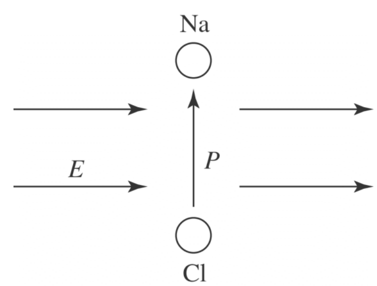
21.58: We did this in class. Here is a synopsis of the solution:
a) Since field lines pass from positive charges and toward negative charges, we can deduce that the top charge is positive, middle is negative, and bottom is positive.
b) The electric field is the smallest on the horizontal line through the middle charge, at two positions on either side where the field lines are least dense. Here the *y*-components of the field are cancelled between the positive charges and the negative charge cancels the *x*-component of the field from the two positive charges.

21.60: a) $d = p/q = (8.9 \times 10^{-30}\ \text{C}\cdot\text{m})/(1.6 \times 10^{-19}\ \text{C}) = 5.56 \times 10^{-11}\ \text{m}.$

b) $\tau_{\text{max}} = pE = (8.9 \times 10^{-30}\ \text{C}\cdot\text{m})(6.0 \times 10^{5}\ \text{N/C}) = 5.34 \times 10^{-24}\ \text{N}\cdot\text{m}.$
Maximum torque:



21.62: $E_{\text{dipole}}(x) = \dfrac{p}{2\pi\varepsilon_0 x^3} \Rightarrow E_{\text{dipole}}(3.00 \times 10^{-9}\ \text{m}) = \dfrac{6.17 \times 10^{-30}\ \text{C}\cdot\text{m}}{2\pi\varepsilon_0 (3.0 \times 10^{-9}\ \text{m})^3} = 4.11$ $\times 10^{6}\ \text{N/C}$. The electric force $F = qE = (1.60 \times 10^{-19}\ \text{C})(4.11 \times 10^{6}\ \text{N/C}) = 6.58 \times 10^{-13}\ \text{N}$ and is toward the water molecule (negative *x*-direction).

22.30: Given $\vec{E} = (-5.00\ (\text{N/C})\cdot\text{m})x\hat{i} + (3.00\ (\text{N/C})\cdot\text{m})z\hat{k},$ edge length $L = 0.300$ m, and $\hat{n}_{S_1} = -\hat{j} \Rightarrow \Phi_1 = \vec{E}\cdot\hat{n}_{S_1}A = 0.$

$\hat{n}_{S_2} = +\hat{k} \Rightarrow \Phi_2 = \vec{E}\cdot\hat{n}_{S_2}A = (3.00\ (\text{N/C})\cdot\text{m})(0.300\ \text{m})^2 z = (0.27\ (\text{N/C})\text{m})z =$
$(0.27\ (\text{N/C})\text{m})(0.300\ \text{m}) = 0.081\ (\text{N/C})\ \text{m}^2.$

$\hat{n}_{S_3} = +\hat{j} \Rightarrow \Phi_3 = \vec{E}\cdot\hat{n}_{S_3}A = 0.$

$\hat{n}_{S_4} = -\hat{k} \Rightarrow \Phi_4 = \vec{E}\cdot\hat{n}_{S_4}A = -(0.27\ (\text{N/C})\cdot\text{m})z = 0\ (z = 0).$

$\hat{n}_{S_5} = +\hat{i} \Rightarrow \Phi_5 = \vec{E}\cdot\hat{n}_{S_5}A = (-5.00\ (\text{N/C})\cdot\text{m})(0.300\ \text{m})^2 x = -(0.45(\text{N/C})\cdot\text{m})x$
$= -(0.45\ (\text{N/C})\cdot\text{m})(0.300\ \text{m}) = -(0.135\ (\text{N/C})\cdot\text{m}^2).$

$\hat{n}_{S_6} = -\hat{i} \Rightarrow \Phi_6 = \vec{E}\cdot\hat{n}_{S_6}A = +(0.45\ (\text{N/C})\cdot\text{m})x = 0\ (x = 0).$

b) Total flux:

$$\Phi = \Phi_2 + \Phi_5 = (0.081 - 0.135)\ (\text{N/C})\cdot\text{m}^2 = -0.054\ \text{Nm}^2/\text{C}$$

$q = \varepsilon_0\Phi = -4.78 \times 10^{-13}\text{C}$