N26 – THE MOLE RATIO AND STOICHIOMETRY

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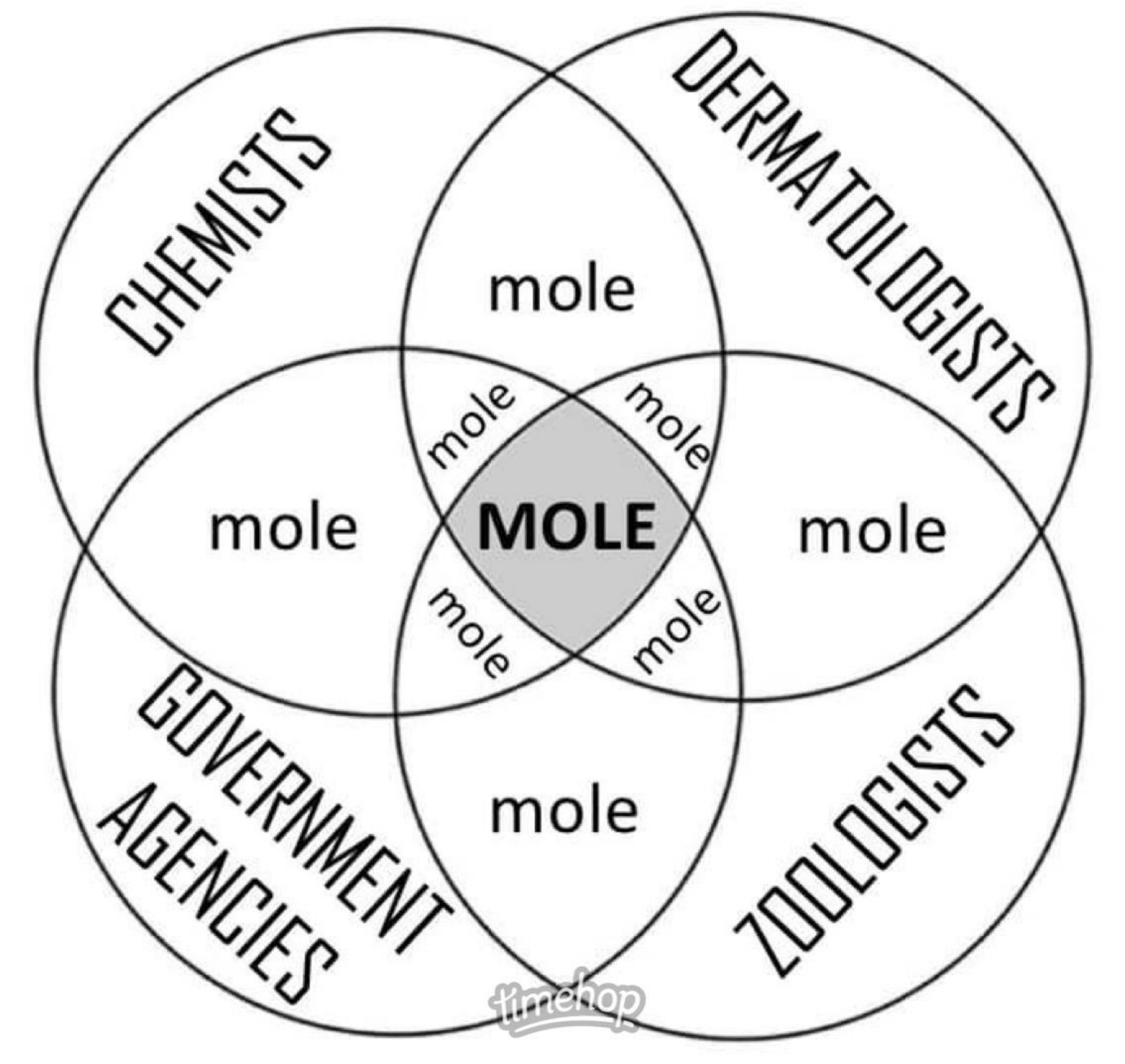
Target: I can use a balanced equation to determine the “mole ratio” between various molecules in a reaction, so that I can perform “stoichiometry” where I convert from an amount of one molecule to an amount of a totally different molecule.


