Yesterday

Solute (thing dissolved)

%

ppm

ppb

$$\frac{\text{part}}{\text{whole}} \times 100 = \%$$

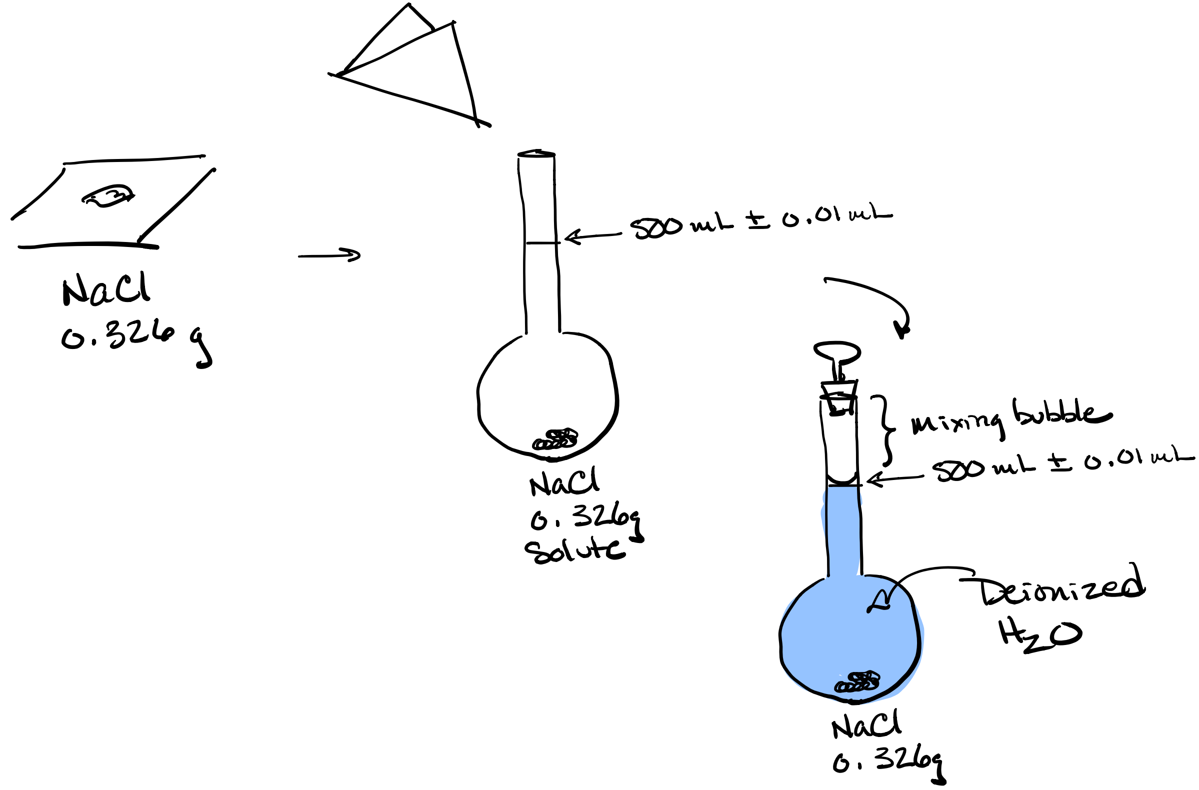
Solution (Solute & Solvent)

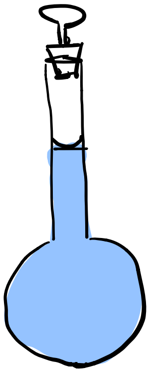
Today

$$\text{molarity} = \frac{\text{moles Solute}}{\text{L solution}} \qquad \frac{\text{part in moles}}{\text{whole volume}}$$

mole to volume ratio

How we make Solutions





NaCl
0.326g
500.0 mL Solution

$$\underline{\text{Molarity}} = \frac{\text{moles NaCl}}{\text{L sol.}}$$

$$\frac{\text{0.326g NaCl}}{\text{500.0 mL sol}} \begin{matrix} \longrightarrow \text{moles NaCl} \\ \longrightarrow \text{L sol} \end{matrix}$$

