Στοιχειομετρία = Stoichiometry

It's hard to say in Greek, and it's hard to say in English too.
It's all about the math, and it's way cool too.

SEE INTO THE PAST

SEE INTO THE FUTURE

THIS IS THE GREEK GOD JANUS, WHO IT WAS SAID,
COULD SEE INTO THE PAST AND SEE INTO THE FUTURE.

THIS IS WHAT STOICHIOMETRY ALLOWS YOU TO DO,
WHEN IT COMES TO CHEMICAL REACTIONS.

Name

Stoichiometry BASICS

Stoichiometry is a big word and it does include some big (long) multistep problems, but really it is just an extension of what we have done before. When we learned of moles and the conversions between mass and moles, and moles and volume, or moles and particles, we would convert from unit to unit. With stoich (the short name) we start with the relationship between the parts of a balanced chemical equation, say the hydrogen and the oxygen in the synthesis of water. We can see in this balanced chemical equation several things.

Make sure you grasp each of the sentences that follow this equation:

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

This can mean

A - Two molecules of hydrogen and one molecule of oxygen make two molecules of water
B - Two moles of hydrogen and one mole of oxygen make two moles of water

Since the second statement is just as true, and we've already learned of mole math conversions, using this relationship and some calculations, you could also see that

C - 4 g H_2 (the molar mass of H_2 x2) + 32g O_2 (the molar mass of O_2) = 36 g H_2O
D - $2x6.02x10^{23}$ molecules H_2 require $6.02\ x10^{23}$ molecules O_2 to form $2x6.02x10^{23}$ molecules H_2O

In fact since the ratio of moles here is 2Hydrogen:1Oxygen:2Water is set, and since we can convert moles to mass, particles, or volumes, we can do all sorts of tricks (mathematically) to this equation.

For instance, the hardest stoich problem might be this

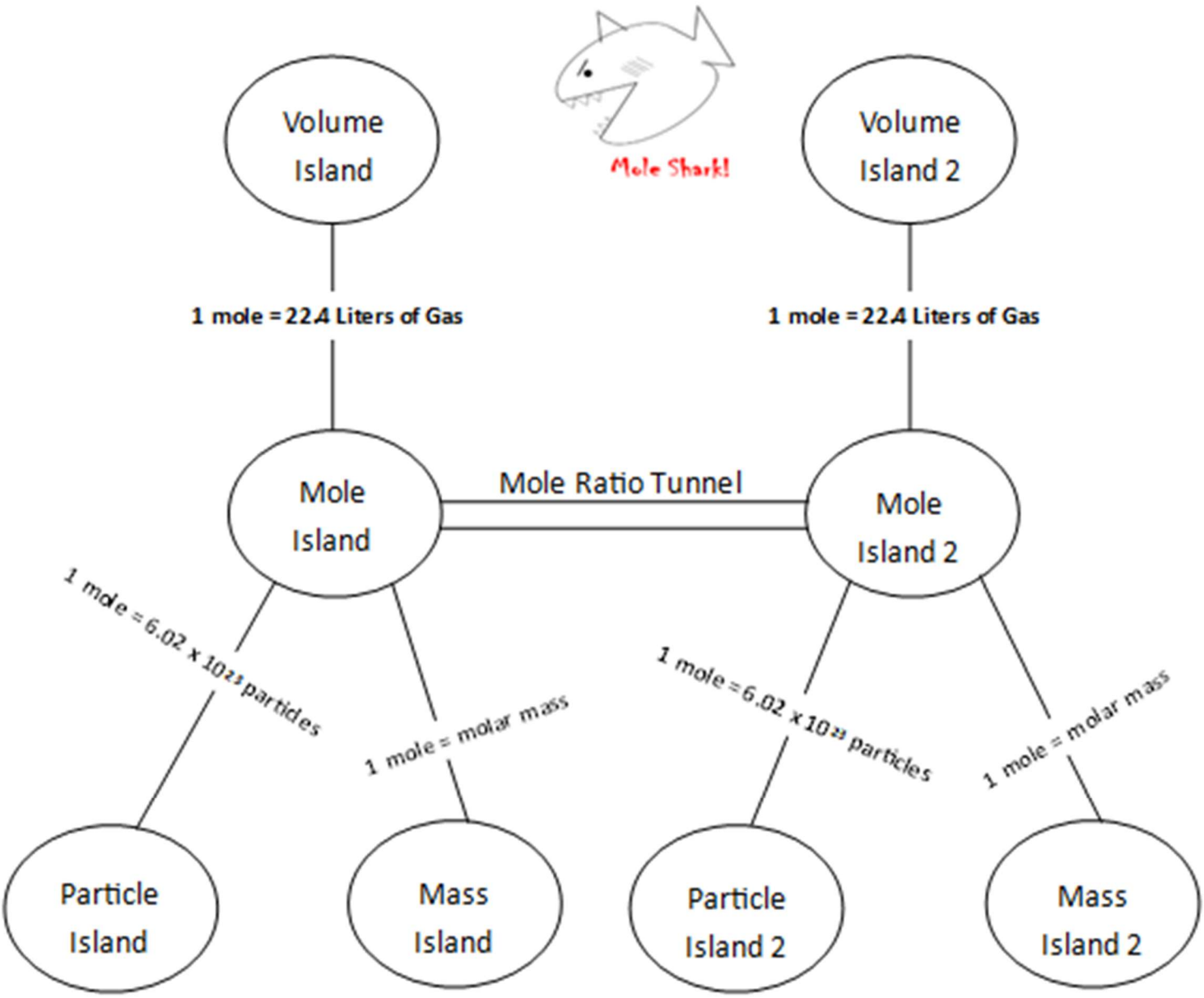
If you start with 34.7 Liters of hydrogen, how many molecules of water form?
Go slowly and follow how this could be easily solved with what you already know.
Step 1 - convert the 34.7 liters of hydrogen into moles of hydrogen
Step 2 - the ratio of moles of Hydrogen to moles of Water (in this equation) is 2:2, we could use a simple ratio to determine how many moles of water will form.
Step 3 - after you calculate the number of moles of water that will form, using Avogadro's number of molecules per mole, you can make this third conversion.

