An Example of Percentage Composition

Chapter 3 Problem 100

$MgCl_2$ often occurs as an impurity in table salt (NaCl) and is responsible for caking of the salt. A 0.5200-gram sample of table salt is found to contain 61.10% Cl, by mass. What is the $\%MgCl_2$ in the sample?

Solution:

There are, as usual, more than one approach to solving this problem. Shown here is the method using percentage composition. All approaches will require solving two simultaneous algebraic equations.

Definition of problem: $\%\text{MgCl}_2 = \dfrac{m_{\text{MgCl}_2}}{m_{\text{salt}}} \times 100$

(eq 1) $m_{\text{salt}} = m_{\text{NaCl}} + m_{\text{MgCl}_2} = 0.5200 \text{ g salt}$

(eq 2) $m_{\text{Cl}} = m_{\text{Cl from NaCl}} + m_{\text{Cl from MgCl}_2}$

$m_{\text{Cl}} = 0.5200 \text{ g salt} \times 0.6110 \frac{\text{g Cl}}{\text{g salt}} = 0.31772 \text{ g Cl}$

Calculate percentage compositions of NaCl and MgCl_2

$$\%\text{Cl in NaCl} = \frac{35.453 \text{ g Cl}}{58.44 \text{ g NaCl}} \times 100 = 60.666\%\text{Cl}$$

$$\%\text{Cl in MgCl}_2 = \frac{2(35.453 \text{ g Cl})}{24.305 \text{ g MgCl}_2} \times 100 = 74.472\%\text{Cl}$$

Rewrite eq 2 using m_{NaCl} and m_{MgCl_2} and their respective percentage compositions:

(eq 3) $0.31772 \text{ g Cl} = \left(m_{\text{NaCl}} \times 0.60666 \frac{\text{g Cl}}{\text{g NaCl}}\right) + \left(m_{\text{MgCl}_2} \times 0.74472 \frac{\text{g Cl}}{\text{g MgCl}_2}\right)$

Rearrange eq 1 and substitute in to eq 3:

(eq 4) $0.31772 \text{ g Cl} = \left(\left(0.5200 \text{ g salt} - m_{\text{MgCl}_2}\right) \times 0.60666 \frac{\text{g Cl}}{\text{g NaCl}}\right) + \left(m_{\text{MgCl}_2} \times 0.74472 \frac{\text{g Cl}}{\text{g MgCl}_2}\right)$

Solve the algebra:

$0.31772 \text{ g Cl} = 0.31546 \text{ g Cl} - 0.60666 \times m_{\text{MgCl}_2} + \left(m_{\text{MgCl}_2} \times 0.74472 \frac{\text{g Cl}}{\text{g MgCl}_2}\right)$

$0.002257 \text{ g Cl} = 0.13807 \times m_{\text{MgCl}_2}$ (The mass of Cl reduces to 2 SF here if rules are closely followed)

$m_{\text{MgCl}_2} = 0.016347 \text{ g MgCl}_2$

Finally, calculate the percentage MgCl_2 :

$$\%\text{MgCl}_2 = \frac{0.016347 \text{ g MgCl}_2}{0.5200 \text{ g salt}} \times 100 = 3.14\% \text{ MgCl}_2$$