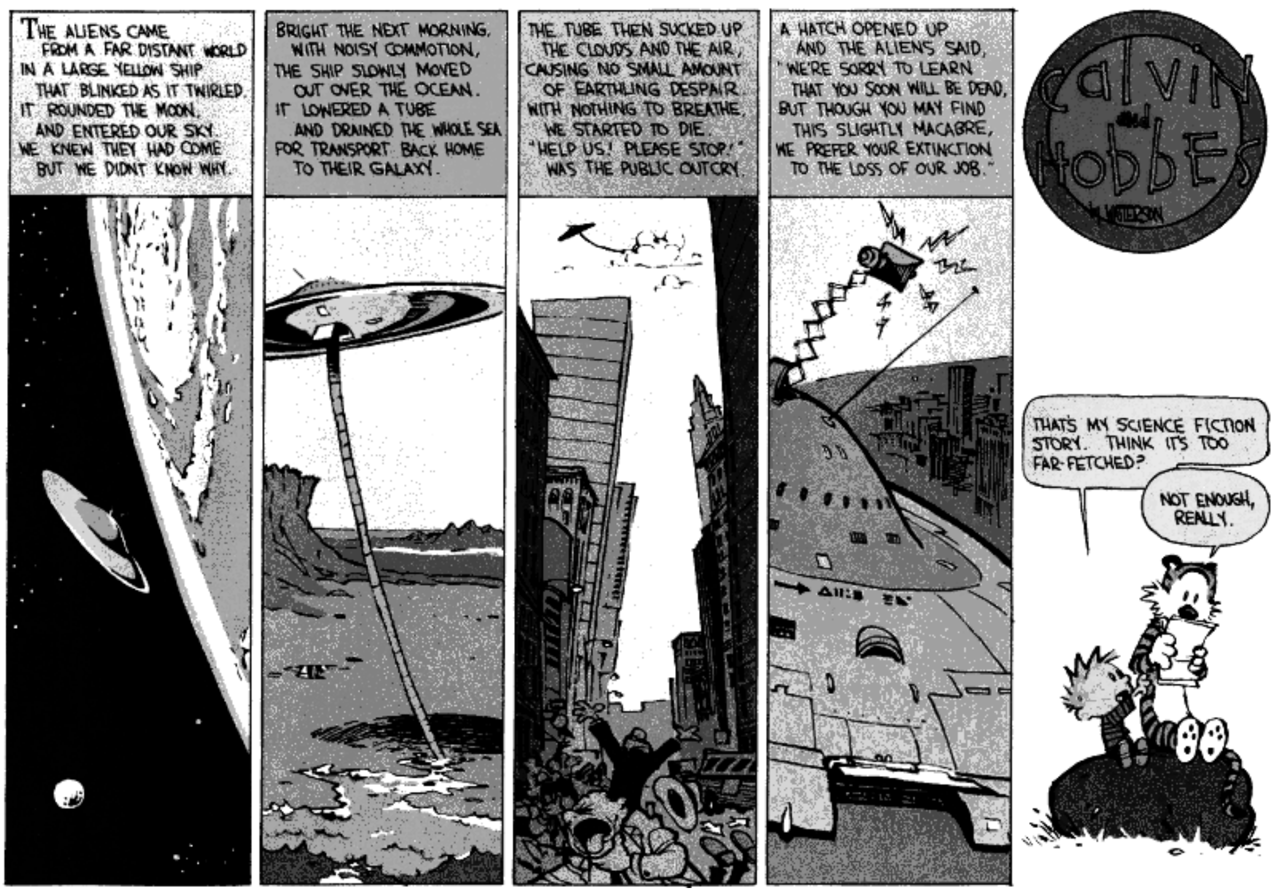
- *A balanced equation to determine…*
- *Concentrations and volumes to determine…*
- *Molar masses to determine…*
- *Precipitation rules to determine…*
- *Net ionic equations to determine…*

Watch out for limiting reactant problems. Be sure final answer is in the desired unit!

