Chapter 22

1. Electric Nature of Matter
2. Conductors, Insulators, Induction
3. Coulomb's Law
4. Electric Field
5. Field Lines
6. Dipoles

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1. Electric Nature of Matter...

→ shocks when you walk on carpet
→ sticking balloons to walls ..

"Electrostatic Forces"

Matter is : ⓐ electrons, $m_e \simeq 9.1 \cdot 10^{-31}$ kg

charged : "−1 fundamental units"

$q_e = -1.6 \cdot 10^{-19}$ Coulombs

$= -e$

Movement of electrons ("current") is responsible for powering your TV, cell phone, etc. Electrons move easily because they have much less mass than

ⓑ protons $m_p \simeq 1.7 \cdot 10^{-27}$ kg

$m_p \simeq 1900 \times m_e$

charged "+1 fundamental units"

$q_p = +1.6 \cdot 10^{-19}$ C

$= +e$

ⓒ neutrons $m_n \simeq m_p$

no charge!

Structure: protons + neutrons are glued together (by non-electric force) into a ball ~ 10^{-15} meters big.

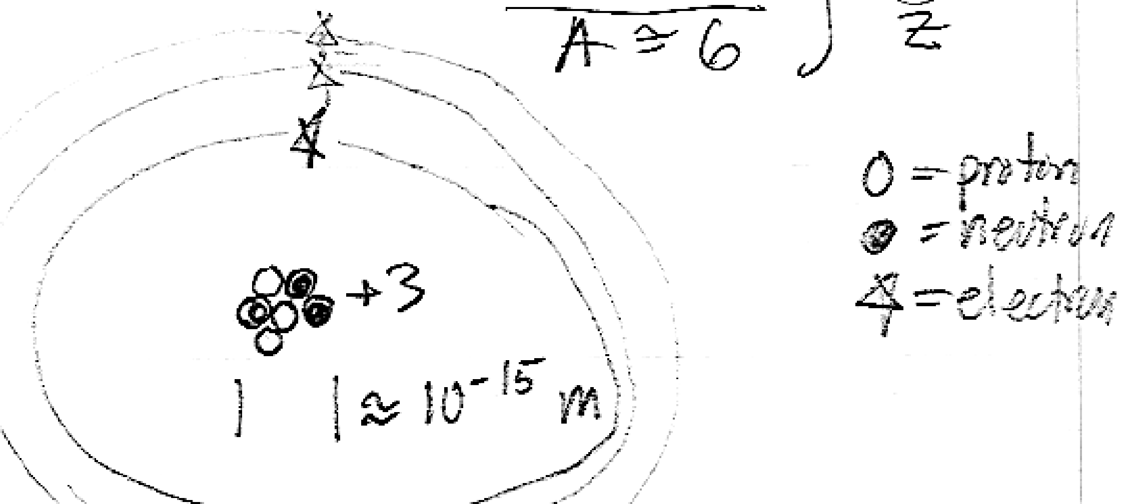
electrons buzz around this nucleus, at a distance ~10^{-10}m away

$$\begin{array}{lll} \text{Atoms neutral: } Z & \text{protons} & (+1) \\ \phantom{\text{Atoms neutral: }} Z & \text{electrons} & (-1) \\ \hline \multicolumn{3}{r}{\text{neutral} + N \text{ protons.}} \end{array}$$

Z → "atomic #" determines element

$Z+N \simeq$ atomic weight A

Example: Lithium → $\left.\begin{array}{l} Z=3 \\ N=3 \\ \hline A\simeq 6 \end{array}\right\} \; {}^{\overset{A}{\textcircled{6}}}_{\underset{Z}{\textcircled{3}}}\mathrm{Li}$



Positive Ion: lose an electron Li^+

Negative Ion: gain one Li^-

Conservation of Charge

→ For an isolated system, the sum of the charges of all particles never changes.

