Q5. Calculate the depression in the freezing point of water when 10 g of $CH_3CH_2CHClCOOH$ is added to 250 g of water. K_a = 1.4 × 10^{-3}, K_f = 1.86 K kg mol^{-1}.

Answer :

Molar mass of $CH_3CH_2CHClCOOH = 15+14+13+35.5+12+16+16+1$

$= 122.5 \text{ g mol}^{-1}$

∴No. of moles present in 10 g of $CH_3CH_2CHClCOOH = \frac{10 \text{ g}}{122.5 \text{ g mol}^{-1}}$

$= 0.0816 \text{ mol}$

It is given that 10 g of $CH_3CH_2CHClCOOH$ is added to 250 g of water.

∴Molality of the solution, $= \frac{0.0186}{250} \times 1000$

$= 0.3264 \text{ mol kg}^{-1}$

Let α be the degree of dissociation of $CH_3CH_2CHClCOOH$.

$CH_3CH_2CHClCOOH$ undergoes dissociation according to the following equation:

	$CH_3CH_2CHClCOOH$	$\leftrightarrow CH_3CH_2CHClCOO^-$	$+H^+$
Initial conc.	$C \text{ mol L}^{-1}$	0	0
At equilibrium	$C(1-\alpha)$	$C\alpha$	$C\alpha$

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

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

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

$= \sqrt{\frac{1.4 \times 10^{-3}}{0.3264}}$ (∵ K_α = 1.4 x 10^{-3})

= 0.0655

Now, Calculation of Vant Hoff factor:

$$CH_3CH_2CHClCOOH \leftrightarrow CH_3CH_2CHClCOO^- + H^+$$

Initial cone	1	0	0
At equilibrium	1-α	α	α

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

= 1 + α

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

=1+a

=1+0.0655

= 1.0655

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

$$\triangle T_f = i.K_f m$$

= 1.0655 x 1.86 K kg mol^{-1} x 0.3264 mol kg^{-1}

= 0.65 K