Try this… Mixing solutions of sodium sulfate and barium nitrate will produce an insoluble barium compound. What volume (in mL) of 0.25 M sodium sulfate would be needed to precipitate out all the barium found in 12.5 mL of 0.15 M barium nitrate?

Try this… 55.0 mL of 1.5 M calcium chloride solution is added to 125 mL of .950 M silver nitrate solution. How many milligrams of precipitate will form?

ANOTHER PERSPECTIVE



"A smooth sea never made a skilled mariner." ~ English Proverb

HONORS CHEMISTRY
SOLUTIONS STOICHIOMETRY

NAME ________________

Treat these like exam problems. List relevant information & show all relevant work.

How many milliliters of 0.75 M sodium hydroxide are needed to neutralize 275 mL of 0.50 M sulfuric acid?

When 53 mL of 0.75 M cobalt (III) nitrate are added to a sodium sulfate solution, how many grams of cobalt (III) sulfate can be precipitated?

What mass of solid aluminum hydroxide is produced when 125mg of aluminum nitrate is added to 200.0 mL of 0.100 M potassium hydroxide?

How many grams of precipitate will you get when 150. mL of 0.500 M silver nitrate is added to 100. mL of 0.400 M potassium chromate?

"If the only tool you have is a hammer, you tend to see every problem as a nail."
- Abraham Maslow

HONORS CHEMISTRY: NEUTRALIZATION REACTIONS DATE:_____

Learning Activities: **SWBAT. . .**

…review dilution work.

…incorporate acids and bases into solution stoichiometry.

NEUTRALIZATION REACTIONS

Strong acids complete dissociate in water. *Ex)*

Strong bases also completely dissociate in water. *Ex)*

If a strong acid is mixed with a strong base, the net ionic equation will be:

When enough acid or base is added to react completely with the other, the solution is said to be…

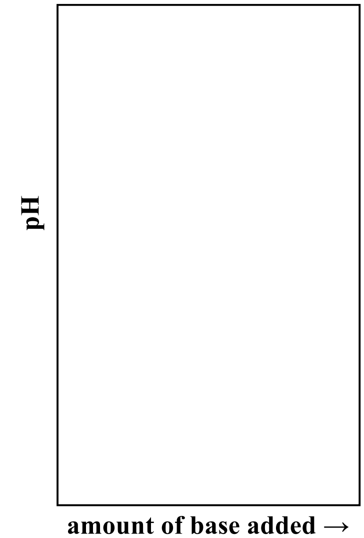
Try this… How many milliliters of .555 M NaOH(aq) are needed to neutralize 9.51 mL of 2.00 M HCl?

TITRATIONS: An analytical method used to determine the concentration of an unknown sample.

- You react the unknown solution with a solution of known concentration
- The data gained can be used to calculate _________________________________.
- Uses an **indicator** to let you know when the **equivalence point** has been reached.
- **Indicator:**
- **Equivalence point:**

FOR EXAMPLE… TITRATING A STRONG ACID WITH A STRONG BASE:

- At the beginning there is an overwhelming amount of acid ∴
- As you add base, some neutralization occurs, but…
- Even when there is only a little acid left…
- At the equivalence point there's just enough base to…
- Add a little more base and…
- Around the equivalence point…
- We use an indicator that changes color around…
- ex) Phenolphthalein:
- Different equivalence points call for…



WHY IS THE EQUIVALENCE POINT SO IMPORTANT?

- At that point, we know that___________________ equal________________________ .
- We can then solve for the concentration of the unknown using a familiar equation:

$$M_aV_a = M_bV_b$$

Where **M_a =** **V_a =**

M_b = **V_b =**

- Note, this equation can be tweaked to handle polyprotic acids. (Can you figure out how?)

Try this… Use the equation about to determine how many milliliters of .555 M NaOH(aq) are needed to neutralize 9.51 mL of 2.00 M HCl?

