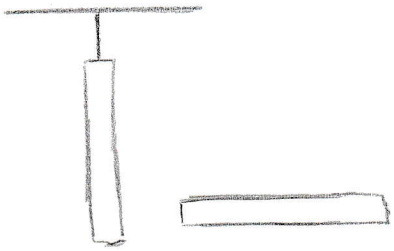
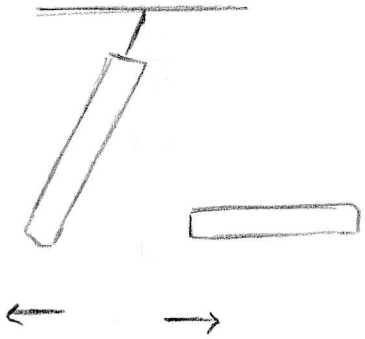
DRAWING 1: EXPERIMENTS WITH RODS --- CHARGING

## CHARGING



PLASTIC RODS, UNTOUCHED OR

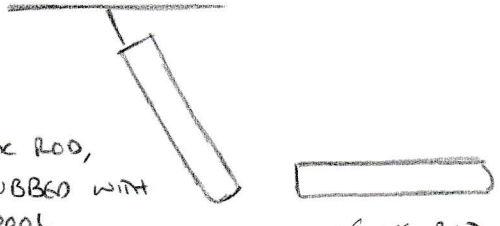
GLASS RODS, UNTOUCHED



PLASTIC RODS, BOTH RUBBED WITH WOOL OR

GLASS RODS, BOTH RUBBED WITH SILK

REPULSIVE FORCE



PLASTIC ROD, RUBBED WITH WOOL

GLASS ROD, RUBBED WITH SILK

ATTRACTIVE FORCE

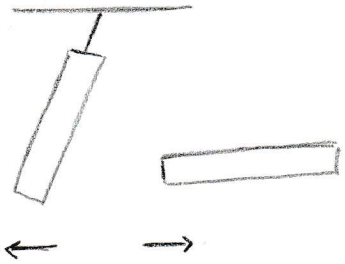
---

OBSERVATIONS:

- OBJECTS CAN ACQUIRE A PROPERTY THAT WE ARE CALLING CHARGE (TWO KINDS)
- LIKE CHARGES REPEL
- UNLIKE CHARGES ATTRACT

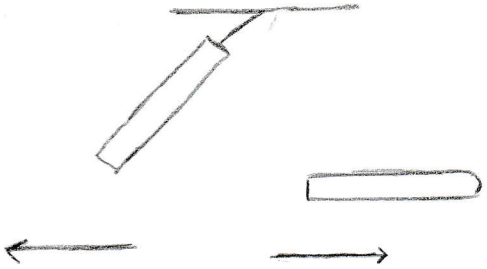
DRAWING 2: EXPERIMENTS WITH RODS --- FORCES

## FORCES



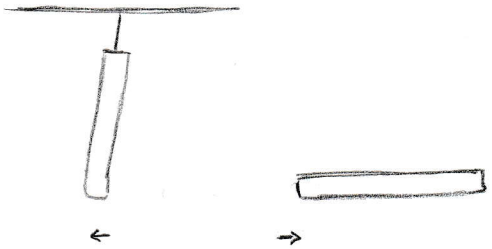
CHARGED RODS

REPULSIVE FORCE



CHARGED RODS,
RUBBED MULTIPLE TIMES

REPULSIVE FORCE, GREATER IN MAGNITUDE



GREATER SEPARATION

REPULSIVE FORCE, LESSER IN MAGNITUDE

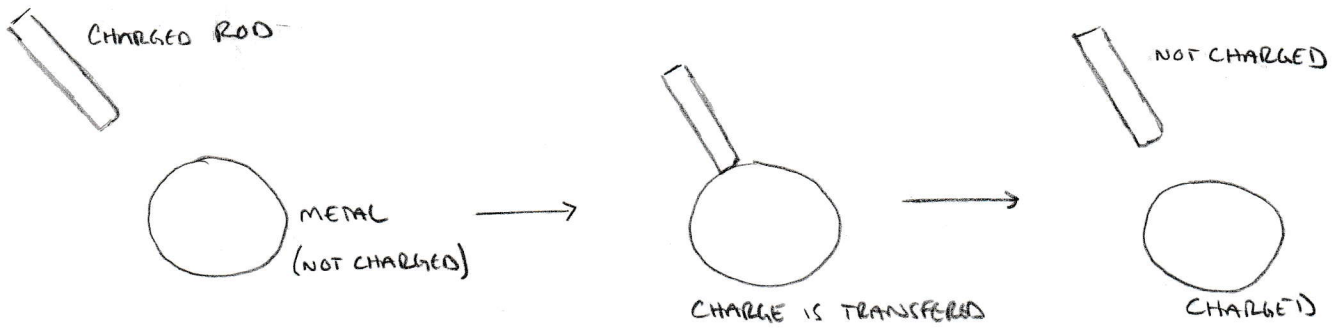
---

OBSERVATIONS:

