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 shorter 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

1. two molecules of hydrogen and one molecule of oxygen make two molecules of water
2. 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

3. 4 g H_2 (the molar mass of H_2 x2) + 32g O_2 (the molar mass of O_2) = 36 g H_2O
4. $2\text{x}6.02\text{x}10^{23}$ molecules H_2 require $6.02\ \text{x}10^{23}$ molecules O_2 to form $2\text{x}6.02\text{x}10^{23}$ molecules H_2O

In fact since the ratio of moles here is 2Hydrogen:1Oxygen:2Water is set, and since we can covert 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: Since 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.

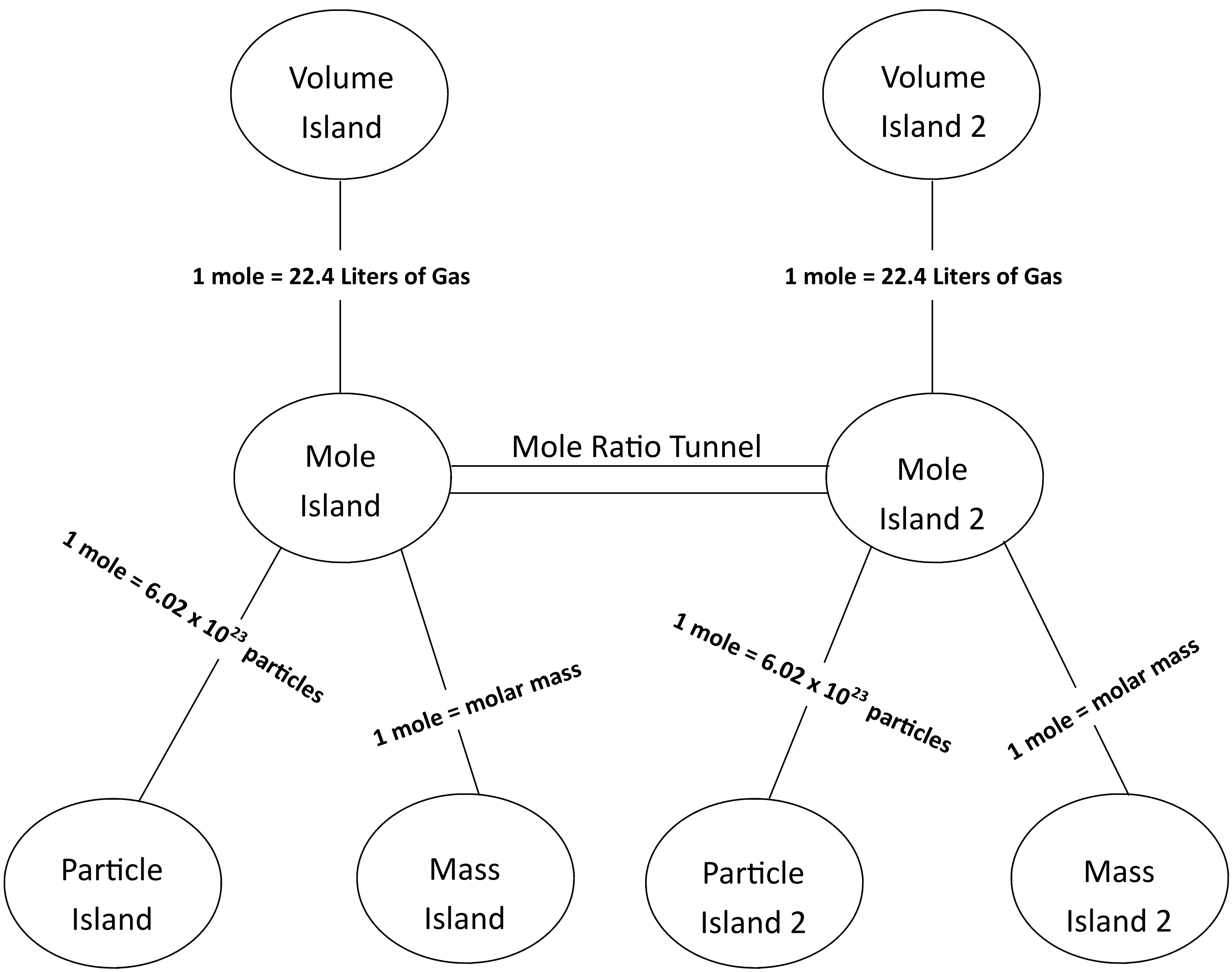
Step 3: Once you calculate the number of moles of water that will form, using Avogadro's number of molecules per mole, you can make this third conversion.

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 covert one thing from mass to moles to 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 covert to get to Particle Island 2. The biggest problem in all of 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, think, and remember that:
"Paper is cheap, knowledge is valuable".



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

If you start with 34.7 Liters of hydrogen, how many molecules of water form?

Step 1: $\frac{34.7\ \cancel{L\ H_2}}{1} \times \frac{1\ \text{mole}\ H_2}{22.4\ \cancel{L\ H_2}} = 1.55\ \text{moles}\ H_2$

MR stands for Mole Ratio

In this case, the ratio between hydrogen + water, the 2 parts of this equation we are dealing with. The oxygen is not part of this problem at all.

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

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

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.

Second big problem: When ammonia forms this way: $N_{2(G)} + 3H_{2(G)} \rightarrow 2NH_{3(G)}$

If you use 632 Liters of hydrogen, how many grams of nitrogen gas are necessary? (assume STP).

Step 1: $\frac{632\ \cancel{L\ H_2}}{1} \times \frac{1\ \text{mole}\ H_2}{22.4\ \cancel{L\ H_2}} = 28.2\ \text{moles}\ H_2$

Step 2: MR $\frac{H_2}{N_2}$ $\frac{3}{2}$ $\frac{28.2\ \text{moles of hydrogen}}{X\ \text{moles of nitrogen}}$ Solving for X: X = 18.8 moles N_2 are necessary

Step 3: $\frac{18.8\ \cancel{\text{mole}\ N_2}}{1} \times \frac{28\ \text{grams}\ N_2}{1\ \cancel{\text{mole}\ N_2}} = 526$ moles N_2 are necessary

Third problem: the combustion of ethane gas,

$$2C_2H_{6(G)} + 7O_{2(G)} \longrightarrow 4CO_{2(G)} + 6H_2O_{(G)}$$

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

Stoichiometry is easy. The basic parts you already know. It's only an extra step. Sometimes the problems are shorter: 2 steps, or even one step mole to mole ratio conversions. Examples:

(2 steps) Ex4: When 308 liters of ethane combust how many moles of oxygen are required?

(2 steps) Ex5: When 13.8 moles of ethane combust, how many grams of oxygen are required?

(1 step) Ex6: When 13.8 moles of ethane combust, how many moles of oxygen are required?