

Mathematical problems:- (Dipole moment & optical rotation)

- ① The dipole moment of chlorobenzene is 1.7 D. Calculate the corresponding values for 1,2- and 1,3-dichloro substituted benzenes. Compare these values with the experimental values of 2.35 D and 1.68 D respectively.

→ We know that

$$\mu = \sqrt{\mu_1^2 + \mu_2^2 + 2\mu_1\mu_2\cos\theta}$$

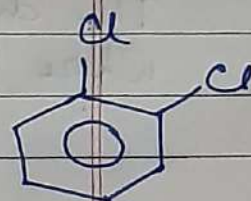
$$\cos 60^\circ = \frac{1}{2}$$

$\mu \Rightarrow$ Resultant dipole moment

For 1,2 - dichloro benzene,

$$\theta = 60^\circ$$

$$\mu_1 = \mu_2$$



$$\therefore \mu_{1,2} = \sqrt{\mu_1^2 + \mu_1^2 + 2\mu_1^2 \cos 60^\circ}$$

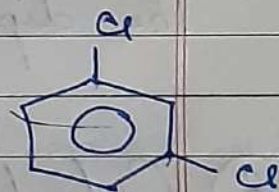
$$= \sqrt{2\mu_1^2 + \mu_1^2}$$

$$= \sqrt{3}\mu_1 = \sqrt{3} \times 1.7 \text{ D} = \boxed{2.94 \text{ D}}$$

For 1,3 - dichloro benzene,

$$\theta = 120^\circ$$

$$\mu_1 = \mu_2$$



$$\therefore \mu_{1,3} = \sqrt{\mu_1^2 + \mu_1^2 + 2\mu_1^2 \cos 120^\circ}$$

$$\cos 120^\circ = -\frac{1}{2}$$

$$= \mu_1 = \boxed{1.70 \text{ D}}$$

For 1,3 - dichloro benzene the experimental value matches with theoretical value (1.68 D).

But for 1,2 - dichloro benzene the experimental value (2.35 D) does not match with theoretical value (2.94 D).

The reason for this deviation of dipole moment may be due to

- i) the angle between C-Cl bond vectors may be larger than 60° because of mutual repulsion of Cl atoms and the magnitude of bond moments may be modified by their close proximity.

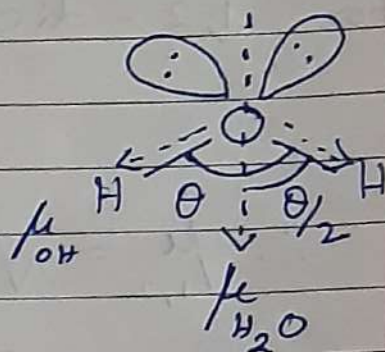
② Calculate the dipole moment of O-H bond from the following information:

The dipole moment of $\text{H}_2\text{O} = 1.86 \text{ D}$, $\cos \theta/2 = 0.64$,
where θ is the H-O-H angle.

$$\mu_{\text{H}_2\text{O}} = 2 \mu_{\text{OH}} \cos \theta/2$$

$$\text{or, } \mu_{\text{OH}} = \frac{\mu_{\text{H}_2\text{O}}}{2 \cos \theta/2}$$

$$= \frac{1.86}{2 \times 0.64} = \frac{1.86}{1.28} = 1.45 \text{ D}$$



The dipole moment of the O-H bond is 1.45 D .

③ Calculate the specific rotation of sucrose if a 20% solution of it when placed in a 2-decimeter polarimeter tube shows an angle of rotation of 26.4° .

Specific rotation,

$$[\alpha]_{\lambda}^t = \frac{\alpha}{l \times d}$$

Here, $\alpha = 26.4^\circ$

$$l = 2 \text{ dm}$$

$$d = \frac{20}{100} = 0.2 \text{ gm/cc}$$

$$\therefore [\alpha]_{\lambda}^t = \frac{26.4}{2 \times 0.2} = 66^\circ$$

Related topic :- (Already discussed in Sem II, in organic chemistry lecture)

- ① Specific rotation unit
- ② Na-D Light (splitting of energy level)
- ③ Absorption line (doublet)
- ④ Plane polarised light. (What is depolarized radiation?)
- ⑤ Racemic mixture
- ⑥ optically active molecule. (condition)