Covert 0.326 g NaCl → moles NaCl

$$\begin{array}{ll} \text{Na} & 22.99 \\ \text{Cl} & 35.45 \\ \hline & 58.44\ \text{g/mol} \end{array}$$

$$\overset{3}{0.326}\text{g} \times \frac{\text{1 mole NaCl}}{\text{58.44g NaCl}} = 0.00557|8371$$

convert 500.0 mL → L

$$500.0\ \text{mL} \times \frac{1\text{L}}{1000\ \text{mL}} = 0.5000\ \text{L}$$

$$\text{Molarity} = \frac{\overset{3}{0.00557}8371\ \text{moles NaCl}}{\underset{4}{0.5000}\ \text{L sol}} = 0.0111|56742\ \text{mols/L}$$

$$= \boxed{0.0112\ \text{mols/L NaCl}}$$

Alternative

$$\frac{0.326\ \cancel{g\ NaCl}}{500.0\ \cancel{mL\ sol}} \times \frac{1\ mole\ NaCl}{58.44\ \cancel{g\ NaCl}} \times \frac{1000\ \cancel{mL\ sol}}{1\ L\ sol} = \boxed{0.0112\ mols/L\ NaCl}$$

How do we use molarity?

Mole Solute to volume of Solution

we no longer need molar mass.

Molar mass is "baked" into molarity

Ex How many mL of a 0.972 Moles/L Na_3PO_4 solution are required to give 3.25×10^{-3} moles of Na_3PO_4?

Road Map

Na_3PO_4 moles ⟶ L sol ⟶ mL Sol

Equality

0.972 moles/L = 0.972 moles = 1 L sol

$$\overset{3}{3.25 \times 10^{-3}}\ moles\ \cancel{Na_3PO_4} \times \frac{1\ L\ sol}{\underset{3}{0.972}\ moles\ \cancel{Na_3PO_4}} \times \frac{\overset{Exact}{1000\ mL}}{1\ L\ sol} = 3.34|36214\ mL$$

