Road Maps

While in my mind road maps make thing easier, the creation of road maps can be a challenge all on their own.

As we stand in the course now there are two major types of problems that we are using road maps for: Dimensional Analysis & Stoichiometry. Stoichiometry utilizes dimensional analysis, but I think of the two differently because Stoichiometry has a general set road map for all problems, while the roadmaps for dimensional analysis can't be generalized. Because of that difference I think it is good to deal with the two types separately.

Dimensional Analysis

The creation of road maps depends on a couple of factors:

1. Identification of "given"
2. Identification of "desired"
3. Indentification of provided equalities
4. Remembering SI & 3 key conversion factors
5. Identifying transitions such as
   SI → Eng measurements or transitions in the property measured such as
   mass → vol or Length → vol or
   time → length
6. Identifying "bridging" equalities, equalities that make the transitions identified is step 5 above.

These 6 steps or keys are identical for Stoichiometry, but Stoichiometry is made easier in that there is a general road map that can be memorized.

Simple problem

While on a business trip in Canada you are told by the hotel concierge that the closest restaurant is 2.7 km away. How many miles away is the restaurant? (1 mi = 5280 ft)

Parcing the problem involves steps 1-4 covered above.

- Given
- Desired
- Provided equalities
- Remembered equalities

While on a business trip in Canada you are told by the hotel concierge that the closest restaurant is 2.7 km away (Given). How many miles away is the restaurant? (Desired) (1 mi = 5280 ft) (Provided Equality)

Given 2.7 km

Desired miles

Provided Equalities 1 mi = 5280 ft

Remembered Equalities 1 ft = 12 in English

1 in = 2.54 cm SI ↔ English

100 cm = 1 m

1000 m = 1 km } SI

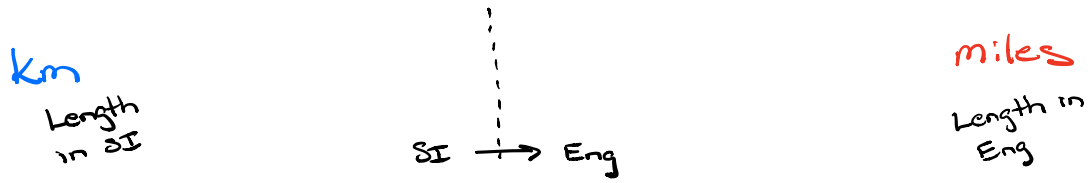
Sometimes it is the creation of the road map that helps in finding needed equalities, sometimes the equalities help in building the road map. They work together.

Building The Road Map

① Start with the "given" & "desired"

km miles

② Identify transitions



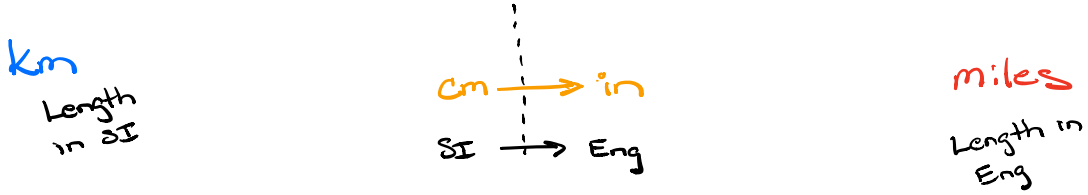
③ Find the bridging conversion factor

1 mi = 5280 ft

1 ft = 12 in English

1 in = 2.54 cm SI ↔ English

100 cm = 1 m
1000 m = 1 km } SI



④ Cross of used equality and look for equalities to fill in the left and right sides. There are multiple ways to do this. The easiest way to do this is to look for a given unit in the list of equalities.

1 mi = 5280 ft

1 ft = 12 in English

~~1 in = 2.54 cm SI ⇔ English~~

100 cm = 1 m

1000 m = 1 km } SI

km
Length in SI

cm → in
SI → Eng

miles
Length in Eng

once you find it, use it by adding to the map, and then cross it off the list.

