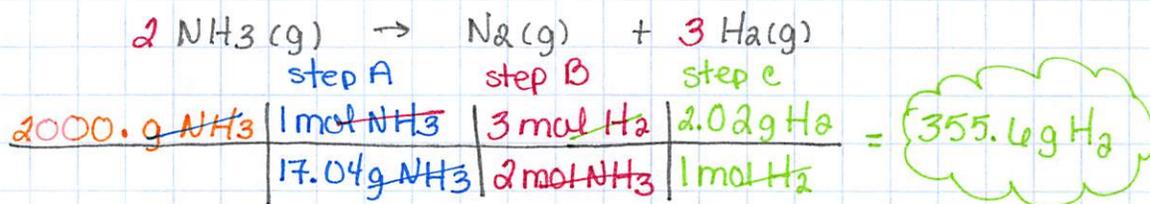


theoretical yield - mass of product theoretically produced when solving a stoichiometry problem

5. What is the theoretical yield of hydrogen gas created when 2000.g ammonia (NH₃) decomposes? GIVEN
- unknown* *just another way to ask, "what is the mass...?"*



molar mass - NH₃

$$1 \text{N} \times 14.01 \text{g} = 14.01 \text{g}$$

$$3 \text{H} \times 1.01 \text{g} = 3.03 \text{g}$$

$$\underline{\hspace{1.5cm}} \\ 17.04 \text{g}$$

molar mass - H₂

$$2 \text{H} \times 1.01 \text{g} = 2.02 \text{g}$$

% yield

In reality, no chemical reaction done in a lab or in a factory or manufacturing plant ever produces products with 100% efficiency. There will always be some sort of error: mechanical error, human error, etc. In real life, people obtain an actual yield

actual yield - amount of product that is actually produced

% yield - a measure of how efficient a reaction is.

amount of product actually produced.

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

determined by solving a stoichiometry problem.

Examples

1. What is the unknown % yield of silver when given 3200.g of copper metal reacts with a solution of excess silver (I) nitrate. The actual yield of silver is 10000.g.

1st - you need to calculate the theoretical yield of silver through stoichiometry.

2nd - use the actual yield (from the question above) ÷ the theoretical yield you just calculated to determine the % yield.



Theoretical yield:

3200.g Cu	$\frac{1 \text{ mol Cu}}{63.55 \text{ g Cu}}$	$\frac{2 \text{ mol Ag}}{1 \text{ mol Cu}}$	$\frac{107.87 \text{ g Ag}}{1 \text{ mol Ag}}$	= 10860 g Ag <i>This is the theoretical yield</i>

$$\% \text{ yield} = \frac{10000 \text{ g Ag}}{10860 \text{ g Ag}} \times 100 = 92.08\%$$

2. The compound calcium cyanamide (CaNCN) is used as a nitrogen source for crops. It is created by the reaction of given 480.75g calcium carbide and nitrogen at high temperatures. The % yield for the reaction is 83.218%. What is the unknown actual yield of calcium cyanamide.



1st use stoichiometry to solve for the theoretical yield of calcium cyanamide

2nd use the % yield from the question ÷ the theoretical yield to calculate the actual yield.

480.75g CaC_2	$\frac{1 \text{ mol CaC}_2}{64.10 \text{ g CaC}_2}$	$\frac{1 \text{ mol CaNCN}}{1 \text{ mol CaC}_2}$	$\frac{80.11 \text{ g CaNCN}}{1 \text{ mol CaNCN}}$	= 600.83g CaNCN <i>Theoretical yield</i>

molar mass - CaC_2

$$\begin{aligned} 1 \text{ Ca} \times 40.08 \text{ g} &= 40.08 \text{ g} \\ 2 \text{ C} \times 12.01 \text{ g} &= +24.02 \text{ g} \\ \hline &64.10 \text{ g} \end{aligned}$$

molar mass - CaNCN

$$\begin{aligned} 1 \text{ Ca} \times 40.08 \text{ g} &= 40.08 \text{ g} \\ 2 \text{ N} \times 14.01 \text{ g} &= 28.02 \text{ g} \\ 1 \text{ C} \times 12.01 \text{ g} &= 12.01 \text{ g} \\ \hline &80.11 \text{ g} \end{aligned}$$

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$83.218 = \frac{\text{actual yield}}{600.83 \text{ g}} \times 100$$

$$83.218 = \frac{(\text{actual yield})(.1664364296)}{.1664364296}$$

$$500.00 \text{ g CANCN} = \text{actual yield}$$

Limiting Reactants

Remember the turkey sandwich problem from p.1 of these notes? No? Go back to p.1, I'll wait here while you go back. Ok, got it now? Why couldn't we make more than 14 sandwiches? Because we ran out of tomatoes. Tomatoes were the limiting reactant in our recipe!

limiting reactant - limits the extent of a reaction & determines how much product is formed. You run out of this reactant.

excess reactant - reactants left over after a reactant stops.
(The bread, turkey, & cheese were excess reactants.)

Try this thought problem:

Your school is sending 30 lucky students to Disney World for 3 days, all expenses paid. Each student should be getting a care package for the trip. Each care package needs to have the following items:

CARE PACKAGE

- 1 backpack
- 2 T-shirts
- 1 bottle sunscreen
- 1 pair sunglasses
- 3 snacks

Dr. G is putting together the care packages. She has the following materials:

- 31 backpacks
- 60 T-shirts
- 32 bottles sunscreen
- 30 pairs sunglasses
- 84 snacks

- What item will Dr. G run out of 1st? That's the limiting reactant?
- How many complete care packages can Dr. G make? Does she need to go back to the store to buy some more materials?
By the way, this is the actual yield.
- What materials are left over? Those are the excess reactants.

Answer to the thought problem:

materials Dr G has \div Care Package

$$31 \text{ backpacks} \div 1 \text{ backpack} = 31 \text{ backpacks}$$

$$60 \text{ T-shirts} \div 2 \text{ T-shirts/set} = 30 \text{ sets of T-shirts}$$

$$32 \text{ sunscreen} \div 1 \text{ sunscreen} = 32 \text{ sunscreen}$$

$$30 \text{ sunglasses} \div 1 \text{ sunglasses} = 30 \text{ sunglasses}$$

$$84 \text{ snacks} \div 3 \text{ snacks/set} = \boxed{28 \text{ sets of snacks}}$$

- The snacks are the limiting reactant because Dr. G will run out of snacks after filling the 28th care package.
- Dr. G can make 28 care packages
- Leftover items (excess reactants) - Since Dr. G can only make 28 care packages, this is how much of each other item she would have left over.

$$31 \text{ backpacks} - 28 \text{ backpacks used} = 3 \text{ backpacks left over}$$

$$30 \text{ sets of T-shirts} - 28 \text{ sets of T-shirts} = 2 \text{ sets of T-shirts} \\ \text{(4 T-shirts total)}$$

$$32 \text{ bottles sunscreen} - 28 \text{ bottles of sunscreen} = 4 \text{ bottles of sunscreen}$$

$$30 \text{ sunglasses} - 28 \text{ sunglasses} = 2 \text{ sunglasses}$$

$$28 \text{ sets of snacks} - 28 \text{ sets of snacks} = 0 \text{ sets of snacks}$$

Looks like Dr. G. needs to go back to the store for more snacks!