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B.Sc (Part - II) Hons

Potential Energy of Electric Dipole in an Electric field.

Consider a electric dipole of dipole moment p is placed in an electric field E. It experiences a toruque $PE\sin\theta$ tending to align it parallel to the field. work done dw in displacing it through a very small angle $d\theta$ is given as

$$dw = \text{torque} \times \text{angle}$$

$$dw = PE\sin\theta \cdot d\theta$$

Therefore the work done in rotating the electric dipole from an angle θ_0 to θ is

$$W = \int_{\theta_0}^{\theta} PE\sin\theta \, d\theta$$

$$= PE\int_{\theta_0}^{\theta} \sin\theta \, d\theta$$

$$= PE\left[-\cos\theta\right]_{\theta_0}^{\theta}$$

$$W = PE\left[-\cos\theta - (-\cos\theta_0)\right]$$

$$W = PE(\cos\theta_0 - \cos\theta)$$

This work is stored as potential energy U in the electric dipole system. It is also the change in potential energy of the electric dipole when rotated from θ_0 to θ.

If $\theta_0 = 90^\circ$, then

$$W = PE\cos\theta$$

It is the potential energy of electric dipole when it rotated through angle θ with the field

An Electric Dipole in Non-uniform Electric field:— Two equal and opposite charges of electric dipole experience equal and opposite forces in the uniform field. So the net force on the electric dipole is zero. In a non-uniform field, the forces on the two charges will not be equal and opposite and as such a net force would be act on the electric dipole.