

GCSE AQA Chemistry Third Edition

Chapter C4 QA

Questions By Topic:

C4: Chemical Calculations

Intext Questions:

C4.1 Relative masses and moles:

1. What is the relative atomic mass of an element? [2 marks]

Answer.

Relative atomic mass is also known as **atomic weight**, is a dimensionless physical quantity. In its modern definition, it is the ratio of the average **mass** of **atoms** of an **element** (in a given sample) to one unified **atomic mass** unit.

2. What is the relative formula mass of:

a) MgF_2 (A_r values: Mg = 24, F = 19) [1 mark]

Answer.

Relative formula mass = $24 + (19 \times 2) = 62$

b) $\text{C}_2\text{H}_{12}\text{O}_6$ (A_r values: C = 12, H = 1, O = 16)? [1 mark]

Answer.

Relative formula mass = $(12 \times 2) + (1 \times 12) + (16 \times 6) = 132$

3.

a) How many moles of helium atoms are there in 0.02 g of helium? [1 mark]

b) How many moles of sulfur atoms are there in:

i) 9.6g of sulfur [1 mark]

ii) 16 tonnes of sulfur (where 1 tonne = 1000 kg)? [1 mark]

4. What is the mass of:

a) 50 moles of calcium carbonate, CaCO_3 [1 mark]

b) 0.05 moles of hydrogen, H_2 [1 mark]

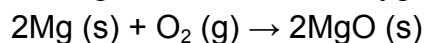
c) 0.6 moles of phosphorus, P_4 ? [1 mark]

5. Why can you have relative atomic masses, which are not whole numbers, e.g., the A_r of chlorine, Cl, is 35.5. [1 mark]

4.2 Equations and calculations:

1. 2HCl can have two meanings. What are they? [1 mark]

2. Magnesium burns in oxygen with a bright white flame:



What mass of oxygen will react exactly with 6.0g of magnesium?

(A_r values: O = 16, Mg = 24) [2 marks]

3.

a) An aqueous solution of hydrogen peroxide, H_2O_2 , decomposes to form water and oxygen gas. Write a balanced symbol equation, including state symbols, for this reaction. [3 marks]

b) When hydrogen peroxide decomposes, what mass of hydrogen peroxide is needed in solution to produce 1.6g of oxygen gas? [2 marks]

4. When a small lump of calcium metal, Ca, is added to water, it reacts giving off hydrogen gas. A solution of calcium hydroxide, Ca(OH)_2 , is also formed in the reaction.

a) Write a balanced symbol equation, including state symbols, for the reaction. [3 marks]

b) Calculate how much calcium metal must be added to an excess of water to produce 3.7g of calcium hydroxide. [2 marks]

4.3 From masses to balanced equations:

1. State what we mean by a limiting reactant in a chemical reaction. [1 mark]

Answer.

The **limiting reagent** in a chemical reaction is the substance that is totally consumed when the **chemical reaction** is complete.

2. When copper metal reacts with oxygen gas, black copper oxide, CuO, is formed. In an experiment it was found that when copper reacted completely with oxygen, 6.35g of copper reacted with 1.60g of oxygen gas, O_2 , to form 7.95g of copper oxide.

a) Calculate the number of moles of each reactant and product. [3 marks]

b) Show how this relates to the balanced symbol equation for the reaction. [2 marks]

3. Aluminium reacts with iron(III) oxide, Fe_2O_3 , to give iron metal and aluminium oxide, Al_2O_3 .

a) Write a balanced symbol equation for this reaction. [3 marks]

b) In an experiment, 32.0g of iron(III) oxide was reacted with 16.2g of aluminium.

Which of the two reactants is limiting reactant? Show your working. [2 marks]

c) Calculate the maximum mass of iron that could be collected at the end of this experiment. [2 marks].

4.4 The yield of a chemical reaction:

1. State why it is good for the environment if industry finds ways to make products using high yield reactions and processes that waste as little energy as possible. [2 marks]

Answer.

Because

- It reduces the waste of reactants.
- It reduces the cost of the process.

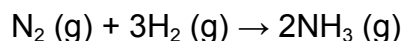
2. List the factors that can affect the percentage yield of a reaction. [5 marks]

Answer.

Some factors are as follows:

- a) The product of a step doesn't get fully dried.
- b) We weighed 14 g of a reactant instead of 15 g which are required for the experiment, but we noted down 15 g.
- c) A reactant that has to be heated in order to produce another product, doesn't get enough heated.
- d) If a solid gets rinsed with only cold water, but not with acetone.

3. Ammonia gas, NH_3 , is made by heating the gases nitrogen and hydrogen under pressure in the presence of an iron catalyst:



If 7.0g of nitrogen are reacted with excess hydrogen and 1.8g of ammonia is collected, what is the percentage yield? [3 marks]

4. Sodium hydrogen carbonate, NaHCO_3 , can be converted into sodium carbonate, Na_2CO_3 , by heating. This is a thermal decomposition reaction in which water vapour and carbon dioxide are also products of the reaction. A student started with 16.8g of sodium hydrogen carbonate and collected 9.20g of sodium carbonate.

- a) Write a balanced symbol equation for the thermal decomposition. [1 mark]
- b) Calculate the percentage yield the student obtained. [3 marks]

4.5 Atom economy

1. Write down the formula that chemists use to calculate the percentage atom economy of a reaction. [1 mark]

Answer.

The formula is atom economy = $\frac{\text{mass of atoms in product}}{\text{mass of atoms in reactant}} \times 100$

2. Calculate the atom economy of the thermal decomposition of calcium carbonate. [2 marks]

Answer.

The thermal decomposition of copper carbonate, with the desired product being copper oxide and waste product being carbon dioxide is shown like this:



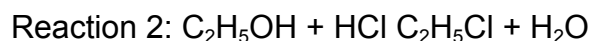
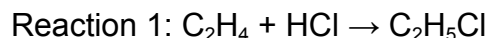
In the reactants there is one copper atom (1Cu), one carbon atom (1C) and three oxygen atoms (3O).

The relative formula mass is $63.5 + 12.0 + (3 \times 16.0) = 123.5$

The desired product is copper oxide (CuO) with a relative formula mass of $63.5 + 16 = 79.5$

atom economy = $\frac{79.5}{123.5} \times 100 = \mathbf{64.4\%}$

3. A chemical company is setting up a plant to manufacture the compound called chloro ethane, $\text{C}_2\text{H}_5\text{Cl}$. Their chemists can make it in two ways, either from ethane (Reaction 1) or ethanol (reaction 2):



a) Calculate the percentage atom economy of Reaction 2. [2 marks]

b) Many factors have to be considered before deciding which route to make too many chloro ethane. However, on the basis of atom economy, explain which reaction is preferable. [2 marks]

c) Suggest two factors that the chemical company should consider before making their decision and give a reason for each. [4 marks]