"You've got to do your own growing, no matter how tall your grandfather was." Irish Proverb

HONORS CHEMISTRY: Acids and Bases Revisited DATE:_____

Learning Goals: **SWBAT. . .**

…expand their definition of what an acid and a base are.
…identify conjugate acid-base pairs.
…differentiate between strong and weak acids.

In the 1880s, **SVANTE ARRHENIUS** came up with the definitions of acids and bases we've been using:

Acid: **Base:**

In the 1920's **JOHANNES BRONSTED + THOMAS LOWRY** defined acids and bases in a new way:

Acid: **Base:**

This was a more inclusive definition since it could account for…

When an acid releases a proton into water, it joins with water molecule to form a _________________.

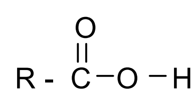
$$H_2O(l) + H^+(aq) \rightarrow H_3O^+(aq)$$

- If an acid releases only one hydrogen ion then it is called _______________. ex)
- If it can release more than one than it is called__________________. ex)

ex) If it can release two protons, it would be called___________________.ex)

(Obviously, polyprotic acids will require _____________ base to completely neutralize.)

- *Oxyacids:* ex)
- *Organic acids:*



ex)

Using the Bronsted-Lowry definitions, an acid dissociation can be represented with:

$$HA(aq) + H_2O(l) \rightarrow H_3O^+(aq) + A^-(aq)$$

CONJUGATE ACID-BASE PAIR:

What are the two pairs?

Try this… Write the conjugate acid for NH_3. Write the conjugate base for $HClO_4$.

Nothing is stopping the conjugate base (hydronium ion) from reacting with the conjugate acid:

$$H_3O^+(aq) + A^-(aq) \rightarrow HA(aq) + H_2O(l)$$

- This is often called the ____________ reaction (as opposed to the *forward* reaction)

This sets up a competition between the forward and reverse reactions (a.k.a.):

$$HA(aq) + H_2O(l) \qquad H_3O^+(aq) + A^-(aq)$$

If water wants the proton more than the conjugate base, then…

$$HA(aq) + H_2O(l) \qquad H_3O^+(aq) + A^-(aq)$$

- The acid completely dissociates/ionizes, so it would be considered a _________________

ex)

If the conjugate base wants the proton more than water, then…

$$HA(aq) + H_2O(l) \qquad H_3O^+(aq) + A^-(aq)$$

- There will be little dissociation/ionization, so it would be considered a _________.

ex)

STRONG ACIDS HAVE ________ CONJUGATE BASES (THAT'S WHY THE FORWARD REACTION DOMINATES).

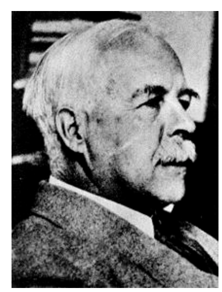
WEAK ACIDS HAVE ________ CONJUGATE BASES (THAT'S WHY THE REVERSE REACTION DOMINATES).

Note: bases can also be strong or weak, depending on how much conjugate acid forms:

ex) $NH_3(aq) + H_2O(l) \rightleftarrows NH_4^+(aq) + OH^-(aq)$ Ammonia is a ______ base.

ex) $NaOH(aq) \xrightarrow{H_2O} Na+(aq) + OH^-(aq)$ Sodium hydroxide is a ______ base.

