## Given:

mass NaCl – $m_{NaCl}$ = 4.01689 g,
mass water – $m_w$ = 99.7 g,
boiling temperature of pure water – T= 99.70 $^oC$,
boiling temperature of solution – $T_s$ = 100.40 $^oC$

Calculate the predicted change in boiling point in °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 $\Delta T$ – 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 $^oC/m$).

NaCl in water solution dissociates as follows:

$$NaCl \leftrightarrow Na^+ + Cl^-$$

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 sobstance (NaCl in this case) per 1 kg of solvent (water in this case):

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

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 – $M_{NaCl}$ = 58.5 g/mole.

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

So, the solution molality is

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

Now we can calculate the predicted change in boiling point:

$$\Delta T = 0.51 \cdot 0.6887 \cdot 2 = 0.70\ ^oC$$

Temperature change is

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

whence

$$T_s = T + \Delta T = 99.70 + 0.70 = 100.40\ ^oC$$

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

## Answer

The predicted change in boiling point $\Delta T = 0.70\ ^oC$.
The calculated boiling point of the solution $T_s = 100.40\ ^oC$, that is equal to the actual boiling point.