The biggest stoichiometry problem is three steps, find your starting point, and use the map on the next page to plot your trip, using the "tolls" or the conversion factors each step of the way. Don't get eaten by the shark!

In mole math, we would convert one thing from mass → moles → volume (or particles). In stoichiometry, you can look at 2 different parts of a chemical equation at once. If there are 3 or more parts, they will take care of themselves in another problem. Here we will focus on 2 things at once now, not more than that.

For example: using the last problem, we'd start at Volume Island, convert the liter of hydrogen to moles of hydrogen, then make a ratio between the hydrogen and water, moving through the Mole Ratio Tunnel, to Mole Island 2. From there, we'd convert to get to Particle Island 2. The biggest problem in stoich is three steps. The math for this problem follows on the next page. Go slowly through it, because this is the whole key. Finding your starting point and doing the steps in order. Use your formulas, watch your SF, and remember:

"Paper is cheap, knowledge is valuable".



$2H_2 + O_2 \rightarrow 2H_2O$

When 34.7 liters of hydrogen react, how many molecules of water form?

Step 1	$\frac{34.7 \text{ L } H_2}{1} \quad X \quad \frac{1 \text{ mole } H_2}{22.4 \text{ L } H_2} = 1.55 \text{ moles } H_2$

Step 2	MR $\frac{H_2}{H_2O} \quad \frac{2}{2} = \frac{1.55 \text{ moles of hydrogen}}{X \text{ moles of water}}$ $X = 1.55$ moles H_2O form

Step 3	$\frac{1.55 \text{ mole } H_2O}{1} \quad X \quad \frac{6.02 \times 10^{23} \text{ molecules } H_2O}{1 \text{ mole } H_2O} = 9.38 \times 10^{23}$ molecules H_2O

This is as hard as it could get, 3 steps of math. Each balanced chemical equation sets the MOLE RATIO for all the parts, and we just need to focus on two of them. All other parts are in "other" problems, but not the one we're doing.

With "mole math" we use one part, or one thing, but in "stoich" we look at two parts of the equation at once. The most common problems to avoid: SF, putting other units than moles into the MOLE RATIO, or not following the map and doing the math out of sequence (wrong). Step by step, use the big map. Add the second part of the map and the Mole Ratio Tunnel to the bottom of Table H in your reference table at any time.

$N_{2(G)} + 3H_{2(G)} \rightarrow 2NH_{3(G)}$

When 632 Liters of $H_{2(G)}$ react, how many grams of $N_{2(G)}$ are necessary to complete the reaction? (assume STP)

Step 1	$\frac{632 \text{ L } H_2}{1} \quad X \quad \frac{1 \text{ mole } H_2}{22.4 \text{ L } H_2} = 28.2 \text{ moles } H_2$

Step 2	MR $\frac{H_2}{N_2} \quad \frac{3}{2} = \frac{28.2 \text{ moles } H_2}{X \text{ moles } V_2}$ $X = 18.8$ moles N_2 are needed

Step 3	$\frac{18.8 \text{ moles } N_2}{1} \quad X \quad \frac{28 \text{ grams } N_2}{1 \text{ mole } N_2} = 526 \text{ moles } N_2$

Third problem: the combustion of ethane gas $2C_2H_{6(G)} + 7O_{2(G)} \rightarrow 4CO_{2(G)} + 6H_2O_{(G)}$

How many grams of oxygen are used up when 308 liters of ethane combusts completely?
Going step by step, slowly, follow along. You should do this problem on loose leaf paper now.

