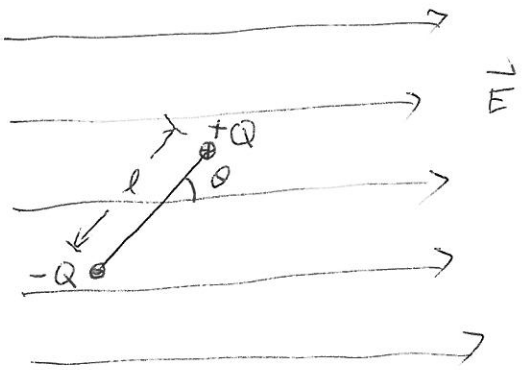
e.g. Dipole in a field.

for a water molecule, $p = Ql = 6.1 \times 10^{-30}\ C\,m$.

In a uniform $\vec{E}$ field, $E = 2.0 \times 10^{5}\ N/C$.

a). Max Torque τ_{max} ?



$\tau = -pE\sin\theta$.

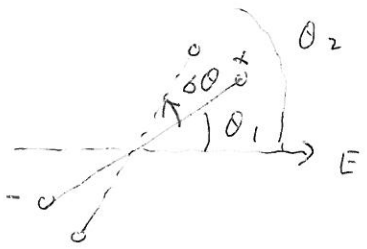
$\tau_{max} = pE$ when $\theta = 90°, 270°$

$= 1.2 \times 10^{-24}\ N \cdot m$

b) Potential energy U when $\tau = \tau_{max}$.

Definition of P.E: $\Delta U = -W$ (W – work by electric field).

When the dipole rotates from θ_1 to θ_2



$$W = \int_{\theta_1}^{\theta_2} \tau\, d\theta$$

$$= -pE\int_{\theta_1}^{\theta_2} \sin\theta\, d\theta$$

$$= pE(\cos\theta_2 - \theta_1) = (\vec{p}\cdot\vec{E})_2 - (\vec{p}\cdot\vec{E})_1 = -\Delta U$$

$\therefore$ $U = -\vec{p}\cdot\vec{E} = -pE\cos\theta$. ⇐ Definition. (we choose this).

(when $\theta = 90°$, $U = 0$. also, when $\theta = 270°$, $U = 0$)

$\therefore$ $U(\theta = 90°) = 0$. (but NOT minimum).

(e.g. when $\theta = 0$, $U = -PE < 0$).

c) when $-\cos\theta = 1$.

i.e. $\theta = 180°$, $U = U_{max} = PE$.