

29.9. Model: A water molecule is at the point of minimum potential energy when it is aligned with an electric field. However, an external force can rotate the water molecule causing its dipole moment to make an angle with the field.

Solve: The potential energy of an electric dipole moment in a uniform electric field is given by Equation 29.23:

$U_{\text{dipole}} = -\vec{p} \cdot \vec{E} = -pE \cos\theta$. This means

$$U_{\text{dipole parallel}} = -pE \cos 0^\circ = -pE \quad U_{\text{dipole perpendicular}} = -pE \cos 90^\circ = 0 \text{ J}$$

$$\Rightarrow U_{\text{dipole perpendicular}} - U_{\text{dipole parallel}} = 1.0 \times 10^{-21} \text{ J} = 0 \text{ J} - (-pE)$$

$$\Rightarrow E = \frac{1.0 \times 10^{-21} \text{ J}}{p} = \frac{1.0 \times 10^{-21} \text{ J}}{6.2 \times 10^{-30} \text{ C m}} = 1.61 \times 10^8 \text{ N/C}$$

Assess: Note that the units with E are J/C m. Because $1 \text{ J/C m} = 1 \text{ N m/C m} = 1 \text{ N/C}$, the units of E are N/C.