

## 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.

<b>Have:</b>				
<b># needed for 1 reaction</b>				
<b># of reactions possible</b>				

“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.

<b>Have:</b>	13	28	16	20
<b># needed for 1 reaction</b>	1	3	2	1
<b># of reactions possible</b>	(13÷1) 13	(28÷3) 9	(16÷2) <b>8</b>	(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.

<b>Have:</b>	13	28	16	20
<b>needed for 1 rxn</b>	1	3	2	1
<b># of reactions</b>	<del>13</del>	9	<b>8</b>	<del>20</del>

(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 =  $8 \times 3 = 24$  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.

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

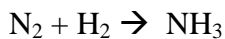
Notice that none of the limiting reactant (pedals) is left at the end.

**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;  $8 \times 1 = 8$ )
4. 5 frames, 4 wheels, and 12 seats will be leftover (starting amounts minus amounts used up)

## Limiting Reactants: Atom / Molecule Problem Example

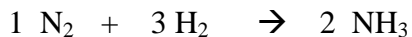
**Question:** You have 10 moles of N<sub>2</sub> and 18 moles of H<sub>2</sub>, and they react as follows:



- What is the limiting reactant? Which reactant is present in excess amounts (will have leftovers)?
- How much NH<sub>3</sub> can be produced?
- How much reactant will be left over?

### Solution:

- Balance the equation first:  $\underline{1}\text{N}_2 + \underline{3}\text{H}_2 \rightarrow \underline{2}\text{NH}_3$
- Make a chart like in the tricycle problem
- Limiting reactant is the one that can support the least number of reactions
- Multiply that number of reactions by the product coefficient calculate the product amount
- Calculate the amount of the non-limiting reactant used up (start with # of reactions from limiting reactant; multiply by coefficient)
- Subtract the amount used up from the starting amount to calculate leftovers



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

Calculating NH<sub>3</sub> produced: 6 reactions take place, and 2 moles NH<sub>3</sub> are produced in each reaction.

6 reactions x 2 mol NH<sub>3</sub>/reaction = **12 mol NH<sub>3</sub> produced**