1 mi = 5280 ft

1 ft = 12 in English

~~1 in = 2.54 cm SI ⇔ English~~

100 cm = 1 m

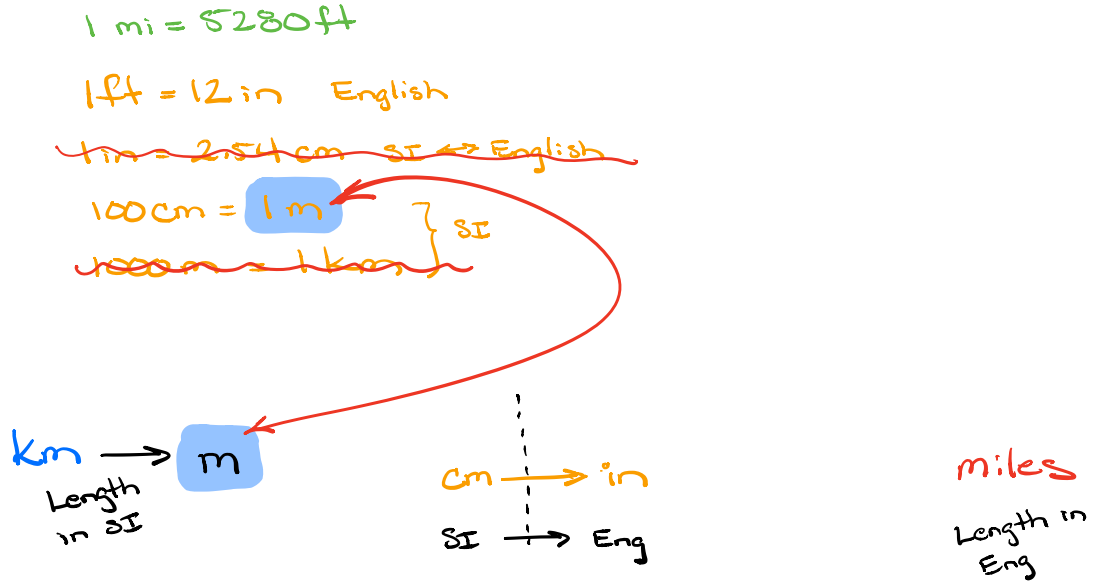
~~1000 m = 1 km~~ } SI

km → m
Length in SI

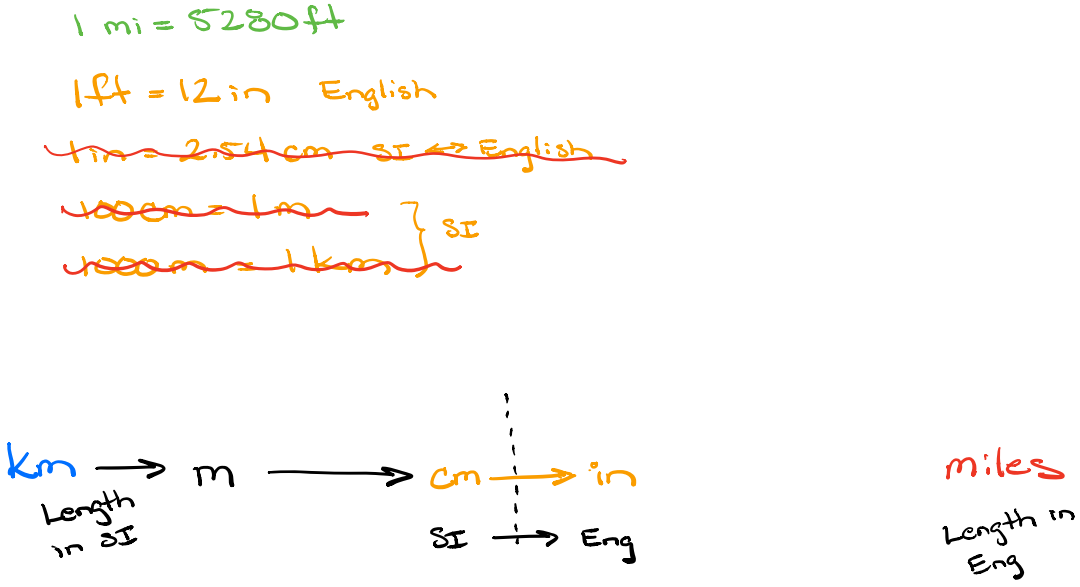
cm → in
SI → Eng

miles
Length in Eng

Repeat the process until the map is completed. Locate next given.



