Limiting Reagents

Caution: this stuff is difficult to follow at first.

Be patient.

Limiting reagent defined

Given: $4NH_3 + 5O_2 \rightarrow 6H_2O + 4NO$

Q - How many moles of NO are produced if __ mol NH_3 are burned in __ mol O_2?

4 mol NH_3, 5 mol O_2

4 mol NH_3, 20 mol O_2

8 mol NH_3, 20 mol O_2

- Here, NH_3 limits the production of NO; if there was more NH_3, more NO would be produced
- Thus, NH_3 is called the "limiting reagent"

4 mol NH_3, 2.5 mol O_2

- In limiting reagent questions we use the limiting reagent as the "given quantity" and ignore the reagent that is in excess …

Limiting reagents in stoichiometry

$4NH_3 + 5O_2 \rightarrow 6H_2O + 4NO$

E.g. How many grams of NO are produced if 4 moles NH_3 are burned in 20 mol O_2?

Since NH_3 is the limiting reagent we will use this as our "given quantity" in the calculation

- Sometimes the question is more complicated. For example, if grams of the two reactants are given instead of moles we must first determine moles, then decide which is limiting …

Solving Limiting reagents 1: g to mol

$4NH_3 + 5O_2 \rightarrow 6H_2O + 4NO$

Q - How many g NO are produced if 20 g NH_3 is burned in 30 g O_2?

A - First we need to calculate the number of moles of each reactant

A – Once the number of moles of each is calculated we can determine the limiting reagent via a chart …

2: Comparison chart

	NH_3	O_2
What we have*	1.176	0.937
	1.176/0.937 = 1.25 mol	0.937/0.937 = 1 mol
What we need**	4	5
	4/5 = 0.8 mol	5/5 = 1 mol

*Choose the smallest value to divide each by

** You should have "1 mol" in the same column twice in order to make a comparison

A - There is more NH_3 (what we have) than needed (what we need). Thus NH_3 is in excess, and O_2 is the limiting reagent.

3: Stoichiometry (given = limiting)

So far we have followed two steps …

1) Expressed all chemical quantities as moles
2) Determined the limiting reagent via a chart

Finally we need to …

3) Perform the stoichiometry using the limiting reagent as the "given" quantity

Q - How many g NO are produced if 20 g NH_3 is burned in 30 g O_2?

$4NH_3 + 5O_2 \rightarrow 6H_2O + 4NO$

Limiting Reagents: shortcut

- Limiting reagent problems can be solved another way (without using a chart)…
- Do two separate calculations using both given quantities. The smaller answer is correct.

Q - How many g NO are produced if 20 g NH_3 is burned in 30 g O_2? $4NH_3 + 5O_2 \rightarrow 6H_2O + 4NO$

g NO=

$$20\ \cancel{g\ NH_3} \times \frac{1\ \cancel{mol\ NH_3}}{17.0\ \cancel{g\ NH_3}} \times \frac{4\ \cancel{mol\ NO}}{4\ \cancel{mol\ NH_3}} \times \frac{30.0\ g\ NO}{1\ \cancel{mol\ NO}} = 35.3\ g\ NO$$

$$30\ \cancel{g\ O_2} \times \frac{1\ \cancel{mol\ O_2}}{32.0\ \cancel{g\ O_2}} \times \frac{4\ \cancel{mol\ NO}}{5\ \cancel{mol\ O_2}} \times \frac{30.0\ g\ NO}{1\ \cancel{mol\ NO}} = 22.5\ g\ NO$$

Practice questions

1. $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$
   If 25 g of aluminum was added to 90 g of HCl, what mass of H_2 will be produced (try this two ways – with a chart & using the shortcut)?
2. $N_2 + 3H_2 \rightarrow 2NH_3$: If you have 20 g of N_2 and 5.0 g of H_2, which is the limiting reagent?
3. What mass of aluminum oxide is formed when 10.0 g of Al is burned in 20.0 g of O_2?
4. When C_3H_8 burns in oxygen, CO_2 and H_2O are produced. If 15.0 g of C_3H_8 reacts with 60.0 g of O_2, how much CO_2 is produced?
5. How can you tell if a question is a limiting reagent question vs. typical stoichiometry?