



# ATOM ECONOMY

- 1 Calculate the atom economy to form copper(II) oxide from copper(II) carbonate.  $\text{CuCO}_3 \rightarrow \text{CuO} + \text{CO}_2$

**Formula mass:  $\text{CuCO}_3 = 123.5$ ,  $\text{CuO} = 79.5$**

$$\text{Atom economy} = \frac{79.5}{123.5} \times 100 = 64.4\%$$

- 2 Calculate the atom economy to form aluminium from aluminium oxide.  $2\text{Al}_2\text{O}_3 \rightarrow 4\text{Al} + 3\text{O}_2$

**Formula mass:  $\text{Al}_2\text{O}_3 = 102$ ,  $\text{Al} = 27$**

$$\text{Atom economy} = \frac{4(27)}{2(102)} \times 100 = 52.9\%$$

- 3 Calculate the atom economy to form iron from iron oxide.  $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$

**Formula mass:  $\text{Fe}_2\text{O}_3 = 160$ ,  $\text{CO} = 28$ ,  $\text{Fe} = 56$**

**Sum of formula mass of all reactants =  $160 + 3(28) = 244$**

$$\text{Atom economy} = \frac{2(56)}{244} \times 100 = 45.9\%$$

- 4 Calculate the atom economy to form aluminium chloride from aluminium in this reaction.  $2\text{Al} + 3\text{Cl}_2 \rightarrow 2\text{AlCl}_3$

**100%**

- 5 Calculate the atom economy to form oxygen from hydrogen peroxide.  $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$

**Formula mass:  $\text{H}_2\text{O}_2 = 34$ ,  $\text{O}_2 = 32$**

$$\text{Atom economy} = \frac{32}{2(34)} \times 100 = 47.1\%$$

6 Hydrogen (H<sub>2</sub>) has many uses, including as the fuel in many fuel cells. It can be made in several ways.

a) Calculate the atom economy to form hydrogen by **method 1**. CO + H<sub>2</sub>O → CO<sub>2</sub> + H<sub>2</sub>

**Formula mass: CO = 28, H<sub>2</sub>O = 18, H<sub>2</sub> = 2**

**Sum of formula mass of all reactants = 28 + 18 = 46**

**Atom economy =  $\frac{2}{46} \times 100 = 4.3\%$**

b) Calculate the atom economy to form hydrogen by **method 2**. CH<sub>4</sub> + 2H<sub>2</sub>O → CO<sub>2</sub> + 4H<sub>2</sub>

**Formula mass: CH<sub>4</sub> = 16, H<sub>2</sub>O = 18, H<sub>2</sub> = 2**

**Sum of formula mass of all reactants = 16 + 2(18) = 52**

**Atom economy =  $\frac{4(2)}{52} \times 100 = 15.4\%$**

c) When choosing which method to use, one factor to consider is the atom economy. In terms of atom economy, which method is preferable. Explain your answer.

**Method 2 as it has a high atom economy, therefore less waste**

d) Identify five other factors, besides atom economy, that should be considered when choosing whether to use **method 1** or **method 2** to make hydrogen.

- percentage yield
- reaction rate
- reversibility (equilibrium position)
- energy cost
- cost of reactants
- environmental impact

7 Calculate the atom economy to form ethene (C<sub>2</sub>H<sub>4</sub>) from cracking decane (C<sub>10</sub>H<sub>22</sub>), C<sub>10</sub>H<sub>22</sub> → C<sub>4</sub>H<sub>10</sub> + 3C<sub>2</sub>H<sub>4</sub>

**Formula mass: C<sub>10</sub>H<sub>22</sub> = 142, C<sub>2</sub>H<sub>4</sub> = 28**

**Atom economy =  $\frac{3(28)}{142} \times 100 = 59.2\%$**

Area	Strength	To develop	Area	Strength	To develop	Area	Strength	To develop
Done with care and thoroughness			Can work out % atom economy			Importance of high atom economy		
Shows suitable working			Can spot 100% atom economy			Aware of other factors		