Percent Yield

Last new concept . . . Hooray

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Theoretical Yield

* **Theoretical yield:** the amount of product predicted by stoichiometric calculations

* ****This value is calculated.**

Actual Yield

* **Actual yield**: The actual amount of product that is recovered after a reaction is complete.

* **This value is measured

Competing Reactions

* **Competing Reactions:** A reaction that occurs along with the principal reaction that involves the reactants/products of the principal reaction.

* Example

  * $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

  * $2C_3H_8 + 7O_2 \rightarrow 6CO + H_2O$

Calculating Percent Yield

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

Let's Try . . .

* In a laboratory experiment, 109.28 g of zinc sulfate is produced when 130.76g of zinc is added to 478.83g of copper (II) sulfate solution. What is the percent yield of copper.

* $Zn_{(s)} + CuSO_{4(aq)} \rightarrow ZnSO_{4(aq)} + Cu_{(s)}$

Make a Plan

* 1) Find limiting reagent.
* 2) Using limiting reagent, use stoichiometry to solve for theoretical yield (amount of product).
* 3) Use theoretical yield to calculate percent yield.

Limiting Reagent

* $Zn_{(s)} + CuSO_{4(aq)} \rightarrow ZnSO_{4(aq)} + Cu_{(s)}$

m_{Zn}=130.76g
M_{Zn}= 65.38 g/mol

m_{CuSO_4}=478.83g
M_{CuSO_4}= 159.61 g/mol

Determine Limiting Reagent

$$Zn_{(s)} + CuSO_{4(aq)} \rightarrow ZnSO_{4(aq)} + Cu_{(s)}$$

List given values

$m_{Zn} = 130.76\ g$
$M_{Zn} = 65.38\ g/mol$

$m_{CuSO4} = 478.83\ g$
$M_{CuSO4} = 159.61\ g/mol$

Convert from mass to moles

$n = m/M$

$n = \frac{130.76\ g}{65.38\ g/mol}$

$n = 2.00\ mols$

$n = 2.00\ mols$

$n = m/M$

$n = \frac{478.83\ g}{159.61\ g/mol}$

$n = 3.00\ mols$

$n = 3.00\ mols$

Determine Limiting Reagent

$$Zn_{(s)} + CuSO_{4(aq)} \rightarrow ZnSO_{4(aq)} + Cu_{(s)}$$

List given values

$m_{Zn} = 130.76\ g$
$M_{Zn} = 65.38\ g/mol$

$m_{CuSO_4} = 478.83\ g$
$M_{CuSO_4} = 159.61\ g/mol$

Convert from mass to moles

$n = m/M$

$n = \frac{130.76\ g}{65.38\ g/mol}$

$n = 2.00\ mols$

$n = m/M$

$n = \frac{478.83\ g}{159.61\ g/mol}$

$n = 3.00\ mols$

n=2.00 mols

n=3.00 mols

Molar Ratio

$\frac{1}{1} = \frac{2\ mol}{n_{ZnSO_4}}$

$n_{ZnSO_4} = 2\ mol$

$\frac{1}{1} = \frac{3\ mol}{n_{CuSO_4}}$

$n_{ZnSO_4} = 3\ mol$

Limiting Reagent

The limiting reagent is zinc, we use the mass of zinc to determine the mass of the product.

Determine Theoretical Yield

$$Zn_{(s)} + CuSO_{4(aq)} \rightarrow ZnSO_{4(aq)} + Cu_{(s)}$$

List given values

$m_{Zn} = 130.76\,g$
$M_{Zn} = 65.38\ g/mol$

$m_{ZnSO_4} = ?$
$M_{ZnSO_4} = 161.47\ g/mol$

Convert from mass to moles

$n = m/M$

$$n = \frac{130.76\ g}{65.38\ g/mol}$$

$n = 2.00$ mols

Molar Ratio

$n = 2.00$ mols → $n = 2.00$ mols

$$\frac{\text{Ratio } Zn}{\text{Ratio } ZnSO_4} = \frac{n_{Zn}}{n_{ZnSO_4}} \rightarrow \frac{1}{1} = \frac{2\ mol}{n_{ZnSO_4}} \rightarrow n_{ZnSO_4} = 2.00\ mols$$

Determine Theoretical Yield

$$Zn_{(s)} + CuSO_{4(aq)} \rightarrow ZnSO_{4(aq)} + Cu_{(s)}$$

List given values

$m_{Zn} = 130.76\,g$

$M_{Zn} = 65.38\ g/mol$

$m\ ZnSO_4 =$ **n=322.94g**

$M\ ZnSO_4 = 161.47\ g/mol$

Convert from mass to moles

$n = m/M$

$n = \dfrac{130.76\ g}{65.38\ g/mol}$

$n = 2.00\ mols$

Convert from moles to mass

$m = n \times M$

$m = 2.00\ g \times \dfrac{161.47\ g}{mol}$

$m = 322.94\ g$

Molar Ratio

n=2.00 mols → **n=2.00 mols**

$$\frac{\text{Ratio } Zn}{\text{Ratio } ZnSO_4} = \frac{n_{Zn}}{n_{ZnSO_4}} \rightarrow \frac{1}{1} = \frac{2\ mol}{n_{ZnSO_4}} \rightarrow n_{ZnSO_4} = 2.00\ mols$$

Limiting Reagent

* Therefore, the theoretical yield of zinc sulfate is 322.94g.