CHEMISTS
DERMATOLOGISTS
mole
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MOLE
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GOVERNMENT AGENCIES
mole
ZOOLOGISTS
timehop

Stoichiometry

Calculating the amounts of reactants and/or products that are involved in a reaction

How much do I have, need, or make?

Stoichiometry

We need a balanced equation before we can do stoichiometry.

The coefficients in the balanced equation gives insight into how much of each thing we need or make

Balanced Equation Coefficients

$$2H_2 + O_2 \rightarrow 2H_2O$$

Can be thought of as how many molecules are needed

- 2 hydrogen molecules
- 1 oxygen molecule
- 2 water molecules

Balanced Equation Coefficients

$2H_2 + O_2 \rightarrow 2H_2O$

Can ALSO be thought of as how many MOLES of molecules

- 2 ***moles*** hydrogen molecules
- 1 ***moles*** oxygen molecule
- 2 ***moles*** water molecules

Why use Molar Coefficients and not Grams for our calculations?

Allows us to compare "apples to apples"

Grams of molecule A

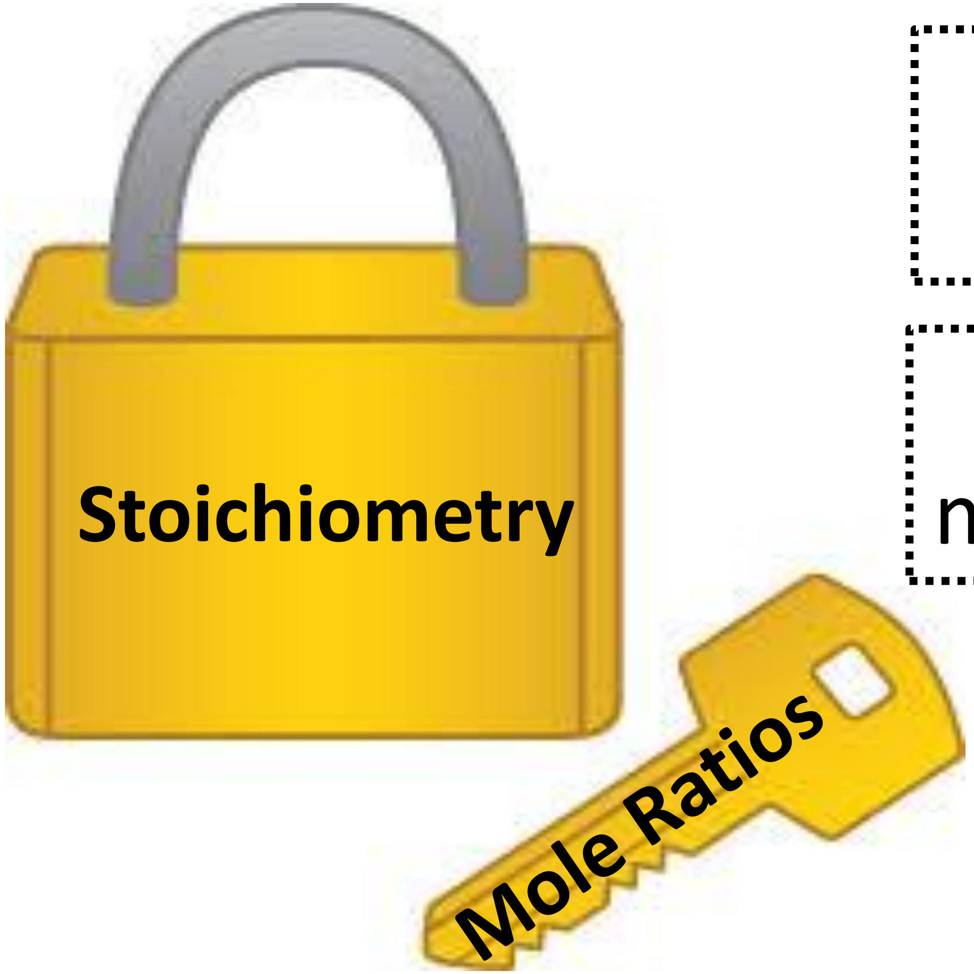
Grams of molecule B

MOLES of molecule A

MOLES of molecule B

Mole Ratios

The "KEY" to stoichiometry!



If I have 3 moles of this, how many moles of that do I have?

If I have 2 moles of this, how many moles of that can I make?

