3.3 Yield and atom economy

Name: _____ Class: _____ Date: _____ **Total: 20 marks**

KEY WORDS percentage yield • atom economy

Objective

Calculate percentage yield and atom economy with the reasons yields fall. Chemistry only. Original questions for spec statement 4.3.3.

1 Key knowledge and worked examples

Yield is below 100 % because: the reaction is **reversible**; product is **lost in separation**; reactants react in **unwanted side reactions**.

$$\% \text{ yield} = \frac{\text{actual mass}}{\text{theoretical mass}} \times 100$$

$$\text{atom economy} = \frac{\text{coefficient} \times M_r(\text{desired product})}{\sum[\text{coefficient} \times M_r(\text{reactant})]} \times 100\ \%$$

High atom economy = more starting material becomes useful product – better for **sustainable development** and cost.

Worked example (4 marks). 4.0 g of product is obtained where theory gives 6.4 g. Calculate the percentage yield.

% yield = 4.0 ÷ 6.4 × 100 = 62.5 %. The shortfall comes from losses in separating the product or incomplete/reversible reaction; atom economy is a different measure – it counts the fraction of reactant mass ending in the desired product.

2 Practice

2.1 Give two reasons why yield is below 100 %. [2]

2.2 Theoretical mass 25 g, actual 20 g – percentage yield? [2]

2.3 Why do industries prefer high-atom-economy processes? [1]

3 Exam-style questions

3.1 A reaction should give 12.0 g of product; 8.4 g is made. Calculate the percentage yield and explain two likely reasons for the loss. [4]

3.2 Hydrogen is made from methane and steam: $CH_4 + H_2O \rightarrow CO + 3\ H_2$ (C = 12, H = 1, O = 16). Calculate the atom economy when hydrogen is the desired product. [4]

3.3 State the difference between percentage yield and atom economy. [3]

3.4 For the same desired product, route A has 90% atom economy, 40% yield and prolonged heating. Route B has 75% atom economy, 95% yield and a saleable by-product. Evaluate the routes using the data and identify one further piece of evidence needed. [4]