

Percentage Yield

amount of product actually produced in a chemical reaction (mol or g)

- ↳ this is often less than theoretical due to inefficiencies in recovering products or side reactions which reduce product
- ↳ calculated by determining mass or volume of product

ratio of actual and theoretical yields.
larger values = more efficient

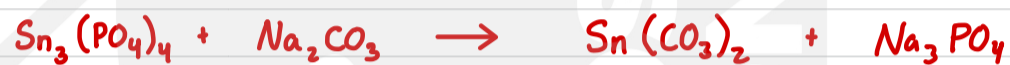
$$\text{Percentage Yield (\%)} = \frac{\text{experimental yield}}{\text{theoretical yield}} \times 100\%$$

amount of product produced in a chemical reaction assuming the limiting reactant is completely used up. (mol or g)
↳ calculated stoichiometrically using the limiting reactant

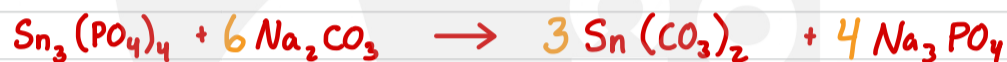
Example problems

- (i) 36 g of tin (IV) phosphate, $\text{Sn}_3(\text{PO}_4)_4$, reacts with 36 g of sodium carbonate, Na_2CO_3 to make tin (IV) carbonate and sodium phosphate. If 29.8 g of tin (IV) carbonate are actually formed, what is the percent yield?

1- write a chemical equation



2- balance the equation



3- calculate number of moles for each reactant

$$36\text{g Sn}_3(\text{PO}_4)_4 \times \frac{\text{mol}}{736.01\text{g}} = 0.04891\text{ mol} \quad 36\text{g Na}_2\text{CO}_3 \times \frac{\text{mol}}{105.99\text{g}} = 0.3397\text{ mol}$$

4- divide moles of reactants by coefficient

$$0.04891\text{ mol} \div 1 = 0.04891\text{ mol}$$

∴ limiting

$$0.3397\text{ mol} \div 6 = 0.05662\text{ mol}$$

5- calculate mass of product (theoretical yield)

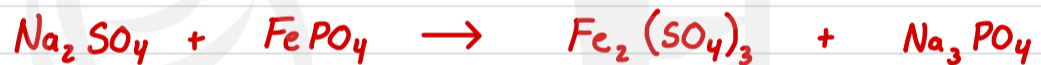
$$0.04891\text{ mol Sn}_3(\text{PO}_4)_4 \times \frac{3\text{ mol Sn}(\text{CO}_3)_2}{1\text{ mol Sn}_3(\text{PO}_4)_4} \times \frac{238.73\text{ g}}{\text{mol}} = 35.0\text{ g Sn}(\text{CO}_3)_2$$

6- calculate % yield

$$\% \text{ yield of Sn}(\text{CO}_3)_2 = \frac{\text{experimental}}{\text{theoretical}} \times 100\% = \frac{29.8\text{ g}}{35.0\text{ g}} \times 100 = 85\%$$

- (ii) 15g of sodium sulfate, Na_2SO_4 , reacts with excess iron (III) phosphate, FePO_4 , producing a 65.0% yield. How many grams of sodium phosphate will actually be made?

1- write a chemical equation



2- balance the equation



3- calculate mass of product (theoretical yield)

$$15\text{g Na}_2\text{SO}_4 \times \frac{\text{mol}}{142.02\text{g}} \times \frac{2\text{ mol Na}_3\text{PO}_4}{3\text{ mol Na}_2\text{SO}_4} \times \frac{163.94\text{ g}}{\text{mol}} = 11.543\text{ g}$$

4- calculate experimental yield

$$\text{experimental yield} = \frac{(\% \text{ yield})(\text{theoretical})}{100} = \frac{(65\%)(11.543\text{g})}{100} = 7.5\text{g}$$

- (iii) What mass of silver could be formed if a large zinc wire is placed in a beaker containing 145.0 mL of 0.095 mol dm^{-3} silver nitrate, AgNO_3 , and allowed to react overnight? Reaction has 97% yield.

1- write and balance chemical equation



2- determine mol of given
 $n = cv$

$$n = cv = \left(\frac{0.095\text{ mol}}{\text{dm}^3} \right) \left(145\text{ mL} \times \frac{\text{L}}{1000\text{ mL}} \right) = 0.013775\text{ mol AgNO}_3$$

3- calculate theoretical yield

$$0.013775\text{ mol AgNO}_3 \times \frac{2\text{ mol Ag}}{2\text{ mol AgNO}_3} \times \frac{107.87\text{ g}}{\text{mol}} = 1.486\text{ g}$$

4- calculate experimental yield

$$\text{experimental yield} = \frac{(\% \text{ yield})(\text{theoretical})}{100} = \frac{(97\%)(1.486\text{g})}{100} = 1.44\text{g}$$

Percentage Purity

Some samples of compounds are composed of a mixture of different substances.

mass of the compound of interest (g)

Percentage of a sample which is a specific product

$$\text{Percentage Purity (\%)} = \frac{\text{mass of pure compound in sample}}{\text{total mass of sample}} \times 100 \%$$

mass of the mixture in total (g)

Example problems

- (i) A 12.00g sample of a crystallised pharmaceutical product was found to contain 11.57g of the active drug. Calculate the percentage purity of the sample of the drug.

use formula
% purity

$$\text{Percentage Purity (\%)} = \frac{\text{mass of active drug in sample}}{\text{total mass of sample}} \times 100 \% = \frac{11.57\text{g}}{12.00\text{g}} \times 100 = 96.4 \%$$

- (ii) 15.0g of 92.5% magnesium hydroxide, $\text{Mg}(\text{OH})_2$, is reacted with excess H_3PO_4 to produce water and magnesium phosphate. Calculate the mass of $\text{Mg}_3(\text{PO}_4)_2$ that will be formed (assuming a 100% yield).

1- write a chemical equation



2- balance the equation



3- determine mass of pure sample

$$\text{mass of Mg}(\text{OH})_2 \text{ in sample} = \frac{(\text{Percent purity})(\text{total mass of sample})}{100} = \frac{(92.5\%)(15.0\text{g})}{100} = 13.875\text{g}$$

4- calculate mass of product (theoretical yield)

$$13.875\text{g Mg}(\text{OH})_2 \times \frac{1 \text{ mol}}{58.33\text{g}} \times \frac{1 \text{ mol Mg}_3(\text{PO}_4)_2}{3 \text{ mol Mg}(\text{OH})_2} \times \frac{262.87\text{g}}{1 \text{ mol}} = 20.8\text{g}$$

- (iii) Automotive air bags inflate when solid sodium azide, NaN_3 , decomposes explosively into sodium and nitrogen gas. What volume of nitrogen gas is formed if 120g of 85% pure sodium azide decomposes. Assume STP conditions.

1- write a chemical equation



2- balance the equation



3- determine mass of pure sample

$$\text{mass of NaN}_3 \text{ in sample} = \frac{(\text{Percent purity})(\text{total mass of sample})}{100} = \frac{(85\%)(120\text{g})}{100} = 102\text{g}$$

4- calculate volume of product (theoretical yield)

$$102\text{g NaN}_3 \times \frac{1 \text{ mol}}{65.02\text{g}} \times \frac{3 \text{ mol N}_2}{2 \text{ mol NaN}_3} \times \frac{22.7 \text{ dm}^3}{1 \text{ mol}} = 53.4 \text{ dm}^3$$