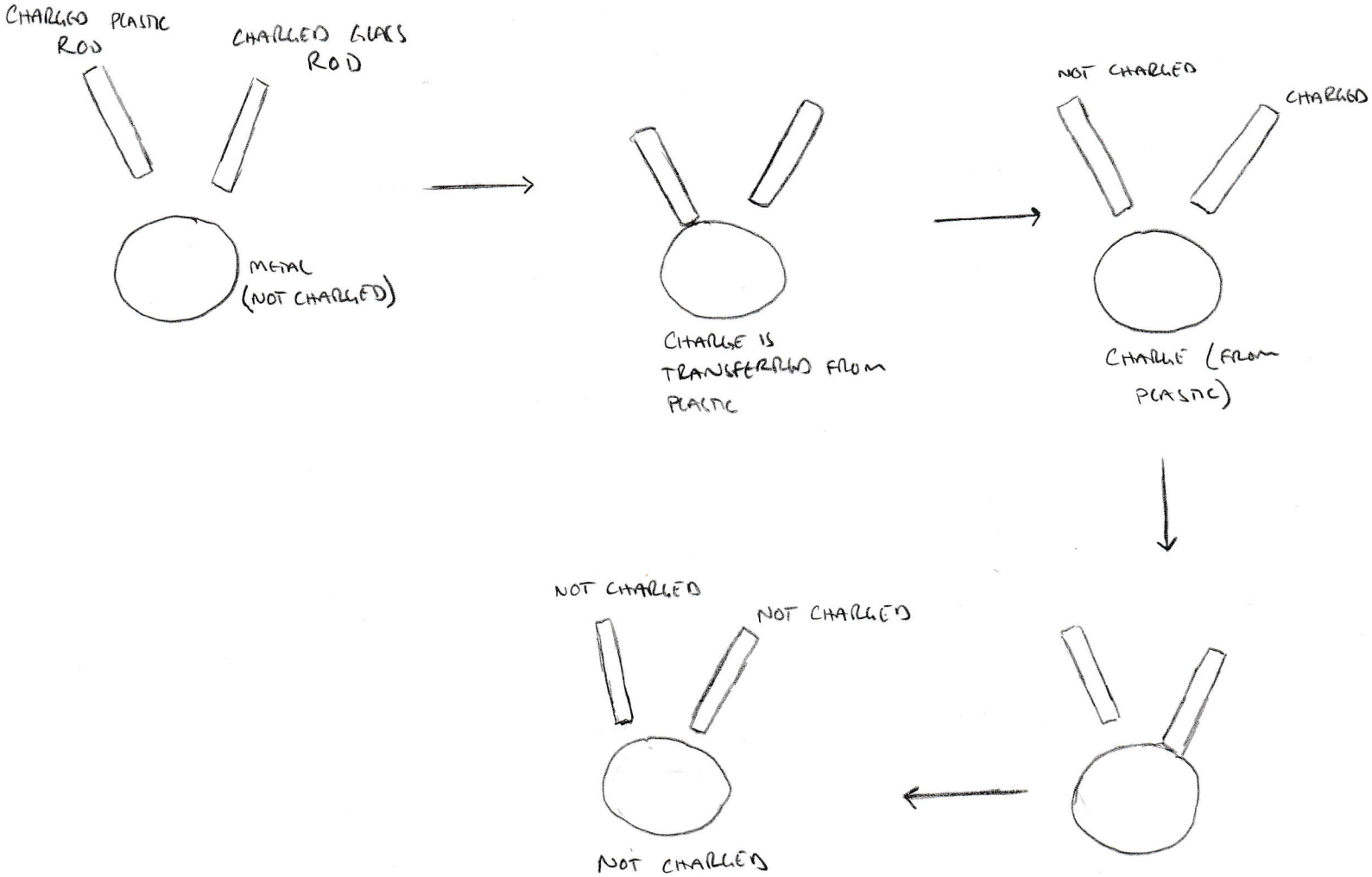
- MULTIPLE CHARGE(S) CAN BE ADDED TO THE RODS, WHICH INCREASES THE ELECTRICAL FORCE
- THE FORCE IS INVERSELY PROPORTIONAL TO THE SEPARATION BETWEEN THE RODS (ACTUALLY THE SQUARE OF IT)

