March 11, 2013 Physics 132 Prof. W. Losert

Outline

- Screening
- Currents

Office hours Thursday 12.30-2

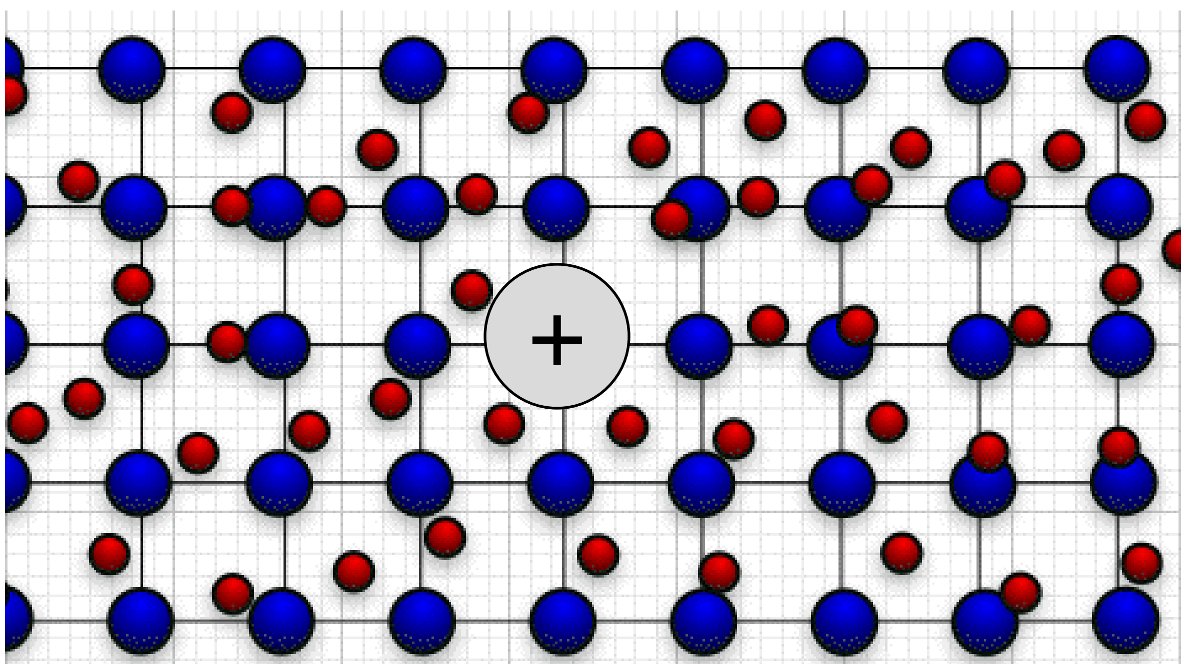
Quiz 6

SCORE	1	2.1	2.2	2.3
5.7				
3.3				
Correct	all equal	A	D	B

Screening

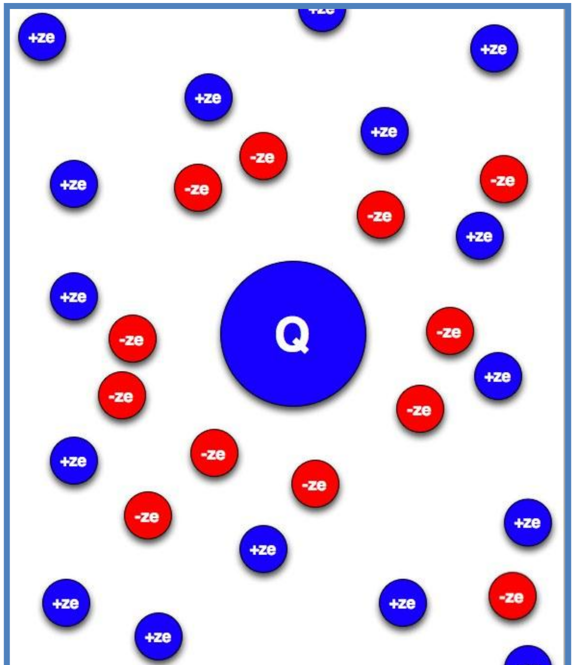
Charged objects in Conducting Solids

- What happens if place a charged object into a neutral conductor?
  - Positive ions are fixed in the solid
  - Some negative charges (shared electrons) are free to move



