Objective 5

Double replacement reactions 1: balancing precipitation reactions,
applying solubility table,
write net ionic equations to predict whether a reaction occurs,
perform mole-mass and mole ratio calculations (gravimetric)

Lab 3: How Do You Make an Antacid??

http://www.vitacost.com/tums-regular-strength-antacid-and-calcium-supplement

http://phillipsrelief.com/products/phillips-milk-magnesia

Stomach acid ≈ 0.2 M HCl (pH 1-2).
When pH is below this value ==> indigestion and heartburn.
Use Antacid to neutralize excess acid and raise pH.

Antacid Ingredient	Properties
$NaHCO_3$	Fast-acting, but can affect the bladder and kidneys upon prolonged use. High Na content.
$CaCO_3$	Excellent antacid but may stimulate the stomach to secrete more acid (acid rebound); prolonged use may cause constipation and impaired kidney function.
$Al(OH)_3$, $Mg(OH)_2$	Relatively safe, slow-acting but provides long lasting antacid action. $Al(OH)_3$ causes constipation so $Mg(OH)_2$ is usually added.

Some antacids contain aspirin or caffeine.

Chem 1A Reactions: **predict products**

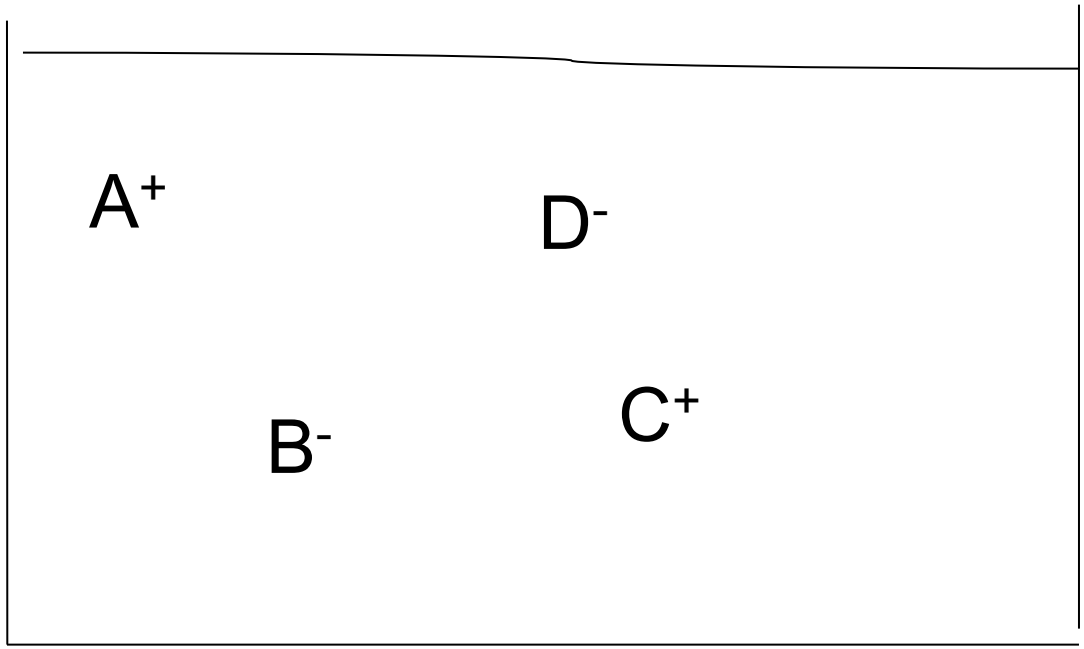
1. Double replacement
    - Precipitation
    - Acid-base
    - Gas forming

2. Single replacement
    - Oxidation-reduction

3. Combustion

A **Double Replacement Reaction** involves the reaction of two compounds to produce two new compounds. *Note the ions exchange with each other.*

$$AB\ (aq) + CD\ (aq) \rightarrow AD + CB$$



Aqueous solution: a soluble ionic compound breaks up into ions (see **Solubility Rules Table**). Forms *electrolyte* solution.

What can you use this solution for?

3 types of **Double Replacement** reactions:

1. Precipitation: see *Solubility Rules Table*.

2. Acid-base

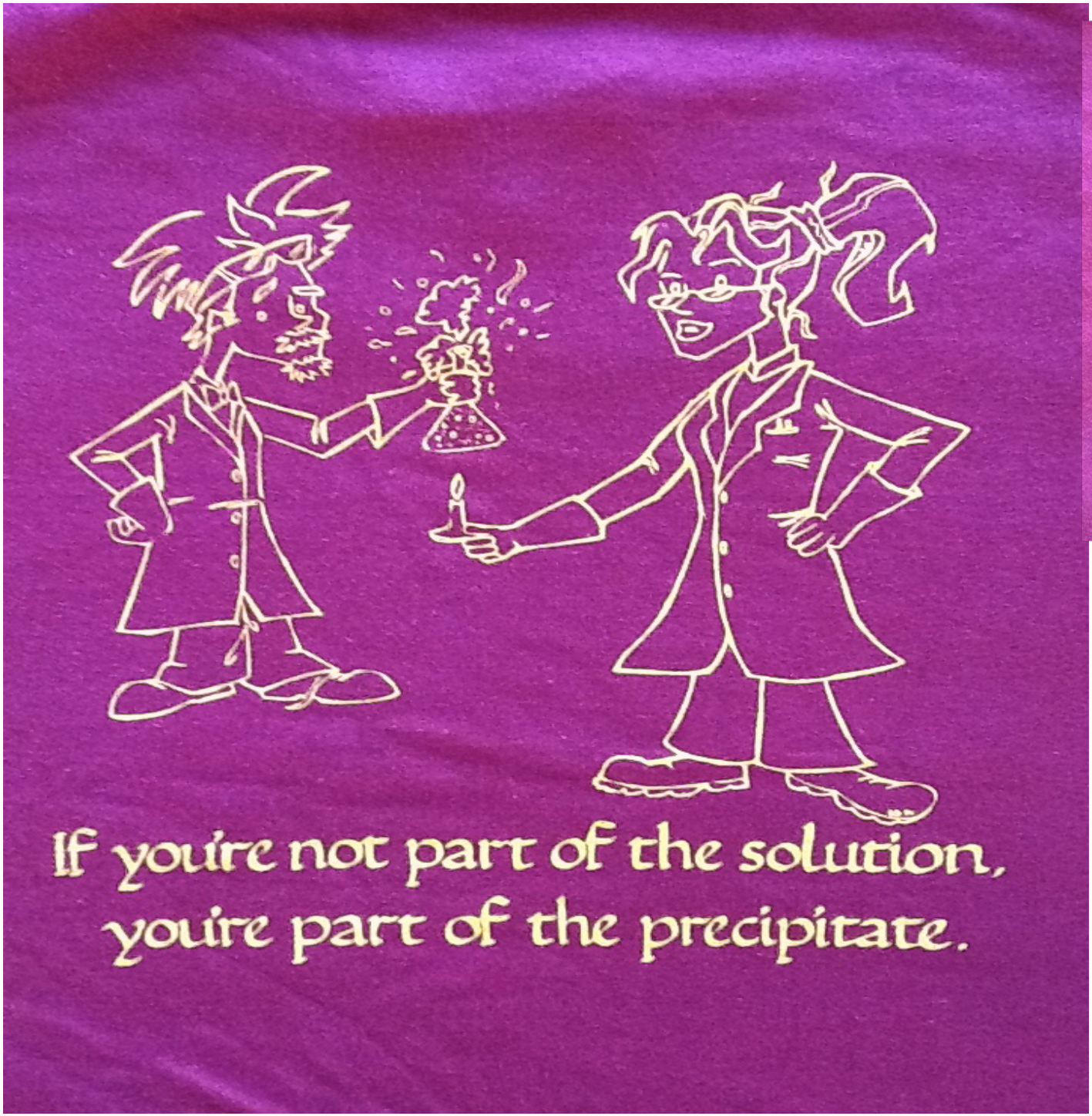
3. Gas forming (type of acid-base reaction):

    one reactant is a **base** that contains CO_3^{2-} or HCO_3^-

    What is the other reactant?

    one product is H_2CO_3 --> H_2O + CO_2 (g).

    3 products total.

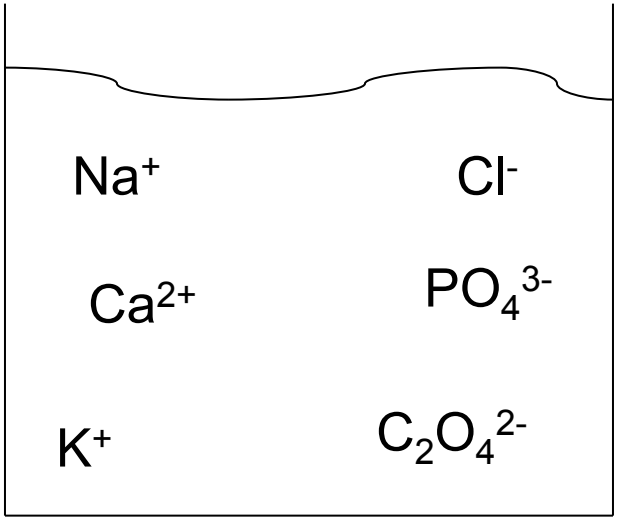


-Steven Wright

Solubility of Ionic Compounds in Water

Soluble	**Exceptions**
Alkali metals (Group 1A) and NH_4^+ salts	Some Li^+ salts are insoluble
Nitrates, bicarbonates	
Halides (F^-, Cl^-, Br^-, I^-)	Ag^+, Pb^{2+}, Hg_2^{2+}
Sulfates	Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}, Ag^+, Hg^{2+}
Insoluble	Exceptions
Hydroxides	Alkali metals (e.g., NaOH), NH_4^+
Carbonates, Phosphates	Alkali metals, Ba^{2+}

How do Kidney Stones form?

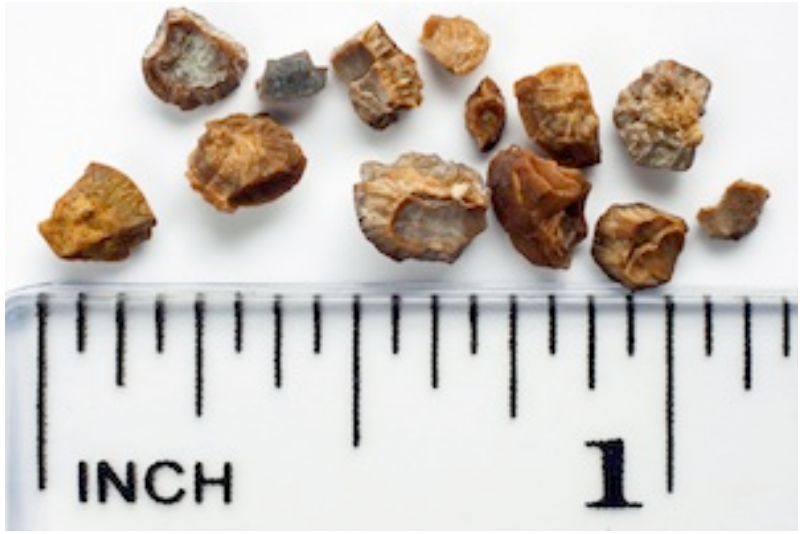


http://www.globalhealingcenter.com/natural-health/what-are-kidney-stones/

Which ions combine to form a *precipitate*?

