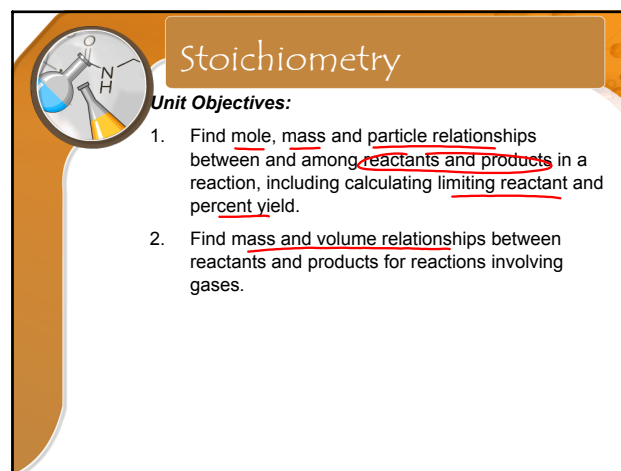


UNIT 10
Stoichiometry

START LESSON

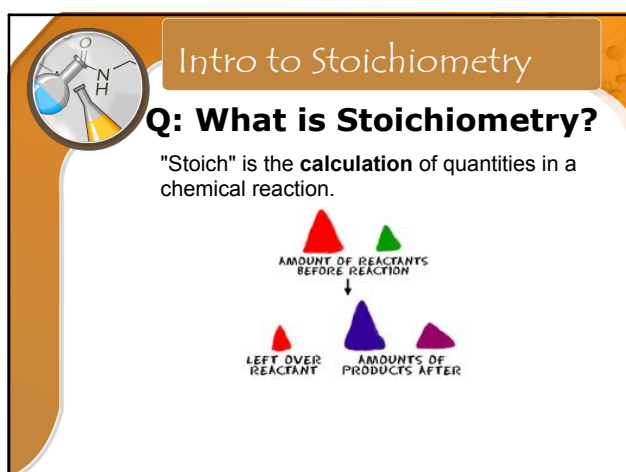
Waterford Institute SMART



Stoichiometry

Unit Objectives:

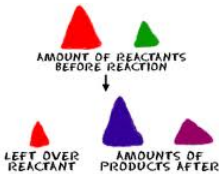
1. Find mole, mass and particle relationships between and among reactants and products in a reaction, including calculating limiting reactant and percent yield.
2. Find mass and volume relationships between reactants and products for reactions involving gases.



Intro to Stoichiometry

Q: What is Stoichiometry?

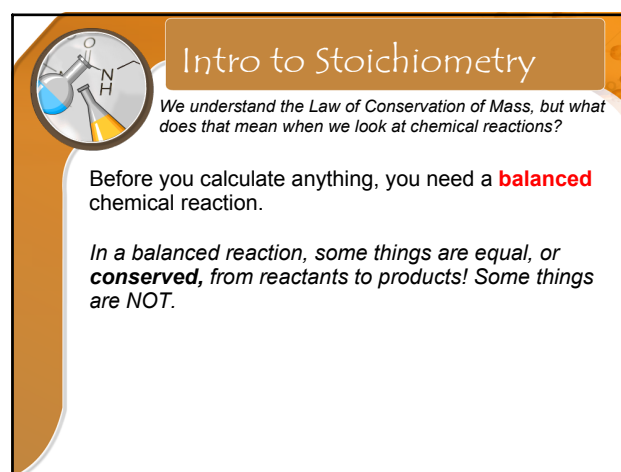
"Stoich" is the **calculation** of quantities in a chemical reaction.



AMOUNT OF REACTANTS BEFORE REACTION

LEFT OVER REACTANT

AMOUNTS OF PRODUCTS AFTER



Intro to Stoichiometry

We understand the Law of Conservation of Mass, but what does that mean when we look at chemical reactions?

Before you calculate anything, you need a **balanced** chemical reaction.

*In a balanced reaction, some things are equal, or **conserved**, from reactants to products! Some things are NOT.*

Intro to Stoichiometry

$_H_2O \rightarrow _H_2 + _O_2$

				Conserved ?
Atoms	4H, 2O	=	4H + 2O	YES
Mass	$2(18.02) = 36.04g$	=	$2(2.02) = 4.04g + 2(16.00) = 32.00g$	YES
Moles	2	=	2 + 1	No
Rep Particles	$2 \times (6.02 \times 10^{23})$	=	$2 \times (6.02 \times 10^{23}) + 1 \times (6.02 \times 10^{23})$	No

Fundamentals

- # of atoms and mass are **ALWAYS conserved** because of the *law of conservation of matter* (mass).
- moles and molecules are not necessarily conserved because they apply to each compound (coefficients), not each element.