DRAWING 3: EXPERIMENTS WITH RODS --- DISCHARGING

TRANSFER OF CHARGE




NOTE: CHARGE IS CONSERVED




INDICATIONS THAT CHARGE HAS A SIGN

OBSERVATIONS:

- CHARGE CAN BE TRANSFERRED
- CHARGE IS CONSERVED
- CHARGE BEHAVES LIKE IT HAS A SIGN

DRAWING #4: CHARGES

NOTE: $q$ IS THE SIGNED MAGNITUDE OF THE CHARGE

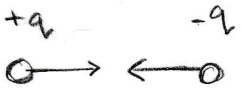
TWO TYPES OF MATTER WITH CHARGES

THE INHERENT PROPERTY OF CHARGE ($q$):

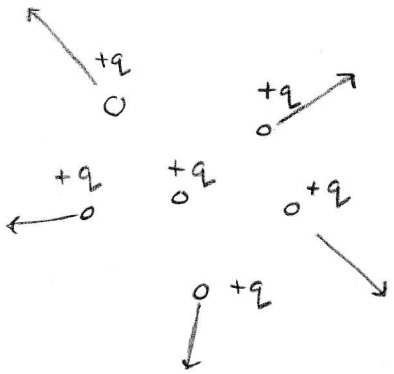

LIKE KINDS REPEL:



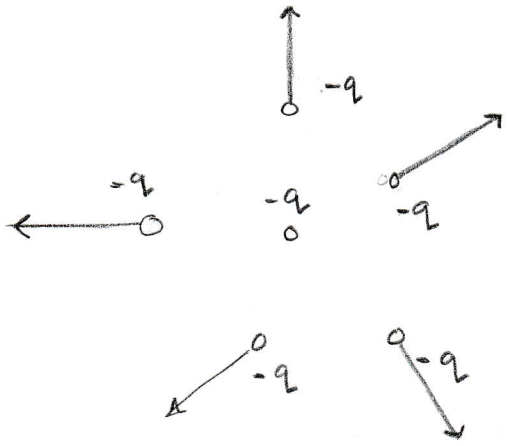
UNLIKE KINDS ATTRACT:



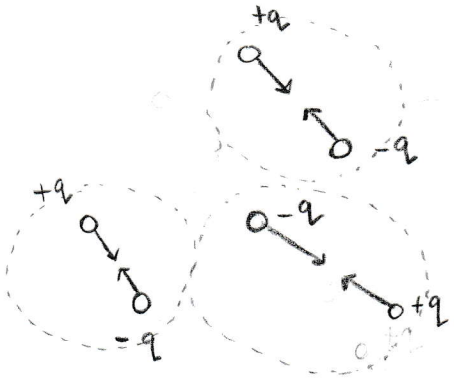
DRAWING #5 : COLLECTION OF CHARGES




A COLLECTION OF POSITIVE CHARGES




A COLLECTION OF NEGATIVE CHARGES




AN EQUAL MIXTURE OF POSITIVE AND NEGATIVE CHARGES

NOTE: NOT ALL FORCES ARE SHOWN

DRAWING #6: MATTER

PROTONS: $q = +e$, $0$

ELECTRONS: $q = -e$, $0$

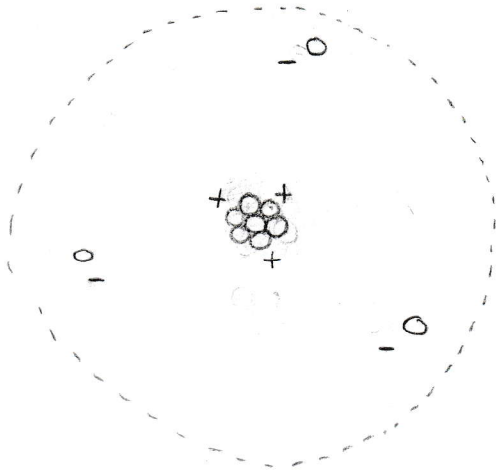
- CHARGE IS AN INHERENT PROPERTY OF PROTONS AND ELECTRONS
- THE CHARGE OF PROTONS AND ELECTRONS IS EQUAL IN MAGNITUDE, BUT OPPOSITE IN SIGN. WE CALL THIS CHARGE ($e$) THE FUNDAMENTAL UNIT OF CHARGE.

$$e = 1.60 \cdot 10^{-19}\ C$$ ($C$ IS COULOMBS)