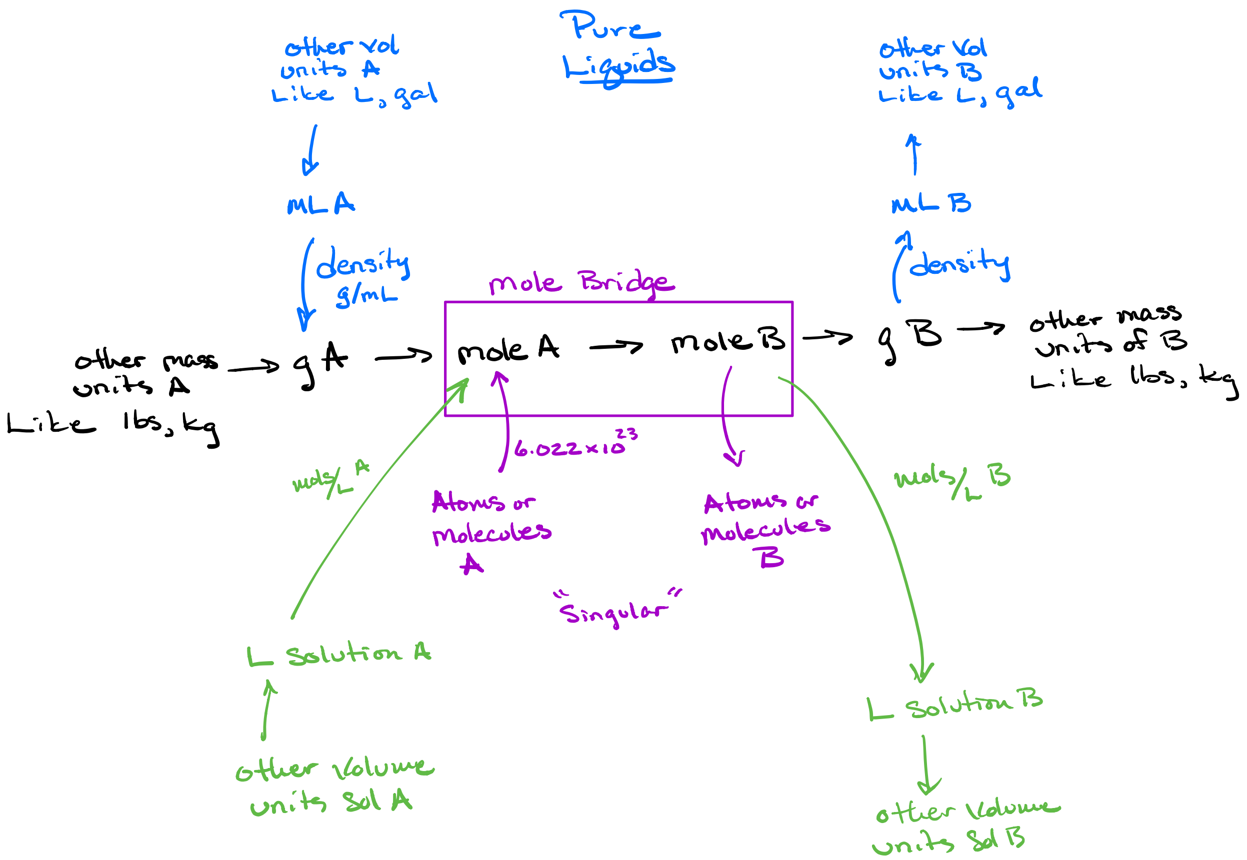
$$= \boxed{3.34\ mL\ of\ Solution}$$

$$\text{Molarity} = \frac{\text{moles Solute}}{\text{L solution}} = \text{mols/L or } \underline{M}$$

M $\underline{\underline{\textit{italic}}}$ = $\underline{M}$

$$\boxed{0.792\ \text{mole/L}\ Na_3PO_4 = 0.792\ \underline{M}\ Na_3PO_4}$$

$0.792\ \text{mole}\ Na_3PO_4/\text{L sol}$


Pure Liquids
other vol units A Like L, gal
mL A
density g/mL
other mass units A Like lbs, kg
g A
mole Bridge
mole A
mole B
g B
other mass units of B Like lbs, kg
mL B
density
other Vol units B Like L, gal
6.022×10^23
Atoms or molecules A
Atoms or molecules B
"Singular"
mols/L A
mols/L B
L Solution A
other Volume units Sol A
L Solution B
other Volume units Sol B

How many moles of Iron (III) Chloride are in 525 mL of a $\overset{\text{Equality}}{0.062\ \underline{M}}$ $FeCl_3$ solution ?

$\underline{M}$ = moles/L = molar = molarity

0.062 molar Solution = 0.062 $\underline{M}$ = 0.062 mols/L

Road Map

mL sol → L sol $\xrightarrow{\ \frac{L\ sol}{moles\ FeCl_3}\ }$ moles $FeCl_3$

volume

Molarity

count

3 def 2

$$525\,\cancel{\text{mL sol}} \times \frac{1\,\cancel{\text{L sol}}}{1000\,\cancel{\text{mL sol}}} \times \frac{0.062\text{ moles }FeCl_3}{1\,\cancel{\text{L sol}}} = 0.032|55\text{ moles }FeCl_3$$

