Atom Economy Notes

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Atom economy: a measure of the efficiency of a reaction.

It makes perfect sense that we would have a measure for how efficient chemical reactions are and it's important for us to know as it can tell us how **cost effective** and **sustainable** a certain chemical reaction is. Reactions that have a higher atom economy are better for the environment and are more cost effective.

How is atom economy different from percentage yield? Percentage yield looks at how much product is actually made while atom economy looks at how efficient the reaction is in using its reactants and turning them into useful products.

Calculating Atom Economy

Atom economy is calculated using the following equation.

$$\text{Atom Economy} = \frac{Mr\ of\ desired\ product}{Mr\ of\ reactant(s)} \times 100$$

Let's look at a few examples 😊

Example 1: Potassium sulfate can be made by reacting potassium hydroxide with sulfuric acid. The balanced equation for the reaction is shown below.

$$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$$

Calculate the atom economy of this process to produce potassium sulfate. Give your answer to 3 significant figures.

Step 1: calculate the Mr of the reactants.

$$2(39 + 16 + 1) + (2 + 32 + 4(16))$$

$$2(56) + 98 = 210$$

Step 2: calculate the Mr of the desired product. In this case, that is potassium sulfate.

$$2(39) + 32 + 4(16)$$

$$= 174$$

Step 3: substitute our values into the equation and solve for the atom economy.

$$\text{Atom Economy} = \frac{174}{210} \times 100$$

$$\text{Atom Economy} = 82.9\%$$

Example 2: Sodium sulfate can be made by reacting sodium hydroxide with sulfuric acid. The balanced equation for the reaction is shown below.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

Calculate the atom economy of this process to produce sodium sulfate. Give your answer to 3 significant figures.

Step 1: calculate the Mr of the reactants.

$$2(23 + 16 + 1) + (2 + 32 + 4(16))$$

$$2(40) + 98 = 178$$

Step 2: calculate the Mr of the desired product.

$$2(23) + 32 + 4(16)$$

$$= 142$$

Step 3: substitute our values into the equation and solve for the atom economy.

$$\text{Atom Economy} = \frac{142}{178} \times 100$$

$$\text{Atom Economy} = 79.8\ \%$$

Example 3: Titanium can be extracted from titanium oxide by reacting it with magnesium. The balanced equation for the reaction is:

$$TiO_2 + 2Mg \rightarrow Ti + 2MgO$$

Calculate the atom economy of this process to produce titanium. Give your answer to 3 significant figures.

Step 1: calculate the Mr of the reactants.

$$48 + 2(16) + 2(24)$$

$$48 + 32 + 48 = 128$$

Step 2: calculate the Mr of the desired product.

$$= 48$$

Step 3: substitute our values into the equation and solve for the atom economy.

$$\text{Atom Economy} = \frac{48}{128} \times 100$$

$$\text{Atom Economy} = 37.5\ \%$$

Why are reactions with high atom economies desirable to industry? Simply, they represent value for money and higher profits. Let's look at the full reasons in case we see a question on this.

Reactions with a high atom economy are desirable because:

1. **They reduce chemical waste** – reactions with high atom economies produce little to no waste.
   The waste doesn't need to be separated from the useful product, which saves energy and time and the waste doesn't need to be disposed of, which can be very expensive.

2. **They are more sustainable** – many of the raw materials used in chemical reactions are finite resources like crude oil for example. Having a higher atom economy means less raw material is needed in the first place.

3. **They have a higher profit –** This is the biggest driver for industry. High atom economy directly leads to more profit. More product to sell means more sales. This means more money for that industry.

That's it 😊 atom economy doesn't get any harder than this.