E.g., does Na^+ combine with Cl^- to form NaCl (s)?
Or does K^+ combine with PO_4^{3-} to form K_3PO_4 (s)?

How do Kidney Stones form?



http://www.globalhealingcenter.com/natural-health/what-are-kidney-stones/

$Ca^{2+}(aq) + PO_4^{3-}(aq) \longrightarrow Ca_3(PO_4)_2(s)$

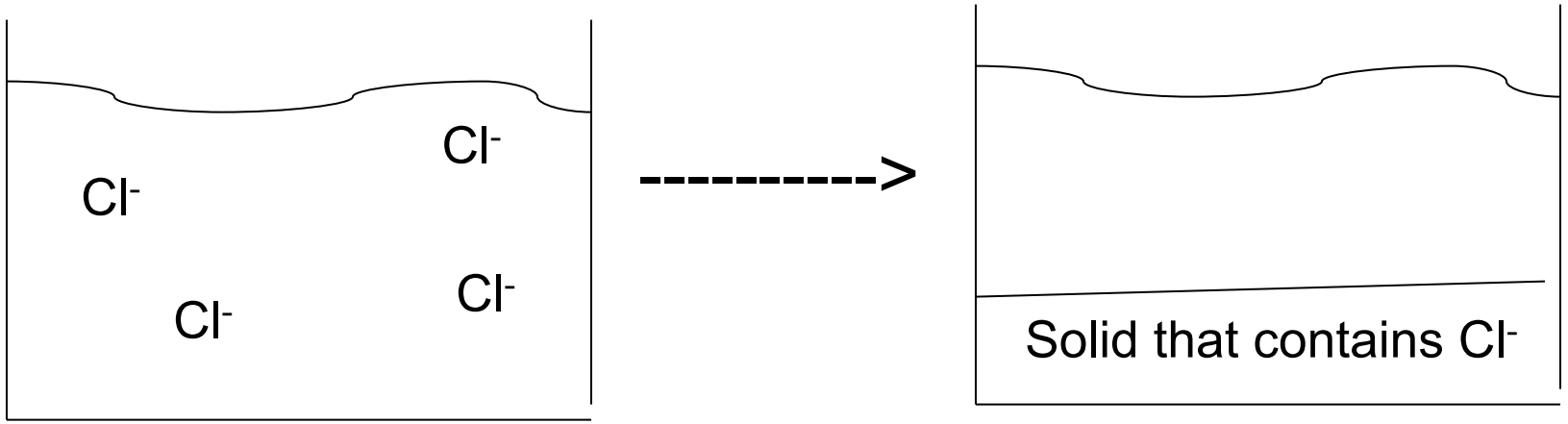
$Ca^{2+}(aq) + C_2O_4^{2-}(aq) \longrightarrow CaC_2O_4(s)$

Best way to prevent kidney stones?

An Ion Can Be <u>Removed</u> from a Solution by ***Precipitation***

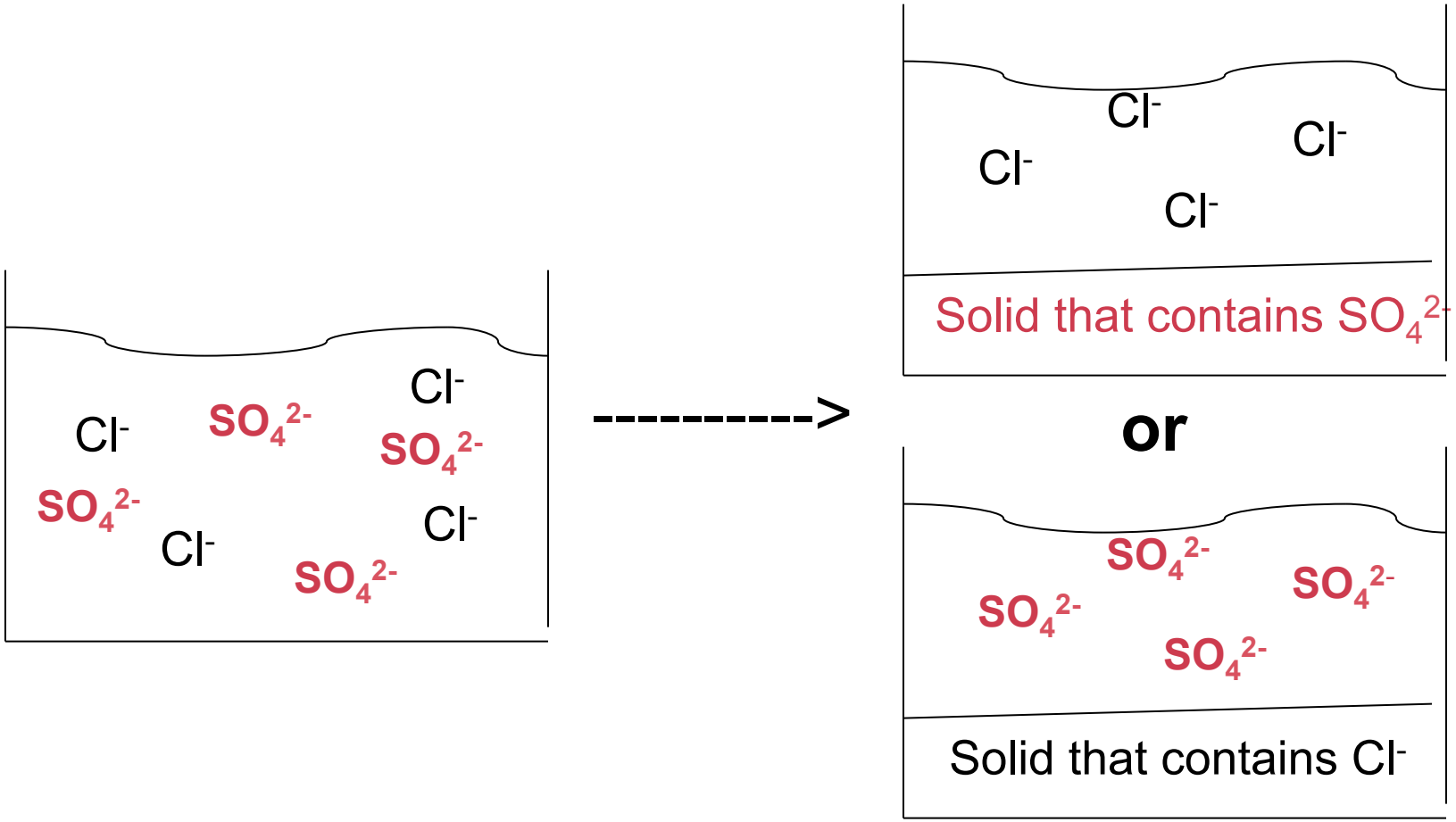
Add a substance that combines with the ion you want removed to form an ***<u>insoluble solid</u>***