DID YOU KNOW… "Gilbert Newton Lewis (of Lewis Dot fame) had an even broader broader definition of acids and bases as electron pair acceptors and donors, respectively. Gilbert Newton Lewis was probably the greatest and most influential influential of American chemists. Lewis believed that a chemistry department should should simultaneously teach science and advance it, always remembering that the most important emphasis must be placed on fundamental principles rather than its technical applications. During his career he published over 150 papers. Lewis' book, Valence and the Structure of Atoms and Molecules, is a classic, one of the greatest greatest contributions to modern bonding theory. Although Lewis never received the Nobel Prize, it is commonly felt that his work more than merited this award." (http://www.woodrow.org)

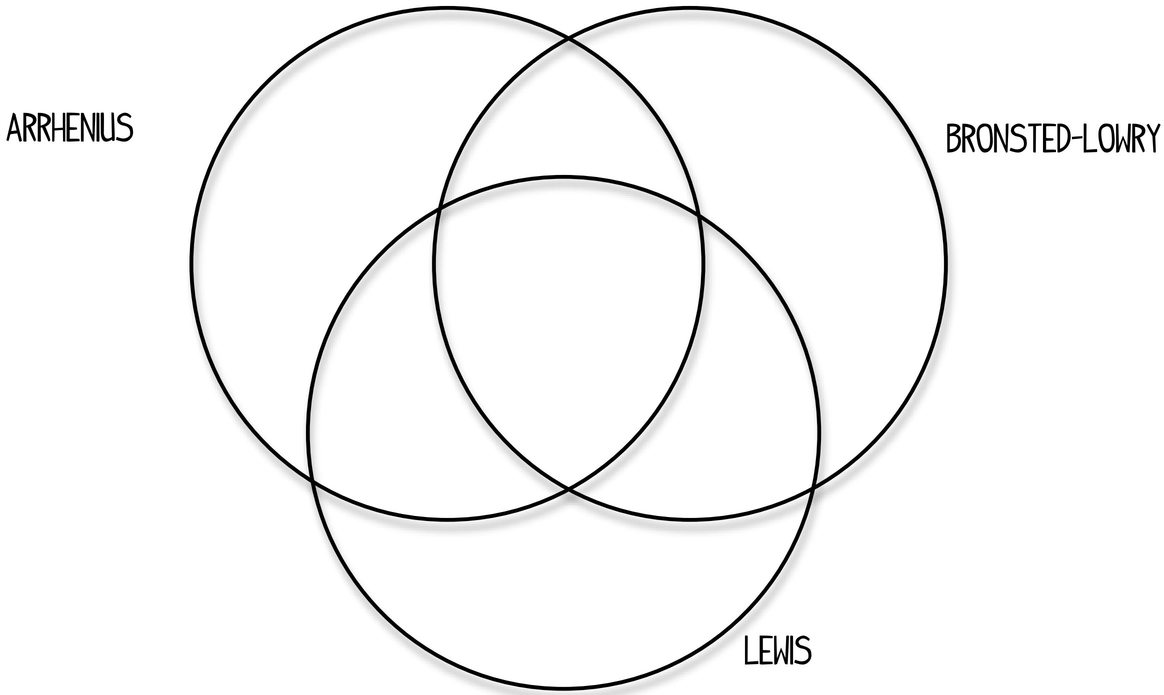


"I have attempted to give you a glimpse…of what there may be of soul in chemistry. But it may have been in vain. Perchance the chemist is already damned and the guardian the blackest. But if the chemist has lost his soul, he will not have lost his courage and as he descends into the inferno, sees the rows of glowing furnaces and sniffs the homey fumes of brimstone, he will call out-: 'Asmodeus, hand me a test-tube.'"-G.N. Lewis

HONORS CHEMISTRY
ACIDS AND BASES REVISITED

NAME _________________

Compare on contrast the different kinds of acids and bases... (research might be needed).



