**Limiting Reagent Problems**

**Problem #1:** For the combustion of sucrose:

C12H22O11 + 12O2 ---> 12CO2 + 11H2O

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

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

2NBr3 + 3NaOH ---> N2 + 3NaBr + 3HOBr

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

2Al + 3Cl2 ---> 2AlCl3

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

**Problem #4:** Suppose 316.0 g aluminum sulfide reacts with 493.0 g of water. What mass of the excess reactant remains?

The unbalanced equation is:

Al2S3 + H2O ---> Al(OH)3 + H2S

**Problem #5:** In this reaction:

CaCO3 + 2HCl ---> CaCl2 + CO2 + H2O

6.088 g CaCO3 reacted with 2.852 g HCl. What mass of CaCO3 remains unreacted?

**Problem #6:** How many grams of PF5 can be formed from 9.46 g of PF3 and 9.42 g of XeF4 in the following reaction?

2PF3 + XeF4 ---> 2PF5 + Xe

**Problem #7:** How many grams of IF5 would be produced using 44.01 grams of I2O5 and 101.0 grams of BrF3?

6I2O5 + 20BrF3 ---> 12IF5 + 15O2 + 10Br2

**Problem #8:** 950.0 grams of copper(II) sulfate are reacted with 460.0 grams of zinc metal. What is the yield of Cu?

**Problem #9:** What weight of each substance is present after 0.4500 g of P4O10 and 1.5000 g of PCl5 are reacted completely?

P4O10 + 6PCl5 ---> 10POCl3

**Limiting Reagent Problems - Solutions**

**Problem #1:** For the combustion of sucrose:

C12H22O11 + 12O2 ---> 12CO2 + 11H2O

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 g / 342.2948 g/mol = 0.0292146 mol

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

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

1:12 = 0.0292146 mol : x

x = 0.3505752 mole of oxygen required

3) Determine limiting reagent:

Oxygen on hand ⇒ 10.0 g / 31.9988 g/mol = 0.3125 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:

sucrose ⇒ 0.0292146 mol   
oxygen ⇒ 0.3125 mol

2) Divide by coefficients of balanced equation:

sucrose ⇒ 0.0292146 mol / 1 mol = 0.0292146   
oxygen ⇒ 0.3125 mol / 12 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.

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

2NBr3 + 3NaOH ---> N2 + 3NaBr + 3HOBr

**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 x 1023 of that entity (be it molecules or formula units) is present.

1) Determine limiting reagent:

NBr3 ⇒ 50 "moles" / 2 = 25   
NaOH ⇒ 57 "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.

**Comment:** I must warn you 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.

2) Use NaOH : NaBr molar ratio:

3:3 = 57: x

x = 57 "moles"

Correctly phrased, the answer is 57 formula units.

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

2Al + 3Cl2 ---> 2AlCl3

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:

Al ⇒ 34.0 g / 26.98 g/mol = 1.2602 mol   
Cl2 ⇒ 39.0 g / 70.906 g/mol = 0.5500 mol

Al ⇒ 1.2602 mol / 2 =   
Cl2 ⇒ 0.5500 mol / 3 =

Seems pretty obvious that chlorine gas is the limiting reagent.

2) Use Cl2 : AlCl3 molar ratio:

3:2 = 0.5500 mol : x

x = 0.3667 mol of AlCl3 produced

3) Convert to grams:

0.3667 mol X 133.341 g/mol = 48.9 g (to three sig fig)

**Problem #4:** Suppose 316.0 g aluminum sulfide reacts with 493.0 g of water. What mass of the excess reactant remains?

The unbalanced equation is:

Al2S3 + H2O ---> Al(OH)3 + H2S

**Solution:**

1) Balance the equation:

Al2S3 + 6H2O ---> 2Al(OH)3 + 3H2S

2) Determine moles, then limiting reagent:

Al2S3 ⇒ 316.0 g / 150.159 g/mol = 2.104436 mol   
H2O ⇒ 493.0 g / 18.015 g/mol = 27.366 mol

Al2S3 ⇒ 2.104436 / 1 = 2.104436   
H2O ⇒ 27.366 / 6 = 4.561

Al2S3 is the limiting reagent.

