Mass, amount and concentration calculations

Answer the following questions. Make sure you show your working out.

Mass and amount

The mass of 1 mol of a substance, given in grams, is equal to its relative mass.
This means that this equation is useful:

$$\text{mass (g)} = \text{relative mass} \times \text{amount (mol)}$$

The relative mass can be relative atomic mass, A_r, or relative formula mass, M_r.

Worked example

Calculate the mass of 0.5 mol of magnesium hydroxide, $Mg(OH)_2$. (Relative formula mass = 58)

$$\text{mass (g)} = 58 \times 0.5 \text{ mol} = 29 \text{ g}$$

Questions

Use these relative atomic masses where necessary.

Element	H	O	Al	Mg	S	Cl	Fe
A_r	1	16	27	24	32	35.5	56

1. Calculate the mass in grams of the following substances.
   (a) 1.0 mol of iron, Fe
   (b) 0.25 mol of oxygen gas, O_2
   (c) 2.0 mol of aluminium chloride, $AlCl_3$
   (d) 0.10 mol of sulfur dioxide, SO_2

2. Calculate the amount (number of moles) of water in these cases. (Relative formula mass = 18)
   (a) 18 g of water
   (b) 9 g of water
   (c) 36 g of water

3. Determine which contains more atoms, 24 g of magnesium or 24 g of sulfur.
   Justify your answer using calculations.

Concentration of a solution

The concentration of an aqueous solution is usually given in mole per decimetre cubed, mol/dm^3.
This equation shows how concentration, amount of solute and volume of solution are related:

$$\text{concentration (mol/dm}^3\text{)} = \frac{\text{amount (mol)}}{\text{volume (dm}^3\text{)}}$$

4. Calculate the concentration of the following solutions.
   (a) 1 mol of NaOH in 1 dm^3 of solution.
   (b) 0.5 mol of NaOH in 0.5 dm^3 of solution.
   (c) 1 mol of NaCl in 2 dm^3 of solution.
   (d) 1 mol of NaOH in 0.25 dm^3 of solution.

5. 250 cm^3 of a solution contains 0.25 mol of NaOH. Calculate the concentration of this solution.
   Hint: 1 dm^3 = 1000 cm^3 and 25 cm^3 = 25 ÷ 1000 = 0.025 dm^3

Mass, amount and concentration calculations – ANSWERS

1. (a) A_r of Fe = 56

   Mass = 56 × 1.0 = 56 g

   (b) *Mr* of O_2 = (2 × 16) = 32

   Mass = 0.25 × 32 = 8 g

   (c) M_r = of $AlCl_3$ = 27 + (3 × 35.5) = 27 + 106.6 = 133.5

   Mass = 133.5 × 2.0 = 267 g

   (d) M_r o f SO_2 = 32 + (2 × 16) = 32 + 32 = 64

   Mass = 64 × 0.10 = 6.4 g

2. (a) 18 g = 18 × amount (mol)

   $$\text{amount} = \frac{18}{18} = 1 \text{ mol}$$

   (b) 9 g = 18 × amount (mol)

   $$\text{amount} = \frac{9}{18} = 0.5 \text{ mol}$$

   (b) 36 g = 18 × amount (mol)

   $$\text{amount} = \frac{36}{18} = 2 \text{ mol}$$

3. Relative atomic masses (given to you): Mg = 24, S = 32

   $$\text{amount of Mg} = \frac{24}{24} = 1.0 \text{ mol} \qquad \text{amount of S} = \frac{24}{32} = 0.75 \text{ mol}$$

   So, 24 g of magnesium contains more atoms than 24 g of sulfur.

Concentration of a solution

4. (a) $$\text{concentration} = \frac{1 \text{ mol}}{1 \text{ dm}^3} = 1 \text{ mol/dm}^3$$

   (b) $$\text{concentration} = \frac{0.5 \text{ mol}}{0.5 \text{ dm}^3} = 1 \text{ mol/dm}^3$$

   (c) $$\text{concentration} = \frac{1 \text{ mol}}{2 \text{ dm}^3} = 0.5 \text{ mol/dm}^3$$

   (d) $$\text{concentration} = \frac{1 \text{ mol}}{0.25 \text{ dm}^3} = 4 \text{ mol/dm}^3$$

5. Volume = 250 ÷ 1000 = 0.25 dm^3

   $$\text{concentration} = \frac{0.25 \text{ mol}}{0.25 \text{ dm}^3} = 1 \text{ mol dm}^3$$