$$= \boxed{0.033\text{ moles }FeCl_3}$$

Round even Rule

0.032|5 ← exactly = 0.032 Round even

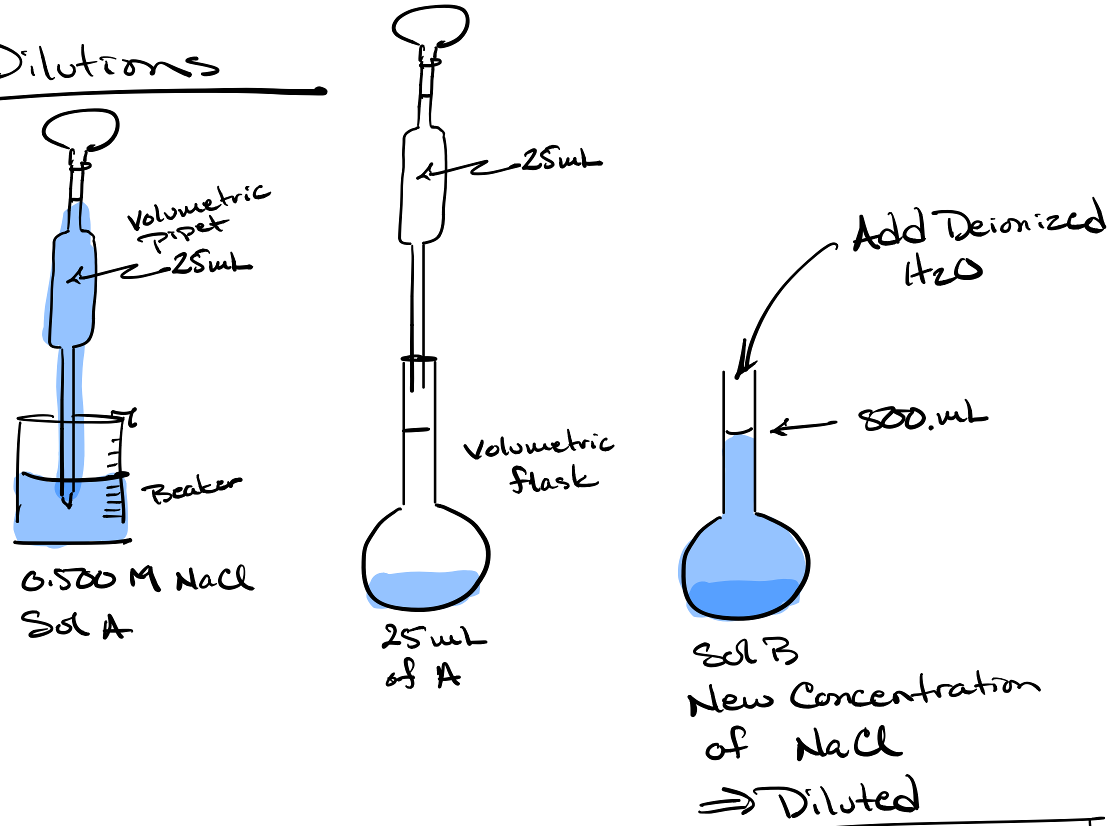
0.032|50001 = 0.033 Round up

\>5

0.032|50 = 0.032 Round even

exactly 5

Dilutions



Dilution Formula

$$C_1V_1 = C_2V_2 \qquad (M_1V_1 = M_2V_2)$$

C = concentration   M = molarity

$$\left(\frac{\text{mols}}{L_1}\right)(L_1) = \text{moles} = \left(\frac{\text{mols}}{L_2}\right)(L_2)$$

$C_1 = 0.500\ \underline{M}\ NaCl$

$V_1 = 25\ mL$

$C_2 = ?$

$V_2 = 500.\ mL$

$$\frac{C_1V_1}{V_2} = \frac{C_2\cancel{V_2}}{\cancel{V_2}}$$

$$\frac{C_1V_1}{V_2} = C_2$$

$$\frac{\overset{3}{(0.500\ M\ NaCl)}\overset{2}{(25\ \cancel{mL})}}{\underset{3}{500.\ \cancel{mL}}} = \boxed{0.025\ \underline{M}\ NaCl}$$

Giga	G	
mega	M	
kilo	k	10^3
deka	D	10^1
Base		
deci	d	10^{-1}
Centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	

Meters	m
Liters	L

mL = milliliters

mm = millimeter

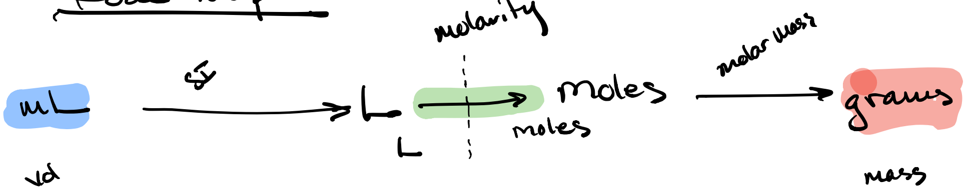
More Examples

How many grams of $AgNO_3$ are required to make 250. mL of a 0.625 M solution?

