

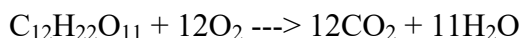
Worksheet - Limiting Reagent Problems #1 - 10

[Limiting Reagent Problems #11-20](#)

[Limiting reagent tutorial](#)

[Stoichiometry Menu](#)

Problem #1: For the combustion of sucrose:



there are 10.0 g of sucrose and 10.0 g of oxygen reacting. Which is the limiting reagent?

Solution path #1:

1) Calculate moles of sucrose:

$$10.0 \text{ g} / 342.2948 \text{ g/mol} = 0.0292146 \text{ mol}$$

2) Calculate moles of oxygen required to react with moles of sucrose:

From the coefficients, we see that 12 moles of oxygen are required for every one mole of sucrose. Therefore:

$$0.0292146 \text{ mol} \times 12 = 0.3505752 \text{ mole of oxygen required}$$

3) Determine limiting reagent:

$$\text{Oxygen on hand} \Rightarrow 10.0 \text{ g} / 31.9988 \text{ g/mol} = 0.3125 \text{ mol}$$

Since the oxygen required is greater than that on hand, it will run out before the sucrose. Oxygen is the limiting reagent.

Solution path #2:

1) Calculate moles:

$$\text{sucrose} \Rightarrow 0.0292146 \text{ mol}$$

$$\text{oxygen} \Rightarrow 0.3125 \text{ mol}$$

2) Divide by coefficients of balanced equation:

$$\text{sucrose} \Rightarrow 0.0292146 \text{ mol} / 1 \text{ mol} = 0.0292146$$

$$\text{oxygen} \Rightarrow 0.3125 \text{ mol} / 12 \text{ mol} = 0.02604$$

Oxygen is the lower value. It is the limiting reagent.

The second method above will be the preferred method to determine the limiting reagent in the following problems.

Problem #2: Calculate the number of NaBr formula units formed when 50 NBr₃ molecules and 57 NaOH formula units react?



Solution:

Comment: we can treat numbers of molecules or formula units in the exact same manner as we would use moles. Keep in mind that the meaning of one mole is that 6.022×10^{23} of that entity (be it molecules or formula units) is present.

1) Determine limiting reagent:

$$\text{NBr}_3 \Rightarrow 50 \text{ "moles"} / 2 = 25$$

$$\text{NaOH} \Rightarrow 57 \text{ "moles"} / 3 = 19$$

NaOH is the limiting reagent.

Note that there need be no conversion from grams to moles. Discussions of numbers of molecules uses numbers that are directly proportional to the number of moles and do not need to be converted.

2) Use NaOH : NaBr molar ratio:

$$3 \text{ is to } 3 \text{ as } 57 \text{ is to } x$$

$$x = 57 \text{ "moles"}$$

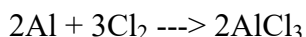
Correctly phrased, the answer is 57 formula units.

Comment: when I was in the classroom, teaching the technique for determining the limiting reagent, I would warn against using the results of the division, in this case the 19 for the NaOH, in the next step of the calculation. The 19 is good only for determining the limiting reagent. You need to use the 57 in the next step.

Well, what did I do? You know it's coming

Yep, I used the 19 when I should have used the 57. It stayed that way for several years, undetected until August 2013, when a student caught it. Thanks, T.

Problem #3: Aluminum reacts with chlorine gas to form aluminum chloride via the following reaction:



How many grams of aluminum chloride could be produced from 34.0 g of aluminum and 39.0 g of chlorine gas?

Solution:

1) Determine the limiting reagent:

$$\text{Al} \Rightarrow 34.0 \text{ g} / 26.98 \text{ g/mol} = 1.2602 \text{ mol}$$
$$\text{Cl}_2 \Rightarrow 39.0 \text{ g} / 70.906 \text{ g/mol} = 0.5500 \text{ mol}$$

$$\text{Al} \Rightarrow 1.2602 \text{ mol} / 2 =$$
$$\text{Cl}_2 \Rightarrow 0.5500 \text{ mol} / 3 =$$

Seems pretty obvious that chlorine gas is the limiting reagent. In a situation like this, you don't have to finish the problem unless it's on a test and the teachers wants it finished!

2) Use $\text{Cl}_2 : \text{AlCl}_3$ molar ratio:

3 is to 2 as 0.5500 mol is to x

$$x = 0.3667 \text{ mol of AlCl}_3 \text{ produced}$$

3) Convert to grams:

$$0.3667 \text{ mol times } 133.341 \text{ g/mol} = 48.9 \text{ g (to three sig fig)}$$

Why don't you determine the mass of aluminum that remains after the reaction ceases by using the proper molar ratio?

By the way, you could have done it this way:

$$48.9 \text{ g minus } 39.0 \text{ g} = 9.9 \text{ g of Al reacted}$$

$$34.0 \text{ g minus } 9.9 \text{ g} = 24.1 \text{ g}$$

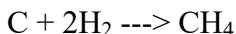
It only works this second way if you have mass data on every substance in the reaction. Look back at the first problem in this file and you'll see you can't do it using this second way because you don't know anything about the mass of carbon dioxide produced. In that problem, you have to use the molar ratio way.