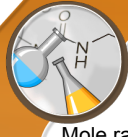
The Zen of Stoich

Q: How do I solve questions about numbers in chemical reactions??

1. Simply, this is mole conversions regarding a particular reaction, SO...
2. You will need to **convert between units**, so you will use **dimensional analysis**.
3. You will need a **balanced chemical equation**, so balance the equation, if necessary.
4. Choose the "given" from the question, just like in moles.
5. Convert to moles and use **mole ratios** to move between players in a chemical reaction!

Converting Moles to Moles

***Mole Ratios** use the **balanced** chemical equation to build ratios to **convert** between components of a reaction. They will be *conversion factors* in your work.

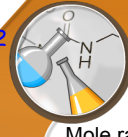


Converting Moles to Moles

Mole ratios for the decomposition of water:

$$\underline{2} \text{ H}_2\text{O} \rightarrow \underline{2} \text{ H}_2 + \underline{1} \text{ O}_2$$

mole H ₂ O	mole H ₂ O	mole O ₂
mole H ₂	mole O ₂	mole H ₂

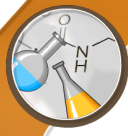


Converting Moles to Moles

Mole ratios for the decomposition of water:

$$\underline{2} \text{ H}_2\text{O} \rightarrow \underline{2} \text{ H}_2 + \underline{1} \text{ O}_2$$

mole H ₂	mole O ₂	mole H ₂
mole H ₂ O	mole H ₂ O	mole O ₂

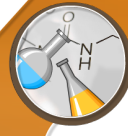


Converting Moles to Moles

$$\underline{2} \text{ H}_2\text{O} \rightarrow \underline{2} \text{ H}_2 + \underline{1} \text{ O}_2$$

1. How many moles of hydrogen gas are produced if 5.3 moles of water are decomposed?

Pull



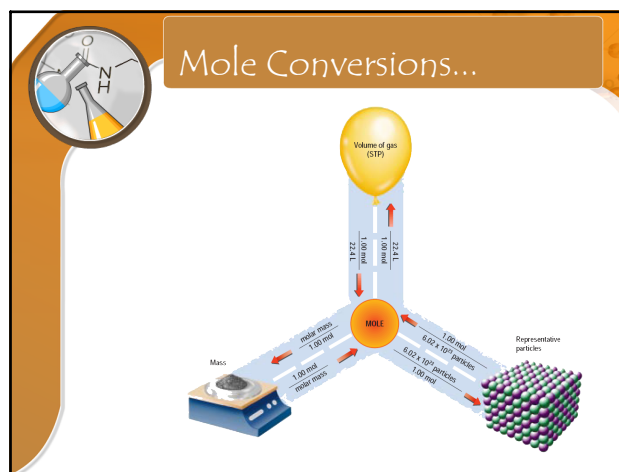
Converting Moles to Moles

$$\underline{2} \text{ H}_2\text{O} \rightarrow \underline{2} \text{ H}_2 + \underline{1} \text{ O}_2$$

2. How many moles of water are needed to form 1.7 moles of oxygen gas?

Pull

This concludes video 1 on stoichiometry.
 You should have taken high quality and in-depth notes with examples.
 Rewatch the video as needed.
 Ask questions!



Jan 2-7:39 AM

Molar Volume of a Gas

Q: What is the volume of 1 mole of a gas?

- The volume of a gas changes when **pressure & temperature** change.
- But, gas volume is *standardized*
- At standard temperature and pressure (STP), 0 °C & 1 atmosphere (a unit of pressure), 1 mole of ANY gas is **22.4L**

22.4 L of a gas
1 mole of gas particles

Stoich Conversions...

$2 A_3B + 3 CD_2 \rightarrow 6 AD + 1 B_2C_3$

The diagram shows two mole conversion diagrams connected by a double-headed arrow labeled **Mole Ratio**.

- Left diagram (A₃B)**: 1.00 mol = 22.4 L; 22.4 L = 1.00 mol; 1.00 mol = 6.02 x 10²³ particles; 6.02 x 10²³ particles = 1.00 mol
- Right diagram (B₂C₃)**: 1.00 mol = 22.4 L; 22.4 L = 1.00 mol; 1.00 mol = 6.02 x 10²³ particles; 6.02 x 10²³ particles = 1.00 mol

Mass to Mass...