Add equality to map and cross off list



Repeat: Find Given

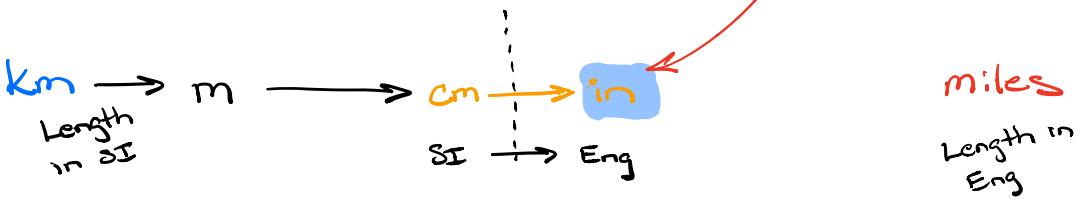
1 mi = 5280 ft

1 ft = 12 in English

~~1 in = 2.54 cm SI ⇔ English~~

~~1000 m = 1 km~~

~~1000 m = 1 km~~ } SI



Add to Map & Cross off list

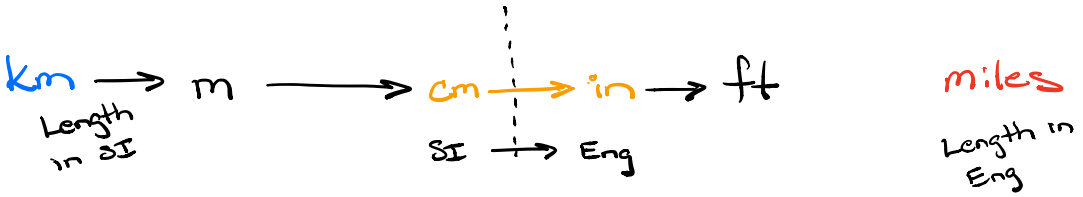
1 mi = 5280 ft

~~1 ft = 12 in English~~

~~1 in = 2.54 cm SI ⇔ English~~

~~1000 m = 1 km~~

~~1000 m = 1 km~~ } SI



Only 1 Equality left

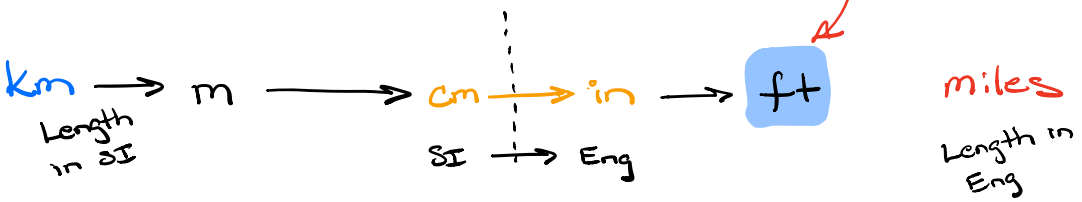
1 mi = 5280 ft

~~1 ft = 12 in English~~

~~1 in = 2.54 cm SI ⇔ English~~

~~1000 m = 1 km~~

~~1000 m = 1 km~~ } SI



And the road map is done

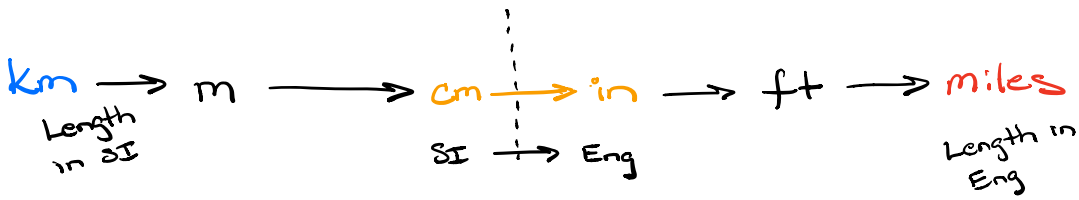
~~1 mi = 5280 ft~~

~~1 ft = 12 in English~~

~~1 in = 2.54 cm SI ⇔ English~~

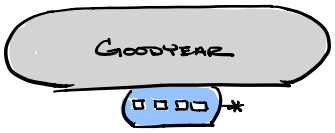
~~1000 m = 1 km~~

~~1000 m = 1 km~~ } SI



Example 2 A bit more complicated

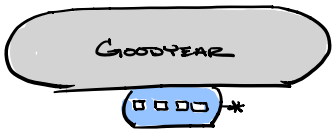
The Goodyear Blimp has a volume of 202,700 ft^3. To stay aloft the blimp is filled with helium gas that has a density of 0.179 g/L. How many pounds of helium gas are used to fill the blimp?



