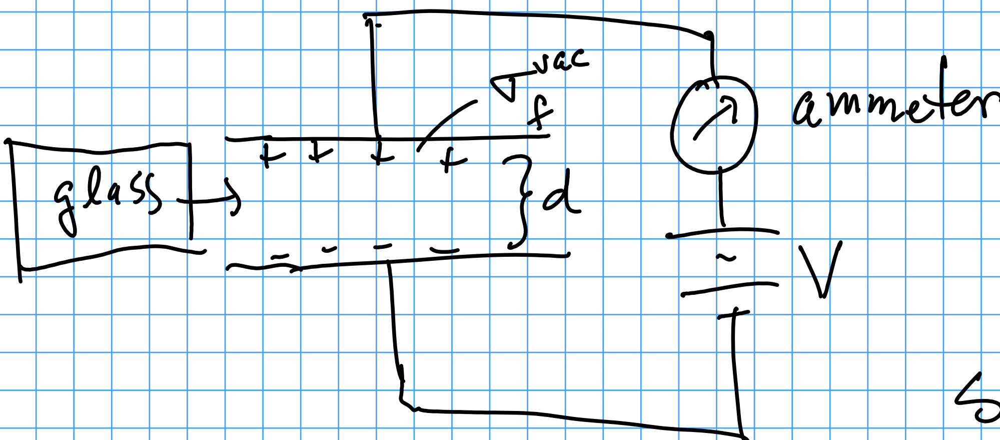
$PV = nRT$

$C = Q/V$

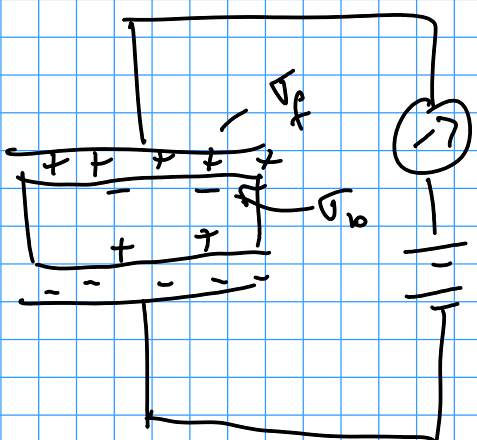
} Both eqns with 3 unknowns, 1 of which is typically fixed



constant → V, d

$$V = Ed$$

so $E_{glass} = E_{vac}$



$$\sigma_b = P = \epsilon_0 \chi_e E$$

↑ in glass

get E_{glass} from Gauss's law in $\vec{D}$

$$\vec{D} = \epsilon_0 \vec{E} + \vec{P} = \epsilon_0 \vec{E} + \epsilon_0 \chi_e \vec{E} = \underbrace{\epsilon_0 (1 + \chi_e)}_{\epsilon} E$$

$$D = \epsilon E = \sigma_f$$

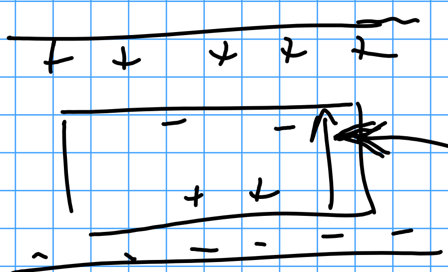
↑ in glass

$$\sigma_b = P = \epsilon_0 \chi_e E = \epsilon_0 \chi_e \frac{\sigma_f}{\epsilon} = \epsilon_0 \chi_e \frac{\sigma_f}{\epsilon_0(1+\chi_e)}$$

$$\boxed{\sigma_b = \frac{\chi_e \sigma_f}{1+\chi_e}}$$

note that this is NOT σ_f^{vac}

$E_{glass} = E_{vac}$ if $V = E_{vac} d = E_{glass} d$ is same



$$E_{\sigma_f} - E_{\sigma_b} = E_{vac}$$

$$\frac{\sigma_f}{\epsilon_0} - \frac{\sigma_b}{\epsilon_0} = \frac{\sigma_f^{vac}}{\epsilon_0} \Rightarrow \boxed{\sigma_f - \sigma_b = \sigma_f^{vac}}$$

$$\sigma_f - \sigma_b = \sigma_f - \frac{\chi_e \sigma_f}{1+\chi_e} = \sigma_f \left(1 - \frac{\chi_e}{1+\chi_e}\right) = \sigma_f^{vac}$$

$$\sigma_f \frac{1}{1+\chi_e} = \sigma_f^{vac} \Rightarrow \sigma_f = (1+\chi_e)\sigma_f^{vac}$$

How much charge has to flow from the battery when the glass is inserted into the capacitor?

$$Q = (\sigma_f - \sigma_f^{vac}) A = \left[(1+\chi_e)\sigma_f^{vac} - \sigma_f^{vac}\right] A = \sigma_f^{vac} A \chi_e$$

(A = area of cap)

