"Low sodium" salt substitutes

Introduction

Salt (sodium chloride) is a vital component of our diet both for health and for its flavouring effect. In appropriate quantities it is needed for transmission of nerve impulses and contraction of muscles, although in excessive amounts it is associated with heart disease, high blood pressure and strokes.

Lo Salt

Some people who for health reasons (high blood pressure, for example) require a diet low in sodium, use salt substitutes - one trade name is LoSalt. Further information is available at *www.losalt.com* (*accessed January 2005*), for example. These products are either potassium chloride or mixtures of sodium chloride and potassium chloride. The titration method described allows you to measure the percentage of potassium chloride in these products.

On dissolving in water, both potassium chloride and sodium chloride dissociate completely to form Cl^- (chloride) ions, *eg*:

$NaCl(s) \rightarrow Na^+(aq)$ and $Cl^-(aq)$

One way of measuring the total concentration of chloride ions is to titrate with silver nitrate. The equation is:

$Cl^-(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NO_3^-(aq)$

Potassium chromate solution (yellow) can be used as an indicator; it goes red at the end point because of the formation of red silver chromate as soon as there are free Ag^+ ions in the solution. In practice the end point is when the white precipitate acquires an off-white colour (a permanent red colour shows that you have overshot the end point).

The calculation is somewhat unusual. It depends on the fact that a given mass of potassium chloride will contain less chloride than the same mass of sodium chloride because the potassium atom is more massive than the sodium atom. The calculation is illustrated by the following example.

0.10 g of a salt substitute (a mixture of sodium chloride and potassium chloride) was dissolved in water and titrated with 0.05 mol dm^{-3} silver nitrate solution using potassium chromate as indicator. 30.52 cm^3 of silver nitrate solution was required.

Using the relationship moles of solute = M x v/1000, where M = concentration in mol dm^{-3} and v = volume in cm^3

moles $AgNO_3$ = moles Cl^- = M x V/1000 = 0.05 x 30.52/1000 = 1.526 x 10^{-3} mol

If the mixture had been 100% NaCl (M_r = 58.5):

moles Cl^- = 0.10/58.5 = 1.709 x 10^{-3}

If the mixture had been 100% KCl (M_r = 74.5):

moles Cl^- = 0.10/74.5 = 1.342 x 10^{-3}

Let % KCl be *x*, then % NaCl = 100-*x*

$$\text{Moles } Cl^- \text{ in mixture} = \frac{1.342 \times 10^{-3}\, x + 1.709 \times 10^{-3}\,(100-x)}{100}$$

$$1.526 \times 10^{-3} = \frac{1.342 \times 10^{-3}\, x + 1.709 \times 10^{-3}\,(100-x)}{100}$$

$$152.6 = 1.342\, x + 170.9 - 1.709\, x$$

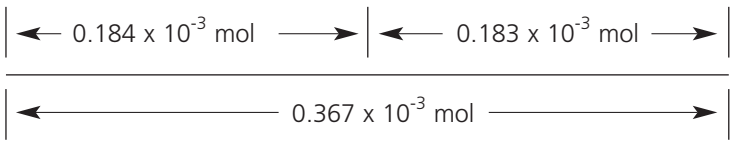
$$18.3 = 0.367\, x$$

$$x = 50$$

So the mixture was 50% potassium chloride and 50% sodium chloride.

Alternatively, the calculation could be set out as below

100% KCl 1.342 x 10^{-3} mol Actual 1.526 x 10^{-3} mol 100% NaCl 1.709 x 10^{-3} mol



Our measured number of moles of Cl^- is (0.183 x 10^{-3}/0.367 x 10^{-3}) x100% = 50% of the way from pure NaCl to pure KCl, so the mixture was 50% NaCl, 50% KCl.

Apparatus and equipment

Your group will need:

- burette stand or retort stand, boss and clamp
- 50 cm^3 burette
- 10 cm^3 pipette
- pipette filler
- white tile
- two or three 250 cm^3 conical flasks
- 100 cm^3 beaker
- access to a top pan balance
- 100 cm^3 volumetric flask
- wash bottle containing deionised water.

Chemicals

Your group will need:

- 0.05 mol dm^{-3} silver nitrate solution (silver nitrate solution is dangerous to the eyes and blackens skin)
- a sample of salt substitute such as LoSalt
- potassium chromate indicator (5 g potassium chromate (toxic) dissolved in 100 cm^3 water), ideally in a dropping bottle.

Safety

- Wear eye protection.

Method

Weigh out accurately about 1 g of salt substitute containing a mixture of sodium chloride and potassium chloride and make it up to 100.00 cm^3 with deionised water in a volumetric flask. Titrate 10.00 cm^3 portions of this solution with 0.05 mol dm^{-3} silver nitrate solution using about 10 drops of potassium chromate solution as the indicator. A white precipitate of silver chloride will form as the silver nitrate is added. The end point is when the white precipitate acquires an off-white colour (a permanent red colour shows that you have overshot the end point). Continue titrating samples until you have two titration results within 0.1 cm^3.

Calculate the percentage of sodium chloride and of potassium chloride in the mixture using the example above as a model. How closely do the percentages you have measured agree with those on the pack?