Introduction to Stoichiometry

Objectives: Introduction to concepts of stoichiometry.

- How we use the coefficients
- How to determine the limiting reactant
- How mass figures into stoichiometry
- How to determine products and un-used material
- Typical Multiple choice questions

Get a visual of stoichiometry

- Link… Notice the following
- the stoichiometric ratio
- how they combine in whole number ratios.
- There are a lot more H_2 molecules but less mass
- Chemicals combine based upon the stoich ratio and that has NOTHING to do with their mass.
- Notice all the mass is conserved!
- We will use mass only as a means to COUNT!

How we use the coefficients

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

- Notice: Through balancing the chemical H_2 and O_2 are used at a 2:1 ratio.
- Excess reactant (reagent): Based on the ratio consumed there was unused chemical leftover when another chemical was completely consumed.
- Limiting reactant(reagent): Reactant completely used stopping the reaction. This substance determines (controls) production.

How to determine the limiting reactant

- How do we know which reactant will be consumed 1st stopping the reaction?
- 2 factors
  - 1: Physical quantity
  - 2: Rate used (coefficient)

Example 1

$2H_2 + O_2 \rightarrow 2H_2O$

5 moles of each reactant

Q: Which will run out 1st?

A: Since they each have the same quantity and the H_2 is being used up twice as fast the H is the LR.

Example 2

$$Mg + S \rightarrow MgS$$

Mg: 5 moles

S: 10 moles

Q: What is the LR in this problem.

A: Notice they are being consumed at the same rate. Therefore since the S is in higher quantity the Mg will run out stopping the reaction.

Think it over…

- Obviously if a substance has less quantity and at a faster rate it has to be the limiting reactant.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

$CH_{4:}$ .75 moles

$O_{2:}$ 1.0 moles

Q: What is the limiting reactant?

A: This is a little more difficult. See next slide.

Answer
In this slide we run CH_4 to 0

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

	CH_4	O_2	
Initial	.75	1.0	← moles
Change	-.75	-1.5	← CH_4 LR
End	0	-.5	

Note: This is not realistic because the O_2 went negative. In order to consume the CH_4 we would need another .5 moles of O_2.

-- Let try this making O_2 the limiting reactant.

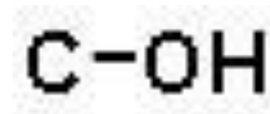
Answer

	CH_4	+ $2O_2$	$\rightarrow$ CO_2	+ $2H_2O$	
Initial	.75	1.0	0	0	$\leftarrow$ moles
Change	-.5	-1.0	+. 5	.1	$\leftarrow$ CH_4 LR
End	.15	0	.5	.1	

Note: O_2 is the LR. A table like this works great to see what is going on. It ONLY works with moles and gases. NOT with grams!

Common Problem

- Methanol, a common fuel used for race cars is the simplest alcohol.



- Even though the actual formula is CH_3OH it is common to leave off the H atoms.

$$2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$$

Lets burn it!

32g/mol		32g/mol				
$2CH_3OH$	+	$3O_2$	$\rightarrow$	$2CO_{2\,(g)}$	+	$4H_2O(g)$
25g		30g		Liters? @STP		Molecules?

- Determine molar masses of each.
- Determine the limiting reactant.
- Determine the products.

Let set up a chart

	$2CH_3OH$ +	$3O_2$ →	$2CO_{2\,(g)}$ +	$4H_2O(g)$
I	.78	.93		
C	-.625	-.93	+.625	1.24 moles
E	.155	0	.625	1.24

<u>Math</u>

.93 O_2 * (2/3) = .625 moles

.93 O_2 * (4/3) = 1.24 moles

Liters of CO_2

- PV = nRT
  - P = pressure (atm)
  - V = Volume (L)
  - n = moles
  - R = .0821
  - T = Temperature (K)
- STP is a common set of conditions
  - 1 atm (760mmHg) Temp. = 273K

PV = nRT
V = nRT/P
V = .625 * .0821 * 273/1
V = 14.0L

Molecules of H_2O

- 1.24 moles H_2O Convert to molecules.
- 1.24 * 6.022E 23 = 7.46E23
- Alternate Question:
- How many atoms of hydrogen are present in the water?
- There are 2 H atoms in each water molecule
- 2:1 ratio
- 7.46E23 * 2 = 1.49E24 atoms

Percent yield

- Theoretical yield : 14.0 L of Carbon dioxide.
- When the experiment was actually ran we only received 10.5 L(Actual yield).

- Percent Yield = Actual/Theoretical * 100
- 10.5/14.0 * 100 = 75%

Typical Multiple Choice Problem

- $2KClO_3 \rightarrow 2KCl + 3O_2$
- Which expression gives the mass of O_2 produced when 15g $KClO_3$ is heated, according to the equation above, in an open vessel until no further weight loss is observed

a. 15.0 x (122.5/1) x (2/3) x (31/1)
b. 15.0 x (1/122.5) x (3/2) x (32/1)
c. 15.0 x (1/122.5) x (3/2) x (1/32)
d. 15.0 x (1/122.5) x (2/3) x (1/32)
e. 15.0 x (122.5/1) x (3/2) x (32/1)

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Start eliminating. 1^{st} you must divide to get into moles.

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e. ~~15.0 x (122.5/1) x (3/2) x (32/1)~~

2nd you must mulitiply to get back to grams!

Typical Question

- Which pair of samples contains the same number of oxygen atoms in each compound?
- (Last Modified 5-13-04)
- a. 0.10 mol Al_2O_3 and 0.50 mol BaO
- b. 0.20 mol Cl_2O and 0.10 mol HClO
- c. 0.20 mol SnO and 0.20 mol SnO_2
- d. 0.10 mol Na_2O and 0.10 mol Na_2SO_4
- e. 0.20 mol $Ca(OH)_2$ and 0.10 mol $H_2C_2O_4$