An aqueous solution contains chloride. Name two substances you would add to this solution to precipitate the chloride out of solution as a solid. Write a chemical equation that represents each reaction.



Ions Can Be Separated from a Solution by ***Precipitation***

An aqueous solution contains chloride and sulfate. You want to separate the chloride and sulfate. What substance would you add to this solution to accomplish this separation? Write a chemical equation that represents this reaction.



Lab 3. How to make an Antacid?

Which reactants would you use to make $CaCO_3$?

Choices:

$NaOH$

K_2CO_3

$MgCl_2$

$Ca(NO_3)_2$

E.g., Mix $NaOH$ with $Ca(NO_3)_2$. Will $CaCO_3$ form?

YES NO

Objective: Predict the product(s) of the following reaction.

$NaOH\ (aq) + Ca(NO_3)_2\ (aq) \text{ -----}>$

a. $NaCa + OHNO_3$

b. $Na(NO_3)_2 + CaOH$

c. $NaNO_3 + Ca(OH)_2$

Then, balance the equation.

A ***Precipitation Reaction*** produces a **Solid** (precipitate)

Hint: use AB (aq) + CD (aq) --> AD + CB

Predict the product(s) and balance the equation:

$NaOH + Ca(NO_3)_2$ --->

Hint: A = _____, B = _____, C = _____, D = _____

Use charge and subscripts to write a correct chemical formula.

Use coefficients to balance the chemical equation.

This reaction makes Lime for fertilizer.

Write a Net Ionic Equation for:

$2\ NaOH + Ca(NO_3)_2 \longrightarrow 2\ NaNO_3 + Ca(OH)_2$

This reaction is used to make lime (fertilizer).

If *you can write a* ***Net Ionic Equation***: a **Reaction occurs**! (Prediction)

If *All the ions are spectator ions*: No ionic equation and *No reaction occurs*.

Nothing happens by just watching!

A ***Net Ionic Equation*** Shows What Is Happening in Solution

IDENTIFY "Active" reactants and "spectator" ions.

$$2\ NaOH + Ca(NO_3)_2 \dashrightarrow 2\ NaNO_3 + Ca(OH)_2$$

Break appropriate compounds into ions (show **sign** and **magnitude**):

Molecular compound: leave as molecule (why?)

Ionic compound soluble in water: break into two ions

Ionic compound insoluble in water: leave as compound

Strong acid: break into two ions (why?)

Weak acid: leave as molecule (why?)

Where do I find this information about acids and solubility?

Molecular eq:

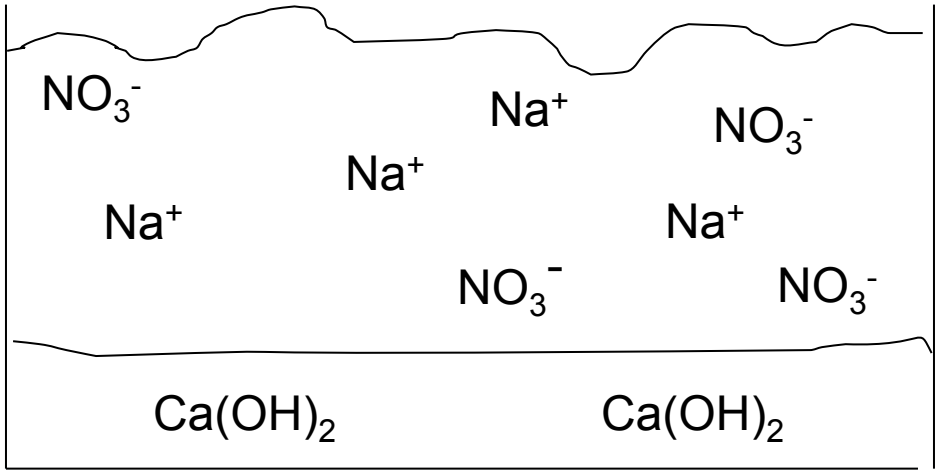
$$2\ NaOH + Ca(NO_3)_2 \rightarrow 2\ NaNO_3 + Ca(OH)_2$$

Ionic eq:

$$2\ Na^+ + 2\ OH^- + Ca^{2+} + 2\ NO_3^- \rightarrow 2\ Na^+ + 2\ NO_3^- + Ca(OH)_2\,(s)$$

Spectator ions (Na^+ and NO_3^-) do **NOT** participate in the reaction.