M = moles/L

Two units = equalities
"Conversion factors"

Road map



Molar Mass

Ag 1 × 107.9 = 107.9

N 1 × 14.01 = 14.01

O 3 × 16.00 = 48.00

169.9

169.9 g/mol

$$\overset{3}{250.}\ \cancel{\text{mL}}\ \text{AgNO}_3\ \text{sol} \times \frac{\overset{\text{Exact}}{1\ \cancel{\text{L}}\ \text{AgNO}_3\ \text{sol}}}{1000\ \cancel{\text{mL}}\ \text{AgNO}_3\ \text{sol}} \times \frac{\overset{3}{0.625\ \cancel{\text{mole}}\ \text{AgNO}_3}}{1\ \cancel{\text{L}}\ \text{AgNO}_3\ \text{sol}} \times \frac{\overset{4}{169.9\text{g AgNO}_3}}{1\ \cancel{\text{mole}}\ \text{AgNO}_3} =$$

$$26.5|46875\ \text{g AgNO}_3$$

$$\boxed{26.5\ \text{g AgNO}_3}$$

What is the molarity of a solution made by dissolving 0.0932 g of ammonium nitrate in enough water to make 1000. mL of solution?
(1.000 L)

$$\text{Molarity} = \frac{\text{Moles}}{\text{L solution}}$$

ammonium nitrate
NH_4^+ NO_3^-

Road Map

$$\frac{\text{g } NH_4NO_3}{\text{mL Sol}} \xrightarrow[\text{SI}]{\text{molar mass}} \frac{\text{moles } NH_4NO_3}{\text{L Sol}}$$

$$\overset{N}{2(14.01)} + \overset{H}{4(1.008)} + \overset{O}{3(16.00)} = 80.05|2 = \boxed{80.05\text{g/mole}}$$

$$\frac{\overset{3}{0.0932}\text{g } NH_4NO_3}{\underset{4}{1000.}\ \text{mL}} \times \frac{1\ \text{mole } NH_4NO_3}{\underset{4}{80.05}\text{g } NH_4NO_3} \times \frac{\overset{\text{def}}{1000\ \text{mL}}}{1\ \text{L}} = 0.00116|42723$$

$= 0.00116\ \underline{M}\ NH_4NO_3$

$= 1.16\ m\underline{M}\ NH_4NO_3$

$= 1.16 \times 10^{-3}\ \underline{M}\ NH_4NO_3$

How many mL of a 1.735 M solution of H_3PO_4 (phosphoric acid) are required to make 350. mL of 0.625 M H_3PO_4?

Dilution = $C_1V_1 = C_2V_2$

using 1 solution to make another

C_1 = 1.735 M

V_1 = ?

C_2 = 0.625 M

V_2 = 350. mL

$$\frac{\cancel{C_1}V_1}{\cancel{C_1}} = \frac{C_2V_2}{C_1}$$

$$V_1 = \frac{C_2V_2}{C_1}$$

$$= \frac{(0.625\,\cancel{M})(350.\,mL)}{(1.735\,\cancel{M})}$$

$$= 126|.08\ mL$$

$$= \boxed{126\ mL\ H_3PO_4}$$

A reaction requires 320. mL of a 0.175 $\underline{M}$ solution of Nitric acid (HNO_3). In the stockroom you find a bottle of 6.725 $\underline{M}$ nitric acid. How many mL of the 6.725 $\underline{M}$ solution are required to make the 320. mL of 0.175 $\underline{M}$?

C_1 = 6.725 $\underline{M}$ ← moles/L

V_1 = ?

C_2 = 0.175 Mols/L

V_2 = 320. mL

$$C_1\underline{\underline{V_1}} = C_2V_2$$

$$V_1 = \frac{C_2V_2}{C_1}$$

$$V_1 = \frac{(0.175\ \text{Mols}/\cancel{L})(320.\ \text{mL})}{(6.725\ \text{Mols}/\cancel{L})}$$

$$\boxed{V_1 = 8.33\ \text{mL}}$$

What is the resulting molarity when 6.72 mL of a stock solution of 10.62 M sulfuric acid is diluted to a final volume of 125 ~~mL~~ L ?

$C_1 = 10.62\ \underline{M}$

$V_1 = 6.72\ mL$

$C_2 = ?$

$V_2 = 125\ \cancel{mL}\ L \times \frac{1000\ mL}{1\ L} = \ mL$