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January 27 Recitation Notes

Unfortunately, there just wasn't much to cover at this point. All you've seen is concepts. We looked at RQ14.1 and RQ14.4:

RQ14.1: Criticize "Since an atom's electron cloud is spherical, the effect of the electrons cancels the effect of the nucleus, so a neutral atom can't interact with a charged object."

While an atom is neutral overall, there are several reasons why they do indeed interact with charged objects. If they didn't, they'd be invisible to one another except for gravitationally, and without the repulsion of their electron clouds we could put our hands through the desk essentially without interaction.

One issue is that in the presence of an electric field, the atom will react by shifting its electron cloud into the field and the proton away, becoming a small dipole that will be attracted into the area of stronger field.

Another is that this does not specify where exactly the charged object is placed. Suppose a proton were placed very close to the electron, in fact closer than its own nucleus. It may well steal the electron, or if it were placed in the atom, rip it apart!

RQ14.4: True or False: "The electric field at the center of an induced dipole due to the point charge is equal in magnitude and opposite in direction to the electric field of the dipole at the location of the point charge due to the induced dipole."

Consider a polarizable atom at a distance r from a point charge q. Then

$\vec{p} = \alpha\vec{E} = \alpha \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$. Now the magnitude of its electric field along the axis of polarization is $\left|\vec{E}_2\right| = \frac{1}{4\pi\varepsilon_0}\frac{2\left|\vec{p}\right|}{r^3} = \frac{1}{4\pi\varepsilon_0}\frac{2\alpha}{r^3}\left[\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\right] = \left(\frac{1}{4\pi\varepsilon_0}\right)^2\frac{2\alpha q}{r^5}$. Now consider the field at the center of the dipole due to the point charge (not its own field, which will be zero at this position.

$\left(\frac{1}{4\pi\varepsilon_0}\right)^2\frac{2\alpha q}{r^5} \neq \alpha\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$ in general.

$$\frac{1}{4\pi\varepsilon_0}\frac{2}{r^3} \neq \frac{1}{4\pi\varepsilon_0}$$

Because of Newton's laws, however, the force on the dipole due to the electric point charge must be equal and opposite the force on the point charge due to the dipole.