TWO SUCH BASIC PARTICLES DO EXIST: PROTONS AND ELECTRONS

## AN ATOM

ATOMS ARE COMPRISED OF PROTONS AND ELECTRONS



THE TOTAL CHARGE OF THIS ATOM IS:

$$q = N_p e - N_e e$$
$$= (N_p - N_e) e$$

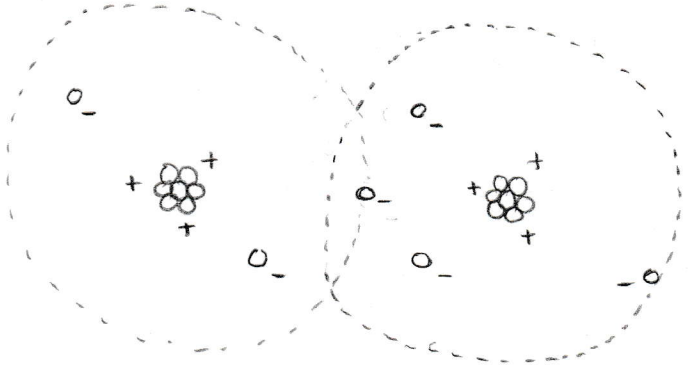
$N_p$: NUMBER OF PROTONS

$N_e$: NUMBER OF ELECTRONS

CHARGE IS QUANTIZED (DISCRETE)

## MATTER

MATTER IS COMPRISED OF ATOMS



$q = +e$ $\qquad$ $q = -e$

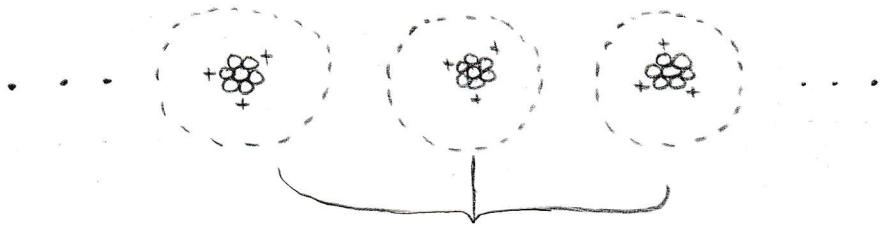
$q = 0$

NOTE: NUCLEI ARE TIGHTLY BOUND ... ELECTRONS CAN MOVE AROUND MORE EASILY

DRAWING #7: TYPES OF MATTER

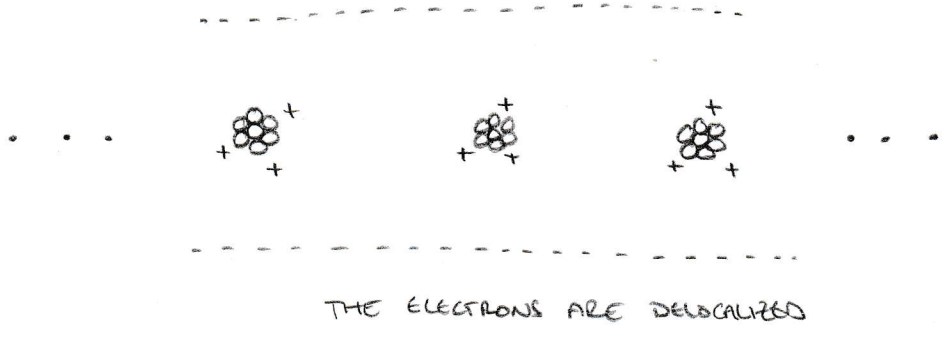
THE INTERPLAY BETWEEN MANY EFFECTS AT SMALL LENGTH SCALES GIVES RISE TO DIFFERENT TYPES OF MATTER.

INSULATORS



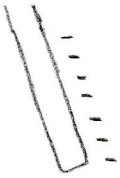
THE ELECTRONS ARE VERY TIGHTLY BOUND TO THE NUCLEI

CONDUCTORS

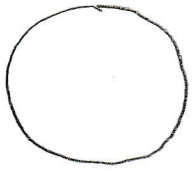


THE ELECTRONS ARE DELOCALIZED

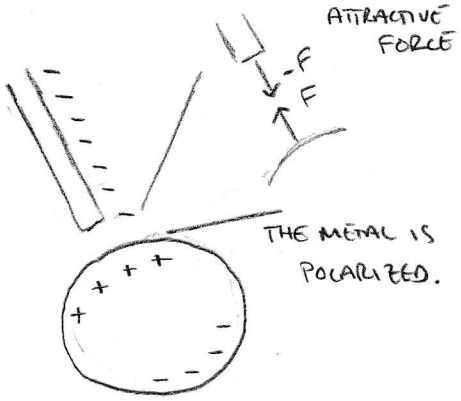
DRAWING #8: REVISITING THE EXPERIMENTS WITH RODS; POLARIZATION



PLASTIC ROD
RUBBED WITH WOOL
(INSULATOR)

