Day 6C.1 Stoich/BCA Intro

Wednesday, February 27, 2019 8:20 AM

Stoichiometry

Stoichiometry is the process of determining how much product is made or how much reactant is needed during a chemical reaction. As we know, in chemical reactions **atoms are conserved**. We show this in a balanced chemical equation.

The balanced chemical equation tells us two things:

1. Reactants and products involved in the chemical change (rearrangement of atoms).
2. The ratio of particles involved. This ratio can be seen either as a ratio of individual particles or as a ratio of moles.

In lab, it is only practical to work with moles of substances rather than individual atoms or molecules, and so we interpret our equations as a ratio of moles, or a **mole ratio**.

Example: $2\ Mg(s) + O_2(g) \rightarrow 2\ MgO(s)$

For the reaction above, we would interpret the balanced chemical equation as:

For every 2 moles of Mg that reacts, 1 mole of O_2 is required and 2 moles of MgO are produced.

Thus, the mole ratio is: **2 moles Mg : 1 mole O_2 : 2 moles of MgO**

The mole ratio relationship can be used to make predictions about how much reactant is needed to make a specific amount of product or how much product can be made from the available amount of reactant.

Making Predictions

In every reaction, there are three stages to consider:

1. **Before:** amounts of each substance present before the reaction takes place.
2. **Change:** how much of each substance actually changes during the reaction.
3. **After:** amounts of each substance present after the reaction takes place.

These three stages will be organized into a Before-Change-After (BCA) table.

G.C. || || || ||
Marsh | | | | |
Choc. | | | | | | | | | | | |

S'more ||||

Stoichiometry: Limiting Reactant (when there are two given values)

1. A S'more is made by combining 2 graham crackers, 1 marshmallow, and 1 bar of chocolate. If you have the following ingredients available, how many S'mores can you make?
   8 graham crackers, 5 marshmallows, and 12 bars of chocolate

Equation:	2 graham crackers +	1 marshmallow +	1 chocolate →	1 S'more
Before:	8	5	12	0
Change:	−8	$-8(\frac{1}{2})$ = −4	$-8(\frac{1}{2})$ = −4	$+8(\frac{1}{2})$ = +4
After:	Ø Limiting	1 Leftover (excess)	8 Excess	4 Made

Which ingredient is used up first? graham crackers

Identify any ingredients that are left over. marsh & choc.

Limiting Reactant (Reagent) - runs out 1st (zero After rxn)

Excess Reactant (Reagent) - left overs

2. If you have the following ingredients available, how many S'mores can you make?
14 graham crackers, 6 marshmallows, and 8 bars of chocolate

Equation: 2 graham crackers + 1 marshmallow + 1 chocolate → 1 S'more

	2 graham crackers	1 marshmallow	1 chocolate	1 S'more
B	14	6	8	∅
~~C~~	~~LR −14~~	~~−14 (1/2) = −7~~ Not Enough	~~−14 ( )~~	~~+14 ( )~~
C	−6 (2/1) = −12	LR ✓ −6	−6 (1/1) = −6	+6 (1/1) = +6
A	14 − 12 = 2 g.c.	6 − 6 = ∅ Limiting	8 − 6 = 2 choc.	∅ + 6 = 6 s'mores

# of S'mores produced: 6 s'mores

Identify the limiting reactant. Marsh.

Identify the excess reactants. g.c. & choc

How much of each excess reactant remain?

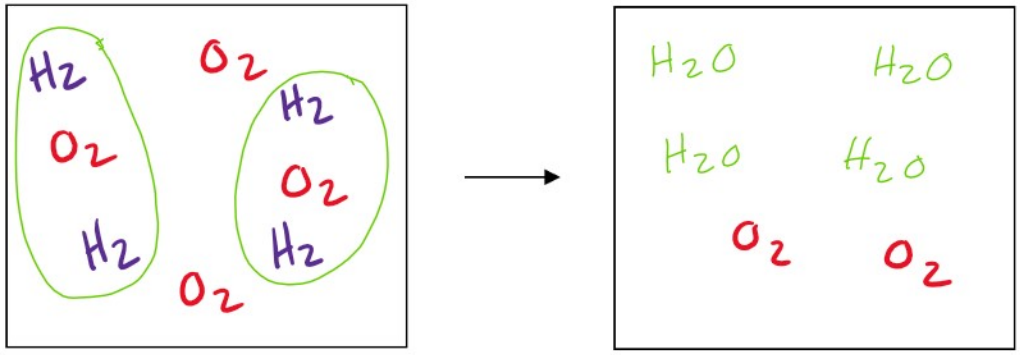
2 g.c. + 2 choc.