Example:

$$\underline{\quad} \text{H}_2\text{O} + \underline{\quad} \text{Na}_2\text{O} \rightarrow \underline{\quad} \text{NaOH}$$

molar m. = molar m. = molar m. =

Balance the equation, set up the stoich, calculate the molar mass of each substance as needed.

Example: How many grams of NaOH are produced from 12.5 grams of water?

Gas Volume to Gas Volume

$$\underline{\quad} \text{Sn} + \underline{\quad} \text{HF} \rightarrow \underline{\quad} \text{SnF}_2 + \underline{\quad} \text{H}_2$$

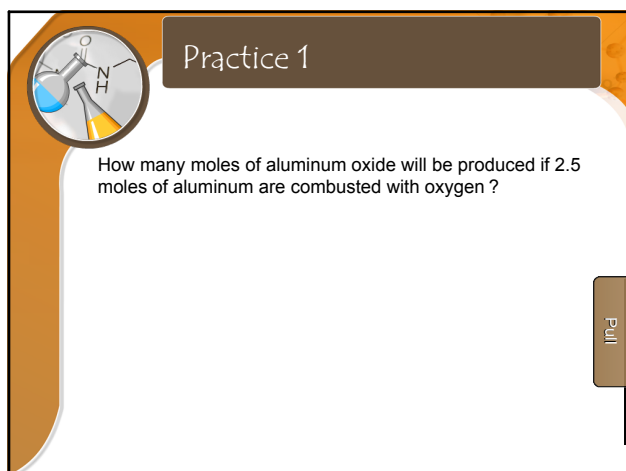
How many liters of HF (a gas) are needed to produce 9.40 liters of hydrogen gas, H₂, at STP?

Mass to Volume

$$\underline{2} \text{NH}_4\text{NO}_3 \rightarrow \underline{2} \text{N}_2 + \underline{4} \text{H}_2\text{O} + \underline{1} \text{O}_2$$

How many liters of N₂ are formed when 228 g NH₄NO₃ is decomposed at STP?

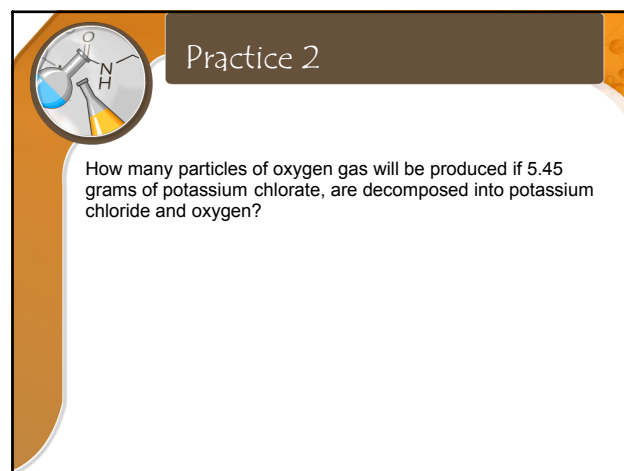
This concludes video 2 on stoichiometry. You should have taken high quality and in-depth notes with examples. Rewatch the video as needed. Ask questions!



Practice 1

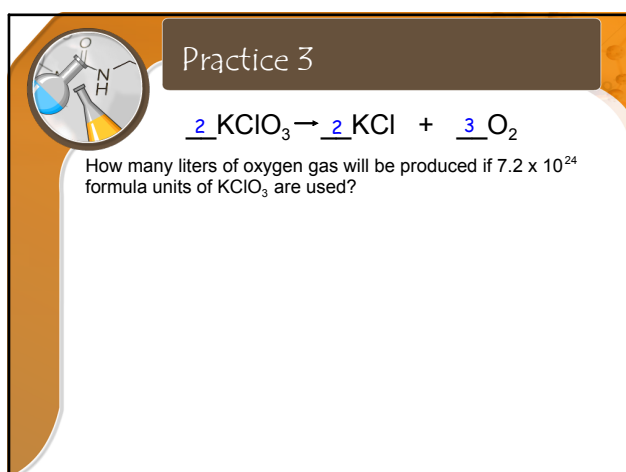
How many moles of aluminum oxide will be produced if 2.5 moles of aluminum are combusted with oxygen ?