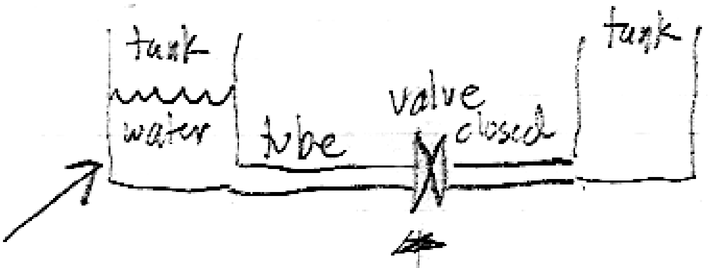
$$Q_{Net} = \sum q_i = \text{same}.$$

Quantization of Charge

→ no isolated particle with charge of magnitude $< e$, $e = 1.6 \cdot 10^{-19}$ C, ever observed (particles of charge $|q| = \frac{1}{3}e$ and $|q| = \frac{2}{3}e$ are trapped in neutrons and protons).

Insulator: don't allow electrons to flow

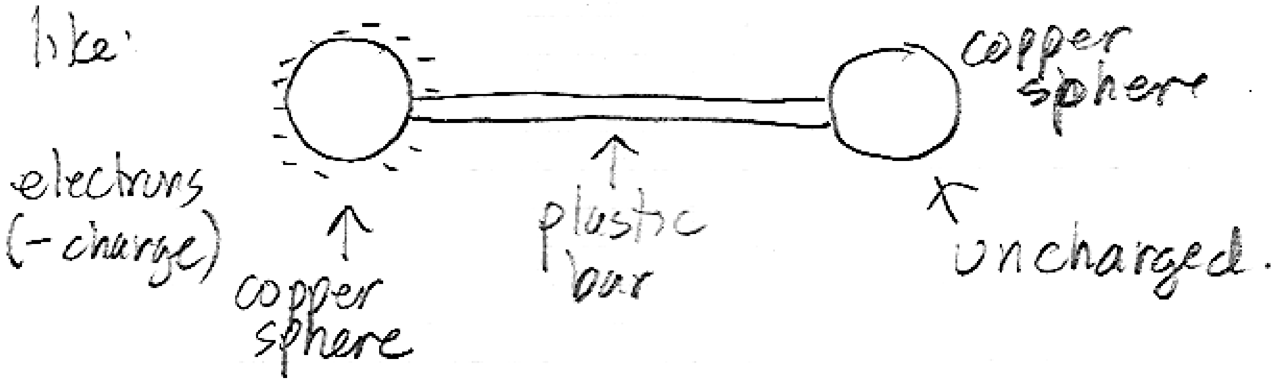
analogy:



water like electrons

valve closed like insulator

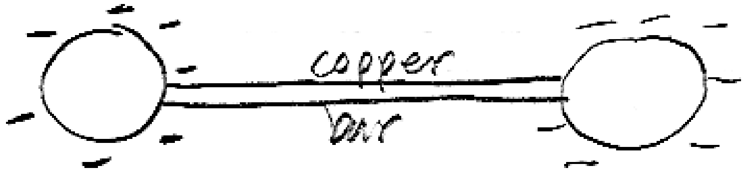
like:



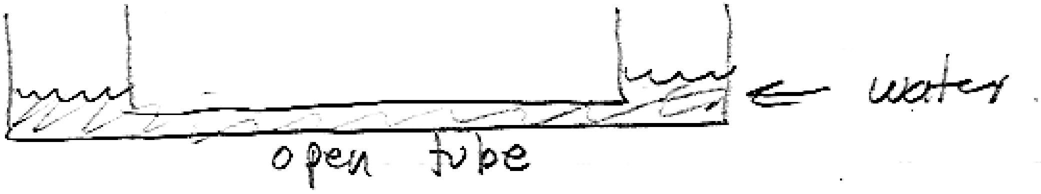
opening valve in tube is like replacing insulator with conductor...

Conductors: do allow electrons to flo

what happens

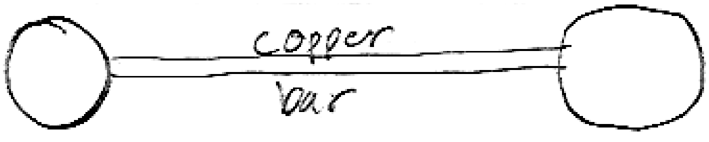


like.



