

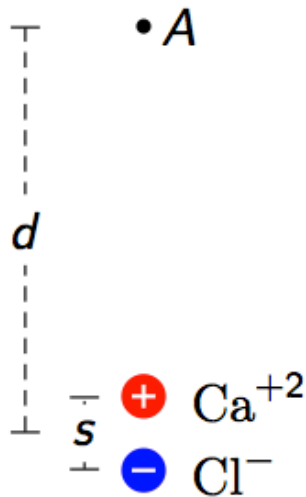
Lecture 5

Revisit dipole field – clicker problem

Dipole System - +/- Q separated by distance s

Field due to q_1 and $-q_2$ where $q_1 > q_2$

Part A: (Note that $s \ll d$ and *think carefully*)



Let $s = 2 \times 10^{-10}$ m and $d = 3 \times 10^{-6}$ m.

What is the magnitude of the electric field at location A?

1. $\frac{1}{4\pi\epsilon_0} \frac{es}{d^3}$
2. $\frac{1}{4\pi\epsilon_0} \frac{2es}{d^3}$
3. None of the above

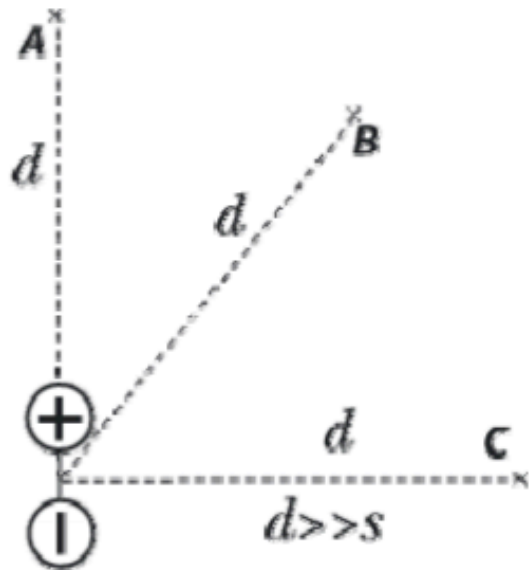
Part B: Which expression gives the approximate magnitude of $\mathbf{E}$ at A?

Choice	$\mathbf{E}_A$
1	$(ke)/d^2$
2	$(kes)/d^2$
3	$(2kes)/d^3$
4	$(1.5kes)/d^3$

Clicker 5-2

Which location has: $E \approx \frac{kp}{d^3}$

Q13.4d



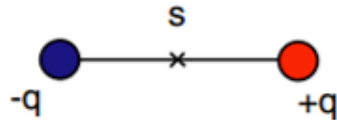
At which locations is the magnitude of the electric field approximately $\frac{1}{4\pi\epsilon_0} \frac{qs}{d^3}$?

- 1) A
- 2) B
- 3) C
- 4) A and C
- 5) A and B and C

Clicker 5-3

Q13.4h

What is the magnitude of the electric field at location x, the center of this dipole (separation s)?



1) $\frac{1}{4\pi\epsilon_0} \frac{2qs}{r^3}$

2) $\frac{1}{4\pi\epsilon_0} \frac{qs}{r^3}$

3) $\frac{1}{4\pi\epsilon_0} \frac{2q}{s^2}$

4) $\frac{1}{4\pi\epsilon_0} \frac{2q}{(s/2)^2}$

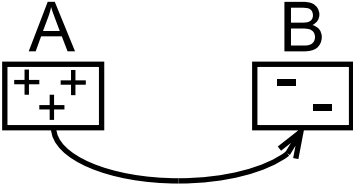
5) 0 *or* infinite (0 in the denominator)

Chapter 15: Electric Field and Matter

Net Charge and Conservation of Charge

Matter: Basic building blocks of matter are made out of + and – and 0 charge. Matter is made out out + and – bits of matter. Net charge of matter can be +, - charged.

Conservation of Charges

Net charge of a system:  Eg. sys, +1 charge

Can have bits of charge move from A to B, but net charge will still be +1

Can also have cancelation process:
$$\begin{array}{ccc} e^+ & e^- & \rightarrow \gamma\gamma \\ \text{Net charge} = 0 & & \text{Net charge} = 0 \end{array}$$

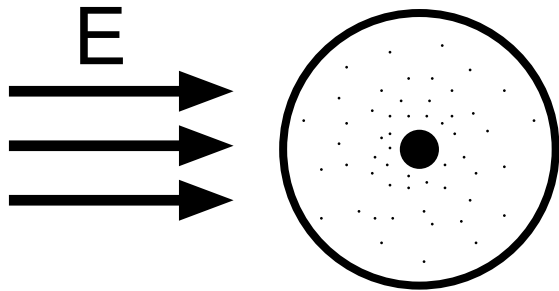
In nature, net charge of an isolated system is conserved.
Total charge of the universe is conserved.