Pull



Practice 2

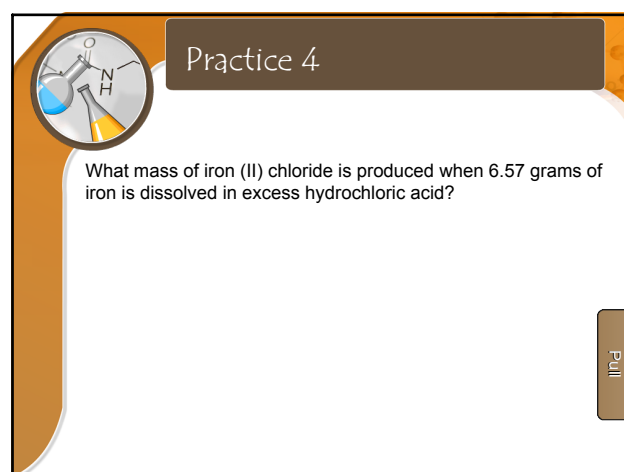
How many particles of oxygen gas will be produced if 5.45 grams of potassium chlorate, are decomposed into potassium chloride and oxygen?



Practice 3

$$2 \text{KClO}_3 \rightarrow 2 \text{KCl} + 3 \text{O}_2$$

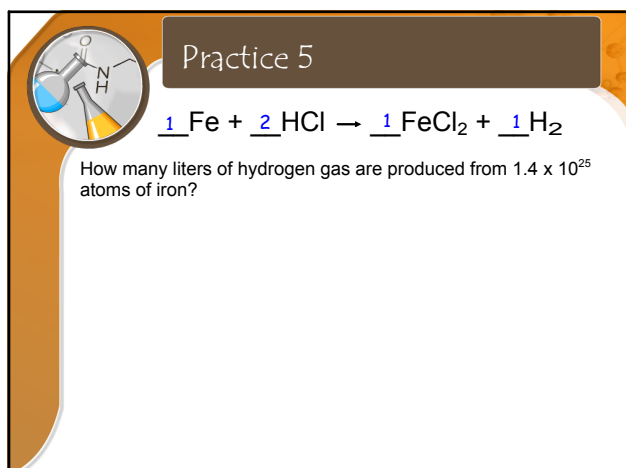
How many liters of oxygen gas will be produced if 7.2×10^{24} formula units of KClO_3 are used?



Practice 4

What mass of iron (II) chloride is produced when 6.57 grams of iron is dissolved in excess hydrochloric acid?

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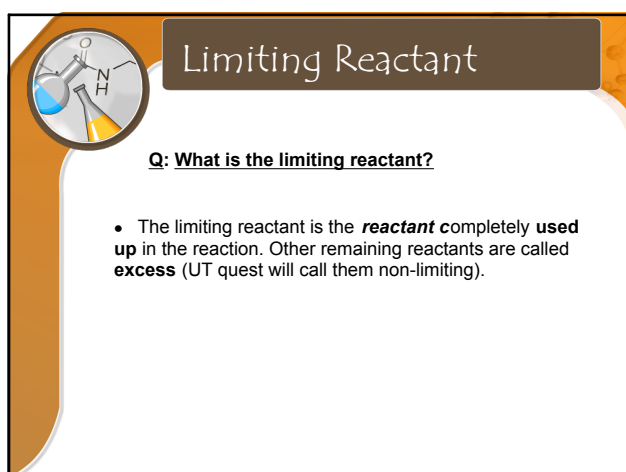
Practice 5

$$\underline{1} \text{ Fe} + \underline{2} \text{ HCl} \rightarrow \underline{1} \text{ FeCl}_2 + \underline{1} \text{ H}_2$$

How many liters of hydrogen gas are produced from 1.4×10^{25} atoms of iron?

This concludes video 3 on stoichiometry. You should have taken high quality and in-depth notes with examples. Rewatch the video as needed. Ask questions!

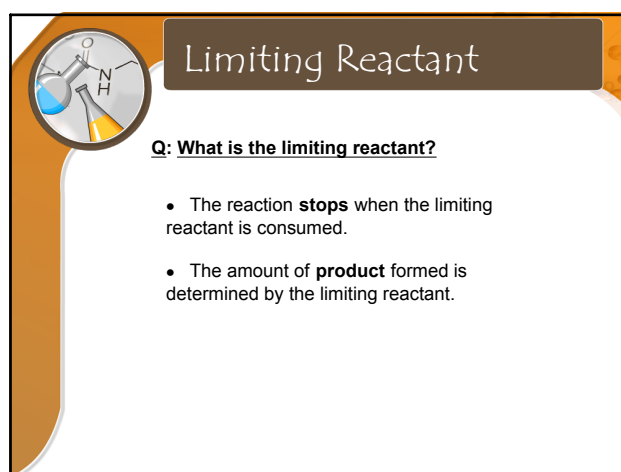
Jan 2-9:24 AM



Limiting Reactant

Q: What is the limiting reactant?