Determine Percent Yield

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

Given
Theoretical Yield: 322.94g
Actual Yield: 109.28

Determine Percent Yield

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

Determine Percent Yield

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

Given
Theoretical Yield: 322.94g
Actual Yield: 109.28

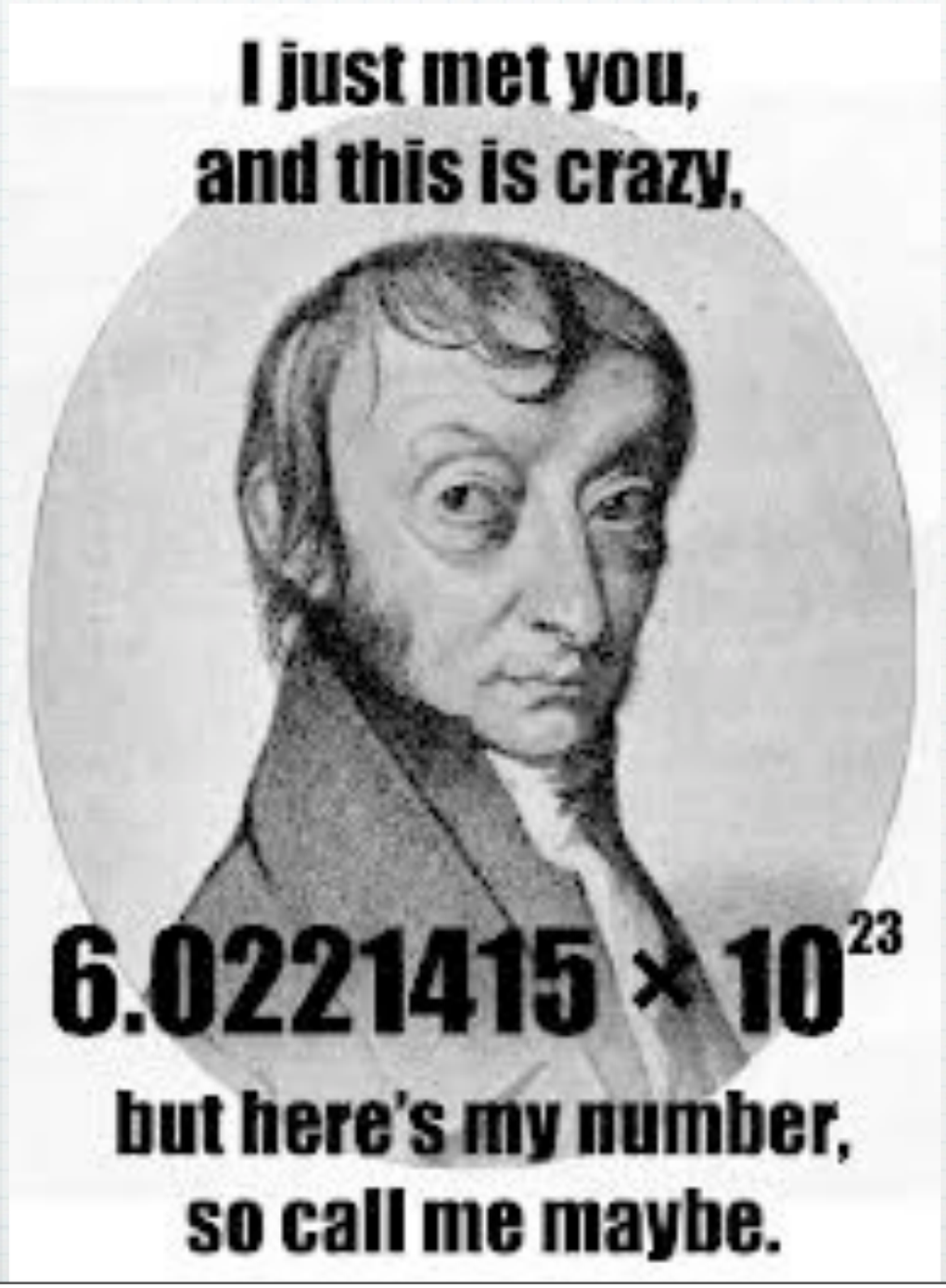
$$\text{Percentage Yield} = \frac{109.28\ \text{g}}{322.94\ \text{g}} \times 100$$

Percentage Yield= 33.84%

The end is near . . .

* Therefore, the percentage yield of zinc sulfate considering 130.76g of zinc is 33.84%.

To make you smile again . . .



Now you try . . .

* Ammonium nitrate (NH_4NO_3) is used to make fertilizer using the following reaction.

* $NH_{3(g)} + HNO_{3(aq)} \rightarrow NH_4NO_{3(s)}$

* You have 17.03 g of ammonia gas and 69.03 g of nitric acid as reactants. What mass in grams would you expect to be produced if the reaction is only 89.5% efficient?