Limiting Reactants

Definition:

- The reactant that runs out first.
  - When the L.R. runs out, the reaction stops
- The reactant that determines how much product can be made
  - Calculate this amount as follows:
    # of reactions limiting reactant can do x coefficient of product (see below)

Example 1: Tricycles
(Practical examples are easier to understand; if you get this example, try to be aware of the logic you use so you can transfer that same logic to the atom / molecule problems)

You are making tricycles.
You have 13 frames, 28 wheels, 16 pedals, and 20 seats.

How many tricycles can you make?

Solution: First we write a "balanced equation." The coefficients will prove to be very important.

1 frame + 3 wheels + 2 pedals + 1 seat → 1 tricycle.

Next make a chart as follows:

1 frame + 3 wheels + 2 pedals + 1 seat → 1 tricycle.

Have:				
# needed for 1 reaction				
# of reactions possible				

"Have" is the numbers given in the problem – the number of each part you actually have.

"# needed for 1 reaction" comes from the coefficients of the balanced equation.

"# of reactions" is calculated as follows: (Have) ÷ (# needed for 1 reaction)

1 frame + 3 wheels + **2 pedals** + 1 seat → 1 tricycle.

Have:	13	28	16	20
# needed for 1 reaction	1	3	2	1
# of reactions possible	(13÷1) 13	(28÷3) 9	(16÷2) **8**	(20÷1) 20

Pedals are the limiting reactant, because the number of tricycles we can make is the smallest for pedals.

The number of pedals allows only 8 reactions.

- The other numbers of reactions possible from the other reactants are now irrelevant – it doesn't matter if you have enough seats for 20 reactions, because you'll have to stop building after you run out of pedals.
- The number 8 (# of reactions possible with limiting reactant) will be used to calculate everything else.

1 tricycle is produced per reaction, and 8 reactions are possible.

8 tricycles are produced.

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Tricycle problem, Part 2: How many of each part are left over at the end?

1 frame + 3 wheels + **2 pedals** + 1 seat → 1 tricycle.

Have:	13	28	16	20
needed for 1 rxn	1	3	2	1
# of reactions	~~13~~	~~9~~	**8**	~~20~~

(note: the key number is 8, and the other "# of reactions" values are crossed off since they're irrelevant)

Solution Part 2:

1) Calculate the amount of each reactant that is **used up.**
   - amount used up = number of reactions (limiting reactant!) x number needed for 1 reaction
2) Subtract to find the amount left over: leftovers = amount you start with minus amount used.

Example leftovers calculation for wheels:

We have 28 wheels.
We're doing 8 reactions, since the limiting reactant can only do 8 reactions.
Each reaction uses up 3 wheels

Amount used = 8 x 3 = 24 wheels used

Leftovers = 28 – 24 = 4 wheels left.

This can also be calculated in chart format by extending the chart:

1 frame + 3 wheels + **2 pedals** + 1 seat → 1 tricycle.

Have:	13	28	16	20
needed for 1 rxn	1	3	2	1
# of reactions	~~13~~	~~9~~	**8**	~~20~~
Amount used	(8 x 1) 8	(8 x 3) 24	(8 x 2) 16	(8 x 1) 8
Leftover	(13-8) 5	(28-24) 4	(16-16) 0	(20-8) 12

Notice that none of the limiting reactant (pedals) is left at the end.

Recap of Answers:

1. Pedals are the limiting reactant
2. 8 reactions will happen (number of reactions possible with pedals, the limiting reactant)
3. 8 tricycles can be produced (number of reactions x number produced in each reaction; 8 x 1 = 8)
4. 5 frames, 4 wheels, and 12 seats will be leftover (starting amounts minus amounts used up)

Limiting Reactants: Atom / Molecule Problem Example

Question: You have 10 moles of N_2 and 18 moles of H_2, and they react as follows:

$N_2 + H_2 \rightarrow NH_3$

a) What is the limiting reactant? Which reactant is present in excess amounts (will have leftovers)?
b) How much NH_3 can be produced?
c) How much reactant will be left over?

Solution:

1) Balance the equation first: $\underline{1}N_2 + \underline{3}H_2 \rightarrow \underline{2}NH_3$
2) Make a chart like in the tricycle problem
3) Limiting reactant is the one that can support the least number of reactions
4) Multiply that number of reactions by the product coefficient calculate the product amount
5) Calculate the amount of the non-limiting reactant used up (start with # of reactions from limiting reactant; multiply by coefficient)
6) Subtract the amount used up from the starting amount to calculate leftovers

$1\ N_2 + 3\ H_2 \rightarrow 2\ NH_3$

Have	10	18
Need for 1 reaction	1	3
# of reactions	10	**6**
Used up	(6x1) 6	(6x3) 18
Leftover	4	0

Calculating NH_3 produced: 6 reactions take place, and 2 moles NH_3 are produced in each reaction.

6 reactions x 2 mol NH_3/reaction = **12 mol NH_3 produced**