



## CHEMISTRY

## PERCENT YIELD

PERCENTAGE YIELD**Theoretical Yield**

Stoichiometry can be used to calculate the amount of product that is created given an amount of reactant. Since these calculations are done on paper and not performed in a lab the results are theoretical. Hence, the values achieved through calculation are called ***Theoretical Yield***.

**Actual Yield**

During an experiment in the lab, one can obtain product mass by using a scale. The amount of product measured in a lab setting is called the ***Actual Yield***.

**Percentage Yield**

There are various factors that cause error in the lab. For example, some of your product may accidentally react with the surrounding oxygen. In this case, the values obtained during an experiment (*actual yield*) may differ from those achieved through calculation (*theoretical yield*).

To quantify this difference, chemists use a calculation called ***Percentage Yield***.



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Formula - Percent Yield

$$\% \text{ yield} = \left( \frac{\text{actual}}{\text{theoretical}} \right) \times 100$$

**Ex:** Ammonia is created by reacting nitrogen gas with hydrogen gas. During an experiment, 75 g of nitrogen was reacted with sufficient hydrogen to produce an actual yield of 17.2 g of ammonia. **What is the percentage yield of the reaction?**

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*Ex: Calcium carbonate decomposes into calcium oxide and carbon dioxide with a 92.4 % yield of calcium oxide. What is the actual yield that can be expected if 12.4 g of calcium carbonate is reacted?*



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## Pg. 319 #51 - 60

## Practice Problems

51. During an investigation, calcium carbide,  $\text{CaC}_2(\text{s})$ , reacted with excess water to make calcium hydroxide,  $\text{Ca}(\text{OH})_2(\text{aq})$ , and acetylene,  $\text{C}_2\text{H}_2(\text{g})$ .
- $$\text{CaC}_2(\text{s}) + 2\text{H}_2\text{O}(\ell) \rightarrow \text{Ca}(\text{OH})_2(\text{aq}) + \text{C}_2\text{H}_2(\text{g})$$
- The data table for this investigation is given below.

Data Table

Mass of Calcium Carbide That Reacted	2.38 g
Mass of Acetylene That Was Produced	0.77 g

