AP PHYSICS 1 BIG IDEAS – Electricity

Electrostatics

Protons and neutrons are bound together in the nucleus of an atom. Electrons are "orbiting" around the nucleus.

An electrical insulator "holds" onto electrons well, a conductor lets electrons freely move from one atom to another.

Charge is always conserved. It cannot be created or destroyed. It can only be moved around.

When two insulators are rubbed together, the material that is a better insulator will grab electrons from the other, becoming negatively charged. The other becomes positive.

One Coulomb is the amount of charge equal to 6.24×10^{18} electrons or protons.
Thus the charge of a single electron or proton is 1.6×10^{-19} Coulombs.

Like charges repel, while opposites charges attract. This force is described by Coulomb's Law, $F_E = k \cdot q_1 \cdot q_2 / r^2$. q is charge, r is distance, and k is Coulomb's constant, 9×10^9. Thus electric force diminishes as an inverse square relationship.

Induction is making something charged even though no direct contact was made.
(Moving charges within an object.)

Conduction is making something charged through direct contact.
(Moving charges from one object to another.)

Polarization is moving charges from one side of the atom to the other. There will be a net force between the object that induced the polarization and the object that got polarized because the opposite charges are closer than the like charges.

Electric Fields

The presence of charge alters space. Space will now put force on other charges.

Convention: The electric field is in the *same direction* as the net *force* put on to *positive* charge. Thus, electric field lines are drawn from positive charges to negative charges.

The strength of the electric field is shown by the number of field lines in a given area.

The electric field is *zero* everywhere inside of a metal sphere.

Voltage, Current, Resistance, Power

Voltage, V, is energy per charge. (Joules/Coulomb) Volts, V.

Electromotive force, emf, causes voltage.

Current, I, is the number of charges that pass a point every second. (Coulombs/second) Amps, A.

It is a convention to say the current is in the *same direction* as the flow of *positive* charge.

When there is a difference in voltage from one side of a wire to the other, current will flow through the wire. The current is directly proportional to the difference in voltage. The proportionality constant is called resistance, R, (Joule·seconds/Coulomb^2) Ohms, Ω.
Thus $V = I \cdot R$.

The resistance of a wire is directly proportional to the resistivity, ρ, (material dependent) and length, ℓ. It is inversely proportional to the cross-sectional area, A. $R = \rho \cdot \ell / A$

Power is energy dissipated per time. It is measured in watts, W. $P = I \cdot \Delta V$

Circuits

Remember that $V = I \cdot R$!

The equivalent resistance, or total resistance in series, R_s, is simply $R_1 + R_2 + R_3 + \ldots$

The equivalent resistance, or total resistance in parallel, R_p, is: $1/R_p = 1/R_1 + 1/R_2 + 1/R_3 + \ldots$

When resistors are in combinations of series and parallel, simplify the circuit by breaking R_s and R_p into equivalent "chunks".

Resistors in Parallel get the *same voltage*, but the *current spits* between the two.

Resistors in Series get the *same current*, but the *voltage adds up* to the total.

Voltage is always measured in parallel. Current is always measured in series.

Kirchhoff's Law states:
1) Current coming into a junction equals the current leaving a junction.
2) The sum of the raises in potential, V, equals the sum of the drops in potential, I·R around any closed loop in the circuit.