Problem #4: Interpret reactions in terms of representative particles, then write balanced chemical equations and compare with your results. Determine limiting and excess reagent and the amount of unreacted excess reactant.

- a) 3 atoms of carbon combine with 4 molecules of hydrogen to produce methane (CH_4)
- b) 7 molecules of hydrogen and 2 molecules of nitrogen gases react to produce ammonia
- c) 4 molecules of hydrogen and 5 molecules of chlorine react.

Solution to a:

1) The balanced equation:



2) Write the carbon-hydrogen molar ratio:

$$1 : 2$$

Remember that this ratio can also be understood in terms of atoms and molecules. Thusly:

one atoms of carbon reacts with two molecules of hydrogen

3) Determine limiting reagent:

$$\text{carbon} \Rightarrow 3/1 = 3$$

$$\text{hydrogen} \Rightarrow 4/2 = 2$$

Hydrogen is the limiting reagent.

4) Determine amount of carbon consumed:

$$1 \text{ is to } 2 \text{ as } x \text{ is to } 4$$

$$x = 2$$

5) Determine remaining amount of carbon, the excess reagent:

$$3 \text{ minus } 2 = 1 \text{ atom of carbon remaining}$$

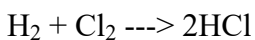
Answers to b: $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$

The molar ratio of importance is nitrogen to hydrogen. It is 1 : 3.

Nitrogen is the limiting reagent.

One molecule of hydrogen remains.

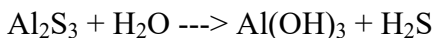
Answers to c:



1 : 1. Chlorine in excess by one molecule.

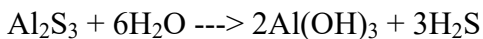
Problem #5: Suppose 316.0 g aluminum sulfide reacts with 493.0 g of water. What mass of the excess reactant remains?

The unbalanced equation is:



Solution:

1) Balance the equation:



2) Determine moles, then limiting reagent:

$$\text{Al}_2\text{S}_3 \Rightarrow 316.0 \text{ g} / 150.159 \text{ g/mol} = 2.104436 \text{ mol}$$

$$\text{H}_2\text{O} \Rightarrow 493.0 \text{ g} / 18.015 \text{ g/mol} = 27.366 \text{ mol}$$

$$\text{Al}_2\text{S}_3 \Rightarrow 2.104436 / 1 = 2.104436$$

$$\text{H}_2\text{O} \Rightarrow 27.366 / 6 = 4.561$$

Al_2S_3 is the limiting reagent.

3) Determine grams of water that react:

The molar ratio to use is 1:6

1 is to 6 as 2.104436 mol is to x

$$x = 12.626616 \text{ mol of water used}$$

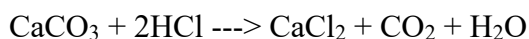
$$12.626616 \text{ mol times } 18.105 \text{ g/mol} = 227.4685 \text{ g}$$

4) Determine excess:

$$493.0 \text{ g minus } 227.46848724 = 265.5 \text{ g (to 4 sig figs)}$$

Notice how the question only asks about the excess reagent, but you have to go through the entire set of steps (determine moles, determine limiting reagent, use molar ratio) to get to the answer. Tricky!

Problem #6: In this reaction:



6.088 g CaCO_3 reacted with 2.852 g HCl. What mass of CaCO_3 remains unreacted?

Solution:

1) Let's verify that the HCl is limiting:

$$\text{CaCO}_3 \Rightarrow 6.088 \text{ g} / 100.086 \text{ g/mol} = 0.0608277 \text{ mol}$$

$$\text{HCl} \Rightarrow 2.852 \text{ g} / 36.461 \text{ g/mol} = 0.0782206 \text{ mol}$$

By inspection, we see that HCl is the limiting reagent. (Mentally divide both values by their respective coefficient from the equation to see this.)

Wouldn't that have been cute if you just assumed the HCl was limiting and the question writer made it a bit of a trick question by making the calcium carbonate limiting?

2) Determine moles, then grams of calcium carbonate used:

$$1 \text{ is to } 2 \text{ as } x \text{ is to } 0.0782206 \text{ mol}$$

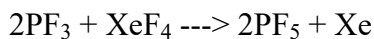
$$x = 0.0391103 \text{ mol}$$

$$0.0391103 \text{ mol times } 100.086 \text{ g/mol} = 3.914 \text{ g}$$

3) Determine grams of CaCO_3 remaining:

$$6.088 \text{ g minus } 3.914 \text{ g} = 2.174 \text{ g}$$

Problem #7: How many grams of PF_5 can be formed from 9.46 g of PF_3 and 9.42 g of XeF_4 in the following reaction?