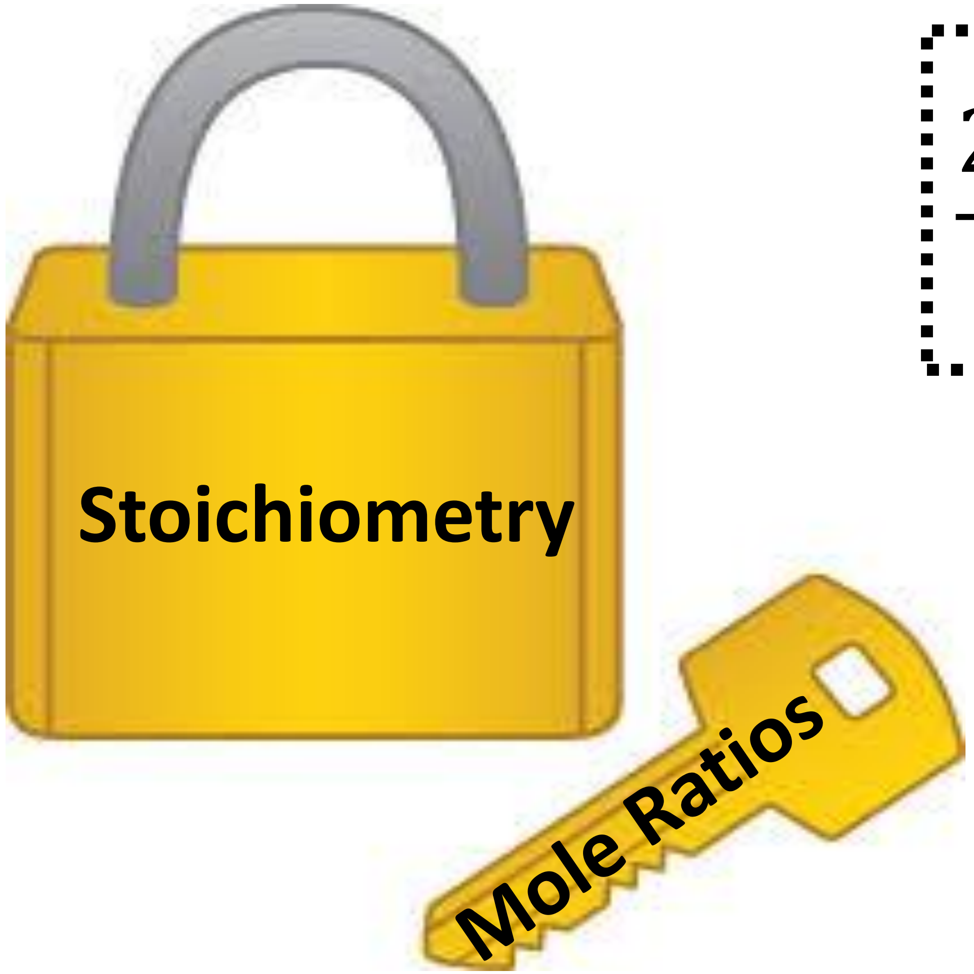
Mole Ratios

$$2H_2 + O_2 \rightarrow 2H_2O$$

$$\frac{2\ moles\ H_2}{1\ mole\ O_2}$$

$$\frac{2\ moles\ H_2}{2\ moles\ H_2O}$$

$$\frac{1\ mole\ O_2}{2\ moles\ H_2O}$$



Mole Ratios

You can flip all mole ratios

$$\frac{2\ moles\ H_2}{1\ mole\ O_2} \rightarrow \frac{1\ mole\ O_2}{2\ moles\ H_2}$$

$$\frac{2\ moles\ H_2}{2\ moles\ H_2O} \rightarrow \frac{2\ moles\ H_2O}{2\ moles\ H_2}$$

$$\frac{1\ mole\ O_2}{2\ moles\ H_2O} \rightarrow \frac{2\ moles\ H_2O}{1\ mole\ O_2}$$

Mole Ratios

Write all the mole ratios

$$2C_2H_2 + 5O_2 \rightarrow 2H_2O + 4CO_2$$

$$\frac{2\ mole\ C_2H_2}{5\ moles\ O_2}$$

$$\frac{2\ mole\ C_2H_2}{2\ moles\ H_2O}$$

$$\frac{2\ mole\ C_2H_2}{4\ moles\ CO_2}$$

$$\frac{5\ moles\ O_2}{2\ moles\ H_2O}$$

$$\frac{5\ moles\ O_2}{4\ moles\ CO_2}$$

$$\frac{2\ moles\ H_2O}{4\ moles\ CO_2}$$

Mole Ratios $2C_2H_2 + 5O_2 \rightarrow 2H_2O + 4CO_2$

Can be used as conversion factors!

