Algebra and equations

In chemistry, we use algebra every time we carry out a calculation. Whether we are working out the concentration of a solution, the density of a material, or how much product a reaction will make, we are substituting values into formulas and solving for unknowns.

The good news is that the algebra used in chemistry is the same as the algebra you use in maths. The formulas look different because the letters represent real physical quantities like mass, volume and concentration, but the process of substituting and solving is identical. If you can solve equations in maths, you can solve them in chemistry.

Balancing chemical equations is also an algebraic skill. When we balance an equation, we are making sure that the number of atoms of each element is equal on both sides, just like making both sides of an equation equal in maths.

In this worksheet you will practise balancing equations, substituting into formulas, and changing the subject of an equation to find unknowns.

- **The golden rule:** whatever you do to one side of an equation you must do to the other.
- **The method:** substitute the values you know into the formula first, then use inverse operations to solve for the unknown. This is the same as solving equations in maths.
- **Balancing equations:** add coefficients (numbers in front of formulas) to make the number of atoms of each element equal on both sides. Never change the subscripts.

Questions

1. Balance the following chemical equations:

(a) $\mathrm{K} + \mathrm{Br_2} \rightarrow \mathrm{KBr}$

(b) $\mathrm{Mg} + \mathrm{HNO_3} \rightarrow \mathrm{Mg(NO_3)_2} + \mathrm{H_2}$

(c) $\mathrm{C_4H_{10}} + \mathrm{O_2} \rightarrow \mathrm{CO_2} + \mathrm{H_2O}$

2. A student writes the equation for the reaction of iron with chlorine as:

$$\mathrm{Fe} + \mathrm{Cl_2} \rightarrow \mathrm{FeCl_3}$$

Explain why this equation is not balanced and write the correct balanced equation.

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3. A student dissolves 12.0 g of copper sulfate in water to make 1.5 dm³ of solution.

Calculate the concentration of the solution in g/dm³.

$$\text{concentration} = \frac{\text{mass}}{\text{volume}}$$

4. A solution of sodium chloride has a concentration of 9.0 g/dm³ and a volume of 0.5 dm³.

Calculate the mass of sodium chloride dissolved in the solution.

$$\text{mass} = \text{concentration} \times \text{volume}$$

5. A block of aluminium has a density of 2.7 g/cm³ and a volume of 15.0 cm³.

Calculate the mass of the block.

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Show your working: substitute first, then change the subject to find the mass.

6. A solution has a concentration of 3.0 g/dm³ and contains 18.0 g of solute.

Calculate the volume of the solution.

$$\text{concentration} = \frac{\text{mass}}{\text{volume}}$$

Show your working: substitute first, then change the subject to find the volume.

7. Zinc reacts with hydrochloric acid to produce zinc chloride and hydrogen, as shown by this equation:

$$Zn + HCl \rightarrow ZnCl_2 + H_2$$

(a) Balance this equation.

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(b) A student dissolves 13.6 g of zinc chloride ($ZnCl_2$) in water to make 2.0 dm³ of solution. Calculate the concentration in g/dm³.

$$\text{concentration} = \frac{\text{mass}}{\text{volume}}$$

8. A student has 4.0 dm³ of sulfuric acid solution with a concentration of 4.9 g/dm³.

(a) Calculate the mass of sulfuric acid in the solution.

$$\text{concentration} = \frac{\text{mass}}{\text{volume}}$$

(b) The student dilutes the solution by adding water until the total volume is 8.0 dm³. The mass of sulfuric acid stays the same. Calculate the new concentration.

(c) What happened to the concentration when the volume was doubled? Explain why.

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