Net Ionic eq: $2\ OH^- + Ca^{2+} \rightarrow Ca(OH)_2\,(s)$



Objective: Given mass of product, calculate mass of reactant
(Similar to Lab 3 calculation)

I want to make 1 g of $Ca(OH)_2$ (s). *(**Slaked lime** – for fertilizer)*

$2\ NaOH + Ca(NO_3)_2 \rightarrow 2\ NaNO_3 + Ca(OH)_2$

How many g of NaOH do I need to use?

Method: 1. convert mass of $Ca(OH)_2$ to moles of $Ca(OH)_2$.
2. Convert moles of $Ca(OH)_2$ to moles of NaOH.
3. Convert moles of NaOH to mass of NaOH.

Answer: 0.54 g 1.0 g 1.1 g

Objective: Given mass of product, calculate mass of reactant
(Similar to Lab 3 calculation)

I want to make 1 g of $Ca(OH)_2$ (s).

$2\ NaOH + Ca(NO_3)_2 \rightarrow 2\ NaNO_3 + Ca(OH)_2$

How many g of $Ca(NO_3)_2$ do I need to use?

Answer: 1.1 g 2.2 g 4.4 g

Check your answer:
How many g of $NaNO_3$ is produced?
Use Conservation of Mass:
Does mass of reactants = mass of products?

Objective: Predict whether a reaction occurs. If so, write a molecular equation and net ionic equation.

Saline solution (NaCl (aq)) is added to $AgNO_3$ (aq).

The precipitate is:

a. NaAg
b. $NaNO_3$
c. AgCl
d. $ClNO_3$
e. No precipitate (no reaction)

This reaction is used to test for the amount of sodium in a water sample.

Saline solution (NaCl (aq)) is added to $AgNO_3$ (aq)

1. ID products. Use charge. Make sure chemical formulas are correct!

$$NaCl\ (aq) + AgNO_3\ (aq) \rightarrow NaNO_3\ (?) + AgCl\ (?)$$

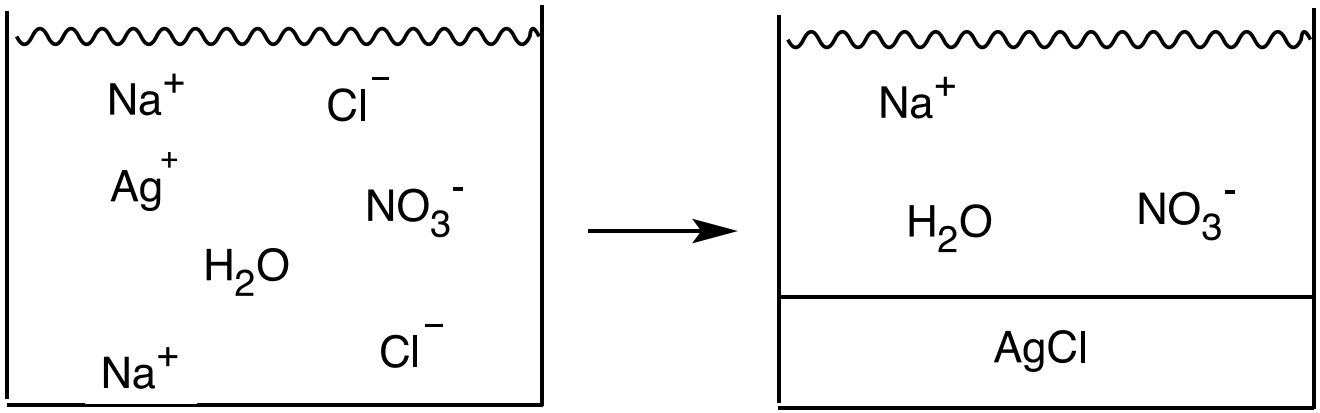
2. Is $NaNO_3$ soluble? Is AgCl soluble? **Use the Solubility Rules Table**

$$Na^+\ (aq) + Cl^-\ (aq) + Ag^+\ (aq) + NO_3^-\ (aq) \rightarrow Na^+\ (aq) + NO_3^-\ (aq) + AgCl\ (s)$$

3. ID and get rid of spectator ions.

So: $Cl^-\ (aq) + Ag^+\ (aq) \rightarrow AgCl\ (s)$

This reaction is used to test for Cl^- in water, which tells you how much Na^+ is in the water.



Gravimetric Analysis

Test for the amount of sodium in a water sample: See Practice Problem 4e.

$NaCl\ (aq) + AgNO_3\ (aq) \rightarrow NaNO_3\ (aq) + AgCl\ (s)$

$AgNO_3$ (aq) is added to a 10.00 ml water sample.
A solid forms and is collected and dried.
The mass of the dried solid is 0.25 g.

What is the solid?
From the mass of solid, calculate the mass of Na in this water sample. (What conversion factor do you use?)