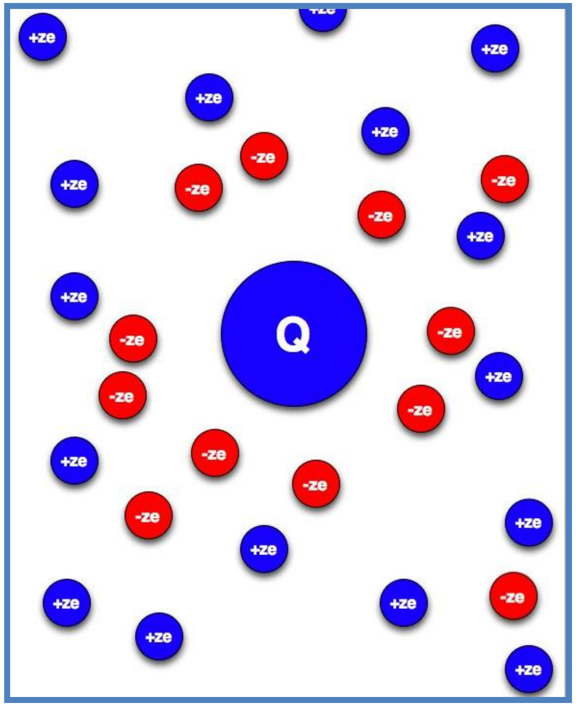
Charged objects in Conducting Fluids

- What happens if place a charged object into a neutral fluid?
  - Opposite charged ions are attracted to object
  - Like charged ions are repelled
  - Thermal energy keeps ions moving



Debye length equations

- Charge imbedded in an ionic solution.
  - Ion charge = *ze*
  - Concentration = c_0
  - Temperature = *T*
  - Dielectric constant = κ
- The ion cloud cuts off the potential



$$l_D = \sqrt{\frac{k_B T}{8\pi\left(\frac{k_C z^2 e^2}{\kappa}\right) c_0}} = \sqrt{\frac{k_B T}{2\left(\frac{z^2 e^2}{\kappa \varepsilon_0}\right) c_0}}$$

$$V(r) = \frac{k_C Q}{\kappa r} e^{-r/l_D}$$

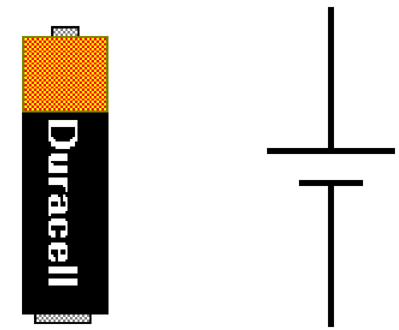
Foothold ideas: Electric charges in materials

- **Electroneutrality** – opposite charges in materials attract each other strongly. Pulling them apart to create a charge unbalance costs energy.
- If a charged object is placed in an ionic solution, it tends to draw up ions of the opposite type and push away ones of the same type.
  - Result: the charge is **shielded**. As you get farther away from it the "apparent charge" gets less.
  - The scale over which this happens is called the **Debye length, λ_D.**

Electric currents

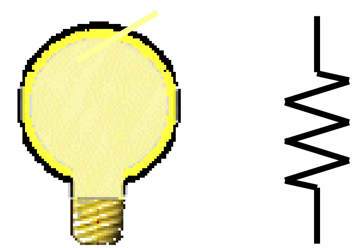
Electric circuit elements

- ***Batteries*** —devices that maintain a constant electrical potential difference across their terminals

