Slide 1

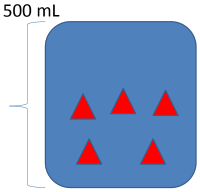
Dilution Solution

Solution Dilution

Slide 2

What's the "concentration" of red triangles?

500 mL



A. $\frac{5}{L}$
B. $\frac{5\ red\ triangles}{Liter}$
C. $\frac{10\ red\ triangles}{Liter}$
D. 10 M
E. 5 M

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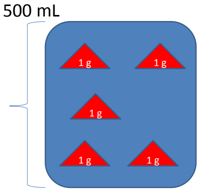
What's the "concentration" of red triangles?

500 mL



A. $10\frac{red\ triangles}{L}$
B. $10\frac{g}{L}$
C. $1\%\ by\ mass$
D. $0.01\frac{g}{mL}$
E. All of the above

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Concentration is…

…any statement of the relationship between the amount of stuff ("solute") dissolved in a solvent/solution.

$$\frac{some\ measure\ of\ solute}{some\ measure\ of\ solution}$$

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Could be ANYTHING

$$\frac{g\ of\ solute}{g\ of\ solution}$$
$$\frac{mL\ of\ solute}{mL\ of\ solution}$$
$$\frac{moles\ of\ solute}{moles\ of\ solution}$$
$$\frac{moles\ of\ solute}{L\ of\ solution}$$

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UNITS! UNITS! UNITS!

The units are your friend – ALWAYS! The units tell you how to measure your "stuff".

$$M = \frac{moles\ of\ solute}{L\ of\ solution}$$

So, if I've got Molarity (M), I probably want to measure the volume…

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$$L\ of\ solution \frac{moles\ of\ solute}{L\ of\ solution} = moles\ of\ solute$$

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If I have…

$$\frac{g\ of\ solute}{g\ of\ solution}$$

Then I want to measure…

GRAMS of solution!

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$$grams\ of\ solution \frac{grams\ of\ solute}{grams\ of\ solution} = grams\ of\ solute$$

Concentration is always just a conversion factor between the way you measured the solution and how much solute you've got!

The SOLUTE is almost always the thing you care about. The solvent/solution is just the carrier.

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When you mix things…

…you "dilute" them.

But the concentration is still just the ratio of the amount of solute and the amount of solution.

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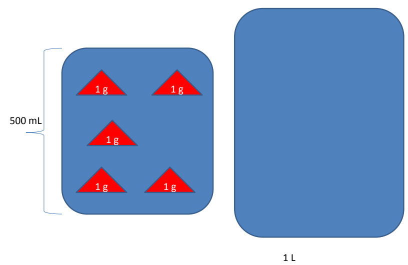
If I add 1 L of water



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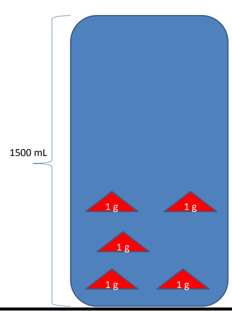

Volumes add.

Pick your favorite concentration unit:

$$\frac{5\ g\ of\ red\ triangles}{1.5\ L\ solution} = 3.333 \frac{g\ of\ rt}{L}$$

$$\frac{5\ red\ triangles}{1.5\ L\ solution} = 3.333\ \frac{rt}{L}$$

Etc.

Chemistry is all about MOLES! MOLES! MOLES!
So something like Molarity is usually our fav

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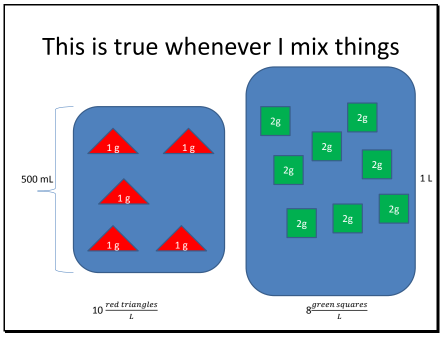

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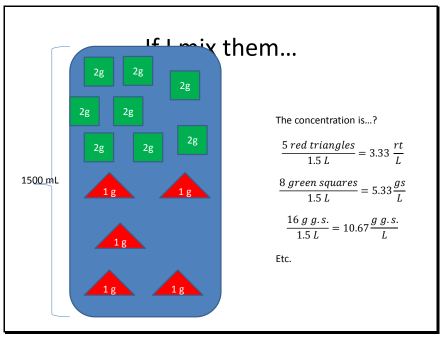

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It's tough when they are invisible…

…so make them visible.

