Electric Current

I = electric current, # of coulombs of charge that passes a given point

$$I = \frac{dq}{dt}$$

Units: C/s = 1 ampere = 1 A

v_e = conduction velocity; average velocity between collisions $\approx 10^5$ m/s

v_d = drift velocity; average velocity on the macroscopic scale $\approx 10^{-3}$ m/s

Carrier Density

let n = charge carrier density, # of free charges per cubic meter (1/m^3)

pure metal $n = \frac{\rho N_A}{M}$

$N_A = 6.022 \times 10^{23}\ \mathrm{mol}^{-1}$

ρ = volume density (kg/m^3)

M = molar mass (kg/mol)

$I = neAv_d$

e = charge electron

let $\vec{J}$ = current density (A/m^2)

$$|\vec{J}| = \frac{I}{A}$$

$$|\vec{J}| = nev_d$$

Ohm's Law

$$\vec{J} = \sigma \vec{E}$$

σ = electric conductivity, a measure of how well the material conducts charge

let ρ = electric resistivity, a measure of how well the material resists current flow

Units of ρ: Ω m

$$\rho = \frac{1}{\sigma}$$

$$\Delta V = \left(\rho \frac{l}{A}\right) I$$

let R = resistance

$$R = \rho \frac{l}{A}$$

Units of R: 1 $\frac{V}{A}$ = 1 ohm = 1 Ω

Resistivity

ρ is not constant, it varies with temperature

$$\rho = \rho_0 (1 + \alpha (T - T_0))$$

let α = temperature coefficient of resistivity (1/°C)

$R = R_0 \big(1 + \alpha \big(T_f - T_0\big)\big)$, if l and A are constant

Power Supplies

example: battery (electro chemical cell)

- two dissimilar metals and an electrolyte

let ε = electromotive force, voltage generated/created by chemical reaction inside battery, (fixed) quantity doesn't change

V_t = terminal voltage, voltage that's available to some external circuit (varies)

r = internal resistance (varies)

$V_t = \varepsilon - Ir$