How many moles of carbon dioxide can be made from 19.46 moles of oxygen gas?

$$\begin{array}{l|l} 19.46\ \cancel{\text{moles}}\ O_2 & 4\ \boxed{\text{moles } CO_2} \\ \hline & 5\ \cancel{\text{moles}}\ O_2 \end{array} = \mathbf{15.57}\ \textbf{moles } \mathbf{CO_2}$$

Mole Ratios $2C_2H_2 + 5O_2 \rightarrow 2H_2O + 4CO_2$

Can be used as conversion factors!

If you made 13.42 moles of water, how many moles of oxygen gas did you start with?

$$\begin{array}{l|l} 13.42\ \cancel{\text{moles H}_2\text{O}} & \boxed{5\ \text{moles O}_2} \\ \hline & 2\ \cancel{\text{moles H}_2\text{O}} \end{array} = \mathbf{33.55}\ \textbf{moles}\ \mathbf{O_2}$$

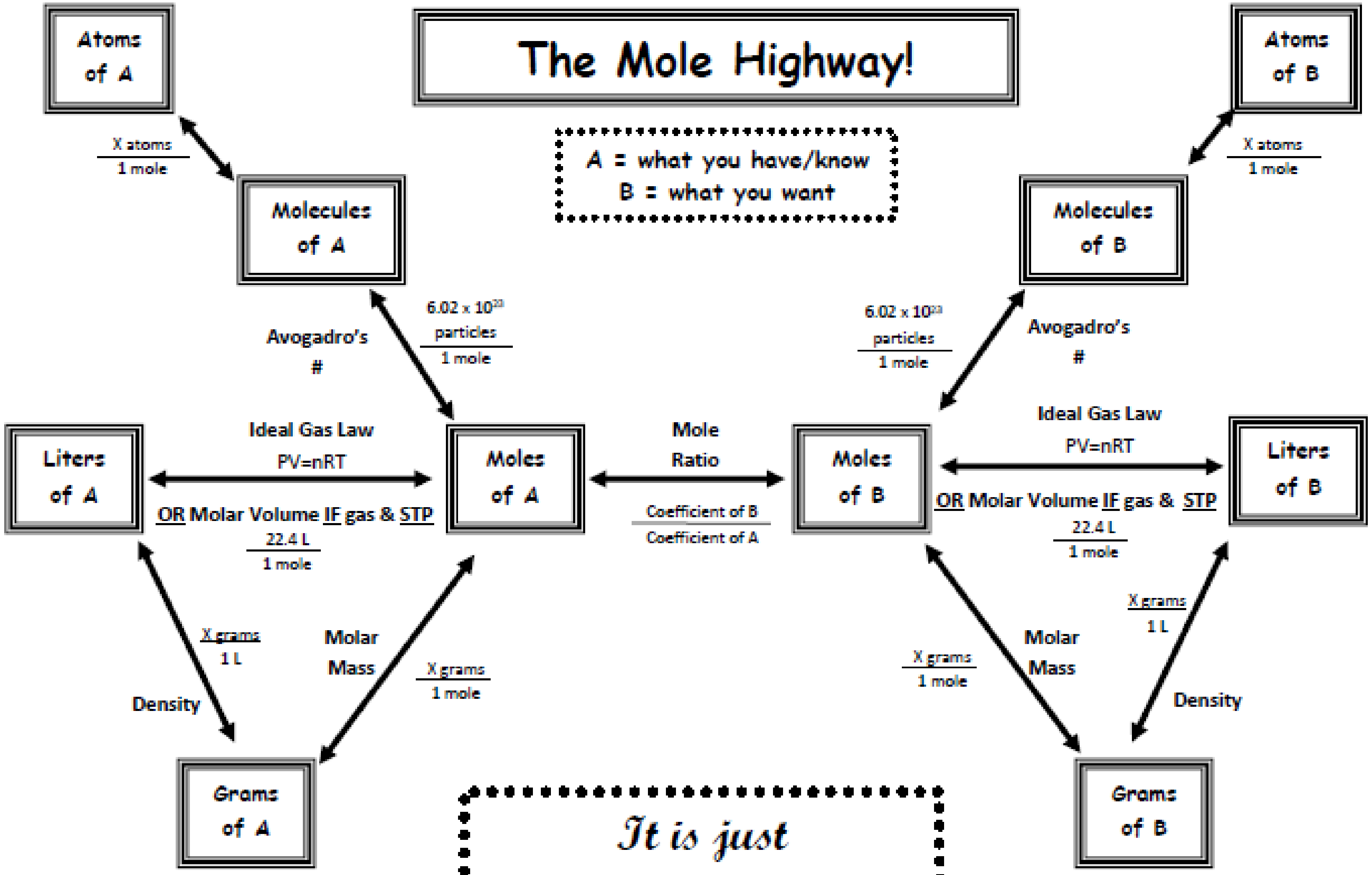
What if you don’t want your answer in moles? What if you weren’t given moles?