3) Determine grams of water that react:

The molar ratio to use is 1:6

1 : 6 = 2.104436 mol : x

x = 12.626616 mol of water used

12.626616 mol X 18.105 g/mol = 227.4685 g

4) Determine excess:

493.0 g - 227.46848724g = 265.5 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 #5:** In this reaction:

CaCO3 + 2HCl ---> CaCl2 + CO2 + H2O

6.088 g CaCO3 reacted with 2.852 g HCl. What mass of CaCO3 remains unreacted?

**Solution:**

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

CaCO3 ⇒ 6.088 g / 100.086 g/mol = 0.0608277 mol   
HCl ⇒ 2.852 g / 36.461 g/mol = 0.0782206 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.)

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

1 :2 = x : 0.0782206 mol

x = 0.0391103 mol

0.0391103 mol X 100.086 g/mol = 3.914 g

3) Determine grams of CaCO3 remaining:

6.088 g - 3.914 g = 2.174 g

**Problem #6:** How many grams of PF5 can be formed from 9.46 g of PF3 and 9.42 g of XeF4 in the following reaction?

2PF3 + XeF4 ---> 2PF5 + Xe

**Solution:**

1) Limiting reagent:

PF3 ⇒ 9.46 g / 87.968 g/mol = 0.10754 mol   
XeF4 ⇒ 9.42 g / 207.282 g/mol = 0.045445 mol

PF3 ⇒ 0.10754 / 2 = 0.05377   
XeF4 ⇒ 0.045445 / 1 = 0.045445

XeF4 is limiting

2) Use XeF4 : PF5 molar ratio:

1 : 2 = 0.045445 mol : x

x = 0.090890 mol of PF5 produced

3) Determine grams of PF5:

0.090890 mol X 125.964 g/mol = 11.45 g

**Problem #7:** How many grams of IF5 would be produced using 44.01 grams of I2O5 and 101.0 grams of BrF3?

6I2O5 + 20BrF3 ---> 12IF5 + 15O2 + 10Br2

**Solution:**

1) Determine limiting reagent:

I2O5 ⇒ 44.01 g / 333.795 g/mol = 0.1318474 mol   
BrF3 ⇒ 101.0 g / 136.898 g/mol = 0.7377756 mol

I2O5 ⇒ 0.1318474 / 6 = 0.02197457   
BrF3 ⇒ 0.7377756 / 20 = 0.03688878

I2O5 is limiting.

2) Use I2O5 : IF5 molar ratio:

The ratio is 6 to 12

6 : 12 = 0.1318474 mol : x

x = 0.2636948 mol of IF5 produced

3) Convert moles to grams:

0.2636948 mol X 221.89 g/mol = 58.51 g (to 4 sig figs)

**Problem #8:** 950.0 grams of copper(II) sulfate are reacted with 460.0 grams of zinc metal. What is the yield of Cu?

1) The balanced chemical equation is:

CuSO4 + Zn ---> ZnSO4 + Cu

2) Determine limiting reagent:

CuSO4 ⇒ 950.0 g / 159.607 g/mol = 5.95212 mol   
Zn ⇒ 460.0 g / 65.38 g/mol = 7.03579 mol

CuSO4 is limiting.

3) Determine moles, then grams of Cu:

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

5.95212 mol X 63.546 g/mol = 378.2 g

**Problem #9:** What weight of each substance is present after 0.4500 g of P4O10 and 1.5000 g of PCl5 are reacted completely?

P4O10 + 6PCl5 ---> 10POCl3

**Solution:**

1) Determine limiting reagent:

P4O10 ⇒ 0.4500 g / 283.886 g/mol = 0.00158514 mol   
PCl5: 1.5000 / 208.239 g/mol = 0.00720326 mol

P4O10 ⇒ 0.00158514 / 1 = 0.00158514   
PCl5: 0.00720326 / 6 = 0.00120054

PCl5 is limiting.

2) Determine mass of P4O10 remaining:

Use 1 : 6 molar ratio.

1 : 6 = x : 0.00720326 mol

x = 0.00120054 mol of P4O10 remaining

0.00158514 mol - 0.00120054 mol = 0.0003846 mol

0.0003846 mol X 283.886 g/mol = 0.1092 g

3) Determine mass of POCl3 produced:

Use 6 : 10 molar ratio

6 :10 = 0.00720326 mol : x

x = 0.01200543 mol of POCl3 produced

0.01200543 mol X 153.332 g/mol = 1.8408 g

Since PCl5 is limiting, zero grams of it will remain.