Look at map first: Start at 308 L ethane (Volume Island 1).
Move to Mole Island 1, then to Mole Island 2, and finally to Mass Island 2. Watch SF.

Step 1 Convert mass of ethane to moles of ethane	$\frac{308 \text{ Liters ethane}}{1} \times \frac{1 \text{ mole ethane}}{22.4 \text{ Liters}} = 13.8 \text{ moles}$ (3SF)	
Step 2 Mole Ratio of moles of ethane to moles of oxygen	MR: $\frac{\text{ethane}}{\text{oxygen}} \quad \frac{2}{7} \quad \frac{13.8}{X}$	Solve for X $2X = 96.6$ $X = 48.3$ moles of oxygen
Step 3 Convert moles of oxygen into grams of oxygen	$\frac{48.3 \text{ moles } O_2}{1} \times \frac{32 \text{ g } O_2}{1 \text{ mole } O_2} = 1550 \text{ grams } O_2$ (3SF)	

Stoichiometry is easy. The basic parts you already know.
Sometimes the problems are shorter: 2 steps, or even one step mole to mole ratio conversions.

Examples:
(2 steps) When 308 liters of ethane combust, how many moles of oxygen are required?

(2 steps) When 13.8 moles of ethane combust, how many grams of oxygen are required?

(1 step) When 13.8 moles of ethane combust, how many moles of oxygen are required?

Use the island map to determine your starting point and ending point, then do the math to get you where you need to be.

1	What is Stoichiometry?

To make brownies, the recipe says mix together 1 box of mix, 3 eggs, 1 cup water, and ½ cup oil, then bake.

The "recipe" ratio is 1 box mix to 3 eggs to 1 cup of water to ½ cup of oil

2	How many atoms and molecules and formula units are in ratio in this $4Al_{(S)} + 3O_{2(G)} \rightarrow 2Al_2O_{3(S)}$
3	$4Al_{(S)} + 3O_{2(G)} \rightarrow 2Al_2O_{3(S)}$ What is the mole ratio for this equation?
4	If you used up 8 moles of Al, how much O_2 would you need to complete the reaction?
5	If you used up only two moles of Al, how many moles of $O_{2(G)}$ would form?
6	Stoichiometry is the math based upon…
7	When 56.9 grams of Al reacts, how many liters of O_2 would be necessary to complete the reaction? $4Al_{(S)} + 3O_{2(G)} \rightarrow 2Al_2O_{3(S)}$

8	Aluminum and chlorine form aluminum chloride. Write balanced equation first.
	If you use 75.0 g of metal, how many grams of product form?
9	When 8.50 moles of propanol combust, how many grams of water form? $2C_3H_7OH_{(G)} + 9O_{2(G)} \rightarrow 6CO_{2(G)} + 8H_2O_{(G)}$

10	If you want to use up 23.1 moles of HCl, how many molecules of hydrogen form? Two steps
11	371.5 grams of candle wax ($C_{21}H_{44}$) combust. How many liters of CO_2 gas form? Assume STP. 3 steps

12	Using the same wax combustion reaction above, if you consume 23.9 moles of oxygen, how many moles of water form? One step. *(sometimes it's easy)*
14	You have 4.56×10^{25} atoms of Zn that you put into $H_3PO_{4(AQ)}$ and hydrogen gas fizzes out. How many grams of hydrogen gas form? Balance this equation first. $\_\_Zn + \_\_H_3PO_{4(AQ)} \rightarrow \_\_Zn_3(PO_4)_{2(AQ)} + \_\_H_{2(G)}$

15. How many liters of N_2 gas are required to combine with 809 liters of H_2 when ammonia (NH_3) forms? Write a balanced equation first.

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16. If exactly 15.6 moles of ethane gas combust, how many moles of oxygen are used? (copy equation)

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17. If exactly 649.6 L of $NO_{(G)}$ form, how many liters of O_2 are used?

18. In this balanced combustion, 125 g of oxygen are used up. How many g of H_2O are produced?

$$2C_8H_{18(L)} + 25O_{2(G)} \rightarrow 16CO_{2(G)} + 18H_2O_{(G)}$$

19. When 105 g of N_2 react with oxygen to form dinitrogen pentoxide. How many molecules of O_2 are required to complete this reaction? Write a balanced equation on the line here.

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20. In an odd chemical reaction, 0.135 moles of H_2 react. How many grams of NH_3 form in this reaction?

$$2NO_{2(G)} + 7H_{2(G)} \rightarrow 2NH_{3(G)} + 4H_2O_{(L)}$$

21. When 9.42×10^{25} atoms of phosphorous react with sufficient chlorine to make phosphorous pentachloride, how many molecules of chlorine gas are necessary? Write a balanced equation first.

Stoichiometry Map for now, and college.

Mole Shark!