A picture paints 1000 words (…so why can't I paint you?).

If you can draw it so you can see it, it makes pretty good common sense.

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50 mL of 0.215 M Na_2SO_4 is mixed with 200 mL of 0.500 M $PbSO_4$. What is the concentration of Na_2SO_4 after mixing?

I think I'll draw a picture!

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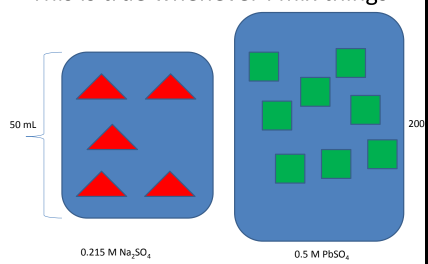
This is true whenever I mix things



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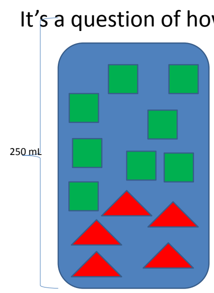
It's a question of how many there are…



MOLES IS NUMBER!

But how many "moles" do I have?

$$0.215\ M = \frac{0.215\ mol}{L}$$

$$0.050\ L\ orig\ \frac{0.215\ mol}{L\ orig}$$

=0.01075 mol

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M is just a conversion factor

Notice I multiply 50 mL by the concentration not 250 mL.

Why? (you may ask)

Because the concentration applied to THAT solution.

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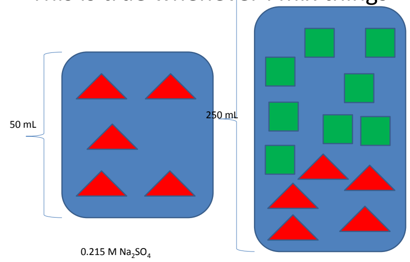
This is true whenever I mix things



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Conservation of moles…

In general, there's no such thing. But in a dilution there is…

Moles at the beginning = moles at the end!

It's just the volumes that change.

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Plug and chug

This sometimes gets written in algebraic form:

$M_1V_1 = M_2V_2$

Or sometimes
$C_1V_1 = C_2V_2$

It still boils down to:
Moles in "solution 1" = Moles in "solution 2"

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Plug and chug

This sometimes gets written in algebraic form:

$M_1V_1 = M_2V_2$

$$\frac{moles\ in\ 1}{L\ of\ 1} L\ of\ 1 = \frac{moles\ in\ 2}{L\ of\ 2} L\ of\ 2$$

Notice that the Molarity of a solution is coupled with the volume of that solution.

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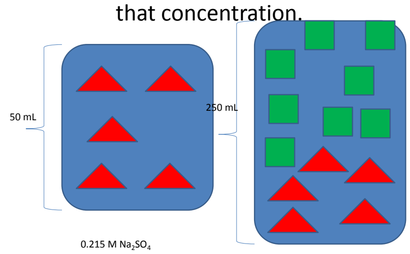
That's why the 0.215 M goes with the 50 mL – that's the solution that has that concentration.



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$0.215\ M\ Na_2SO_4$ (50 mL) = M_2 (250 mL)

M_2=0.043 M Na_2SO_4

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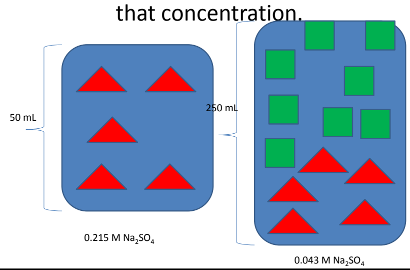
That's why the 0.215 M goes with the 50 mL – that's the solution that has that concentration.



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The units must cancel…

…but it doesn't matter what they are…

$C_1V_1 = C_2V_2$

As long as the "C"s are in the SAME units and the "V"s are in the SAME units, everything is fine.

