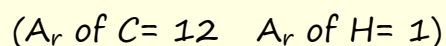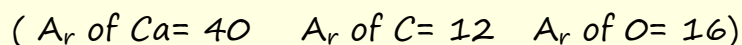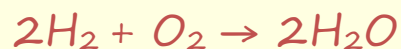ATOM ECONOMY

Answer the following questions then check your answers.

1.   Define atom economy.

2.   Why is a high atom economy desirable in industrial processes?

3.   What is the atom economy of a reaction where the desired product has a molecular mass of 90 g/mol and the total molecular mass of all reactants is 150 g/mol?

4.   Explain why atom economy is an important consideration in the chemical industry.

5.   Calcium oxide or lime is a valuable chemical which is commonly used in the agricultural and construction industries, it can be formed by the thermal decomposition of calcium carbonate ($CaCO_3$) which forms calcium oxide (CaO) and carbon dioxide gas(CO_2), an equation for this reaction is shown below:

a.   Calculate the atom economy for this reaction. The relative masses for the elements calcium, carbon and oxygen are given below:

    (A_r of Ca= 40 A_r of C= 12 A_r of O= 16)

6.   Worked example: Calculate the atom economy for both products in the reaction below:

    (A_r of C= 12 A_r of H= 1)

7.	Calculate the atom economy for the production of water from hydrogen and oxygen, an equation for this reaction is shown below:

	(A_r of O= 16 A_r of H= 1)

$$2H_2 + O_2 \rightarrow 2H_2O$$

8.	Explain the significance of atom economy in chemistry.

9.	Explain how atom economy can influence the environmental and economic impact of a chemical process. Provide examples to support your answer.

1. Define atom economy.

    Answer: Atom economy is a measure of the efficiency of a chemical reaction in terms of much of the reactants ends up in desired product, it is calculated by the formula:

    $$\% \ atom \ economy = \frac{M_r \ of \ useful \ product}{sum \ of \ M_r \ of \ all \ reactants} \times 100\%$$

2. Why is a high atom economy desirable in industrial processes?

    Answer: A high atom economy is desirable because it indicates a more efficient use of raw materials, producing less waste and being more cost-effective and environmentally friendly.

3. What is the atom economy of a reaction where the desired product has a molecular mass of 90 g/mol and the total molecular mass of all reactants is 150 g/mol?

    Answer: Atom Economy= (90 ÷150) × 100 = 60%

4. Explain why atom economy is an important consideration in the chemical industry.

    Answer: Atom economy is important in the chemical industry because it helps to:

    - Minimize waste production, reducing environmental impact.
    - Improve the efficiency and profitability of processes by maximizing the use of reactants.
    - Conserve resources by using them more effectively.

5. Calcium oxide or lime is a valuable chemical which is commonly used in the agricultural and construction industries, it can be formed by the thermal decomposition of calcium carbonate ($CaCO_3$) which forms calcium oxide (CaO) and carbon dioxide gas(CO_2), an equation for this reaction is shown below:
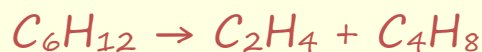
$$CaCO3 \rightarrow CaO + CO_2$$

a. Calculate the atom economy for this reaction. The relative masses for the elements calcium, carbon and oxygen are given below:

(A_r of Ca= 40 A_r of C= 12 A_r of O= 16)

Answer: Atom Economy =(56 ÷ 100) × 100 = 56%

6. Worked example: Calculate the atom economy for both products in the reaction below:

(A_r of C= 12 A_r of H= 1)

$$Hexane \rightarrow ethene + butene$$

$$C_6H_{12} \rightarrow C_2H_4 + C_4H_8$$

Answer:

Atom economy for ethene:

Atom Economy= (28 ÷ 84) × 100 = 33.33%

Atom economy for butene:

Atom Economy= (56 ÷ 84) × 100 = 66.66%

7. Calculate the atom economy for the production of water from hydrogen and oxygen, an equation for this reaction is shown below:

(A$_r$ of O= 16   A$_r$ of H= 1)

$$2H_2 + O_2 \rightarrow 2H_2O$$
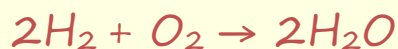
Answer:

It is not necessary to carry out any calculations here since there is only one product, so all of the reactants must end up min this product; so the atom economy will be 100%.

However if you wish to set out the atom economy calculation then it is shown below:

Molecular mass of desired product (2 moles of H_2O): 2×18= 36g

Atom Economy = (36 ÷ 36) × 100 = 100%

8. Explain the significance of atom economy in chemistry.

Answer:

Atom economy is crucial in green chemistry as it promotes the design of processes that maximize the use of all materials involved, reducing waste and environmental impact.

9. Explain how atom economy can influence the environmental and economic impact of a chemical process. Provide examples to support your answer.

Answer: Atom economy influences the environmental impact of a chemical process by reducing the amount of waste generated. Higher atom economy means more efficient use of reactants, leading to less waste and fewer by-products that need disposal, which can reduce pollution and environmental harm. Economically, high atom economy means more of the raw materials are converted into the desired product, lowering costs for raw materials and waste management. For example, in the production of water from hydrogen and oxygen where the atom economy is 100%.

$$2H_2 + O_2 \rightarrow 2H_2O$$