TABLE 23.1

Charge and Mass of the Electron, Proton, and Neutron

Particle	Charge (C)	Mass (kg)
Electron (e)	$-1.602\,176\,5 \times 10^{-19}$	$9.109\,4 \times 10^{-31}$
Proton (p)	$+1.602\,176\,5 \times 10^{-19}$	$1.672\,62 \times 10^{-27}$
Neutron (n)	0	$1.674\,93 \times 10^{-27}$

TABLE 27.2 *Resistivities and Temperature Coefficients of Resistivity for Various Materials*

Material	Resistivity[a] ($\Omega \cdot m$)	Temperature Coefficient[b] $\alpha[(°C)^{-1}]$
Silver	1.59×10^{-8}	3.8×10^{-3}
Copper	1.7×10^{-8}	3.9×10^{-3}
Gold	2.44×10^{-8}	3.4×10^{-3}
Aluminum	2.82×10^{-8}	3.9×10^{-3}
Tungsten	5.6×10^{-8}	4.5×10^{-3}
Iron	10×10^{-8}	5.0×10^{-3}
Platinum	11×10^{-8}	3.92×10^{-3}
Lead	22×10^{-8}	3.9×10^{-3}
Nichrome[c]	1.00×10^{-6}	0.4×10^{-3}
Carbon	3.5×10^{-5}	-0.5×10^{-3}
Germanium	0.46	-48×10^{-3}
Silicon[d]	2.3×10^{3}	-75×10^{-3}
Glass	10^{10} to 10^{14}	
Hard rubber	$\sim 10^{13}$	
Sulfur	10^{15}	
Quartz (fused)	75×10^{16}	

[a] All values at 20°C. All elements in this table are assumed to be free of impurities.

[b] See Section 27.4.

[c] A nickel–chromium alloy commonly used in heating elements. The resistivity of Nichrome varies with composition and ranges between 1.00×10^{-6} and $1.50 \times 10^{-6}\ \Omega \cdot m$.

[d] The resistivity of silicon is very sensitive to purity. The value can be changed by several orders of magnitude when it is doped with other atoms.

Formula Sheet (PHY121)

$$\vec{F}_{12} = k_e \frac{q_1 q_2}{r_{12}^2}\hat{r}, \quad \vec{E} = \frac{\vec{F}}{q}, \quad \vec{E} = k_e \frac{q}{r^2}\hat{r}, \quad \vec{E} = k_e \sum_i \frac{q_i}{r_i^2}\hat{r}, \quad \vec{E} = k_e \int \frac{dq}{r^2}\hat{r}, \quad q = \pm Ne,$$

$$dq = \rho dV, \quad dq = \sigma dA, \quad dq = \lambda dl, \quad \rho = \frac{Q}{V}, \quad \sigma = \frac{Q}{A}, \quad \lambda = \frac{Q}{l}, \quad \vec{a} = \frac{q\vec{E}}{m},$$

$$v_{xf} = v_{xi} + a_x t, \quad v_{xf}^2 = v_{xi}^2 + 2a_x(x_f - x_i), \quad x_f = x_i + v_x t + \frac{1}{2}a_x t^2, \quad x_f = x_i + \frac{1}{2}(v_{xi} + v_{xf})t$$

$$\Phi_E = EA\cos\theta, \quad \Phi_E = \int_{surface} \vec{E}.d\vec{A}, \quad \Phi_E = \oint \vec{E}.d\vec{A} = \frac{q_{enc}}{\varepsilon_0}, \quad A_{sphere} = 4\pi r^2, \quad A_{cylinder} = 2\pi r l$$

$$V_{sphere} = \frac{4}{3}\pi r^3, \quad \vec{F} = q\vec{E}, \quad \Delta U = -q\vec{E}\cdot d\vec{s}, \quad \Delta U = -q\int_A^B \vec{E}\cdot d\vec{s}, \quad \Delta V = \frac{\Delta U}{q}, \quad \Delta V = -\int_A^B \vec{E}\cdot d\vec{s},$$

$$\Delta V = Ed, \quad V = k_e \frac{q}{r}, \quad V = k_e \sum_i \frac{q_i}{r_i}, \quad U = k_e \frac{q_1 q_2}{r_{12}}, \quad U = k_e \sum_i \frac{q q_i}{r_i}, \quad E_x = \frac{\partial V}{\partial x}, \quad E_y = \frac{\partial V}{\partial y},$$

$$E_z = \frac{\partial V}{\partial z}, \quad C = \frac{Q}{\Delta V}, \quad \sigma = \frac{Q}{A}, \quad C = \frac{\varepsilon_o A}{d}, \quad Q_{eq} = Q_1 + Q_2, \quad C_{eq} = C_1 + C_2,$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}, \quad \Delta V_{eq} = \Delta V_1 + \Delta V_2, \quad W = U = \frac{Q^2}{2C} = \frac{1}{2}Q\Delta V = \frac{1}{2}C(\Delta V)^2, \quad U = \frac{1}{2}\varepsilon_o A d E^2,$$

$$u_E = \frac{1}{2}\varepsilon_o E^2, \quad C = \kappa C_o, \quad C = \kappa \frac{\varepsilon_o A}{d}, \quad Q = \kappa Q_o, \quad V = \frac{V_o}{\kappa}, \quad I_{avg} = \frac{\Delta Q}{\Delta t}, \quad I_{ins} = \frac{dQ}{dt},$$

$$I_{avg} = nqv_d A, \quad J = nqv_d, \quad J = \frac{I}{A}, \quad J = \sigma E, \quad \rho = \frac{1}{\sigma}, \quad V = IR, \quad R = \rho\frac{l}{A}, \quad a = \frac{qE}{m},$$

$$v_d = \frac{qE}{m}\tau, \quad \sigma = \frac{nq^2\tau}{m}, \quad \rho = \frac{m}{nq^2\tau}, \quad \rho = \rho_0[1 + \alpha(T - T_0)], \quad R = R_0[1 + \alpha(T - T_0)], \quad \Delta V = \varepsilon - Ir,$$

$$P = I\Delta V, \quad \rho = \frac{m}{V}, \quad P = I^2(R + r), \quad R_{eq} = R_1 + R_2 + R_3 + \ldots, \quad \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots,$$

$$\sum_{junction} I = 0, \quad \sum_{closed\ loop} V = 0, \quad q(t) = Q\left(1 - e^{-t/RC}\right), \quad I(t) = \frac{\varepsilon}{R}e^{-t/RC}, \quad Q = C\varepsilon, \quad \tau = RC,$$

$$q(t) = Qe^{-t/RC}, \quad I_i = \frac{Q}{RC}, \quad I(t) = -I_i e^{-t/RC}, \quad \vec{F} = q\vec{v}\times\vec{B}, \quad F = |q|vB\sin\theta,$$