Identify the acid, base, conjugate acid and conjugate base in each of the following:

$$\mathbf{HNO_3\ (ag) + H_2O\ (l) \rightarrow H_3O^+\ (aq) + NO_3^-\ (aq)}$$

$$\mathbf{HCO_3^-\ (aq) + OH^-\ (aq) \rightarrow CO_3^{2-}\ (aq) + H_2O\ (l)}$$

$$\mathbf{NH_3\ (aq) + HCl\ (aq) \rightarrow NH_4^+\ (aq) + Cl^-\ (aq)}$$

$$\mathbf{H_2O\ (l) + H_2O\ (l) \rightarrow H_3O^+\ (aq) + OH^-\ (aq)}$$

"The meek shall inherit the earth? Well... I don't think so. If by meek you mean friendly and introverted, okay maybe, but if by meek you mean unwilling to take a chance, then never. If I was a betting man and I had to wager on who I thought would inherit the earth, my money would be on the curious." - Jim Coudal,

HONORS CHEMISTRY: pH   DATE:_____

Learning Activities: **SWBAT. . .**

…define amphoteric.
…apply the ion-product constant to water.
…calculate $[H_3O^+]$,$[OH^-]$, pH and pOH.

WATER IS AMPHOTERIC:

ex) $\mathbf{H_2O(l) + H_2O(l) \rightleftarrows H_3O^+(aq) + OH^-(aq)}$

- Water will **auto-ionize** into_____________ and______________ ions, but only to a very small degree.
- At pH 7, 25ºC, the concentrations are… $[H_3O^+] = [OH^-] = 1.0\text{x}10^{-7}$ *M*   [brackets indicate concentration]

The product of the concentrations of water is a constant known as $\mathbf{K_w}$

$\mathbf{K_w}$ **= ion-product constant =** $\mathbf{[H_3O^+][OH^-] = 1.0x10^{-14}}$ @25ºC (units are dropped)

This means that as one concentration increases, the other must…

- In neutral solutions,
- In acidic solutions,
- In basic solutions,

Note: $[H_3O^+]$ ***often written as just*** $[H^+]$

But no matter what, the product of these two concentrations must equal $\mathbf{K_w}$**!**

Try this… given one concentration, calculate the other. Then determine if acidic, basic, or neutral.

$[H^+] = 2.1\text{x}10^{-5}$ M   **$[OH^-] = 8.5\text{x}10^{-3}$ M**   **$[OH^-] = 1.0\text{x}10^{-7}$ M**

THE ACIDITY OF SOLUTIONS ARE MEASURED ON A LOGARITHMIC SCALE.

THE CONCEPT OF A LOGARITHM =

ex) 100 = $\therefore$ logarithm of 100 is $\therefore$ log(100) =

ex) 1000 = $\therefore$ logarithm of 1000 is $\therefore$ log(1000) =

ex) 0.1 = $\therefore$ logarithm of .1 is $\therefore$ log(0.1) =

- The log of a number like 457 will be in between…
- A change of one unit in a log scale represents a___________change in the numerical value.
- This allows us to see…
- Small changes in a log scale mean…
- Since the concentrations of $[H^+]$ and $[OH^-]$ can be small values, a log scale makes sense.

Since the log of numbers less than one are negative, $[H^+]$ is measured as…

$$pH = -\log [H^+] \quad \text{and} \quad pOH = -\log [OH^+]$$

Since strong acids and bases completely dissociate…

ex) **2.0 *M* HCl = *M* H^+**

2.0 *M* H_2SO_4 = *M* H^+

Logs have a special rule for significant figures. The number of decimal places for a log equals the sig.figs of the original number! ie. 1.0×10^{-1} *M* H^+ =

Try this… determine the pH and pOH of the three prior examples.

