Appendix 4
Useful Equations and Constants

EM Waves

\[ \lambda f = c; \ E = hf; \ \lambda = \frac{hc}{\Delta E}; \ c = 2.998 \times 10^8, \ 1 \text{ eV} = 1.602 \times 10^{-19} \text{ J} \]

\[ h = \text{Planck’s Constant} = \begin{cases} 
6.626 \times 10^{-34} \text{ J} \cdot \text{s} \\
4.136 \times 10^{-15} \text{ eV} \cdot \text{s} 
\end{cases} \]

\[ \Delta E (\text{eV}) = \frac{1.24 \times 10^{-6}}{\lambda (\text{m})} = \frac{1.24}{\lambda (\mu \text{m})} \]

Bohr Atom

\[ r_n (\text{m}) = n^2 \times 0.528 \times 10^{-10} / Z. \]

\[ E_n = -\frac{1}{2} \left( \frac{Ze^2}{4\pi \varepsilon_0 \hbar} \right)^2 \frac{m}{n^2} = Z^2 \frac{E_i}{n^2}; \ E_i = -\frac{me^4}{32\pi^2 \varepsilon_0 \hbar^2} = -13.58 \text{ eV}; \]

Blackbody Radiation

\[ k = 1.38 \times 10^{-23} \frac{\text{J}}{\text{K}}; \ \sigma = 5.67 \times 10^{-8} \frac{\text{W}}{\text{m}^2 \text{K}^4}; \ a = 2.898 \times 10^{-3} \text{ mK} \]

\[ \text{Radiance} = L = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda kT}} - 1} \]

\[ \text{Stefan-Boltzmann law:} \ R = \sigma \varepsilon T^4 \left( \frac{\text{W}}{\text{m}^2} \right) \]
Wien’s law: $\lambda_{\text{max}} = \frac{a}{T}$

$T_{\text{radiance}} = e^{1/4} T_{\text{kinetic}}$

Reflection and Refraction

$$n = \frac{c}{v} \quad n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$r_\perp = \frac{n_1 \cos \theta_1 - n_2 \cos \theta_2}{n_1 \cos \theta_1 + n_2 \cos \theta_2} \quad r_\parallel = \frac{n_2 \cos \theta_1 - n_1 \cos \theta_2}{n_2 \cos \theta_1 + n_1 \cos \theta_2} \quad R = \left( \frac{n_1 - n_2}{n_1 + n_2} \right)^2$$

Optics

$$\frac{1}{f} = \frac{1}{i} + \frac{1}{o}; \quad f/# = \frac{\text{focal length}}{\text{diameter}}$$

Rayleigh criteria: $\text{GSD} = \Delta \theta \cdot \text{range} = \frac{1.22 \times \lambda}{\text{diameter}} \cdot \text{range}$

Orbital Mechanics and Circular Motion

$$v = \omega r; \quad \omega = 2\pi \frac{f}{\tau}; \quad \tau = \frac{1}{f} = \frac{2\pi}{\omega}$$

$$F_{\text{centripetal}} = m \frac{v^2}{r} = m \omega^2 r$$

$$\mathbf{F} = -G \frac{m_1 m_2}{r^2}, \quad F = g_o m \left( \frac{R_{\text{Earth}}}{r} \right)^2; \quad G = 6.67 \times 10^{-11} \text{N} \text{ m}^2 \text{ kg}^{-2};$$

$$g_o = G \frac{m_{\text{Earth}}}{R_{\text{Earth}}^2} = 9.8 \frac{m}{s^2}$$

$R_{\text{Earth}} = 6.38 \times 10^6 \text{ m}, m_{\text{Earth}} = 5.9736 \times 10^{24} \text{ kg}.$

Circular motion: $v = \sqrt{\frac{g_o}{r} R_{\text{Earth}}}$

Elliptical orbit: $v = \sqrt{GM \left( \frac{2}{r} - \frac{1}{a} \right)}$

$$\tau^2 = \frac{4\pi^2}{g_o R_{\text{Earth}}^2} r^3 = \frac{4\pi^2}{M_{\text{Earth}} G} r^3$$
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