Concentration expressed as percentage composition

Concentration expressed as a percentage composition is referring to the percentage of solute in a particular solution. This may be on a mass or volume basis and leads to notations such as 10% (m/m), 5% (m/v) or 15% (v/v).

$$\text{percentage composition by mass (\%m/m)} = \frac{\text{mass solute in g}}{\text{mass solution in g}} \times 100$$

$$\text{percentage composition by volume (\% v/v)} = \frac{\text{volume of solute in mL}}{\text{volume of solution in mL}} \times 100$$

$$\text{percentage composition by mass/volume (\%m/v)} = \frac{\text{mass of solute in g}}{\text{volume of solution in mL}} \times 100$$

Problems

1. Calculate the moles of sodium ions present in 650 mL of a 2.00% (g/mL) sodium carbonate solution. (0.245 mol Na^+)

2. The concentration of calcium in milk is 0.114% (m/m) and the recommended daily amount of calcium consumed by a teenager is 1300 mg. How many glasses of milk would need to be consumed to achieve this recommended daily amount? Assume the volume of the glass is 250 mL and that 100 mL of milk has a mass of 103 g.
(4.42)

3. Concentrated hydrochloric acid has a density of 1.16 g mL^{-1} and contains 32.0% by mass of hydrogen chloride. What volumes of this concentrated acid and of water would need to be mixed together to prepare 500 mL of a 2.00 $molL^{-1}$ HCl solution?
(v_{acid}=98.2 mL; v_{water} = 401.8 mL)

4. A sample of household cloudy ammonia is found to contain 5.00% ammonia by mass. Its density is 0.977 g mL^{-1} . What is the concentration in $molL^{-1}$ of this ammonia solution? (2.87M)

5. A common method for commercially peeling potatoes is to soak them for 1-5 minutes in a 10 - 20 % (m/m) solution of NaOH at 60 - 88^{o}C and to spray off the peel once the potatoes are removed from the solution. As an economy measure a manufacturer titrates the used NaOH with a standardised solution of H_2SO_4 at the end of each day to determine whether the solution is still capable of peeling potatoes.

    a) If at the end of the day the chemist finds that it takes 64.0mL of a 0.200M solution of H_2SO_4 to titrate a 10.0 mL sample of NaOH solution what was the concentration of the NaOH in mol L^{-1}? (2.56M)

    b) To be able to peel potatoes the NaOH solution must be at least 10% by mass. Is the solution able to be recycled? The density of the solution was found to be 1.10 g mL^{-1}
    (the 2.56M solution not suitable as it needs to be 2.75M)

ANSWERS

1. $\%(m/v) = 2 = \frac{\text{mass solute (g)}}{\text{volume solution (mL)}}$

$$2 = \frac{\text{mass } Na_2CO_3}{650} \times 100$$

$$\Rightarrow {}^{mass}Na_2CO_3 = \frac{(2)(650)}{100} = 13 \text{ g}$$

$${}^{n}Na_2CO_3 = \frac{13}{2 \times 22.99 + 12.01 + 3 \times 16}$$

$$= \frac{13}{105.99} = 0.127 \text{ mol}$$

$${}^{n}Na^{+} = 2 \times 0.127 = 0.245 \text{ mol}$$

2. First find mg of Ca in a glass of milk

Mass glass milk = 2.5 x 103 = 257.5 g

$$\%(m/m) = 0.114 = \frac{\text{mass Ca}}{\text{mass milk}} \times 100$$

$$0.114 = \frac{\text{mass Ca}}{257.5} \times 100$$

$$\Rightarrow \text{mass Ca} = 0.294 \text{ g}$$

$$= 294 \text{ mg}$$

Need 1300 mg

$$\text{Number of glasses milk needed} = \frac{1300}{294} = 4.42$$

3. ${}^{n}HCl = cv = (2)(0.5) = 1 \text{ mole}$

${}^{mass}HCl \text{ needed} = 1.008 + 35.45 = 36.458 \text{ g}$

$$\%(m/m) = 32 = \frac{\text{mass HCl}}{\text{mass solution}} \times 100$$

$$32 = \frac{36.458}{\text{mass solution}} \times 100$$

$$\Rightarrow \text{mass solution} = \frac{36.458}{32} \times 100 = 113.9 \text{ g}$$

$$\text{density} = 1.16 = \frac{\text{mass}}{\text{volume}}$$

$$1.16 = \frac{113.9}{\text{volume}}$$

$$\Rightarrow \text{volume acid} = \frac{113.9}{1.16} = 98.2 \text{ mL}$$

Volume water = 500 – 98.2 = 401.8 mL

4. %(m/m) = 5 = $\frac{\textbf{mass } NH_3}{977}$ x 100 (assume volume of 1000 mL)

$\Rightarrow$ mass NH_3 = $\frac{5 \; x \; 977}{100}$ = 48.85 g

$^{n}NH_3$ = $\frac{48.85}{14.01 + 3 \; x \; 1.008}$ = $\frac{48.85}{17.034}$ = 2.87 mol

c = $\frac{n}{v}$ = $\frac{2.87}{1}$ = 2.87 mol L^{-1}

5. a) $H_2SO_4 + 2NaOH \rightarrow 2H_2O + Na_2SO_4$

v = 64 mL v = 10 mL
c = 0.2 M

n = cv $^{n}NaOH = \frac{2}{1}$ x $^{n}H_2SO_4$

= (0.2) (0.064) $= \frac{2}{1}$ x 0.0128 = 0.0256 mol

c = $\frac{n}{v}$ = $\frac{0.0256}{0.01}$ = 2.56 M

b) NaOH needs to by 10% (m/m)

10 = $\frac{\textbf{mass NaOH}}{\textbf{mass solution}}$ x 100

10 = $\frac{\textbf{mass NaOH}}{1100}$ x 100 (assume 1 litre)

$\Rightarrow$ $^{mass}NaOH$ = $\frac{10 \; x \; 1100}{100}$ = 110 g

$^{n}NaOH$ = $\frac{110}{22.99 + 16 + 1.008}$ = $\frac{110}{39.998}$ = 2.75 mol

c = $\frac{n}{v}$ = $\frac{2.75}{1}$ = 2.75 M is what the molarity of the NaOH solution needs to be

2.56 < 2.75 so the solution cannot be used to peel potatoes