Solution:

1) Determine moles:

$$\text{PF}_3 \Rightarrow 9.46 \text{ g} / 87.968 \text{ g/mol} = 0.10754 \text{ mol}$$

$$\text{XeF}_4 \Rightarrow 9.42 \text{ g} / 207.282 \text{ g/mol} = 0.045445 \text{ mol}$$

2) Determine limiting reagent:

$$\text{PF}_3 \Rightarrow 0.10754 / 2 = 0.05377$$

$$\text{XeF}_4 \Rightarrow 0.045445 / 1 = 0.045445$$

XeF_4 is limiting

2) Use XeF_4 : PF_5 molar ratio:

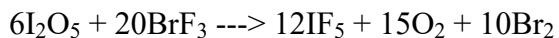
1 is to 2 as 0.045445 mol is to x

$$x = 0.090890 \text{ mol of } \text{PF}_5 \text{ produced}$$

3) Determine grams of PF_5 :

$$0.090890 \text{ mol times } 125.964 \text{ g/mol} = 11.45 \text{ g}$$

Problem #8: How many grams of IF_5 would be produced using 44.01 grams of I_2O_5 and 101.0 grams of BrF_3 ?



Solution:

1) Determine moles:

$$\text{I}_2\text{O}_5 \Rightarrow 44.01 \text{ g} / 333.795 \text{ g/mol} = 0.1318474 \text{ mol}$$

$$\text{BrF}_3 \Rightarrow 101.0 \text{ g} / 136.898 \text{ g/mol} = 0.7377756 \text{ mol}$$

2) Determine limiting reagent:

$$\text{I}_2\text{O}_5 \Rightarrow 0.1318474 / 6 = 0.02197457$$
$$\text{BrF}_3 \Rightarrow 0.7377756 / 20 = 0.03688878$$

I_2O_5 is limiting.

2) Use I_2O_5 : IF_5 molar ratio:

The ratio is 6 to 12, so I'll use 1 to 2

1 is to 2 as 0.1318474 mol is to x

$$x = 0.2636948 \text{ mol of IF}_5 \text{ produced}$$

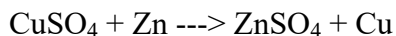
3) Convert moles to grams:

$$0.2636948 \text{ mol times } 221.89 \text{ g/mol} = 58.51 \text{ g (to 4 sig figs)}$$

Problem #9: 950.0 grams of copper(II) sulfate are reacted with 460.0 grams of zinc metal. (a) What is the theoretical yield of Cu? (b) If 295.8 grams of copper are actually obtained from this reaction, what is the percent yield?

Solution to a:

1) The balanced chemical equation is:



2) Determine limiting reagent:

$$\text{CuSO}_4 \Rightarrow 950.0 \text{ g} / 159.607 \text{ g/mol} = 5.95212 \text{ mol}$$

$$\text{Zn} \Rightarrow 460.0 \text{ g} / 65.38 \text{ g/mol} = 7.03579 \text{ mol}$$

CuSO_4 is limiting.

The coefficients of Zn and CuSO_4 are both one, so I just eliminated the whole 'divide by 1' thing.

3) Determine moles, then grams of Cu:

5.95212 mol of Cu is produced (due to the 1 : 1 molar ratio involved)

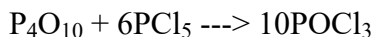
$$5.95212 \text{ mol times } 63.546 \text{ g/mol} = 378.2 \text{ g}$$

Solution to b:

Percent yield is:

$$295.8 \text{ g} / 378.2 \text{ g} = 78.21 \%$$

Problem #10: What weight of each substance is present after 0.4500 g of P_4O_{10} and 1.5000 g of PCl_5 are reacted completely?



Solution:

1) Determine moles:

$$P_4O_{10} \Rightarrow 0.4500 \text{ g} / 283.886 \text{ g/mol} = 0.00158514 \text{ mol}$$

$$PCl_5 \Rightarrow 1.5000 / 208.239 \text{ g/mol} = 0.00720326 \text{ mol}$$

2) Determine limiting reagent:

$$P_4O_{10} \Rightarrow 0.00158514 / 1 = 0.00158514$$

$$PCl_5 \Rightarrow 0.00720326 / 6 = 0.00120054$$

PCl_5 is limiting.

2) Determine mass of P_4O_{10} remaining:

Use 1 : 6 molar ratio.

1 is to 6 as x is to 0.00720326 mol

$x = 0.00120054$ mol of P_4O_{10} remaining

$$0.00158514 \text{ mol} \text{ minus } 0.00120054 \text{ mol} = 0.0003846 \text{ mol}$$

$$0.0003846 \text{ mol} \text{ times } 283.886 \text{ g/mol} = 0.1092 \text{ g}$$

3) Determine mass of $POCl_3$ produced:

Use 6 : 10 molar ratio (or, if you prefer, use 3 : 5).

3 is to 5 as 0.00720326 mol is to x

$x = 0.01200543$ mol of $POCl_3$ produced

$$0.01200543 \text{ mol} \text{ times } 153.332 \text{ g/mol} = 1.8408 \text{ g}$$

Since PCl_5 is limiting, zero grams of it will remain.