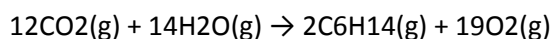


## Lesson 8 Atom economy and percentage yield

[Click](#) to revise atom economy and percentage yield.

Atom economy is a way to measure the efficiency of a reaction. It gives a measure of the atoms wasted when making a desired product. The higher the atom economy, the more efficient a reaction is. A 100 per cent atom economy indicates that all the atoms in the reactants have been converted to the desired product. A 100% atom economy is achieved when there is only one product. For example the production of water from hydrogen and oxygen gases has a 100% atom economy.  
 $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$ .

Example 1 Butane is burnt as a fuel on a particular space station. The  $\text{CO}_2$  and  $\text{H}_2\text{O}$  produced are then used to regenerate  $\text{O}_2$  gas using solar energy according the equation below.



What is the percentage atom economy of the production of oxygen gas according to the reaction above?

Step 1 From the equation find the mass, in grams, of reactants.

$$\Rightarrow 12 \times 44 + 14 \times 18 = 528 + 252 = 780 \text{ grams}$$

Step 2 From the equation find the mass of desired product, in this case it is  $\text{O}_2$  gas.

$$\Rightarrow 19 \times 36 = 684 \text{ grams}$$

Step 3 Find the % atom economy

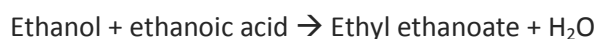
$$\Rightarrow (684 / 780) \times 100 = 87.7\%$$

- 1) Calculate the % atom economy for the production of ethanol from glucose.

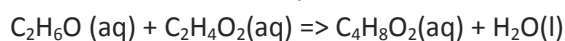


$$\Rightarrow (2 \times 46.0 / 180.2) \times 100 = 51.1\%$$

- 2) Ethyl ethanoate is formed from the reaction of ethanoic acid and ethanol.



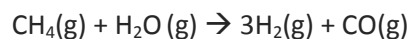
a) Write the chemical equation for the reaction with the word equation above.



b) Calculate the % atom economy for the production of ethyl ethanoate via this reaction.

$$\Rightarrow (88.1 / (46.1 + 60.1)) \times 100 = 83.0\%$$

- 3) Hydrogen gas can be produced by a process called steam reformation according to the equation below.

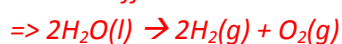


a) Calculate the % atom economy for the production of hydrogen via this reaction.

$$\Rightarrow (6 / 34) \times 100 = 18\%$$

b) A student argued that it was more efficient to produce hydrogen gas via the electrolysis of water. Is the student correct? Explain why.

*It is less efficient*

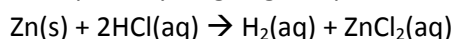


$$\Rightarrow (4 / 36) \times 100 = 11\%$$

The percentage yield of a reaction, distinguishes the theoretical amount of product from the actual amount. Unlike percentage atom economy, to calculate the percentage yield experimental results must be obtained. Percentage yield really tells us how effective the reaction is in producing the product .

$\frac{\text{Actual mass of desired product}}{\text{Theoretical mass of desired product}} \times 100$
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Example 1 Hydrogen gas is produced by the reaction below.



6.54 grams of zinc is placed in excess HCl solution to produce 0.0500 grams of H<sub>2</sub> gas. Calculate the percentage yield for the reaction.

Step 1 Find the mol of zinc.

$$\Rightarrow 6.54 / 65.4 = 0.100$$

Step 2 find the mol of H<sub>2</sub> that should be produced.

$$\Rightarrow 0.100$$

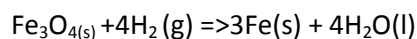
Step 3 Find the mass of H<sub>2</sub>

$$\Rightarrow 0.100 \times 2 = 0.200 \text{ grams}$$

Step 4 find the % yield

$$\Rightarrow (0.0500 / 0.200) \times 100 = 25.0\%$$

- 1) For the balanced equation shown below, if the reaction of 0.110 grams of H<sub>2</sub> produces 0.852 grams of H<sub>2</sub>O, what is the percentage yield?



*Step 1 Find the mol of H<sub>2</sub> used*

$$\Rightarrow 0.110 / 2.00 = 0.055$$

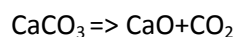
*Step 2 Find the theoretical mass of H<sub>2</sub>O produced*

$$\Rightarrow 0.055 \times 18 = 0.99$$

*Step 3 % yield*

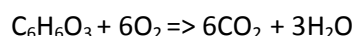
$$\Rightarrow (0.852 / 0.99) \times 100 = 86\%$$

- 2) For the balanced equation shown below, if the reaction of 21.8 grams of CaCO<sub>3</sub> produces 5.82 grams of CaO, what is the percentage yield?



*Answer 48%*

- 3) For the balanced equation shown below, if the reaction of 39.8 grams of C<sub>6</sub>H<sub>6</sub>O<sub>3</sub> produces a 45.0% yield, how many grams of H<sub>2</sub>O would be produced ?



*Step 1 find the mol C<sub>6</sub>H<sub>6</sub>O<sub>3</sub>*

$$\Rightarrow 39.8 / 126 = 0.316$$

*Step 2 find the theoretical yield of water in grams*

$$\Rightarrow 3 \times 0.316 \times 18 = 17.1 \text{ grams}$$

*Step 3 find the actual mass of water => 17.1 X 0.45 = 7.7 grams*