Ch 3: Mole ratio for a compound
The chemical formula tells us the mole ratio.
CO_2 = 1 CO_2 molecule : 1 C atom : 2 O atoms.

Ch 4: Mole ratio for a reaction
The balanced chemical reactions tells us.
$C_{12}H_{22}O_{11}$ + 12 O_2 → 12 CO_2 + 11 H_2O

1 $C_{12}H_{22}O_{11}$ molecule: 12 O_2 molecules : 12 CO_2 molecules : 11 H_2O molecules.

Applications of the mole ratio concept
grams <--> moles <--> moles <--> grams

Another empirical formula example:

An organic compound contains only C, H, and O. Combustion analysis of 0.105 g of the compound yields 0.257 g of CO_2 and 0.0350 g H_2O. What is the empirical formula of the compound? (what is the C:H:O mole ratio?)

g CO_2 → mol CO_2 → mol C

g H_2O → mol H_2O → mol H

Practice:

An organic compound contains only C, H, and O. Combustion analysis of 1.000 g of the compound yields 1.502 g of CO_2 and 0.409 g H_2O. What is the empirical formula of the compound?

Limiting Reactant and Excess Reactant

A balanced chemical equation is like a recipe.

If we have the right amount of starting ingredients and we follow the recipe correctly, we will use up all the ingredients.

If we have extra amounts of ingredients and we follow the recipe correctly, we will have leftover ingredients.

In a chemical equation, the starting ingredients are the reactants.

The BLT and identifying the limiting reactant:

Bacon Lettuce Tomato sandwich =
2 bread : 4 bacon : 1 tomato : 1 lettuce

2 bread + 4 bacon + 1 tomato + 1 lettuce → 1 sandwich

Example: If given 10 pieces of bread, 24 pieces of bacon, and unlimited tomato and lettuce, how many sandwiches could you make?

In your head,
$10 \text{ bread} \times \frac{1 \text{ sandwich}}{2 \text{ bread}} = 5 \text{ sandwiches.}$

$24 \text{ bacon} \times \frac{1 \text{ sandwich}}{4 \text{ bacon}} = 6 \text{ sandwiches.}$

Calculate which reactant would make the most product, by pretending the other reactant is unlimited. Then identify the limiting reactant (LR).
(Mass Method in textbook)

The limited amount of bread means we can only make 5 sandwiches, not 6.
Bread is the limiting reactant!

Here's another way of looking at this problem, (Mole Ratio Method in textbook)

$$10 \text{ bread} \times \frac{4 \text{ bacon}}{2 \text{ bread}} = 20 \text{ bacon needed}$$

… we have enough bacon (24), so bread is limiting.

OR

$$24 \text{ bacon} \times \frac{2 \text{ bread}}{4 \text{ bacon}} = 12 \text{ bread needed}$$

… we don't have enough bread (10), so bread is limiting.

Identify the limiting reactant (LR) first, then use the LR to find out how many sandwiches can be made.

$$10 \text{ bread} \times \frac{1 \text{ sandwich}}{2 \text{ bread}} = 5 \text{ sandwiches.}$$

We can also see that we have 4 leftover bacon by knowing that we started with 24 and used up 20 bacon with the 10 bread.

Chemistry example:
The recipe: $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$.
The ingredients:84.0 g N_2 and 24.2 g H_2.
What is the limiting reactant?
How much ammonia can be made?
How much excess reactant is leftover?

MM N_2 = 28.0134 g/mol
MM H_2 = 2.0158 g/mol
MM NH_3 = 17.0304 g/mol

Need to use mole ratios because of the recipe units!

Mass method

Mole ratio method

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

Organization for either method: Table of amounts in moles

Convert grams into moles using MM, then use a table to organize data (in units of moles):

	$N_2(g)$	+	$3H_2(g)$	→	$2NH_3(g)$
Start	3		12		0
Change	-3		-9		+6
Final	0		3		6

Negative sign means the compound is consumed in that amount.

Positive sign means the compound is produced in that amount.

Final amount of limiting reactant should be zero.

No final amounts can be negative (not possible to have a negative amount of a substance).

Percent yield (% yield)

Reacting 10 bread and 24 bacon should produce 5 sandwiches.

What if only 4 sandwiches were actually made?

What is the % yield of sandwiches?

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

(in $\frac{\text{grams}}{\text{grams}}$ OR $\frac{\text{moles}}{\text{moles}}$)

$$\% \text{ yield} = \frac{4 \text{ sandwiches}}{5 \text{ sandwiches}} \times 100 = 80\%$$

Reacting 84.0 g N_2 and 24.2 g H_2 should produce 102.18 g NH_3.

What if only 91.37 g NH_3 were actually made?

What is the % yield?

Practice:

The recipe: $2Al + 3Cl_2 \rightarrow Al_2Cl_6$.

The ingredients: 2.70 g Al and 4.05 g Cl_2.

What is the limiting reactant?

How much product can be made?

How much excess reactant is leftover?

(from periodic table …

MM Al = 26.9815 g/mol

MM Cl_2 = 70.906 g/mol

MM Al_2Cl_6 = 266.681 g/mol)

What if the reaction does not work perfectly, and the percent yield is only 95.0%? How much Al_2Cl_6 will be produced?