The RDA of sodium is 2300 mg per day.
Would you drink a cup (240 ml) of this water to get your RDA of sodium?

LIMITING and EXCESS reactants

It is BEST to use the exact amount of reactants to make products to reduce waste (green chemistry)

But many reactions need an EXCESS of one reactant to make the reaction occur.

Excess reactant – doesn't all react, some leftover
Limiting reactant – completely reacts
- "limits" the amount of product formed

LIMITING and EXCESS reactants

Example: 1 torso (T) + 1 head (H) + 2 arms (A) + 2 legs (L) make 1 body ($T_1H_1A_2L_2$)

$$1\ T + 1\ H + 2\ A + 2\ L \rightarrow T_1H_1A_2L_2$$

Dr. Frankenstein has 10 heads, 17 torsos, 18 arms, and 21 legs. How many “Frankies” can Dr. Frankenstein make?

LIMITING and EXCESS reactants

Example: 1 torso (T) + 1 head (H) + 2 arms (A) + 2 legs (L) make 1 body ($T_1H_1A_2L_2$)

$$1\ T + 1\ H + 2\ A + 2\ L \rightarrow T_1H_1A_2L_2$$

Initial	10	17	18	21	
Reacts	9	9	18	18	Produced = 9
Leftover	1	8	0	3	

Dr. Frankenstein has 10 heads, 17 torsos, 18 arms, and 21 legs. Dr. Frankenstein can make 9 “Frankies”.

LIMITING and EXCESS reactants

Example: 1 torso (T) + 1 head (H) + 2 arms (A) + 2 legs (L) make 1 body ($T_1H_1A_2L_2$)

$$1\ T + 1\ H + 2\ A + 2\ L \rightarrow T_1H_1A_2L_2$$

The mass per body part ("molar" mass) of A = 3.6 kg, L = 10.4 kg, H = 3.9 kg, T = 23.8 kg. 500 g each of A, L, H, and T are mixed together and undergo a reaction. What is the theoretical yield of bodies?

Hint: determine limiting reactant.
Limiting reactant determines amount of product (bodies)

LIMITING and EXCESS reactants

Na_2SO_4 is used as a drying agent.
100 g of TSP reacts with 100 ml 1 M $MgSO_4$.

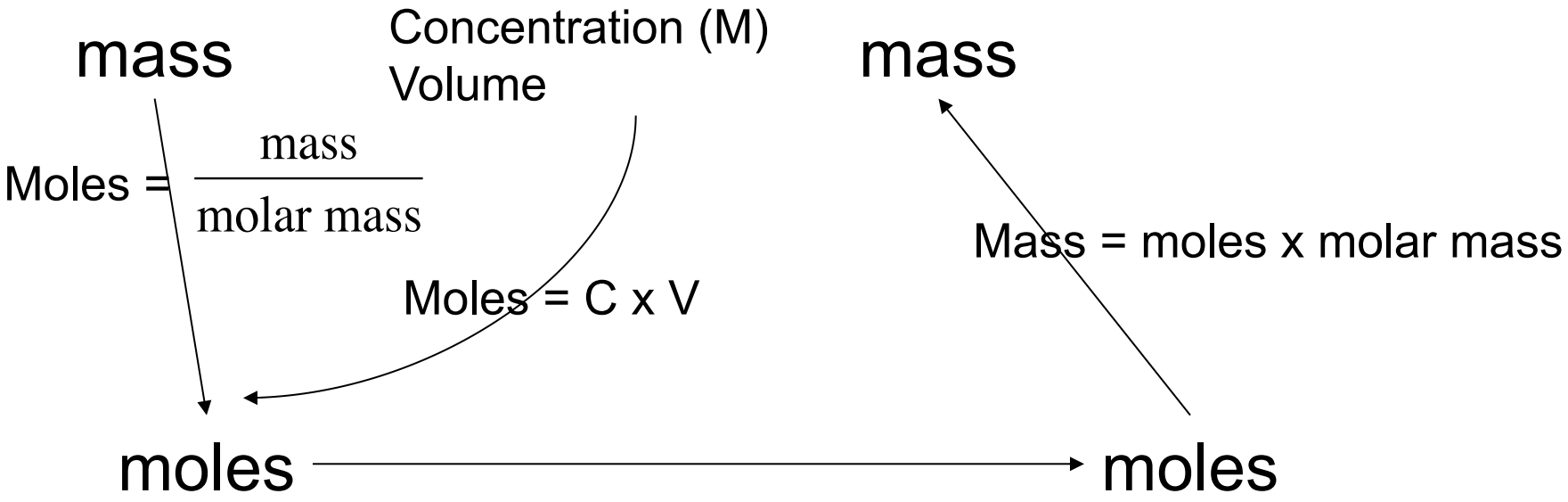
TSP (Na_3PO_4) reacts with $MgSO_4$ (aq)

a. Write a molecular equation and net ionic equation.
b. Which reactant is the limiting reactant?
c. Calculate the mass of Na_2SO_4 that is produced.

100 g of TSP reacts with 100 ml 1 M $MgSO_4$.
Calculate the mass of Na_2SO_4 that is produced.

USE MOLES MOLES MOLES!!

$$2\ Na_3PO_4 + 3\ MgSO_4 \rightarrow 3\ Na_2SO_4 + Mg_3(PO_4)_2$$



Use coefficients to determine mole ratio:
2 moles Na_3PO_4 to 3 mole Na_2SO_4.
3 moles $MgSO_4$ to 3 mole Na_2SO_4.

Na_2SO_4 is used as a drying agent.