3. Hydrogen and oxygen react to form water according to the equation below. 4.0 moles of hydrogen and 4.0 moles of oxygen are mixed together and allowed to react.

H_2 O_2

$$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$$

a) Draw a particulate representation of the particles in the reaction container.



Before After

i. How many moles of water are produced?

4 mol H_2O

ii. Which reactant is completely used?

H_2

iii. Which reactant is in excess?

O_2

iv. How many moles of excess reactant remain after the reaction?

2 mol O_2

b) Construct a Before-Change-After Table for the reaction mixture.

	$2\ H_2$ +	O_2 →	$2\ H_2O$
B	4	4	∅
C	(LR) −4	$-4\left(\frac{1}{2}\right)$ = −2	$+4\left(\frac{2}{2}\right)$ = +4
A	4 − 4 = ∅ Limiting	4 − 2 = 2 mol O_2 Excess	∅ + 4 = 4 mol H_2O

i. How many moles of water are produced?

4 mol H_2O

ii. Which reactant is completely used?

H_2

iii. Which reactant is in excess?

O_2

iv. How many moles of excess reactant remain after the reaction?

2 mol O_2

c) Based on the two methods above (particulate drawing and BCA table), what determines how much product is made from a particular reactant mixture?

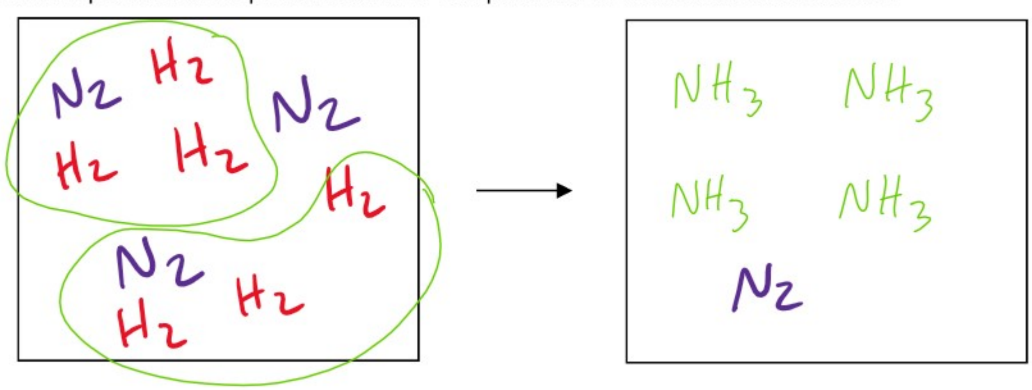
Limiting reactant determines quantity product

4. Nitrogen gas and hydrogen gas react to form ammonia gas according to the equation below. 3 moles of nitrogen and 6 moles of hydrogen are placed into a reaction vessel and allowed to react.

1 sig fig

$$N_2(g) + 3\,H_2(g) \rightarrow 2\,NH_3(g)$$

a) Draw a particulate representation of the particles in the reaction container.



Before | After

i. How many moles of ammonia gas are produced?

4 mol NH_3

ii. What is the limiting reactant?

H_2

iii. Which reactant is in excess?

N_2

iv. How many moles of excess reactant remain?

1 mol N_2

b) Construct a Before-Change-After Table for the reaction mixture.

	N_2 +	$3H_2$ →	$2NH_3$
B	3	6	Ø
~~C~~	~~(LR) −3~~	~~−3 (3/1) = −9~~	~~+3 ( )~~
C	−6 (1/3) = −2	(LR) −6	+6 (2/3) = +4
A	3 − 2 = 1 mol N_2	6 − 6 = Ø Limiting	Ø + 4 = 4 mol NH_3

i. How many moles of ammonia gas are produced?

4 mol NH_3

ii. What is the limiting reactant?

H_2

iii. Which reactant is in excess?

N_2

iv. How many moles of excess reactant remain after the reaction?

1 mol N_2

c) How many liters of NH_3 gas are produced (Made) at STP from this reaction mixture?

Standard Temp + Press.
0 °C 1 atm

1 mole = 22.4 L

$$\frac{4\ \text{mol}\ NH_3}{} \times \frac{22.4\ \text{L}\ NH_3}{1\ \text{mol}\ NH_3} = 89.6\ \text{L}\ NH_3$$

= **90 L NH_3**

1 sig fig