- The limiting reactant is the **reactant** completely **used up** in the reaction. Other remaining reactants are called **excess** (UT quest will call them non-limiting).



Limiting Reactant

Q: What is the limiting reactant?

- The reaction **stops** when the limiting reactant is consumed.
- The amount of **product** formed is determined by the limiting reactant.

Limiting Reactant

Q: How do I determine which reactant is limiting?

Each sandwich is to have:
 2 slices of bread + 3 pieces of lunchmeat + 1 slice of cheese

We have:
 6 slices of bread (Limiting reactant) + 12 pieces of lunchmeat + 5 slices of cheese

Makes 3 sandwiches

3 pieces of lunchmeat excess
 2 pieces of cheese excess

Limiting Reactant

Q: How do I determine which reactant is limiting?
 Suppose you have 10 molecules of hydrogen gas and 7 molecules of oxygen and you are synthesizing water.

$$2\text{H}_2 + 1\text{O}_2 \rightarrow 2\text{H}_2\text{O}$$

7 O₂ makes 14 H₂O.
 10 H₂ makes 10 H₂O.

So, H₂ is limiting and 10 H₂O can be made for which we need only 5 O₂, so 2 O₂ are in excess!

Before reaction

10 H₂ and 7 O₂

→

After reaction

10 H₂O and 2 O₂

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Limiting Reactant

Q: How do I determine which reactant is limiting?

METHOD 1
 1) Convert both reactant units to moles of one product.
 2) The limiting reactant results in a smaller mass of product.

METHOD 2
 1) Convert one reactant to the same units as the other. If the "other" is smaller than your result, it is limiting.
 2) If it is larger, it is in excess.

Limiting Reactant

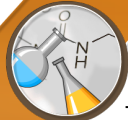
$$\underline{2} \text{H}_2 + \underline{1} \text{O}_2 \rightarrow \underline{2} \text{H}_2\text{O}$$

If 100. grams of H₂ and 80.0 grams of O₂ are used to produce H₂O, which is the limiting reactant?

What mass of water can be made?

How much excess remains?

L.R. is O₂



Limiting Reactant

$$1 \text{ BaO} + 1 \text{ H}_2\text{SO}_4 \rightarrow 1 \text{ BaSO}_4 + 1 \text{ H}_2\text{O}$$

If 28.0 grams of barium oxide react with 140. grams of sulfuric acid to produce barium sulfate and water, which is the limiting reactant?

What mass of barium sulfate can you produce?

How much excess, in grams, do you expect?

L.R. is
BaO

Full

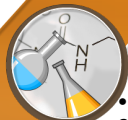
This concludes video 4 on stoichiometry.

You should have taken high quality and in-depth notes with examples.

Rewatch the video as needed.

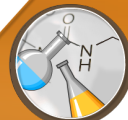
Ask questions!

Jan 2-2:03 PM



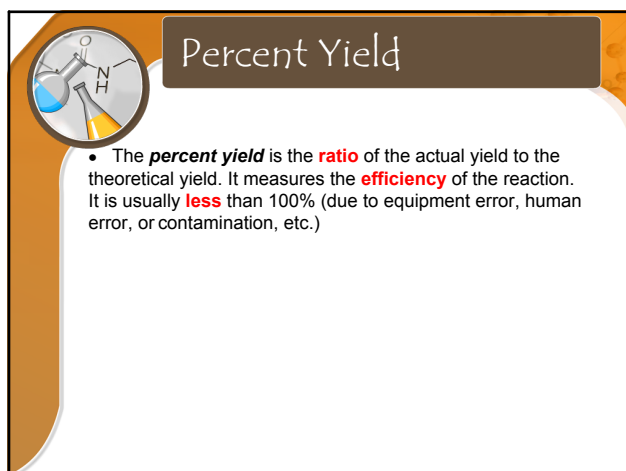
Percent Yield

- In a reaction, the **actual** yield is the amount of product **actually formed** during a real lab investigation.
- SO, actual yield must be GIVEN in a question or actually found in a lab.