Process is same as before.

- Given
- Desired
- Equalities

The Goodyear Blimp has a volume of 202,700 ft^3. To stay aloft the blimp is filled with helium gas that has a density of 0.179 g/L. How many pounds of helium gas are used to fill the blimp?



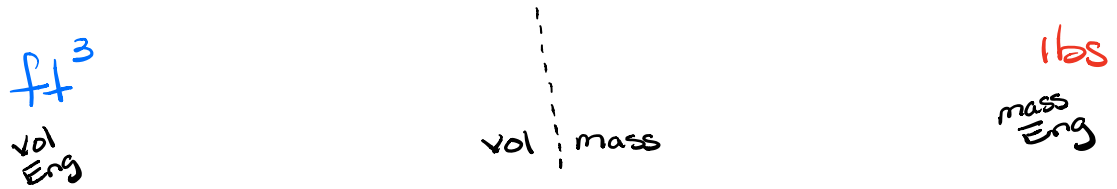
Given 202,700 ft^3

Desired lbs

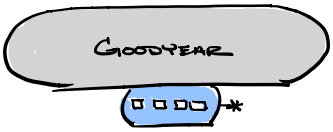
Equality 0.179 g/L $\Rightarrow$ 0.179 g = 1 L

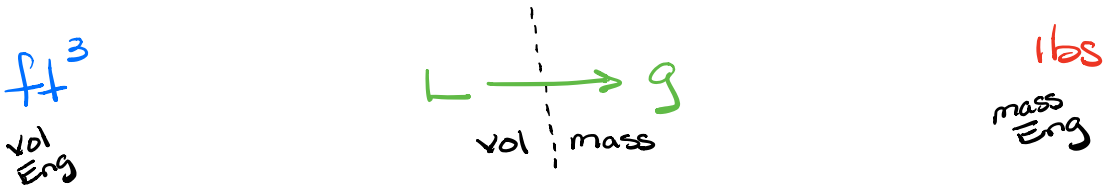
Easier to work with written this way

Start the road map & find transitions



Note that the given equality is a volume to mass equality $0.179\,g = 1\,L$ (mass, volume)





Now that we have found the transition we can fill in the left & right sides using memorized equalities. The problem will provide any equalities beyond what you were asked to memorize. You should memorize the "3 keys" & SI equalities. Also helpful are $1\,cm^3 = 1\,mL$ and the concept of derived volume

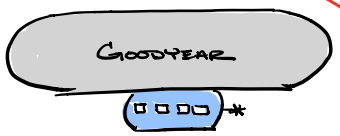
$1^3\,ft^3 = 12^3\,in^3$ & $1^3\,in^3 = 2.54^3\,cm^3$

