AQA Chemistry
GCSE Student calculation sheet C4.4

Name ..... Class ..... Date .....

Concentrations of solutions

Specification references

- C3.2.5 Concentration of solutions (H)
- MS 1c
- MS 3b

Aims

This worksheet gives you practice in calculating the concentration of a solution in units of mol/dm^3 and g/dm^3, and also in calculating the amount of solute in a given volume of a solution of known concentration.

Learning outcomes

After completing this worksheet, you should be able to:

- calculate the concentration, in mol/dm^3 and g/dm^3, of a solution when the number of moles and volume is given
- calculate the mass of a chemical when any volume and concentration is given and independently express your answers to an appropriate number of significant figures.

Setting the scene

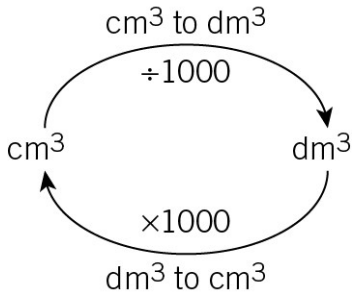
Chemists often carry out their reactions in solution. To record, interpret, and communicate their results they need to express the concentration of the solution they use. Chemists do this by stating the amount of substance dissolved in a certain volume of solution.

If the amount of substance is expressed in grams, then the concentration of the solution is expressed in units of grams per decimetre cubed (*g/dm^3*) and can be calculated using the equation:

$$\text{concentration (g/dm}^3\text{)} = \frac{\text{amount of substance (g)}}{\text{volume of solution (dm}^3\text{)}}$$

You will notice that the volume of the solution is always expressed in decimetres cubed (dm^3). 1 dm^3 is equal to 1000 cm^3, so to convert between the two units you need to multiply or divide by a factor of 1000. The diagram below will help you with this conversion;

Name ..... Class ..... Date .....



Worked example

32.5 g of sulfuric acid, H_2SO_4, is dissolved in water and the solution is made up to 400 cm^3. Calculate the concentration of the final solution in (a) g/dm^3 and (b) mol/dm^3.

Relative atomic masses, A_r, values: H = 1, S = 32, O = 16

Step 1

The final volume of the solution is 400 cm^3. This must be expressed in dm^3 before substituting into the equation for concentration.

If 1000 cm^3 = 1 dm^3, then 400 cm^3 = $\frac{400}{1000}$ = 0.400 dm^3.

Step 2

The mass of H_2SO_4 is 32.5 g and the volume of the solution is 0.400 dm^3. Substitute these values into the equation to calculate the concentration of the solution formed in g/dm^3.

$$\text{concentration (g/dm}^3\text{)} = \frac{\text{amount of substance (g)}}{\text{volume of solution (dm}^3\text{)}} = \frac{32.5\text{ g}}{0.400\text{ dm}^3} = 81.3\text{ g/dm}^3$$

Note that the final answer can only be expressed to three significant figures to match the values that were used to calculate it (32.5 g and 0.400 dm^3).

Step 3

To express the concentration of the solution in units of mol/dm^3, it is first necessary to convert the amount of substance from a mass in grams to an amount in moles.

To convert a mass to an amount in moles, we use the equation:

$$\text{amount of substance (mol)} = \frac{\text{mass (g)}}{M_r\text{ (g/mol)}}$$

M_r (H_2SO_4) = (2 × H) + S + (4 × O)

= (2 × 1) + 32 + (4 × 16)

= 98 g/mol

Name ..... Class ..... Date .....

Substitute the values into the equation to determine the amount of substance, in moles, in 32.5 g of H_2SO_4:

$$\text{amount of substance (mol)} = \frac{32.5\text{ g}}{98\text{ g/mol}} = 0.33\text{ mol}$$

Step 4

The amount of H_2SO_4 is 0.33 mol and the volume of the solution is 0.400 dm^3. Substitute these values into the equation to calculate the concentration of the solution formed in mol/dm^3.

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

$$= \frac{0.33\text{ mol}}{0.400\text{ dm}^3} = 0.83\text{ mol/dm}^3$$

Note that this time the concentration can only be expressed to two significant figures, because the relative formula mass of H_2SO_4 is only expressed to two significant figures.

Questions

1 Calculate the concentrations of each of the following solutions in units of g/dm^3:

- **a** 10.0 g of sodium chloride dissolved in 2.00 dm^3 of water (*1 mark*)
- **b** 2.5 g of glucose dissolved in 0.5 dm^3 of water (*1 mark*)
- **c** 3.8 g of copper sulfate dissolved in 250 cm^3 of water (*2 marks*)
- **d** 25.6 g of potassium chloride dissolved in 1500 cm^3 of water. (*2 marks*)

2 Calculate the concentrations of each of the following solutions in units of mol/dm^3:

(Relative atomic masses, A_r, values: H = 1, C = 12, O = 16, Na = 23, Cl = 35.5, S = 32, K = 39, Cu = 63.5)

- **a** 10.0 g of sodium chloride, NaCl, dissolved in 2.00 dm^3 of water (*3 marks*)
- **b** 2.5 g of glucose, $C_6H_{12}O_6$, dissolved in 0.5 dm^3 of water (*3 marks*)
- **c** 3.8 g of copper sulfate, $CuSO_4$, dissolved in 250 cm^3 of water (*3 marks*)
- **d** 25.6 g of potassium chloride, KCl, dissolved in 1500 cm^3 of water (*3 marks*)
- **e** 2.5 g of hydrated copper sulfate, $CuSO_4 \cdot 5H_2O$, dissolved in 0.025 dm^3 of water. (*3 marks*)

Name ..... Class ..... Date .....

3 Calculate the amount of solute in each of the following solutions.

a in units of *moles* (*6 marks*)

b in units of *grams* (*8 marks*)

Relative atomic masses, A_r, values: H = 1, Cl = 35.5, Na = 23, O = 16, N = 14, Ca = 40

i 0.20 dm^3 of a solution of hydrochloric acid, HCl, with a concentration of 1.5 mol/dm^3

ii 4.5 dm^3 of a solution of sodium hydroxide, NaOH, with a concentration of 0.40 mol/dm^3

iii 80 cm^3 of a solution of nitric acid, HNO_3, with a concentration of 1.25 mol/dm^3

iv 1250 cm^3 of a solution of calcium hydroxide, $Ca(OH)_2$, with a concentration of 0.87 mol/dm^3.