

Q5. Calculate the depression in the freezing point of water when 10 g of $\text{CH}_3\text{CH}_2\text{CHClCOOH}$ is added to 250 g of water. $K_a = 1.4 \times 10^{-3}$, $K_f = 1.86 \text{ K kg mol}^{-1}$.

Answer :

$$\begin{aligned} \text{Molar mass of } \text{CH}_3\text{CH}_2\text{CHClCOOH} &= 15 + 14 + 13 + 35.5 + 12 + 16 + 16 + 1 \\ &= 122.5 \text{ g mol}^{-1} \end{aligned}$$

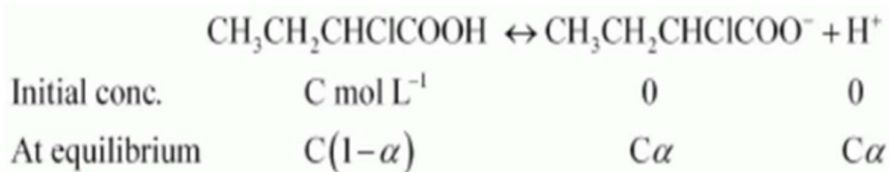
$$\begin{aligned} \therefore \text{No. of moles present in 10 g of } \text{CH}_3\text{CH}_2\text{CHClCOOH} &= \frac{10 \text{ g}}{122.5 \text{ g mol}^{-1}} \\ &= 0.0816 \text{ mol} \end{aligned}$$

It is given that 10 g of $\text{CH}_3\text{CH}_2\text{CHClCOOH}$ is added to 250 g of water.

$$\begin{aligned} \therefore \text{Molality of the solution,} &= \frac{0.0816}{250} \times 1000 \\ &= 0.3264 \text{ mol kg}^{-1} \end{aligned}$$

Let α be the degree of dissociation of $\text{CH}_3\text{CH}_2\text{CHClCOOH}$.

$\text{CH}_3\text{CH}_2\text{CHClCOOH}$ undergoes dissociation according to the following equation:



$$\text{Now } K_\alpha = \frac{C\alpha^2}{1}$$

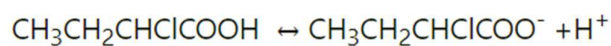
$$\Rightarrow K_\alpha = C\alpha^2$$

$$\alpha = \sqrt{\frac{K_\alpha}{C}}$$

$$= \sqrt{\frac{1.4 \times 10^{-3}}{0.3264}} \quad (\because K_\alpha = 1.4 \times 10^{-3})$$

$$= 0.0655$$

Now, Calculation of Vant Hoff factor:



Initial conc 1 0 0

At equilibrium 1- α α α

Total moles of equilibrium = 1 - α + α + α

$$= 1 + \alpha$$

$$\therefore i = \frac{1 + \alpha}{1}$$

$$= 1 + \alpha$$

$$= 1 + 0.0655$$

$$= 1.0655$$

Hence, the depression in the freezing point of water is given as:

$$\Delta T_f = i \cdot K_f m$$

$$= 1.0655 \times 1.86 \text{ K kg mol}^{-1} \times 0.3264 \text{ mol kg}^{-1}$$

$$= 0.65 \text{ K}$$