The 3 key conversion factors are

1 lbs = 453.6 g

1 gal = 3.785 L

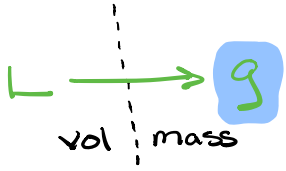
1 in = 2.54 cm



other English System we might need

1 ft = 12 in

ft^3
vol
Eng



lbs
mass
Eng

Add to the map & Cross off list

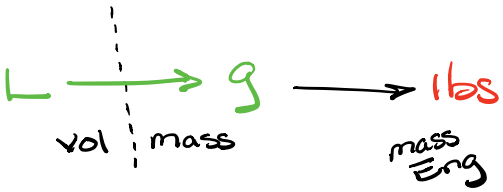
~~1 lbs = 453.6 g~~

1 gal = 3.785 L

1 in = 2.54 cm

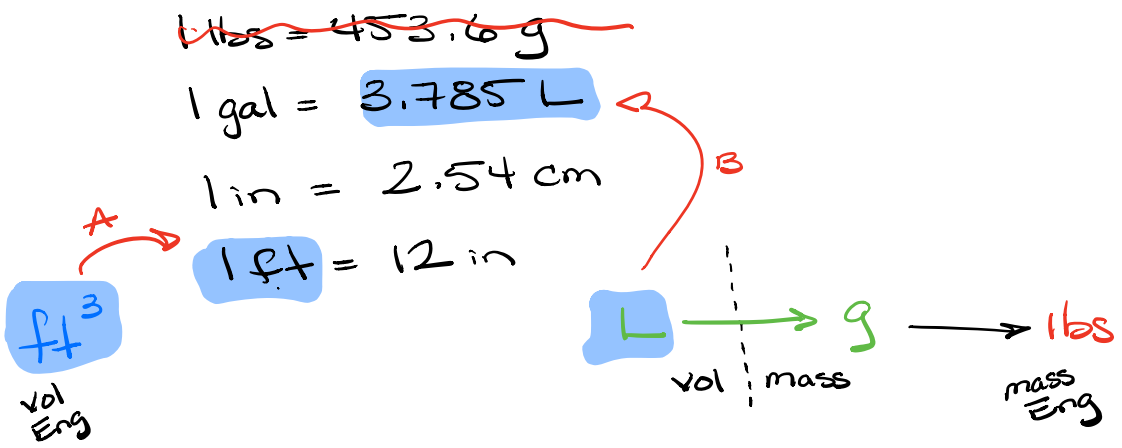
1 ft = 12 in

ft^3
vol
Eng



mass
Eng

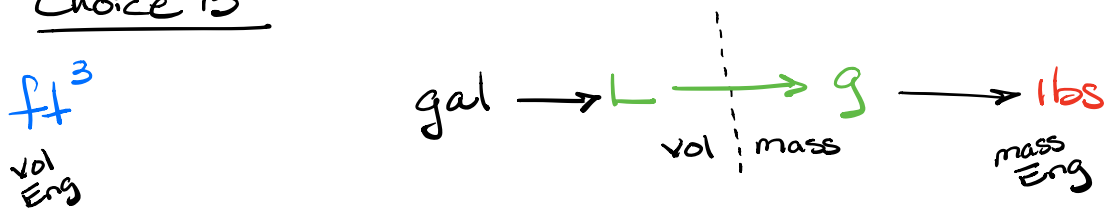
Repeat the process



Unanticipated problem: There seem to be two choices:

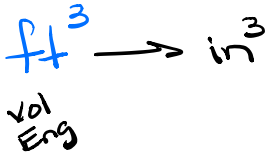
Choice A

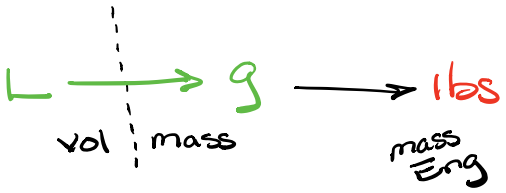
Choice B



This is a hard choice. To make the correct choice requires experience & working knowledge of some of the problems we've done in lecture & lab.

Choice A





Requires remembering that $1 cm^3 = 1 mL$. Without this you can't complete the map. Thus, Sometimes the list of equalities isn't complete and we need to rely on equalities we have in working memory. This makes the job much harder.

