Topic: Chemical calculations

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CONTENT:

% YIELD

% PURITY

Percentage Yield

WHAT IS IT?

- There are 2 types of yield:

I. Theoretical → The calculated quantity of product that is expected be formed.

II. Actual → The amount of products that is actually obtained in a reaction.

- The % yield is always less than the theoretical yield.
- Percentage yield:

$$\frac{\text{Actual yield}}{\text{Theoretical yield}} \quad x \quad 100$$

Example 1:

128g of *sulphur dioxide, SO_2*, was reacted with oxygen to produce sulphur trioxide, SO_3. The equation for the reaction is:

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

140g of SO_3 was produced in the reaction. Calculate the percentage yield of the SO_3.

Solution

Step 1 : Balanced equation	$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$
Step 2 : Mole ratio	2 : 2
Step 2.5*: Calculate no. of moles (SO_2)	No. of moles = $\frac{\text{Mass}}{\text{Molar mass or Mr}}$ = $\frac{128\text{ g}}{64\text{ (g)}}$ = <u>2 mol.</u>
Step 3 : Find no. of moles (SO_3)	2 : 2 2 : x No. of moles of SO_3 = $\frac{(2 \times 2)}{2}$ <u>= 2 mol.</u>
Step 4 : Find the mass (SO_3)	Mass = No. of moles X Molar Mass or Mr = 2 mol X 80 (g) = <u>160 g</u>.
Step 5 : Percentage yield (SO_3)	= Actual / theoretical X 100% = 140 / 160 X 100% = <u>87.5%</u>

Example 2

50.0 cm^3 of 0.105 mol/dm^3 aqueous calcium chloride was treated with an excess of aqueous silver nitrate. White silver chloride was precipitated. The precipitate was dried and weighed. A mass of 1.45g was recorded. Calculate the percentage yield.

Solution:

Step 1 : Balanced equation	$2AgNO_3(aq) + CaCl_2(aq) \rightarrow 2AgCl(s) + Ca(NO_3)_2\ (aq)$
Step 2 : Mole ratio	1 : 2
Step 2.5*: Calculate no. of moles ($CaCl_2$)	$\text{Conc. (mol/dm}^3\text{)} = \dfrac{\text{No. of moles (mol)}}{\text{Volume (dm}^3\text{)}}$ No. of moles = Conc. X Volume = 0.105 X (50.0 / 1000) = <u>0.00525 mol.</u>
Step 3 : Find no. of moles (AgCl)	1 : 2 0.00525 : x No. of moles of AgCl $= \dfrac{(0.00525 \text{ X } 2)}{1}$ <u>= 0.0105 mol.</u>
Step 4 : Find the mass (AgCl)	Mass = No. of moles X Molar Mass or Mr = 0.0105 mol X 143.5 (g) = <u>1.51 g</u>.
Step 5 : Percentage yield	= Actual / theoretical X 100% = 1.45 / 1.51 X 100% = 96.0%

Percentage Purity

- Sometimes, chemical are not pure and contains impurity.
- It gives the indication of the amount of impurity in a chemical substance.
- Formula for percentage purity:

$$\frac{\text{Mass of pure substance in sample}}{\text{Mass of sample}} \times 100\%$$

Example 1

An impure sample of calcium carbonate ($CaCO_3$) contains calcium sulphate as an impurity. When excess hydrochloric acid was added to **6g of the sample**, **1200 cm^3 of gas** was produced (measured at r.t.p.). Calculate **the percentage purity of the calcium carbonate** sample.

Solution:

Step 1 : Balanced equation	$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$
Step 2 : Mole ratio	1 : 1
Step 2.5*: Calculate no. of moles (CO_2)	No. of moles = $\frac{\text{Volume of gas}}{\text{Molar volume}}$ $= \frac{1200}{24\ 000}$ = <u>0.05 mol.</u>
Step 3 : Find no. of moles ($CaCO_3$)	1 : 1 0.05 : x No. of moles of AgCl = $\frac{(0.05 \text{ X } 1)}{1}$ <u>= 0.05 mol.</u>
Step 4 : Find the mass ($CaCO_3$)	Mass = No. of moles X Molar Mass or Mr = 0.05 mol X 100 (g) = <u>5 g</u>.
Step 5 : Percentage purity	= Mass of $CaCO_3$ / Mass of sample X 100%

Example 2:

A **3.21g** sample of <u>copper (II) carbonate</u> was reacted with excess hydrochloric acid. It was found that **480cm^3** of <u>carbon dioxide</u> gas measured at r.t.p. was given off. What is the **<u>percentage purity of the copper (II) carbonate in the given sample</u>**?

[1 mol gas occupies 24.0 dm^3 at r.t.p]

<u>Solution:</u>

Step 1 : Balanced equation	$CuCO_3 + 2HCl \rightarrow CuCl_2 + CO_2 + H_2O$
Step 2 : Mole ratio	1 : 1
Step 2.5*: Calculate no. of moles (CO_2)	No. of moles = $\frac{\text{Volume of gas}}{\text{Molar volume}}$ = $\frac{480}{24\ 000}$ = <u>0.02 mol.</u>
Step 3 : Find no. of moles ($CaCO_3$)	1 : 1 0.02 : x No. of moles of AgCl = $\frac{(0.02 \text{ X } 1)}{1}$ <u>= 0.02 mol.</u>
Step 4 : Find the mass ($CaCO_3$)	Mass = No. of moles X Molar Mass or Mr = 0.02 mol X 123.5 (g) = <u>2.47 g</u>.
Step 5 : Percentage purity	= Mass of $CaCO_3$ / Mass of sample X 100%