Chemistry calculations

This post is about answering O level chemistry calculations questions which are part of stoichiometry. To fully understand these calculations you should be familiar with:

- how to use the periodic table
- relative molecular mass
- molar mass
- moles
- concentration
- valency

These questions are compatible with Zimsec O level Chemistry and Combined science.

Question 1

Using the periodic table calculate the molecular masses of the following compounds:

- $Na_2Cr_2O_7$
- $KMnO_4$
- $KClO_3$
- $(NH_4)_2SO_4$
- $NaHCO_3$
- $CuCO_3$
- $Fe_2(SO_4)_3$

Solution 1

As we know, the relative molecular mass, M_r of a compound is found by adding the relative atomic masses, A_r of the atoms that make up the compound.

- M_r of $Na_2Cr_2O_7 = (23 \times 2) + (52 \times 2) + (16 \times 7) = 262$
- M_r of $KMnO_4 = 39 + 55 + (16 \times 4) = 158$
- M_r of $KClO_3 = 39 + 35.5 + (16 \times 3) = 122.5$
- M_r of $(NH_4)_2SO_4 = (14 \times 2) + (1 \times 8) + 32 + (16 \times 4) = 132$
- M_r of $NaHCO_3 = 23 + 1 + 12 + (16 \times 3) = 84$
- M_r of $CuCO_3 = 64 + 12 + (16 \times 3) = 124$
- M_r of $Fe_2(SO_4)_3 = (56 \times 2) + (32 \times 3) + (16 \times 12) = 400$

Question 2

Write the formulae formulae for the following compounds and then calculate their molecular or formula mass:

- Water
- Carbon monoxide
- Carbon dioxide
- Sulphur dioxide
- Sulphur trioxide
- Carbon tetrachloride
- Magnesium chloride
- Sodium sulphate
- Beryllium hydroxide

Solution 2

Something to take note of before answering this question: mono- means 1, di- means 2, tri- means 3, tetra- means 4. For example if a compound's name ends with **di**oxide it means that the compound contains 2 oxygen atoms.

- Water → H_2O
- Carbon monoxide → CO
- Carbon dioxide → CO_2
- Sulphur dioxide → SO_2
- Sulphur trioxide → SO_3
- Carbon tetrachloride → CCl_4

Next comes ionic compounds and to write their formulae we need to consider the valencies of their ions or radicals.

- Magnesium chloride → Mg^{2+} Cl^-, then the valency of magnesium = number of chlorine atoms required and valency chlorine = number of magnesium atoms required. Therefore the formula = $MgCl_2$.
- Sodium sulphate → Na^+ SO_4^{2-}. So the valency of the sulphate radical becomes the number of sodium ions and the valency of the sodium ion becomes the number of sulphate radicals in the formula. The formula becomes Na_2SO_4.

  by the same token we can find the formulae of the remaining compounds
- Beryllium hydroxide → Be^{2+} OH^- = $Be(OH)_2$

Question 3

Find the mass of:

- 2 moles of nitrogen dioxide
- 0.5 mole of sodium oxide
- 0.01 mole of water
- 4 moles of sodium chloride
- 1.5 mole of calcium carbonate

Solution 3

- mass of NO_2 = number of moles × molar mass

  = 2 × [14 + (16 × 2)]
  = 2 × (14 + 32)
  = 2 × 46
  = 92 grams

- mass of Na_2O = number of moles × molar mass

  = 0.5 × [(23 × 2) + 16]
  = 0.5 × 46 + 16
  = 0.5 × 62
  = 31 grams
- mass of H_2O = number of moles × molar mass

  = 0.01 × [(1 × 2) + 16]
  = 0.01 × 18
  = 0.18 grams
- mass of NaCl = number of moles × molar mass
  = 4 × (23 + 35.5) = 4 × 58.5
  = 234 grams
- mass of $CaCO_3$ = number of moles × molar mass

  = 1.5 × [40 + 12 + (16 × 3)]
  = 1.5 × (52 + 48)
  = 1.5 × 100
  = 150 grams

Question 4

How many moles are there in the following masses?

- 6 g $CuCl_2$
- 30 g $FeSO_4$

Solution 4

This question can be answered using the formulae:
$number\ of\ moles\ = \frac{mass}{molar\ mass}$

- $N = \frac{m}{M_r}$
  $N\ of\ CuCl_2 = \frac{6}{64+(35.5\times2)}$
  $N\ of\ CuCl_2 = \frac{6}{64+71}$
  $N\ of\ CuCl_2 = \frac{6}{135}$
  = 0.0444 moles
- $N = \frac{m}{M_r}$
  $N\ of\ FeSO_4 = \frac{30}{56+32+(16\times4)}$
  $N\ of\ FeSO_4 = \frac{30}{152}$
  = 0.2 moles

Question 5

Calculate the number of moles of the solute in the following volumes of solution:

- 50 cm^3 of 0.5 mol/dm^3 solution
- 2 dm^3 of 2 mol/dm^3 solution

Solution 5

Before we answer this question let us look at the units. Homogeneity of units is the integral part of any correct formula. For example, if the units of concentration are in mol/**dm^3** then the volume has to be in **dm^3** for the concentration formula to be correct. Since 1000 cm^3 = 1 dm^3 we convert cm^3 to dm^3 by dividing the volume by 1000.

- Number of moles of solute = Concentration × volume of solution
  N = CV
  $N = \frac{50}{1000} \times 0.5$
  = 0.025 moles
- N = CV
  N = 2 × 2 (no conversion is necessary in this case because the volume is already in dm^3) N = 4 moles

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Question 6

Find the mass of solute in the following volumes:

- 24 cm^3 of 0.1 mol/dm^3 NaCl
- 250 cm^3 of 11,1 g/dm^3 of $CaCl_2$

Solution 6

In the first case we are given the volume and the molar concentration (mol/dm^3), so to find the mass we first have to find the number of moles.

- N = CV
  $N = \frac{24}{1000} \times 0.1$
  = 0.0024 moles
  then we convert the moles to mass using the formula:
  mass = number of moles × molar mass
  m = 0.0024 × (23 + 35.5)
  = 0.1404 grams

Now we are given the mass concentration (g/dm^3) the formula changes to:

- mass = concentration × volume
  m = 11.1 × 0.25
  = 2.775 g