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$$Molarity \times mL = Molarity \times mL$$
$$\% \; by \; mass \; \times L = \% \; by \; mass \; \times L$$

$$Molarity \; \times gallons = Molarity \; \times gallons$$

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Question

When 50.00 mL of 0.125 M silver (I) nitrate is mixed with 50.00 mL of 0.250 M sodium sulfate a greyish solid forms. If I recover 0.813 g of solid, what is the yield of the reaction?

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Limiting reactant problem

How do I know?
I have limited amounts of each reactant.

When 50.00 mL of 0.125 M silver (I) nitrate is mixed with 50.00 mL of 0.250 M sodium sulfate a greyish solid forms. If I recover 0.813 g of solid, what is the yield of the reaction?

Where do I start?

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ALWAYS A BALANCED EQUATION!

When 50.00 mL of 0.125 M silver (I) nitrate is mixed with 50.00 mL of 0.250 M sodium sulfate a greyish solid forms.

$AgNO_3$ (aq) + Na_2SO_4(aq) → ???

What type of reaction is this?

Double replacement – two ionic reactants!

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ALWAYS A BALANCED EQUATION!

$AgNO_3$ (aq) + Na_2SO_4(aq) → Ag^+ + NO_3^- + Na^+ + SO_4^{2-}

$AgNO_3$ (aq) + Na_2SO_4(aq) → Ag_2SO_4 + $NaNO_3$

2 $AgNO_3$ (aq) + Na_2SO_4(aq) → Ag_2SO_4 + 2 $NaNO_3$

2 $AgNO_3$ (aq) + Na_2SO_4(aq) → Ag_2SO_4 (s) + 2 $NaNO_3$ (aq)

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2 $AgNO_3$ (aq) + Na_2SO_4(aq) → Ag_2SO_4 (s) + 2 $NaNO_3$ (aq)

When 50.00 mL of 0.125 M silver (I) nitrate is mixed with 50.00 mL of 0.250 M sodium sulfate a greyish solid forms. If I recover 0.813 g of solid, what is the yield of the reaction?

$$0.050\ L\ AgNO_3 solution \frac{0.125\ mol\ AgNO_3}{L\ solution} = 6.25 \times 10^{-3} mol\ AgNO_3$$

$$0.050\ L\ Na_2SO_4 sol \frac{0.250\ molNa_2SO_4}{L\ solution} = 1.25 \times 10^{-2} mol\ Na_2SO_4$$

These numbers don't compare! Apples and oranges.

It's not how much you have, it's how much you need.

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2 $AgNO_3$ (aq) + Na_2SO_4(aq) → Ag_2SO_4 (s) + 2 $NaNO_3$ (aq)

$$6.25 \times 10^{-3} mol\ AgNO_3 \frac{1\ mol\ Ag_2SO_4}{2\ mol\ AgNO_3} = 3.125 \times 10^{-3} mol Ag_2SO_4$$

$$1.25 \times 10^{-2}\ mol\ Na_2SO_4 \frac{1\ mol\ Ag_2SO_4}{1\ mol Na_2SO_4} = 1.25 \times 10^{-2} mol\ Ag_2SO_4$$

These numbers compare!

The silver nitrate runs out first!

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2 $AgNO_3$ (aq) + Na_2SO_4(aq) → Ag_2SO_4 (s) + 2 $NaNO_3$ (aq)

$$3.125 \times 10^{-3} mol Ag_2SO_4 \frac{311.80\ g\ Ag_2SO_4}{mol Ag_2SO_4} = 0.974\ g Ag_2SO_4$$

This is the "theoretical yield" – what I get if everything goes perfectly. In this reaction, it didn't!

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I only got 0.813 g of product!

When 50.00 mL of 0.125 M silver (I) nitrate is mixed with 50.00 mL of 0.250 M sodium sulfate a greyish solid forms. If I recover 0.813 g of solid, what is the yield of the reaction?

$$Yield = \frac{actual\ stuff}{theoretical\ stuff} \times 100$$

$$Yield = \frac{0.813\ g\ recovered}{0.974\ g\ theoretical} \times 100$$

$$Yield = 83.4\%$$