

# UNIT B – FORCES & FIELDS

## ELECTROSTATICS

- unlike/opposite charges attract
- like/same charges repel
- atoms are made of protons, neutrons & electrons
- neutrons have no electrical charge
- symbol for charge:  $q$ , unit:  $C$  (Coulomb)
- protons have a charge of  $p = +1e = +1.60 \times 10^{-19} C$
- electrons have a charge of  $e^- = -1e = -1.60 \times 10^{-19} C$
- alpha particles  $\alpha^{2+} = +2e$
- all charges are a whole number multiple of the elementary charge:  $e = 1.60 \times 10^{-19} C$
- net charge of an atom is typically zero: they have the same number of protons as electrons
- when an atom gains or loses electrons, it becomes an ion
- protons do not typically transfer to other objects

## CHARGING BY FRICTION

- when two substances are rubbed together, electrons can be transferred from one substance to another
- some materials hold onto electrons more tightly than other materials (affinity for electrons)
- two materials rubbed together
  - negatively charged material gained electrons
  - positively charged material lost electrons
- total amount of charge of the system doesn't change: Law of Conservation of Charge
- Van de Graff generators build up charge using friction
- electroscopes are used to detect presence of electric charge
  - the more the leaves diverge, the greater the charge

## CHARGING BY INDUCTION

- no electrons are transferred from object to object because no contact is made
- charges are redistributed on objects
  - thus charge separation is induced
- example: Positively charged rod is placed near a grounded electroscope
  - electrons in leaves move toward the head, leaving the leaves positive and therefore the leaves diverge
  - when rod is removed, leaves return to original position
  - during the whole process, electroscope is neutral
- example: Negatively charged rod is placed near electroscope
  - electrons travel to leaves because they are repelled by negatively charged rod
  - negatively charged leaves repel each other and thus diverge

## CAUSING PERMANENT CHARGE BY INDUCTION

- if a charged object is brought near another object that is connected to a much larger object (eg: Earth), electrons can move up or down the connection
- always induces opposite charge
- example: Positively charged rod brought near neutral electroscope
  - electrons move to head, leaves diverge due to repulsion of positively charged leaves

- connect electroscope to ground
  - more electrons come up ground due to attractive forces to rod and leaves
  - ground is removed
  - rod is removed
  - electroscope is permanently charged negative
- example: Negatively charged rod brought near electroscope
    - electrons move to leaves, thus leaves diverge
    - connect electroscope to ground
    - electrons on leaves move down ground due to repulsive forces from rod
    - ground is removed
    - rod is removed
    - electroscope is permanently charged positive

## CHARGING BY CONDUCTION (CONTACT)

- when a charged object touches another object, charges are shared equally
  - the objects will have the same final charge due to repulsive forces and/or attractive forces
- example: Negatively charged object touches a neutral object
    - both objects will have the same negative charge when separated
  - example: Positively charged object touches neutral object
    - electrons will move from neutral object to positively charged object
    - when separated, objects will have some final positive charge

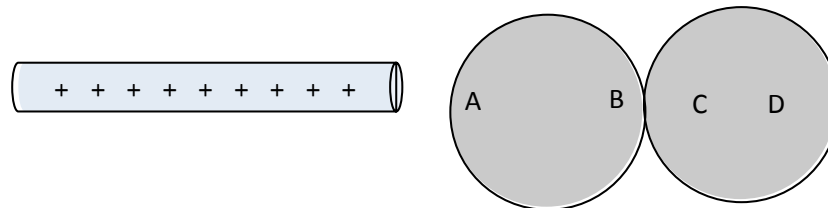
*Use the following information to answer the next question.*

A negatively charged object is brought near to, but does not touch, one end of a neutral metal rod on an insulated stand. The opposite end of the metal rod is grounded. The ground is removed, and then the negatively charged object is removed.

37. As a result of the procedure described above, what type of charge will the metal rod have?

*Use the following information to answer the next question.*

A positively charged rod is placed near, but not touching, a neutral metal ball AB. Metal ball AB is touching a neutral metal ball CD. After several minutes, ball CD is separated from ball AB and the rod is removed.



38. As a result of the rod's position, what is the relative charge of ball CD?
39. A conducting sphere R that has an initial charge of  $+5.3 \times 10^{-6}$  C and an identical conducting sphere S that has an initial charge of  $-8.1 \times 10^{-6}$  C are touched together. After they are separated, what is the charge on sphere R?