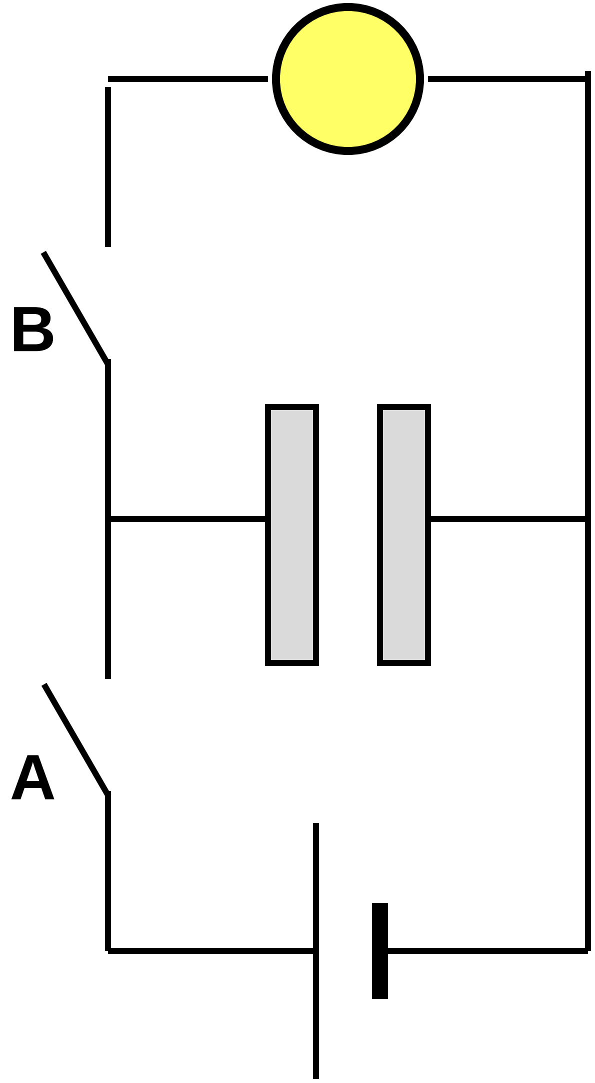


- ***Wires*** — charges flow quickly need very little forces to move

- ***Resistances*** — charges need a larger force to move. Examples are Resistors and Lightbulbs



- Suppose we:
  - Close A for a few seconds
  - Open A
  - Close B
- What happens to the bulb?
  - 1. It stays off.
  - 2. It stays on after you close A
  - 3. It stays on after you close B
  - 4. It flashes when you close A
  - 5. It flashes when you open A
  - 6. It flashes when you close B



As the lightbulb flashes which of the following is true

1. **Positive** charges move across the lightbulb, they move at roughly constant speed
2. **Positive** charges move across the lightbulb, they move slowest at the lightbulb
3. **Negative** charges move across the lightbulb, they move at roughly constant speed
4. **Negative** charges move across the lightbulb, they move slowest at the lightbulb
5. None of the above

Foothold ideas: Currents

- Charge is moving:
  How much?

$$I = \frac{Dq}{Dt}$$

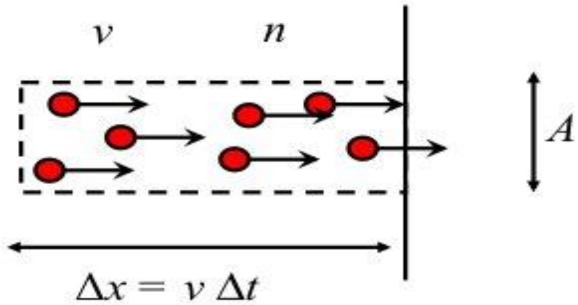
- How does this relate to the individual charges?

$$I = q\,n\,A\,v$$

- What pushes the charges through resistance? Electric force implies a drop in *V*!

$$F_e = qE$$

$$DV = -\frac{E}{L}$$



Ohm's Law

- Current proportional to change in Electrical Potential

$$\Delta V = IR$$

- Does R depend on the Area of the resistor?
- Does R depend on the length of the resistor?

1. R Increases
2. R decreases
3. R remains the same
4. Depends on material

Resistivity and Conductance

- The resistance factor in Ohm's Law separates into a geometrical part (L/A) times a part independent of the size and shape but dependent on the material. This coefficient is called the *resistivity* of the material (ρ).
- Its reciprocal (g) is called *conductivity*. *(The reciprocal of the resistance is called the conductance (G).)*

$$R = \rho \frac{L}{A} = \frac{1}{g}\frac{L}{A} = \frac{1}{G}$$