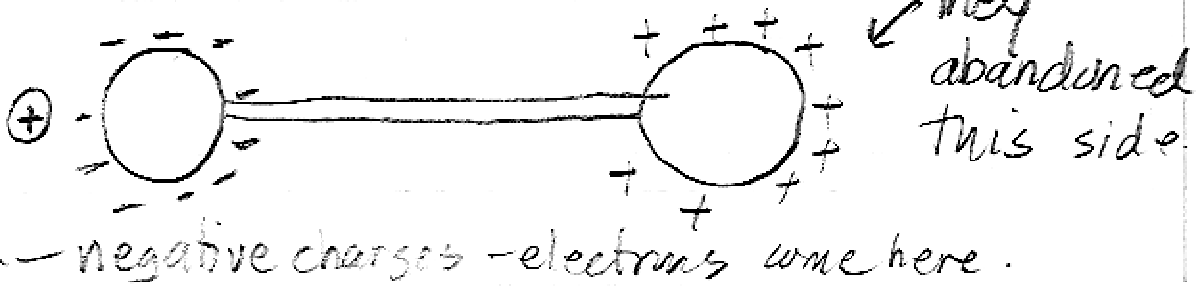
Induction → redistribution of charge.

①



NO NET CHARGE

② Bring up + charge next to left one:



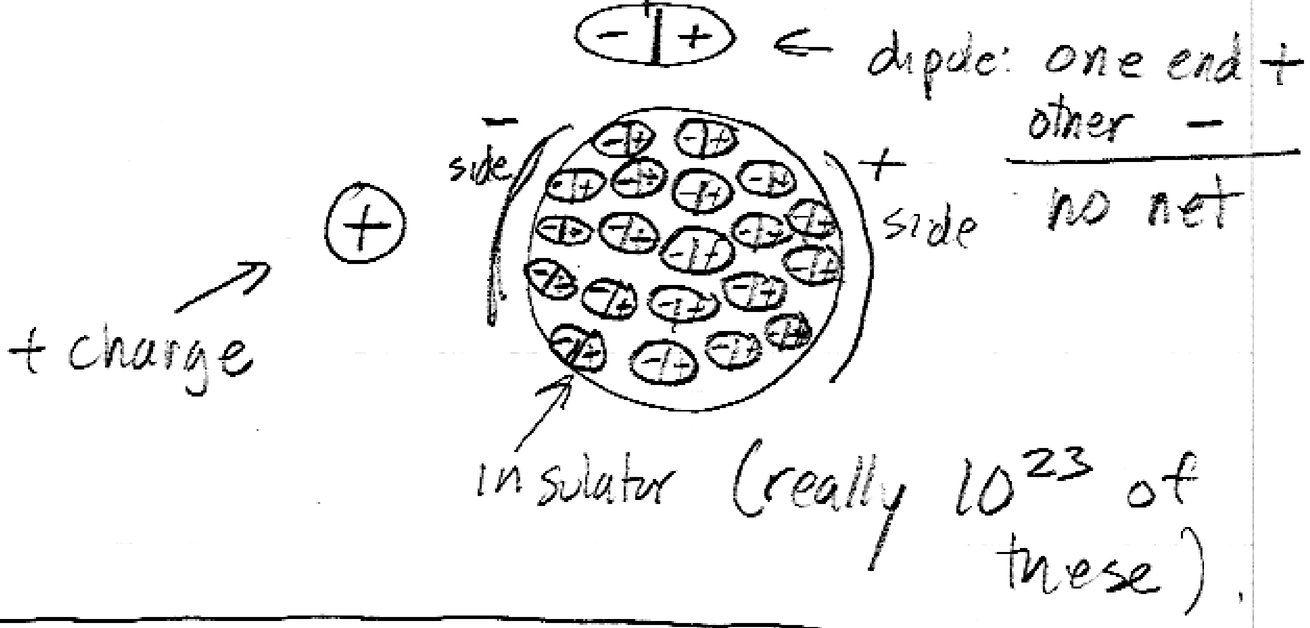
attraction — negative charges - electrons come here.

Forgot to say: + attracts −
− attracts +
− repels −
+ repels +

Redistribution of charge so net unchanged, but so some "peaks out," is "induction of charge".

Insulators Have Induced Charge.