Notice: pH + pOH =

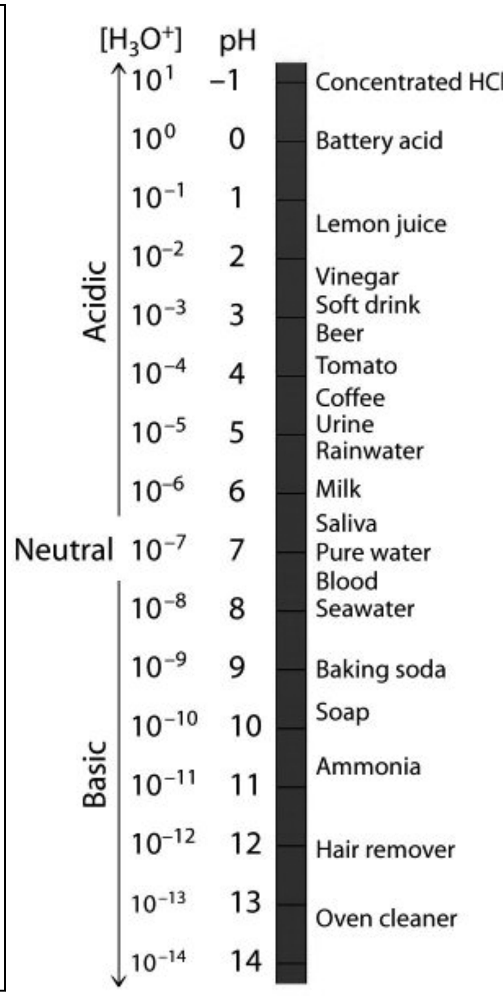
DID YOU KNOW… "…In solution at 25 °C, a pH of 7 indicates neutrality. Pure water, when exposed to the atmosphere, however, will take in carbon dioxide, some of which reacts with water to form carbonic acid, thereby lowering the pH to about 5.7.

…Neutral pH 25 °C at is not exactly 7. The value is consistent, however, with neutral pH being 7.00 to two significant figures, which is near enough for most people to assume that it is exactly 7.

…The pH of water gets smaller with higher temperatures. For example, at 50 °C, pH of water is 6.55±0.01. This means that a diluted solution is neutral at 50 °C when its pH is around 6.55 and that a pH of 7.00 is basic..

…Extremely acidic or extremely basic substances may have pH less than 0 or greater than 14. An example is acid mine runoff, with a molar concentration of 3981 M and a pH of - 3.6.

~www.wikipedia.org



"Fear secretes acids; but love and trust are sweet juices." ~ Henry Ward Beecher

HONORS CHEMISTRY

NAME ________________

PH

A. For each of the following, determine the missing information:

Log (10,000) = ___________	Log (___________) = -2
Log (-12.6) = ___________	Log (___________) = 10.2
Log (50,000) = ___________	Log (___________) = -8.22
Log (-1.6) = ___________	Log (___________) = 4.69

B. For each of the following, determine the missing information:

$[H_3O^+] = 4.43 \times 10^{-6}$	$[OH^-]$ = ___________	Acidic, basic or neutral?
$[H_3O^+]$ = ___________	$[OH^-] = 2.13 \times 10^{-4}$	Acidic, basic or neutral?
$[H_3O^+] = 1.9 \times 10^{-8}$	$[OH^-]$ = ___________	Acidic, basic or neutral?
$[H_3O^+]$ = ___________	$[OH^-] = 7.5 \times 10^{-11}$	Acidic, basic or neutral?

C. Write down the equations for pH and pOH:

D. Determine the pH and pOH of each of the solutions in part B. (You can write it to the left of the hydrodium and hydroxide concentrations.)

E. Why is it harder to determine the pH of a weak acid?

"The real hero is always a hero by mistake;
he dreams of being an honest coward like everybody else." - Umberto Eco

HONORS CHEMISTRY
NEUTRALIZATION & TITRATION

NAME ________________

You used 47.2 mL of .965 M sodium hydroxide to titrate 200.0 mL of hydrochloric acid of an unknown concentration.

Estimate the concentration and original pH of the acid.
Then solve for the concentration and original pH of the acid.

There are a lot more pH indicators out there besides good old phenolphthalein. Color in these pH scales to show what color they are at different pHs. (Research needed!)

Litmus

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

Red cabbage juice

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

methyl red

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

bromothymol blue

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

"You can know the name of a bird in all the languages of the world, but when you're finished, you'll know absolutely nothing whatever about the bird... So let's look at the bird and see what it's doing -- that's what counts. I learned very early the difference between knowing the name of something and knowing something." - Richard Feynman