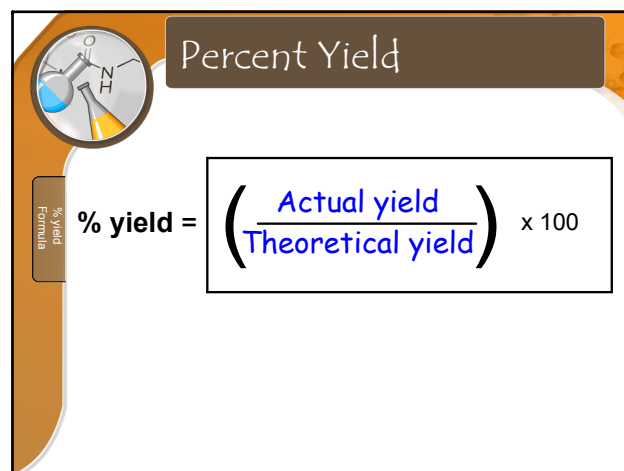
Percent Yield

- The **theoretical** yield is the maximum amount of product that can be formed (the result of stoich **calculations**).

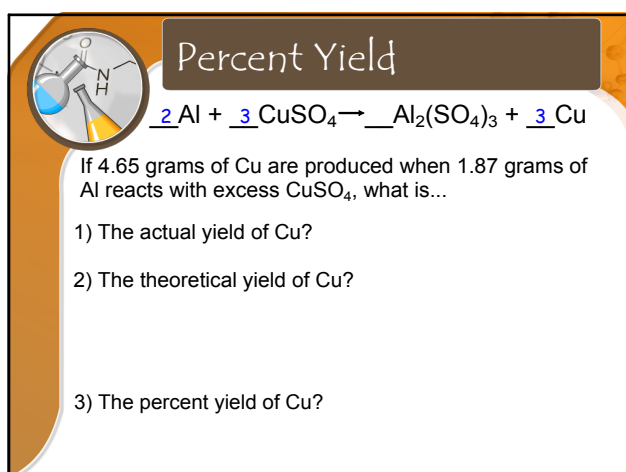


Percent Yield

- The **percent yield** is the **ratio** of the actual yield to the theoretical yield. It measures the **efficiency** of the reaction. It is usually **less** than 100% (due to equipment error, human error, or contamination, etc.)



Percent Yield

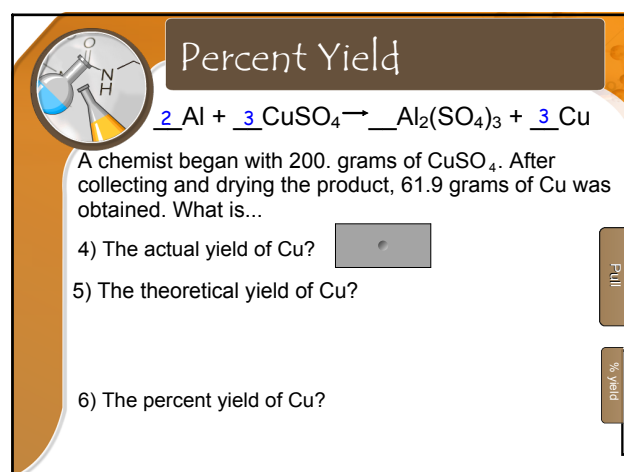
$$\% \text{ yield} = \left(\frac{\text{Actual yield}}{\text{Theoretical yield}} \right) \times 100$$


Percent Yield

$$2 \text{ Al} + 3 \text{ CuSO}_4 \rightarrow \text{Al}_2(\text{SO}_4)_3 + 3 \text{ Cu}$$

If 4.65 grams of Cu are produced when 1.87 grams of Al reacts with excess CuSO₄, what is...

- The actual yield of Cu?
- The theoretical yield of Cu?
- The percent yield of Cu?



Percent Yield

$$2 \text{ Al} + 3 \text{ CuSO}_4 \rightarrow \text{Al}_2(\text{SO}_4)_3 + 3 \text{ Cu}$$

A chemist began with 200. grams of CuSO₄. After collecting and drying the product, 61.9 grams of Cu was obtained. What is...

- The actual yield of Cu?
- The theoretical yield of Cu?
- The percent yield of Cu?

This concludes video 5 on stoichiometry.

You should have taken high quality and in-depth notes with examples.

Rewatch the video as needed.

Ask questions!

Jan 2-2:03 PM