Abnormal molar mass (van't Hoff factor):

In case of dissociation and association of solute particles in solution, the experimental or observed value of molar mass of solute in lower or higher than its normal value is called abnormal molar mass.

Colligative properties depend upon the total number of solute particles present in a given volume of the solution. Colligative properties do not depend upon the composition, structure and nature of the solute particles. When a solute dissociate or associate in the solution, the number of particles are changed. Therefore, in such cases abnormal results of colligative properties are obtained.

① In case of dissociation:

When solute is an electrolyte, it dissociate to give ions. The number of particles ~~are changed~~ in the solutions are increased. Due to the increase in the number of solute particle in the solution, the observed (experimental) value of colligative property is higher than expected.

Since molar mass $\propto \frac{1}{\text{colligative property}}$.

$$NaCl \longrightarrow Na^+ + Cl^-$$
1 mole → 1 mole, 1 mole.

1 mole NaCl give two mole, so normal molar mass of NaCl = 23 + 35.5 = 58.5

abnormal molar mass of NaCl = $\frac{58.5}{2}$

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In case of association

When solute molecules associate, the number of solute particles in the solution decreased. The observed (experimental) value of colligative property is lower than expected. Hence molar mass determined is higher than the normal value.

Acetic acid associate in benzene and forms dimer.

$$2\,CH_3COOH \longrightarrow (CH_3COOH)_2$$

2 molecules — 1 molecule

Thus no. of molecules becomes 1/2 in the solution. Therefore, the value of colligative property will be 1/2 of its ~~molar~~ normal value.

Normal molar mass of $CH_3COOH = 60$.

Abnormal molar mass of $CH_3COOH = 60 \times 2 = 120$.

To determine the colligative property of the solute which dissociate or associate in solution, van't Hoff introduced the factor (i) known as van't Hoff factor

$$i = \frac{\text{No. of Particles after association}}{\text{No. of Particles before association}} \quad \text{or} \quad \frac{\text{Abnormal value of colligative Property}}{\text{Normal value of colligative property}}$$

$$\text{or } i = \frac{\text{Normal molar mass of solute.}}{\text{Abnormal molar mass of solute.}}$$

In case of dissociation or association the formula used for relative lowering in vapour pressure, elevation in boiling point, depression in freezing point, osmotic pressure is to be modified.

(i) $\frac{P_1^\circ - P_1}{P_1^\circ} = \frac{i \times w_2 \times M_1}{m_2 \times w_1}$ (ii) $\Delta T = \frac{i \times K_b \times w_2 \times 1000}{M_2 \times w_1}$

(iii) $\Delta T = \frac{i \times K_f \times w_2 \times 1000}{m_2 \times w_1}$ (iv) $\pi = i\,mRT$ or $\pi = i\frac{nRT}{V}$

or $\pi = i\frac{w_2 RT}{m_2 \times V}$.