THE MOLE HIGHWAY

All roads lead to the mole!

The Mole Highway!

A = what you have/know
B = what you want



Atoms of A

$\frac{\text{X atoms}}{\text{1 mole}}$

Molecules of A

Avogadro's #

$\frac{6.02 \times 10^{23} \text{ particles}}{\text{1 mole}}$

Liters of A

Ideal Gas Law

PV=nRT

<u>OR</u> Molar Volume <u>IF</u> gas & <u>STP</u>

$\frac{\text{22.4 L}}{\text{1 mole}}$

Moles of A

Mole Ratio

$\frac{\text{Coefficient of B}}{\text{Coefficient of A}}$

Moles of B

Density

$\frac{\text{X grams}}{\text{1 L}}$

Molar Mass

$\frac{\text{X grams}}{\text{1 mole}}$

Grams of A

Atoms of B

$\frac{\text{X atoms}}{\text{1 mole}}$

Molecules of B

$\frac{6.02 \times 10^{23} \text{ particles}}{\text{1 mole}}$

Avogadro's #

Ideal Gas Law

PV=nRT

<u>OR</u> Molar Volume <u>IF</u> gas & <u>STP</u>

$\frac{\text{22.4 L}}{\text{1 mole}}$

Liters of B

$\frac{\text{X grams}}{\text{1 mole}}$

Molar Mass

$\frac{\text{X grams}}{\text{1 L}}$

Density

Grams of B

It is just dimensional analysis!

Guided Stoichiometry Practice Problems

Q #1

$N_2 + 3H_2 \rightarrow 2NH_3$

A B

54 grams N_2 → ? moles NH_3

Pathway: *grams A → moles A → moles B*

Molar mass of A

$$\frac{X\ g\ A}{1\ mole\ A}$$

Mole Ratio

$$\frac{moles\ B}{moles\ A}$$

Q #1

$N_2 + 3H_2 \rightarrow 2NH_3$

A B

54 grams N_2 → ? moles NH_3

Pathway: *grams A → moles A → moles B*

Molar mass of A

$$\frac{X\ g\ A}{1\ mole\ A}$$

Mole Ratio

$$\frac{moles\ B}{moles\ A}$$

Q #1

$$\underset{A}{N_2} + 3H_2 \rightarrow \underset{B}{2NH_3}$$

54 grams N_2 → ? moles NH_3

$$\frac{54\ \text{g}\ \cancel{N_2}}{} \;\Bigg|\; \frac{1\ \text{mol}\cancel{\text{e}\ N_2}}{28.01\ \cancel{\text{g}\ N_2}} \;\Bigg|\; \frac{2\ \text{mole}\ NH_3}{1\ \text{mol}\cancel{\text{e}\ N_2}}$$

= 3.9 moles NH_3

Q #2

$$N_2 + \underset{B}{3H_2} \rightarrow \underset{A}{2NH_3}$$

75 grams NH_3 → ? g H_2

Pathway:

grams A → moles A → moles B → grams B

Molar mass of A	**Mole Ratio**	**Molar mass of B**
$\frac{X\ g\ A}{1\ mole\ A}$	$\frac{moles\ B}{moles\ A}$	$\frac{X\ g\ B}{1\ mole\ B}$