Insulator

Matter medium {
insulators
conductors

induced dipole:

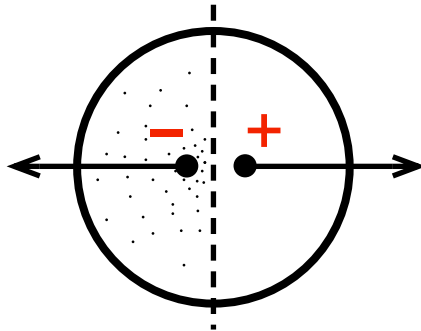
insulator: electrons are bound to the atom “no free electrons”



Induced dipole

With dipole moment:

$$p = qs$$

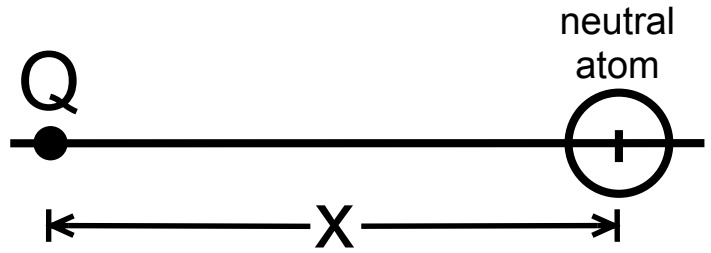


Atom is polarized

$$F^+ = qE$$

$$F^- = -qE$$

Force between Q (positive) and neutral atom



$$F_Q^{induced\ p} = Q E_0^p = Q \frac{2kp}{x^3} = \frac{Q2k}{x^3} \cdot \alpha E_x^Q$$

$$E_x^Q = \frac{kQ}{x^2}$$

$$= \frac{2\alpha(kq)^2}{x^5}$$

$$F_{induced\ p}^Q = F_{+q}^{-Q} \left(x + \frac{s}{2}\right) + F_{-q}^Q \left(x - \frac{s}{2}\right)$$

$$= \frac{kQq}{\left(x + \frac{s}{2}\right)^2} - \frac{kQq}{\left(x - \frac{s}{2}\right)^2} = \frac{kQq}{x^2} \left[\frac{1}{(1 + \epsilon)^2} - \frac{1}{(1 - \epsilon)^2} \right]$$

$$F_{atom} = \frac{2Qq}{x^3} (-2) = -F_Q$$

$$-4\epsilon = -\frac{4\frac{s}{2}}{x}$$

$$= -\frac{2s}{x}$$

If Q < 0, there is still an attraction force

Microscopic view of insulating medium

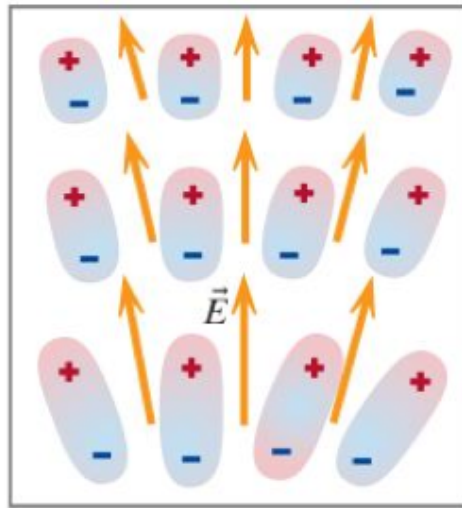


Figure 15.19 A block of insulating material (plastic, glass, etc.) polarized by an applied electric field. The molecules are not shown to scale!

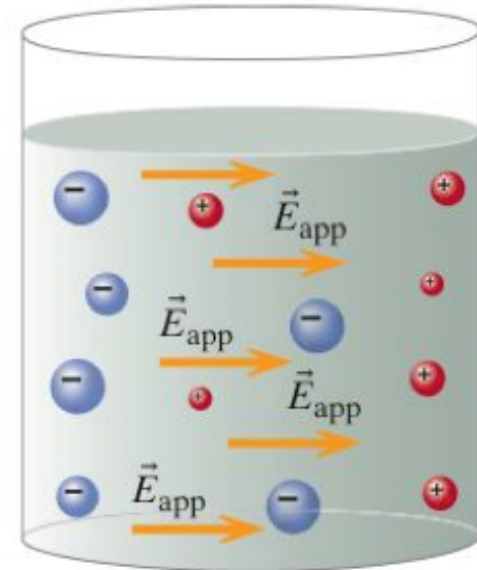


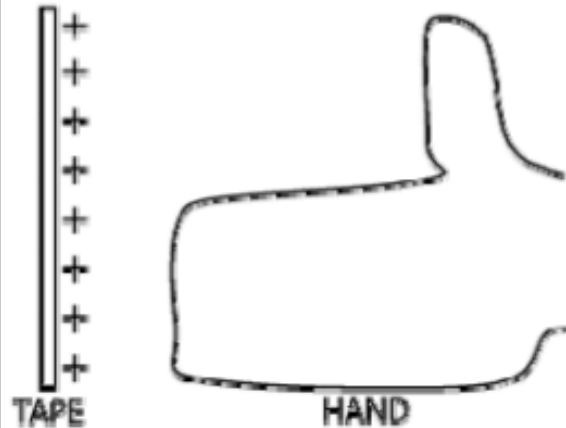
Figure 15.22 Under the influence of an applied electric field (labeled $\vec{E}_{\text{app}}$), the liquid polarizes. There is a slight excess ion concentration at the two sides of the beaker. The electric field due to the redistributed ions is not shown.

15.X.6 Atom *A* is easier to polarize than atom *B*. Which atom, *A* or *B*, would experience a greater attraction to a point charge a distance *r* away?

15.X.7 If the distance between a neutral atom and a point charge is doubled, by what factor does the force on the atom by the point charge change?

Q14.5c

You neutralize a positively charged tape by running your finger across it.



What happens?

1. mobile electrons move from skin to tape
2. Cl^- ions move from skin to tape
3. protons move from tape to skin
4. $+$ ions move from tape to skin
5. no charges move