Q3.

A 5% solution (by mass) of cane sugar in water has freezing point of 271 K. Calculate the freezing point of 5% glucose in water if freezing point of pure water is 273.15 K.

Answer :

Here, ΔT_f = (273.15 - 271) K

= 2.15 K

Molar mass of sugar ($C_{12}H_{22}O_{11}$) = 12 × 12 + 22 × 1 + 11 × 16

= 342 g mol^{-1}

5% solution (by mass) of cane sugar in water means 5 g of cane sugar is present in (100 - 5)g = 95 g of water.

Now, number of moles of cane sugar $= \frac{5}{342}\text{mol}$

= 0.0146 mol

Therefore, molality of the solution, $m = \frac{0.0146\ \text{mol}}{0.095\ \text{kg}}$

= 0.1537 mol kg^{-1}

Applying the relation,

$\Delta T_f = K_f \times m$

$$\Rightarrow K_f = \frac{\Delta T_f}{m} = \frac{2.15\ \text{K}}{0.1537\ \text{mol kg}^{-1}}$$

= 13.99 K kg mol^{-1}

Molar of glucose ($C_6H_{12}O_6$) = 6 × 12 + 12 × 1 + 6 × 16

= 180 g mol^{-1}

5% glucose in water means 5 g of glucose is present in (100 - 5) g = 95 g of water.

$\therefore$ Number of moles of glucose $= \frac{5}{180}\ \text{mol}$

= 0.0278 mol

Therefore, molality of the solution, $m = \frac{0.0278\ \text{mol}}{0.095\ \text{kg}}$

= 0.2926 mol kg^{-1}

Applying the relation,

$\Delta T_f = K_f \times m$

= 13.99 K kg mol^{-1} × 0.2926 mol kg^{-1}

= 4.09 K (approximately)

Hence, the freezing point of 5% glucose solution is (273.15 - 4.09) K= 269.06 K.