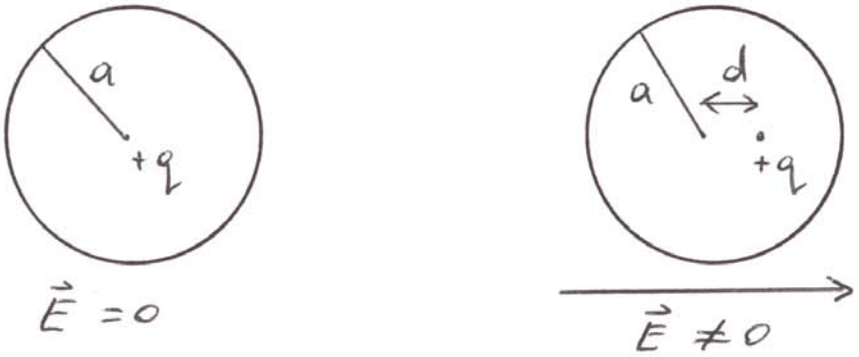
Assignment 5

1. A simple model of the atom is a point nucleus of charge $+q$ surrounded by a uniformly charged spherical cloud $-q$ of radius a. In the presence of an external field $\vec{E}$ the nucleus is displaced slightly relative to the electron cloud as shown below. Assuming $d << a$, the electron cloud nearly retains its spherical shape.



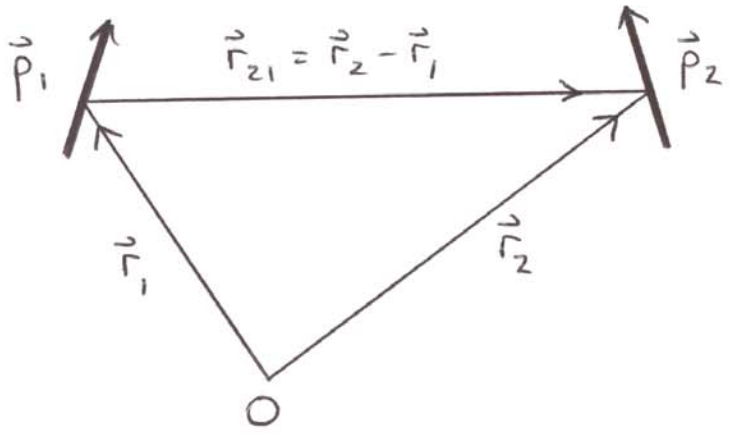
a) Show the electric field generated by the displaced spherical electron cloud at the nucleus is given by the following.

$$E_e = \frac{qd}{a^3}$$

b) For equilibrium $\vec{E}_e + \vec{E} = 0$. Show that the polarizability $\alpha = a^3$. Evaluate α for hydrogen.

c) Consider a hydrogen atom between two metal plates 1 mm apart which are connected to opposite terminals of a 500 volt battery. What fraction of the Bohr radius is d?

2. Consider the two dipoles $\vec{p}_1$ and $\vec{p}_2$ shown below.

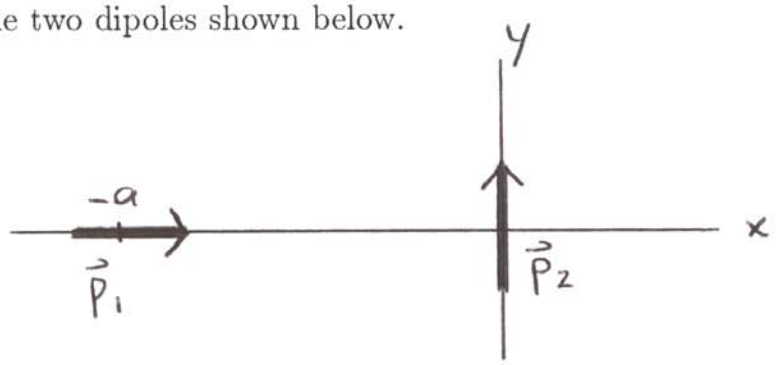


a) Show that the interaction energy of the two dipoles is:

$$U = \frac{\vec{p}_1 \cdot \vec{p}_2}{{r_{21}}^3} - 3\frac{(\vec{p}_1 \cdot \vec{r}_{21})(\vec{p}_2 \cdot \vec{r}_{21})}{{r_{21}}^5}$$

b) Suppose that $\vec{p}_1$ is parallel to $\vec{p}_2$ and θ is the angle between the two dipoles. Find θ such that U is i) a maximum and ii) a minimum.

3. Consider the two dipoles shown below.



a) Evaluate the electric field generated by $\vec{p}_2$ at an arbitrary position $\vec{r}$.

b) Evaluate the force on $\vec{p}_1$ due to $\vec{p}_2$.