- What was the theoretical yield and actual yield of acetylene?
52. Suppose that 0.250 mol of potassium carbonate,  $\text{K}_2\text{CO}_3(\text{s})$ , reacts with excess hydrochloric acid as follows:
- $$\text{K}_2\text{CO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{H}_2\text{O}(\ell) + \text{CO}_2(\text{g}) + 2\text{KCl}(\text{aq})$$
- Calculate the theoretical yield of potassium chloride.
  - Calculate the percentage yield of water if 0.189 mol of water is produced.
53. Phosphoric acid,  $\text{H}_3\text{PO}_4(\text{aq})$ , is neutralized by potassium hydroxide,  $\text{KOH}(\text{aq})$ , according to the following reaction:
- $$\text{H}_3\text{PO}_4(\text{aq}) + 3\text{KOH}(\text{aq}) \rightarrow \text{K}_3\text{PO}_4(\text{aq}) + 3\text{H}_2\text{O}(\ell)$$
- If 49.0 g of potassium phosphate,  $\text{K}_3\text{PO}_4(\text{aq})$ , is recovered after 49.0 g of phosphoric acid reacts with 49.0 g of potassium hydroxide, what is the percentage yield of the reaction?
54. The reaction of glucose,  $\text{C}_6\text{H}_{12}\text{O}_6(\text{s})$ , with sulfuric acid,  $\text{H}_2\text{SO}_4(\ell)$ , produces carbon as follows:
- $$\text{C}_6\text{H}_{12}\text{O}_6(\text{s}) + 2\text{H}_2\text{SO}_4(\ell) \rightarrow 6\text{C}(\text{s}) + 6\text{H}_2\text{O}(\ell) + 2\text{H}_2\text{SO}_4(\text{aq})$$
- If 20.8 g of glucose reacts with excess sulfuric acid, what is the theoretical yield, in grams, of carbon?
  - If the percentage yield is 72.0%, what mass of carbon is produced?
55. Calcium chloride,  $\text{CaCl}_2(\text{aq})$ , is mixed with silver nitrate,  $\text{AgNO}_3(\text{aq})$ , to form calcium nitrate,  $\text{Ca}(\text{NO}_3)_2(\text{aq})$ , and silver chloride,  $\text{AgCl}(\text{s})$ .
- $$\text{CaCl}_2(\text{aq}) + 2\text{AgNO}_3(\text{aq}) \rightarrow \text{Ca}(\text{NO}_3)_2(\text{aq}) + 2\text{AgCl}(\text{s})$$
- If this reaction has an 81.5% yield, what mass of silver chloride is produced when 21.2 g of calcium chloride is added to excess silver nitrate?
56. The following reaction has a 68% yield.
- $$\text{AlCl}_3(\text{aq}) + 4\text{NaOH}(\text{aq}) \rightarrow \text{NaAlO}_2(\text{aq}) + 3\text{NaCl}(\text{aq}) + 2\text{H}_2\text{O}(\ell)$$
- Calculate the actual mass of sodium chloride that is recovered if 18.2 g of aluminum chloride,  $\text{AlCl}_3(\text{aq})$ , reacts with 16.00 g of sodium hydroxide.
57. Ethyl butanoate,  $\text{C}_6\text{H}_{13}\text{O}_2(\ell)$ , is an organic ester that has the flavour and scent of pineapple. It is prepared as follows:
- $$\text{C}_4\text{H}_9\text{O}_2(\ell) + \text{C}_2\text{H}_6\text{O}(\ell) \rightarrow \text{C}_6\text{H}_{13}\text{O}_2(\ell) + \text{H}_2\text{O}(\ell)$$
- During an investigation, 0.573 mol of butanoic acid,  $\text{C}_4\text{H}_9\text{O}_2(\ell)$ , reacts with excess ethanol,  $\text{C}_2\text{H}_6\text{O}(\ell)$ . What mass of ethyl butanoate is produced if this reaction has a 92.0% yield?
58. An impure sample of barium hydroxide,  $\text{Ba}(\text{OH})_2(\text{aq})$ , has a mass 0.540 g. It is dissolved in water and then treated with excess sulfuric acid,  $\text{H}_2\text{SO}_4(\text{aq})$ . This results in the formation of a precipitate of barium sulfate,  $\text{BaSO}_4(\text{s})$ .
- $$\text{H}_2\text{SO}_4(\text{aq}) + \text{Ba}(\text{OH})_2(\text{aq}) \rightarrow \text{BaSO}_4(\text{s}) + 2\text{H}_2\text{O}(\ell)$$
- The barium sulfate is filtered, and any remaining sulfuric acid is washed away. Then the barium sulfate is dried and its mass is measured to be 0.62 g. What mass of barium hydroxide was in the original (impure) sample?
59. Iron pyrite,  $\text{FeS}_2(\text{s})$ , reacts with oxygen as shown in the reaction below:
- $$4\text{FeS}_2(\text{s}) + 11\text{O}_2(\text{g}) \rightarrow 2\text{Fe}_2\text{O}_3(\text{s}) + 8\text{SO}_2(\text{g})$$
- In a laboratory, 5.000 kg of an impure mineral, which contains 45.3% iron pyrite, reacts with oxygen. Calculate the mass of iron(III) oxide,  $\text{Fe}_2\text{O}_3(\text{s})$ , that forms. Assume that all the pyrite reacts.
  - Suppose that the reaction has a 78.0% yield, due to an incomplete reaction. How many grams of iron(III) oxide is produced?
60. Sodium oxide,  $\text{Na}_2\text{O}(\text{s})$ , reacts with water to form the base sodium hydroxide.
- $$\text{Na}_2\text{O}(\text{s}) + \text{H}_2\text{O}(\ell) \rightarrow 2\text{NaOH}(\text{aq})$$
- If this reaction has a 91% yield, what mass of sodium hydroxide is obtained when 0.483 mol of sodium oxide reacts with excess water?

## Answers

51. 0.97 g, 0.77 g
52. a. 37.3 g  
b. 75.6 %
53. 79.3%
54. a. 8.32 g  
b. 5.99 g
55. 44.6 g
56. 11.9 g
57. 61.8 g
58. 0.46 g
59. a. 1.51 kg  
b. 1.18 kg
60. 35 g