Q #2

$$N_2 + \underset{B}{3H_2} \rightarrow \underset{A}{2NH_3}$$

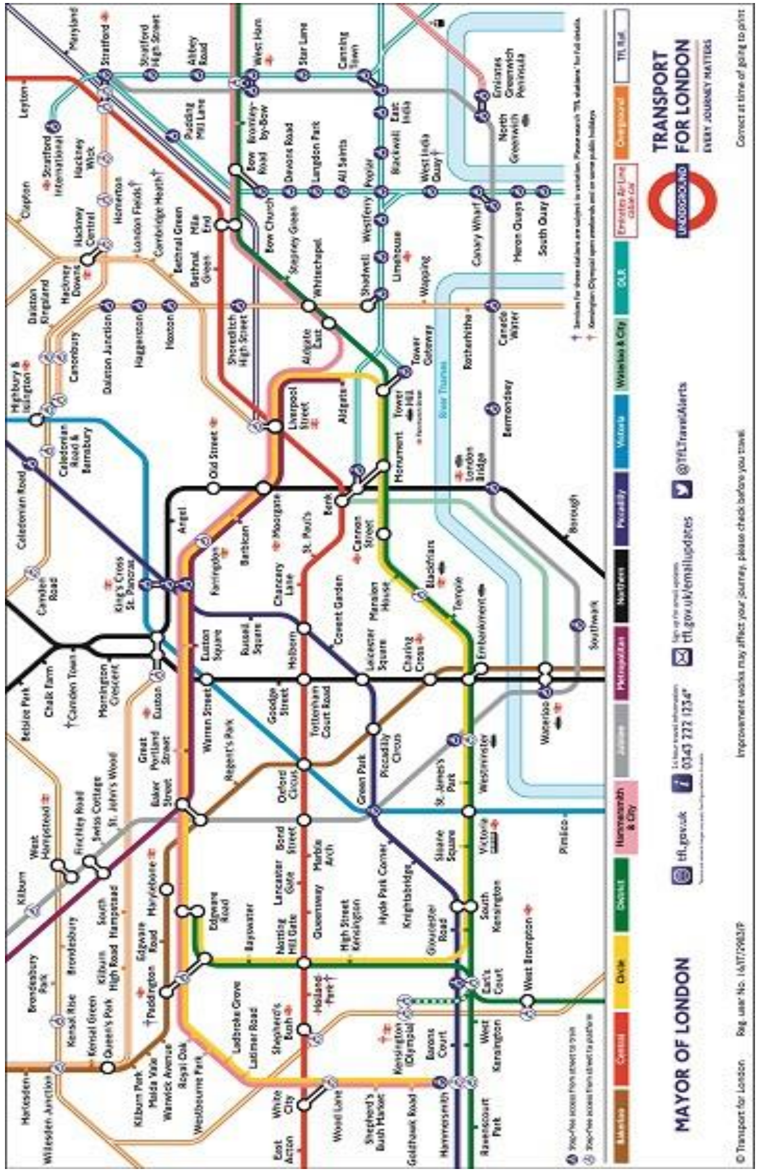
75 grams NH_3 → ? g H_2

$$\begin{array}{l|l|l|l}
75\ g\ \cancel{NH_3} & 1\ \cancel{mole}\ NH_3 & 3\ \cancel{mole}\ H_2 & 2.02\ \boxed{g\ H_2} \\
\hline
 & 17.03\ \cancel{g}\ NH_3 & 2\ \cancel{mole}\ NH_3 & 1\ mole\ \cancel{H_2}
\end{array}$$

