LIMITING REACTANT PROBLEMS IN MOLES

A number of limiting reactant problems can be solved very simply and straightforwardly by a following the reaction with an initial line, change line and final line. This can be illustrated easily by the following situation.

An Illustration

Consider the simple illustration of making bicycles from frames and wheels according to the equation:

1 frame + 2 wheels ⟶ 1 bicycle

If one starts with 16 frames and 36 wheels, to determine how many bicycles can be made and how many frames or wheels will remain the following method will be very effective.

	1 frame	+	2 wheels	⟶	1 bicycle
starting quantities	16		36		0
change line	–16		–32		+16
final quantities	0		4		16

The Method

1. Write the equation for the process: 1 frame + 2 wheels ⟶ 1 bicycle
2. Write under the equation the starting quantities for each item in the equation—16, 36, and 0.
3. Determine the change line as numbers that will be added to the starting line to arrive at the final quantities.
   (a) Reactants are given negative values and products are given positive values.
   (b) The limiting reactant is given a value equal to the negative of its starting quantity--so that when the starting lines and change lines are added the final value will be zero.
   (c) Once the limiting reactant is chosen and its change value set (equal to minus the starting quantity—in this case –16), all of the change line values are determined by the coefficients in the equations. –16 frames × (**2** wheels / **1** frame) = –32 wheels and 16 frames × (**1** bicycle / **1** frame) =16 bicycles.
   (d) No final values can be negative. The change in wheels cannot be –36, because then the **change** in frames would be –36 wheels × (**1** frame / **2** wheels) = –18 frames, which would leave –2 (= 16 –18) frames for a final quantity**.**
4. Add the change line to the starting quantities to get the final quantities. The limiting reactant will end at zero, The excess reactant will end up with a final quantity equal to the amount in excess. The product value(s) will be the amount(s) produced.

Note

This method will work for chemical reactions if the starting quantities are given in moles (or even molecules). It will **not** work for starting quantities given as masses. However, it will work for any problem in which the starting quantities are converted to moles.

A Chemical Problem

Silver reacts with sulfur according to: 2 Ag(s) + S(s) ⟶ $Ag_2S(s)$ How many moles of silver sulfide can be produces starting with 6.0 moles of silver and 4.0 moles of sulfur?

	2 Ag(s)	+	S(s)	⟶	$Ag_2S(s)$
Starting	6.0		4.0		0
Change	–6.0		–3.0		+3.0
Final	0.0		1.0		3.0

Notice that the Ag change is –6.0 so S is –6.0 Ag × (**1** S / **2** Ag) = –3.0 S. S cannot be limiting, because a change in S of –4.0 would make the Ag change = –4.0 S × (**2** Ag / **1** S) = –8.0 Ag, which is not possible because 6.0 Ag (starting) – 8.0 Ag (change) = –2.0 Ag (less than zero

This problem can easily be done using the concept of **moles of reaction**.

Squeeze in a line above the starting line with calculated moles of reaction. It is determined by dividing the starting quantity (below) by the coefficient (above) in the equation. The limiting reactant is the reactant with the smallest moles of reaction.

	2 Ag(s)	+	S(s)	⟶	$Ag_2S(s)$	
mol rxn	(3.0) (= 6.0/2)		4.0 (= 4.0/1)			so Ag is limiting
Starting	6.0		4.0		0	
Change	–6.0		–3.0		+3.0	
Final	0.0		1.0		3.0	

Notice the change line is determined by multiplying the smallest mol rxn (circled) by the coefficient for each reactant and product. 2×**3.0** = 6.0 for Ag, 1×**3.0** = 3.0 for S and Ag_2S. Then reactants are negative (used up) and products are positive (produced).

Another Chemical Problem

How many moles of calcium phosphide can be prepared starting with 18 moles of calcium and 16 moles of phosphorus.

	3 Ca(s)	+	2 P(s)	⟶	$Ca_3P_2(s)$
mol rxn	(6)		8		
starting	18		16		0
change	–18		–12		+6
final	0		4		6

Mol rxn for Ca is 18/3 =**6** and for P is 16/2 =8. **6**<8 so Ca is limiting. The change line is the coefficients times smallest mol rxn. So 3×**6**=18(–) for Ca, 2×**6**=12(–) for P and 1×**6**=6(+) for Ca_3P_2.

Also

	4 Au(s)	+8 NaCN(aq)	+	$O_2(g)$	+	2 H_2O	⟶	4 $NaAu(CN)_2(aq)$	+	4 NaOH(aq)
start	12	16		10		20		0		0
change	–8	–16		–2		–4		+8		+8
final	4	0		8		16		8		8

And

	$2\ C_2H_2(g)$	+	$10\ NO(g)$	$\longrightarrow$	$4\ CO_2(g)$	+	$2\ H_2O(g)$	+	$5\ N_2(g)$
start	10		30		0		0		0
change	-6		-30		+12		+6		+15
final	+4		0		12		6		15