

Solutions

Original authored marking guidance; award equivalent balanced working.

2.1 Relative formula mass is the sum of relative atomic masses in the formula, a dimensionless ratio. Molar mass is mass per mole, with units such as g mol^{-1} . Sodium chloride has a giant ionic lattice rather than discrete NaCl molecules.

2.2 $V = 250/1000 = 0.250 \text{ dm}^3$; $n = m/M = 4.00/40.0 = 0.100 \text{ mol}$.

$$c = n/V = 0.100/0.250 = 0.400 \text{ mol dm}^{-3}$$

Mass concentration = $m/V = 4.00/0.250 = 16.0 \text{ g dm}^{-3}$.

2.3 Fraction = $0.0420/100 = 0.000420$. ppm = $0.000420 \times 10^6 = 420$. Do not multiply the percentage itself by 10^6 .

3.1 $V = 100 \times 10^{-6} = 1.00 \times 10^{-4} \text{ m}^3$.

$$n = \frac{pV}{RT} = \frac{1.00 \times 10^5 \times 1.00 \times 10^{-4}}{8.31 \times 373} = 0.00323 \text{ mol}$$

$M = m/n = 0.230/0.00323 = 71.3 \text{ g mol}^{-1}$. The gas equation requires the absolute temperature already supplied in K.

3.2 Available amount/coefficient is $0.0600/2 = 0.0300$ for aluminium and $0.0600/3 = 0.0200$ for chlorine. Chlorine limits. Product amount = $0.0600 \times 2/3 = 0.0400 \text{ mol}$; aluminium left = $0.0600 - 0.0400 = 0.0200 \text{ mol}$.

3.3 $\text{Na}_2\text{CO}_3(\text{aq}) + \text{CaCl}_2(\text{aq}) \rightarrow \text{CaCO}_3(\text{s}) + 2\text{NaCl}(\text{aq})$. $\text{Ca}^{2+}(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{CaCO}_3(\text{s})$. Na^+ and Cl^- are spectator ions; the white solid is calcium carbonate.

3.4 Yield = $3.20/4.00 \times 100 = 80.0\%$. Atom economy concerns the balanced reaction products, while incomplete reaction or isolation losses can lower actual yield even if no by-product is formed.