Another Type of Double Replacement Reaction:

Precipitate dissolves (reverse of ppt reaction)
E.g., tooth enamel dissolves in acid

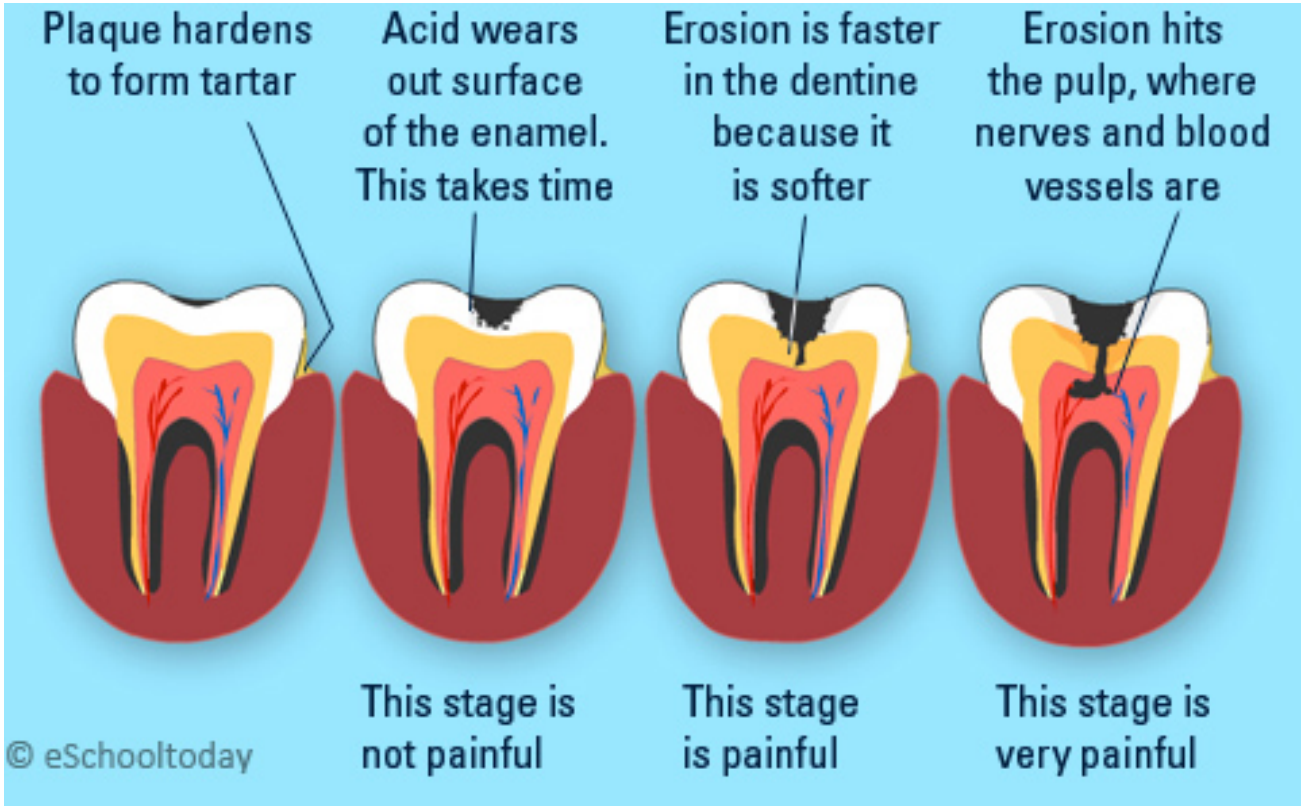
http://aidicine.com/about-your-teeth/

Tooth enamel is the mineral apatite, $Ca_5(PO_4)_3(OH)$.

Enamel is the hardest substance in our body

http://blogs.sacurrent.com/index.php/soda-tax-would-likely-reduce-diabetes-rates-in-san-antonio/

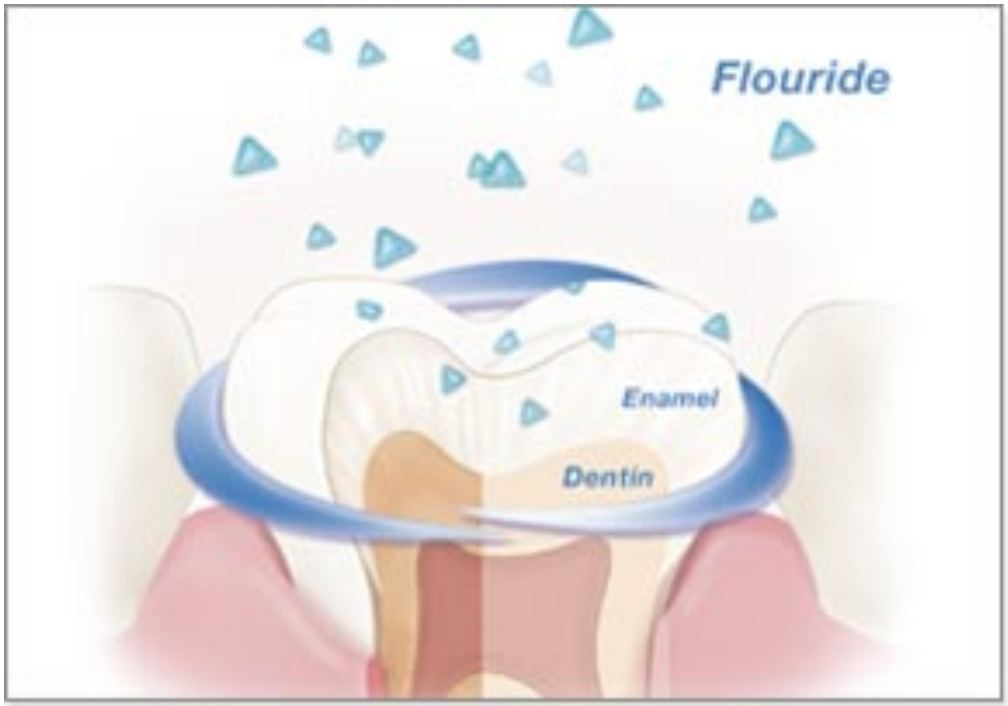
Acidic foods, like soda and tomato sauce, can remove tooth enamel and lead to tooth decay (cavities).