~~1 lbs = 453.6 g~~

1 gal = 3.785 L

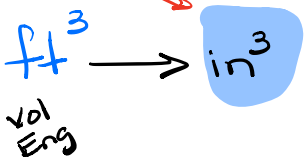
1 in = 2.54 cm

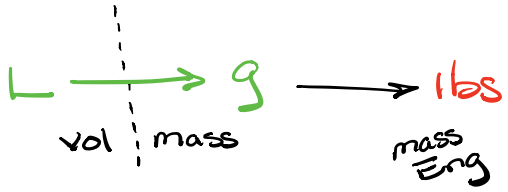
~~1 ft = 12 in~~

Working Memory

$1 cm^3 = 1 mL$

1000 mL = 1 L





Add to map & Cross off

~~1 lbs = 453.6 g~~

1 gal = 3.785 L

~~1 in = 2.54 cm~~

~~1 ft = 12 in~~

Working Memory

$1\ cm^3 = 1\ mL$

1000 mL = 1 L

$ft^3 \rightarrow in^3 \rightarrow cm^3$

vol Eng

L → g → lbs

vol | mass

mass Eng

Add to map & Cross off

~~1 lbs = 453.6 g~~

1 gal = 3.785 L

~~1 in = 2.54 cm~~

~~1 ft = 12 in~~

Working Memory

~~$1\ cm^3 = 1\ mL$~~

1000 mL = 1 L

$ft^3 \rightarrow in^3 \rightarrow cm^3 \rightarrow mL$

vol Eng

L → g → lbs

vol | mass

mass Eng

Add to map & Cross off and Road map is complete

~~1 lbs = 453.6 g~~

1 gal = 3.785 L

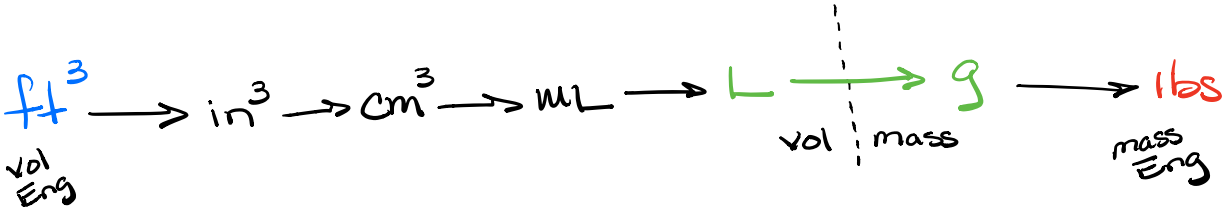
~~1 in = 2.54 cm~~

~~1 ft = 12 in~~

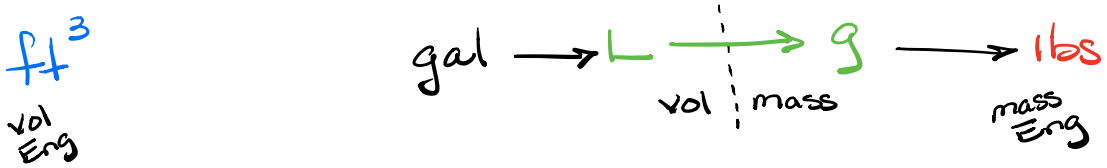
Working Memory

~~$1\ cm^3 = 1\ mL$~~

~~1000 mL = 1 L~~



Choice B



~~1 lbs = 453.6 g~~

1 gal = 3.785 L

1 in = 2.54 cm

1 ft = 12 in

Working Memory

$1\ cm^3 = 1\ mL$

1000 mL = 1 L

The problem with option B is that we have no equalities linking ft^3 & gal. I'm sure we could find one on the web with a quick Google search, but it's not in our working memory.

Here are a couple problems to practice with:

(1) A fan belt for an air conditioning unit has a length of 28.75 in. The company website lists the part in millimeters. How many millimeters is the fanbelt that should be ordered as a replacement?

(2) A barel used to capture rain water has captured 372 gal of water. If the density of the water is 0.997 g/mL, how many kilograms does the water weigh?

(3) The gas tank in a mini Cooper holds 18.0 gal of gas. If the density of gasoline is 0.768 g/mL, how many pounds of gas would the tank hold if it were filled?

Answers upside down to slow you down a bit.