Insulators have dipoles in them:



Coulomb's Law: Force Law between point charges.
↑ no measurable size

1) Force direction always along line joining the charges

2) Force magnitude

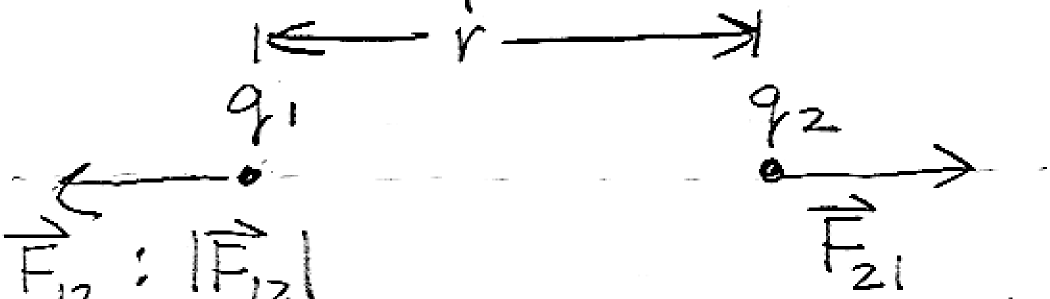
a) $\propto$ product of two charges

b) $\propto 1/(\text{distance})^2$

3) Attractive : $+-$, $-+$

Repulsive : $--$, $++$

Picture + Equation :



$\vec{F}_{12}$: $|\vec{F}_{12}| = k\frac{|q_1 q_2|}{r^2}$

$|\vec{F}_{21}| = k\frac{|q_1 q_2|}{r^2}$

$$k = 9.0 \cdot 10^9 \ N \cdot \frac{m^2}{C^2}$$

as drawn, repulsive, either:

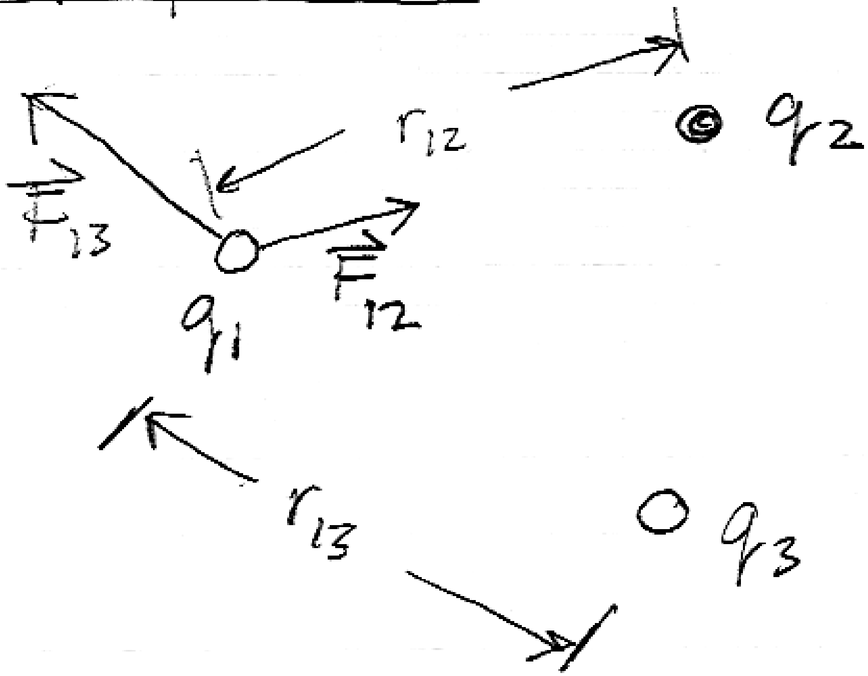
1) $q_1 > 0$, $q_2 > 0$

2) $q_1 < 0$, $q_2 < 0$

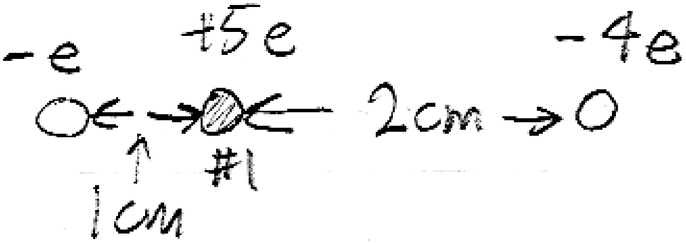
Newton 3: $\vec{F}_{12} = -\vec{F}_{21}$.

in SI : $k = \frac{1}{4\pi\varepsilon_0}$ $\quad \varepsilon_0 \rightarrow$ useful later.

Superposition



Net force on #1: $\underbrace{\vec{F}_{12} + \vec{F}_{13}}_{\text{need detailed geometry to compute.}}$



net force on #1 ?