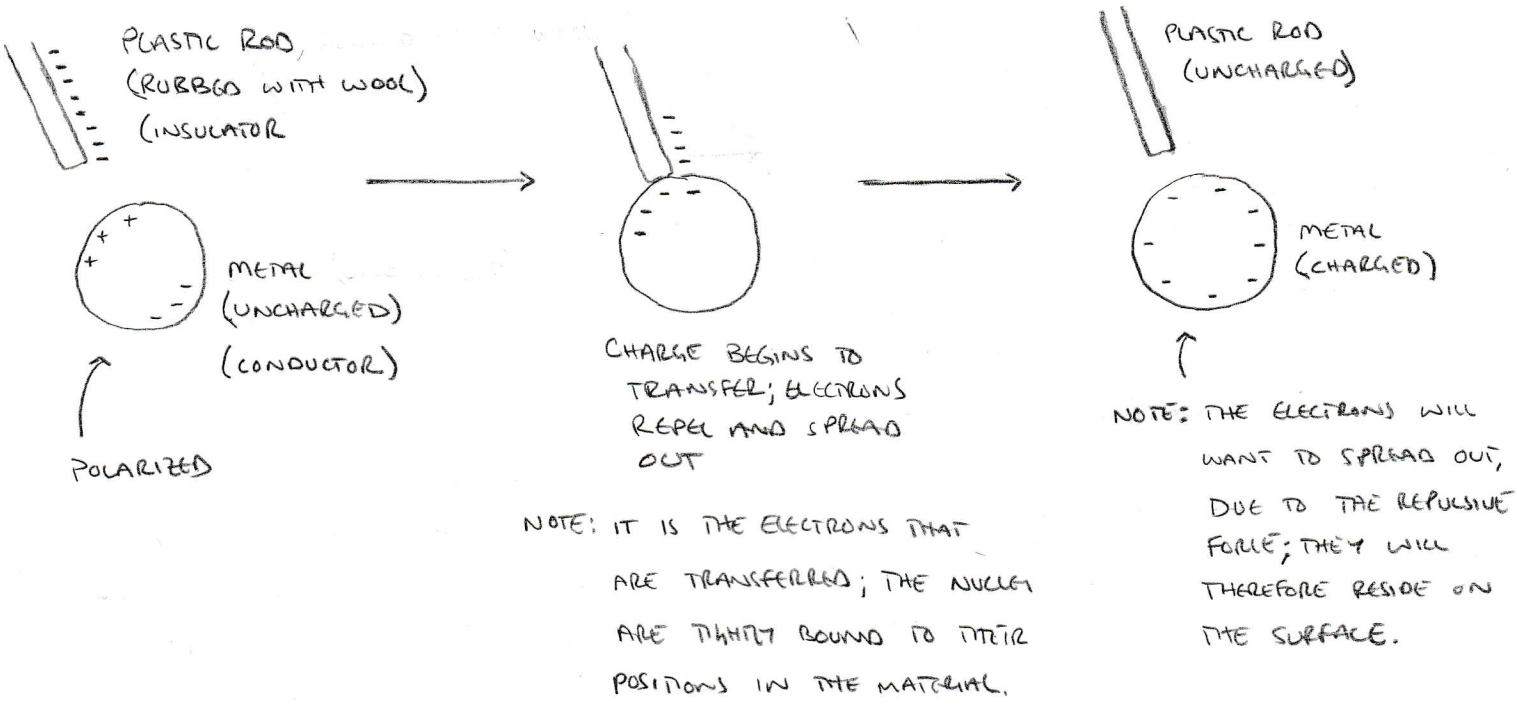


METAL
(UNCHARGED)
(CONDUCTOR)




NOTE: REMEMBER, IT IS THE ELECTRONS THAT ARE DELOCALIZED AND MOVE; THE NUCLEI ARE TIGHTLY BOUND TO THEIR POSITIONS IN THE MATERIAL.

DRAWING #9 : REVISITING THE EXPERIMENTS WITH RODS ; CHARGE TRANSFER




NOTE: IT IS THE ELECTRONS THAT ARE TRANSFERRED; THE NUCLEI ARE TIGHTLY BOUND TO THEIR POSITIONS IN THE MATERIAL.

NOTE: THE ELECTRONS WILL WANT TO SPREAD OUT, DUE TO THE REPULSIVE FORCE; THEY WILL THEREFORE RESIDE ON THE SURFACE.