1. in → cm → m → mm

   or

   in → cm → mm

2. gal → L → mL → g → kg

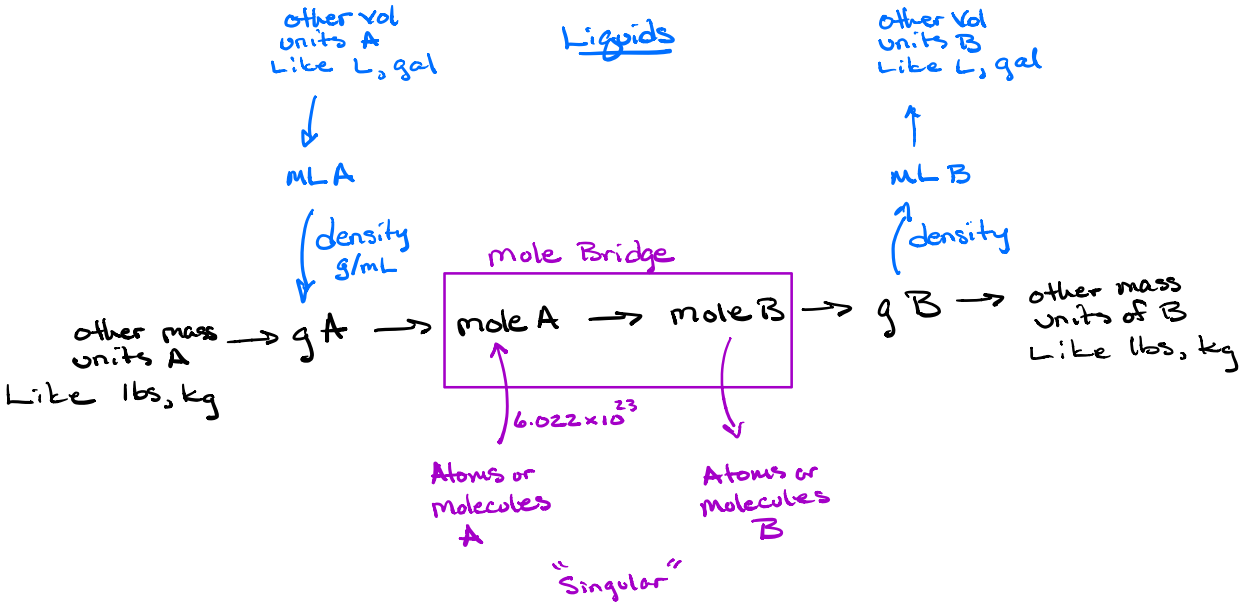
3. gal → L → mL → g → lbs

Stoichiometry

The stoichiometry road map is always the same and can be memorized to an extent. The foundation is:

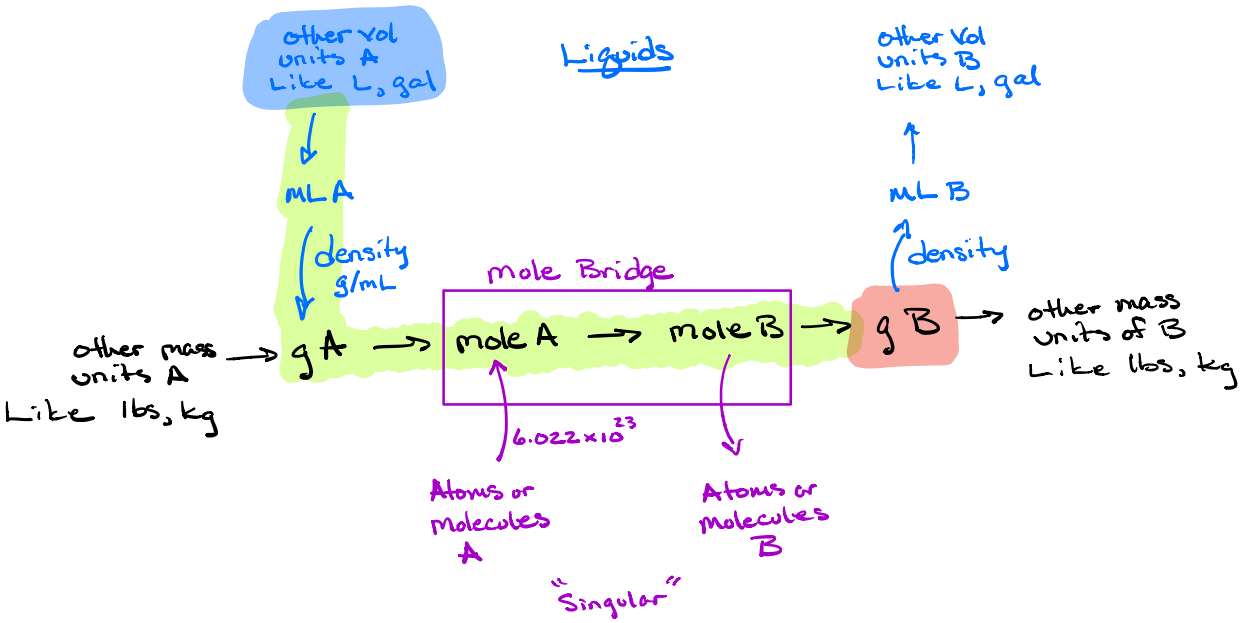
$$g\,A \rightarrow \text{mole } A \rightarrow \text{mole } B \rightarrow g\,B$$

However the road map is much larger. Here is what we have covered so far:



Here is how you might use this general map.

Octane (C_8H_{18}) has a density of 0.703 g/mL. How many grams of carbon would be in a sample of octane with a volume of 32.6 L?



Road Map

L A → mL A → g A → mole A → mole B → g B

A = C_8H_{18} B = Carbon (C)

L C_8H_{18} → mL C_8H_{18} → g C_8H_{18} → mole C_8H_{18} → mole C → g C