

Given:

mass NaCl – $m_{\text{NaCl}} = 4.01689 \text{ g}$,

mass water – $m_w = 99.7 \text{ g}$,

boiling temperature of pure water – $T = 99.70 \text{ }^\circ\text{C}$,

boiling temperature of solution – $T_s = 100.40 \text{ }^\circ\text{C}$

Calculate the predicted change in boiling point in $^\circ\text{C}$.

What is the calculated boiling point of the solution? Compare this with the actual boiling point.

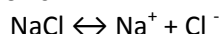
Solution

The boiling point elevation can be predicted using the equation:

$$\Delta T = K_b \cdot m \cdot i ,$$

where ΔT – change in boiling point, i – number of moles of ions in the solution per mole of dissolved substance, m – molality of the solution, and K_b – molal boiling point constant (for water $K_b = 0.51 \text{ }^\circ\text{C/m}$).

NaCl in water solution dissociates as follows:



So, the number of moles of ions in the solution per mole of NaCl is equal to two, i.e. $i = 2$.

Molality of the solution is defined as number of moles of dissolved substance (NaCl in this case) per 1 kg of solvent (water in this case):

$$m = \frac{n_{\text{NaCl}}}{m_w} ,$$

where n_{NaCl} – number of moles of NaCl.

Number of moles of NaCl may be calculated as a quotient of mass to molar mass. Molar mass of NaCl – $M_{\text{NaCl}} = 58.5 \text{ g/mole}$.

$$n_{\text{NaCl}} = \frac{m_{\text{NaCl}}}{M_{\text{NaCl}}} = \frac{4.01689}{58.5} = 0.06866 \text{ moles}$$

So, the solution molality is

$$m = \frac{0.06866}{0.0997} = 0.6887 \text{ moles/kg} ,$$

Now we can calculate the predicted change in boiling point:

$$\Delta T = 0.51 \cdot 0.6887 \cdot 2 = 0.70 \text{ }^\circ\text{C}$$

Temperature change is

$$\Delta T = T_s - T ,$$

whence

$$T_s = T + \Delta T = 99.70 + 0.70 = 100.40 \text{ }^\circ\text{C}$$

So, the calculated boiling point of the solution is equal to the actual boiling point.

Answer

The predicted change in boiling point $\Delta T = 0.70 \text{ }^\circ\text{C}$.

The calculated boiling point of the solution $T_s = 100.40 \text{ }^\circ\text{C}$, that is equal to the actual boiling point.