http://www.eschooltoday.com/tooth-care-for-children/tooth-gum-dental-decay.html

Fluoride is added to water or toothpaste to prevent tooth decay. Fluoride reacts with tooth enamel to form an acid-resistant coating. Write a chemical equation that represents this reaction.

$Ca_5(PO_4)_3(OH) + F^- \rightarrow$



http://www.amazon.com/Rembrandt-Intense-Stain-Toothpaste-Ounce/dp/B00005IBW1

New Materials for Tooth Decay

(http://cen.acs.org/articles/94/i31/New-materials-take-bite-tooth.html)

Cavity slayer:
silver diamine fluoride = $AgF(NH_3)_2$

When silver diamine fluoride is brushed on a cavity, the silver acts as an antimicrobial agent and the fluoride promotes tooth remineralization. Ammonia stabilizes the mixture in solution.

http://cen.acs.org/articles/90/i14/Removing-Radioactivity.html

4/2/12, CEN, "Removing Radioactivity"

Radioactive ^{89}Sr and heavy metals are removed from beverages with $CaWO_4$ nanoparticles:

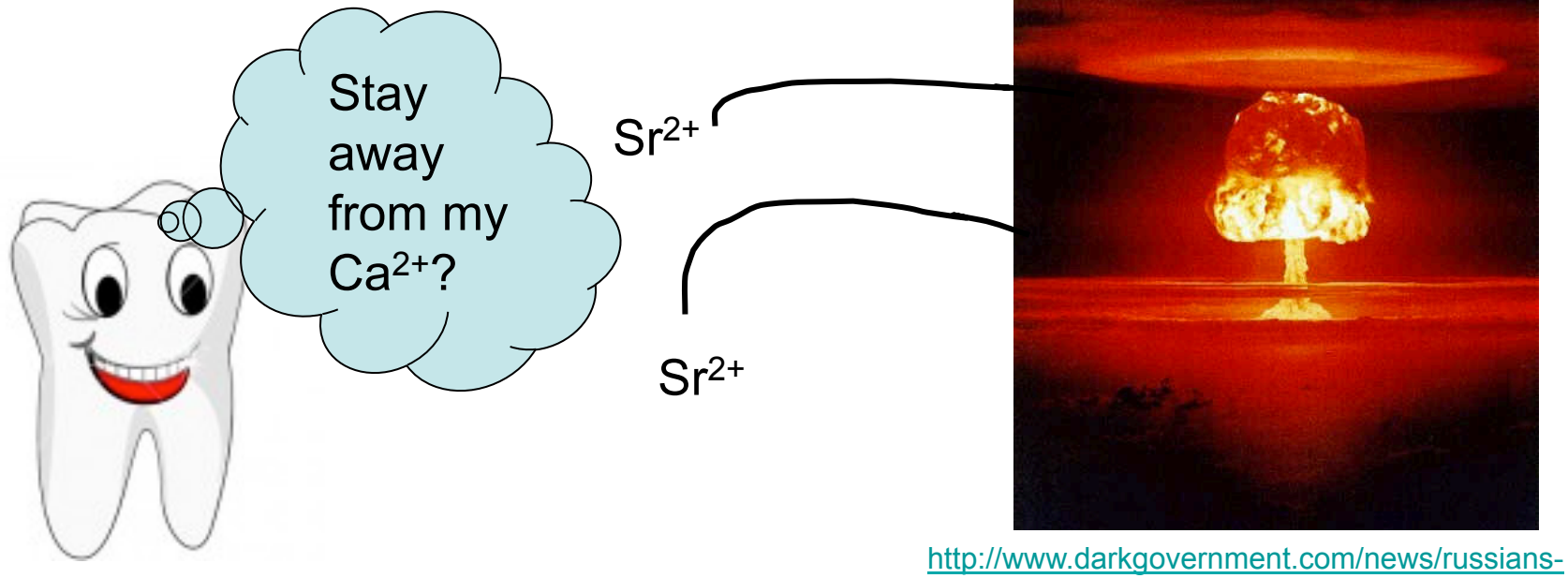
$$CaWO_4 + {}^{89}Sr^{2+} \quad \text{---->}$$

Yellow pellets composed of $CaWO_4$ nanoparticles can be used to remove radioactive Sr from liquids, such as milk.

Strontium-90, a radioactive isotope of strontium, is considered the most dangerous part of radioactive fallout from atom bomb tests because it can replace the calcium in foods and become concentrated in bones and teeth.

Explain why strontium can replace calcium.

Tooth enamel is the mineral apatite, $Ca_5(PO_4)_3(OH)$. Write a chemical equation that represents the reaction between strontium and tooth enamel.



http://www.darkgovernment.com/news/russians-claim-nuclear-blast-occurred-in-illinois/