1 Radioactivity

Nuclear radius: $r \approx (1.2 \times 10^{-15}\text{ m})A^{1/3}$

Atomic mass unit: $1\text{ u} = 1.66 \times 10^{-27}\text{ kg}$

α **decay:** ${}^{A}_{Z}X \rightarrow^{A-4}_{Z-2} X' +^{4}_{2}\text{ He}$

β **decay:** ${}^{A}_{Z}X \rightarrow^{A}_{Z+1} X' + e^{-}(+\text{ neutrino})$

γ **decay:** ${}^{A}_{Z}X* \rightarrow^{A}_{Z} X +\text{ photon}$

Radioactive decay law: $N(t) = N_0 e^{-\lambda t}$

Half-life: $T_{1/2} = \frac{\ln 2}{\lambda}$

Activity: $\left|\frac{dN}{dt}\right| = \lambda N \left[1\text{ Ci} = 3.70 \times 10^{10}\text{ decays/s}\right]$

1.1 Dosimetry

Absorbed dose: $\text{dose}_{\text{abs}} = E/m\,[1\text{ rad} = 0.01\text{ J/kg}]$

Effective dose: $\text{dose}_{\text{eff}} = \text{dose}_{\text{abs}} \times \text{ QF}$
$[1\text{ rem} = 1\text{ rad} \times 1\text{ QF}, 1\text{ Sv} = 100\text{ rem} = 1\text{ J/kg} \times 1\text{ QF}]$

2 Electricity

Elementary charge: $e = 1.60 \times 10^{-19}\text{ C}$

Coulomb const.: $k = \frac{1}{4\pi\epsilon_0} = 8.99 \times 10^{9}\text{ N}\cdot\text{m}^2/\text{C}^2$

Permittivity: $\epsilon_0 = 8.85 \times 10^{-12}\text{ C}^2/\text{N}\cdot\text{m}^2$

Electron Volt: $1\text{ eV} = 1.60 \times 10^{-19}\text{ J}$

2.1 Electric Field

Coulomb's law: $\mathbf{F}_{12} = k\frac{Q_1 Q_2}{r^2}\hat{\mathbf{r}}_{21}$

Force on q**:** $\mathbf{F} = q\mathbf{E}$

Coulomb's law: $\mathbf{E} = \frac{kQ}{r^2}\hat{\mathbf{r}}$

Gauss's law: $\Phi_E = \sum_{\text{surfaces}} E_\perp A = \frac{Q_{\text{encl}}}{\epsilon_0}$

2.2 Potential

Potential energy of q**:** $U = qV$

Gradient of V**:** $E_l = -\frac{dV}{dl}$

Uniform field: $V = -E_l l$

Point charge: $V = \frac{kQ}{r}$

2.3 Capacitance

Capacitance: $Q = CV\,[1\text{ F} = 1\text{ C/V}]$

Parallel plates: $C = \frac{\epsilon_0 A}{d}$

...In series: $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + ...$

...In parallel: $C_{eq} = C_1 + C_2 + ...$

Potential energy: $U = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$

Dielectric: $C = KC_0$

2.4 Current and Resistance

Current: $I = \frac{dQ}{dt}\ [1\text{ A} = 1\text{ C/s}]$

Ohm's law: $V = IR$

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

...In series $R_{eq} = R_1 + R_2 + ...$

...In parallel $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + ...$

Power: $P = IV\,[1\text{ W} = 1\text{ J/s}]$

3 Magnetism

Permeability: $\mu_0 = 4\pi \times 10^{-7}\text{ T}\cdot\text{m/A}$

3.1 Magnetic field

Force on wire: $F = IlB_\perp \left[1\text{ T} = 1\text{ N/A}\cdot\text{m}, 1\text{ G} = 10^{-4}\text{ T}\right]$

Force on charge: $F = qvB_\perp$

Ampère's law: $\sum_{\text{segments}} B_\parallel l = \mu_0 I_{\text{encl}}$

Long wire: $B = \frac{\mu_0 I}{2\pi r}$

Solenoid: $B = \mu_0 \frac{N}{l} I$

3.2 Induction

Flux: $\Phi_B = NB_\perp A \left[1\text{ Wb} = 1\text{ T}\cdot\text{m}^2\right]$

Faraday's law: $\mathscr{E} = -\frac{d\Phi_B}{dt}$

Transformer: $\frac{V_p}{N_p} = \frac{V_s}{N_s}$

Self-inductance: $\mathscr{E} = -L\frac{dI}{dt}\ [1\text{ H} = 1\ \Omega\cdot\text{s}]$

Solenoid: $L = \frac{\mu_0 N^2 A}{l}$

Potential energy: $U = \frac{1}{2}LI^2$

4 Circuits

4.1 DC Circuits

Kirchhoff's branch: at a branch $\sum I_{in} = \sum I_{out}$

Kirchhoff's loop: around a loop $\sum V = 0$

Reaction Time:
$$\begin{aligned} I(t) - I_\infty &= (I_0 - I_\infty)\, e^{-t/\tau} \\ V(t) - V_\infty &= (V_0 - V_\infty)\, e^{-t/\tau} \end{aligned}$$

RC circuits: Time constant: $\tau = RC$
$I_{\infty,C} = 0$

LR circuits: Time constant: $\tau = \frac{L}{R}$
$V_{\infty,L} = 0$

4.2 AC Circuits

Sinusoidal: $V_{\text{RMS}} = \frac{V_0}{\sqrt{2}}$, $I_{\text{RMS}} = \frac{I_0}{\sqrt{2}}$

Angular frequency: $\omega = 2\pi f = \frac{2\pi}{T}$

L Reactance: $X_L = \omega L$

C Reactance: $X_C = \frac{1}{\omega C}$

LRC Impedance: $Z = \sqrt{R^2 + (X_L - X_C)^2}$

LRC Phase: $\cos\phi = \frac{R}{Z}$

LRC Resonance: $\omega_0 = \frac{1}{\sqrt{LC}}$

LRC Power: $\overline{P} = I^2_{\text{RMS}} R = I_{\text{RMS}} V_{\text{RMS}} \cos\phi$

5 Electromagnetic waves

Speed of light: $c = 3.00 \times 10^{8}\text{ m/s}$

Wavelength: $f\lambda = c$