"thermo approach"

$$C = \frac{Q}{V} \quad \text{we want to know } Q = CV$$

as glass comes in C varies

$$\delta Q = \left.\frac{\partial Q}{\partial C}\right|_V \delta C = V \delta C = V \chi_e \epsilon_0 \frac{A}{d}$$

$$\delta C = C_{glass} - C_{vac}$$

$$C_{glass} = K C_{vac} = \frac{\epsilon}{\epsilon_0} C_{val} = \frac{\epsilon_0 (1+\chi_e)}{\epsilon_0} C_{vac}$$

$$C_{glass} - C_{vac} = C_{vac}(1 + \chi_e - 1) = \chi_e C_{vac} = \epsilon_0 \frac{A}{d}$$

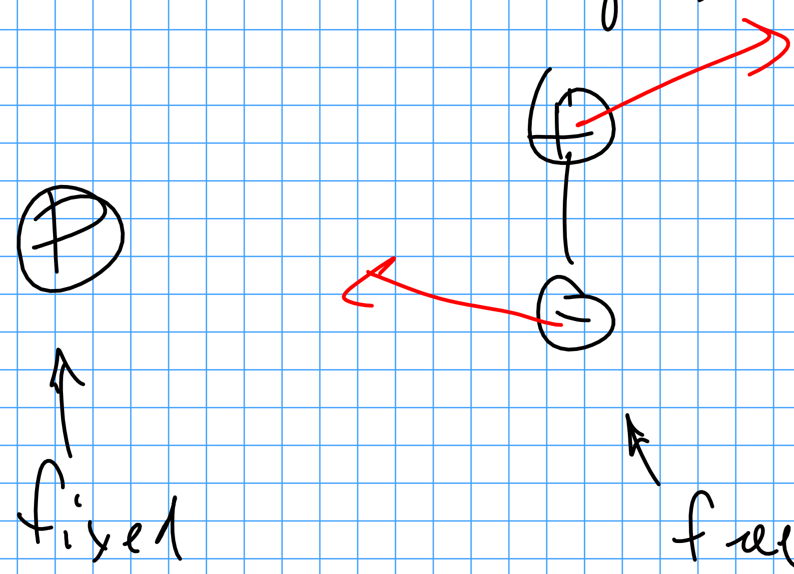
So $\delta Q = V \epsilon_0 \frac{A}{d} \chi_e$

but $Ed = V$ so $\delta Q = E d \epsilon_0 \frac{A}{d} \chi_e = \sigma_f^{vac} A \chi_e$

$$E = \frac{\sigma_f^{vac}}{\epsilon_0}$$

which is the same result we had before.

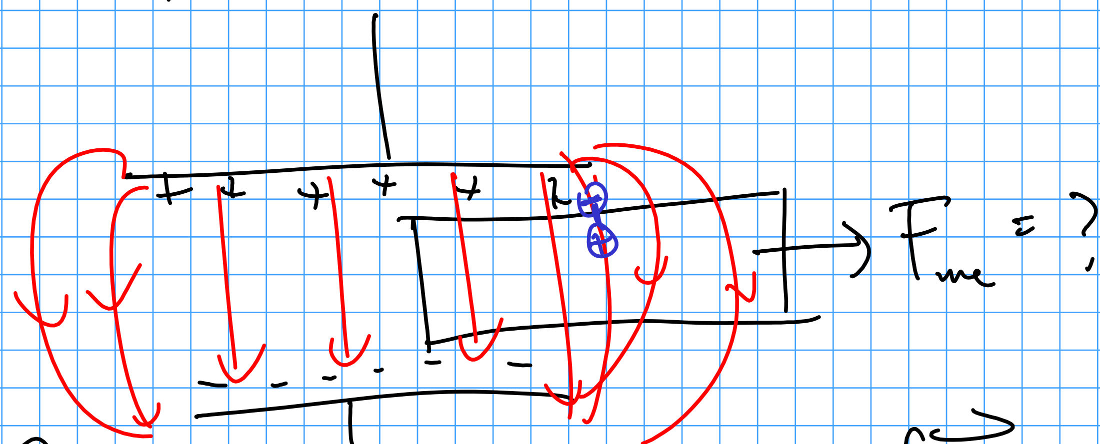
Hmwk applet: Net force on this dipole is up (also a torque)



How can you use the applet to show this force when only the point charge moves in the applet?

Ans: use Newton's 3rd law & set up ⊕ force on dipole is equal & opposite to force on point charge. Run applet & note direction of force on pt charge to infer force on dipole.

Forces on Dielectrics



Principles: Energy $W_{me} = \int \vec{F}_{me} \cdot d\vec{l} =$

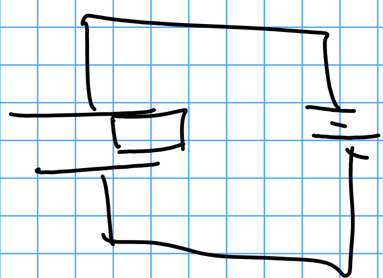
$W_{nc} = \Delta(KE + PE)$

$W_{nc} = W_{ms}$

$KE = 0$ motion at constant

$\Delta PE = \Delta E_{nergy}$ stored in Cap

$$= \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$$

1.) 

const V : $\frac{1}{2}CV^2$

2.) 

const Q : $\frac{1}{2}\frac{Q^2}{C}$