

GCSE / IGCSE Chemistry – Quantitative Chemistry

GCSE / IGCSE (Edexcel / Cambridge style) · Total marks: 31 · Answers on the last page

Covers moles, reacting masses, concentration, titration calculations and percentage yield. A calculator is needed throughout; molar gas volume at rtp is taken as $24 \text{ dm}^3 \text{ mol}^{-1}$ and $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$.

Section A – Skills (Calculator allowed)

1. Calculate the relative formula mass, M_r , of CaCO_3 . (A_r : Ca 40, C 12, O 16) [1]
2. Calculate the number of moles in 22.0 g of CO_2 . ($M_r = 44$) [2]
3. Calculate the mass of 0.250 mol of NaCl. ($M_r = 58.5$) [2]
4. Calculate the concentration, in mol dm^{-3} , of a solution made by dissolving 4.00 g of NaOH ($M_r = 40$) in water and making up to 250 cm^3 . [3]
5. Calculate the number of molecules in 0.0200 mol of H_2O . ($N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$) [2]

Section B – Exam-style (Calculator allowed)

6. $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$. Calculate the maximum mass of CaO that can be made from 50.0 g of CaCO_3 . (M_r : $\text{CaCO}_3 = 100$, $\text{CaO} = 56$) [3]
7. $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$. Calculate the volume, in cm^3 at rtp, of hydrogen gas produced from 0.0600 mol of magnesium reacting with excess acid. (1 mol of gas occupies 24 dm^3 at rtp) [3]
8. 25.0 cm^3 of sodium hydroxide solution was exactly neutralised by 22.5 cm^3 of $0.100 \text{ mol dm}^{-3}$ hydrochloric acid: $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$. Calculate the concentration of the sodium hydroxide solution. [3]
9. A reaction has a theoretical yield of 4.50 g of product. A student actually obtains 3.60 g. Calculate the percentage yield. [2]
10. Explain, in terms of particle collisions, why increasing the concentration of a reactant increases the rate of reaction. [2]

Section C – Challenge (Calculator allowed)

11. A 2.00 g sample of impure calcium carbonate reacts fully with excess dilute hydrochloric acid. The carbon dioxide released has a mass of 0.660 g. Calculate the percentage purity of the calcium carbonate sample. (M_r : $\text{CaCO}_3 = 100$, $\text{CO}_2 = 44$) [4]
12. A 10.0 cm^3 sample of a stock NaOH solution is diluted to 100 cm^3 with water. 25.0 cm^3 of the diluted solution requires 20.0 cm^3 of $0.0500 \text{ mol dm}^{-3}$ HCl for exact neutralisation. Calculate the concentration of the original stock NaOH solution. [4]

Answers

Check your working against these. If an answer does not match, try the question again before looking for the method.

1. $M_r = 40 + 12 + 3 \times 16 = 100$
2. $n = \frac{22.0}{44} = 0.500 \text{ mol}$
3. $\text{mass} = 0.250 \times 58.5 = 14.6 \text{ g}$
4. $n = \frac{4.00}{40} = 0.100 \text{ mol}$; $c = \frac{0.100}{0.250} = 0.400 \text{ mol dm}^{-3}$
5. $\text{molecules} = 0.0200 \times 6.02 \times 10^{23} = 1.20 \times 10^{22}$
6. $n(\text{CaCO}_3) = \frac{50.0}{100} = 0.500 \text{ mol} = n(\text{CaO})$; $\text{mass} = 0.500 \times 56 = 28.0 \text{ g}$
7. $n(\text{H}_2) = n(\text{Mg}) = 0.0600 \text{ mol}$; $V = 0.0600 \times 24 = 1.44 \text{ dm}^3 = 1440 \text{ cm}^3$
8. $n(\text{HCl}) = 0.100 \times \frac{22.5}{1000} = 2.25 \times 10^{-3} \text{ mol} = n(\text{NaOH})$; $c(\text{NaOH}) = \frac{2.25 \times 10^{-3}}{25.0/1000} = 0.0900 \text{ mol dm}^{-3}$
9. $\text{percentage yield} = \frac{3.60}{4.50} \times 100 = 80.0 \text{ percent}$
10. Increasing concentration increases the number of reactant particles in a given volume, so particles are closer together and collide more frequently; this increases the frequency of successful collisions (with energy $\geq$ activation energy) per unit time, increasing the rate of reaction.
11. $n(\text{CO}_2) = \frac{0.660}{44} = 0.0150 \text{ mol} = n(\text{CaCO}_3) \text{ reacted}$; $\text{mass CaCO}_3 = 0.0150 \times 100 = 1.50 \text{ g}$; $\text{purity} = \frac{1.50}{2.00} \times 100 = 75.0 \text{ percent}$
12. $n(\text{HCl}) = 0.0500 \times \frac{20.0}{1000} = 1.00 \times 10^{-3} \text{ mol} = n(\text{NaOH}) \text{ in } 25.0 \text{ cm}^3 \text{ diluted}$; $c(\text{diluted}) = \frac{1.00 \times 10^{-3}}{0.0250} = 0.0400 \text{ mol dm}^{-3}$; $\text{moles in } 100 \text{ cm}^3 \text{ diluted} = 0.0400 \times 0.100 = 4.00 \times 10^{-3} \text{ mol}$, all from 10.0 cm^3 of stock, so $c(\text{stock}) = \frac{4.00 \times 10^{-3}}{0.0100} = 0.400 \text{ mol dm}^{-3}$

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