$$= 13.34\ g\ H_2$$

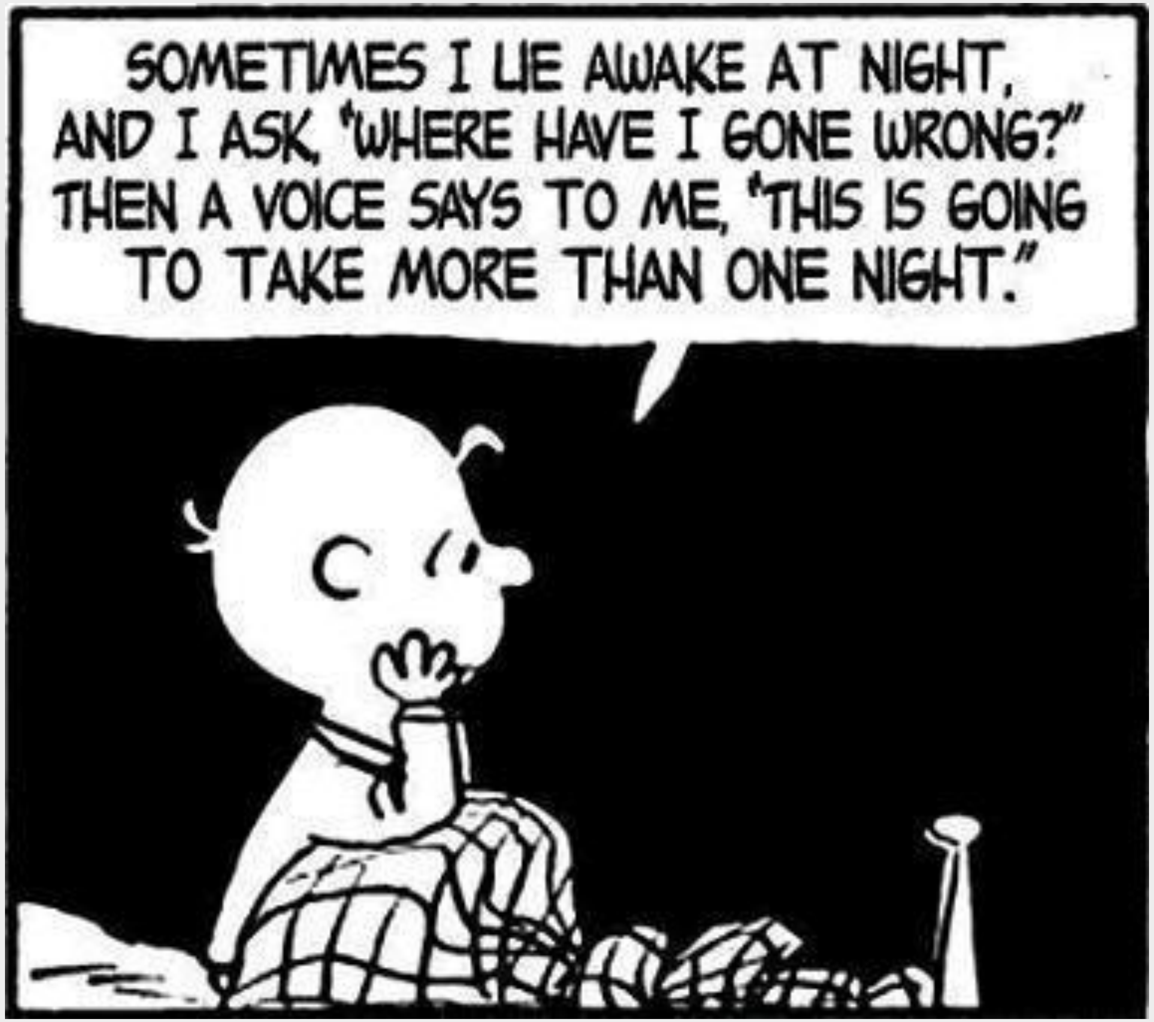
LOTS of possible routes!

- Just follow the mole highway
- Use dimensional analysis
- Flip conversion factors
- Cancel units



Things don’t always work perfectly…

In the lab sometimes you don’t make 100% of what your stoichiometry calculation says you should make



Theoretical Yield

The quantities that the stoichiometry calculations predict *should* be made

Actual/Experimental Yield

The quantity that you
actually made in the lab experiment

% Yield

How good did you do!?

$$\text{percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

Not the same as % error!!!

Careful finding extra stuff online!

Do not do anything that says “limiting reagents” – we haven’t learned that yet. Don’t do problems that give you two starting values (you start with 15 grams of N_2 and 7 grams of H_2, how much NH_3 can you make?) – that is a limiting reagent problem. We will do limiting reagents after winter break!

Class Group Practice

15 g sodium nitrate and excess calcium hydroxide react. How many grams of your calcium containing product can be made?

14.5 g

$Ca(NO_3)_2$

Class Individual Practice – timed!

15 g magnesium nitrite and excess ammonium phosphate react. How many grams of your magnesium containing product can be made?

11.3 g
$Mg_3(PO_4)_2$

YouTube link to presentation

https://youtu.be/FjNpLz_Wxt4