Modern Physics

Constants and units:

$\sigma = 5.67 \times 10^{-8}$ W/m^{2}K^4, $h = 6.63 \times 10^{-34}$ Js $= 4.14 \times 10^{-15}$ eV s, $\hbar = 1.06 \times 10^{-34}$ Js,

$k_B = 1.38 \times 10^{-23}$ J/K, $c = 3 \times 10^8$ m/s, $c^2 = 931.5$ MeV/u, $e = 1.6 \times 10^{-19}$ C,

$\epsilon_0 = 8.85 \times 10^{-12}$ F/m,

$m_e = 9.11 \times 10^{-31}$ kg, $m_p = 1.6726 \times 10^{-27}$ kg, $m_n = 1.6750 \times 10^{-27}$ kg,

1 eV$= 1.6 \times 10^{-19}$ J, 1 fm$= \times 10^{-15}$ m, 1 Å$= 10^{-10}$ m,

20 $^\circ C = 293$ K, $T = 273 + \theta$

Unit combinations:

$m_e c^2 = 0.511$ MeV ≈ 0.5 MeV, $m_p c^2 = 938.28$ MeV, $m_n c^2 = 939.57$ MeV,

$hc = 12400$ eVÅ, $\hbar c = 1973$ eVÅ, $m_p = 1836\, m_e \approx 2000\, m_e$,

$k_B T_0 = 1/40$ eV ($T_0 = 300$ K), $ke^2 = 14.4$ eVÅ

Useful formulas:

$$I(T) = \sigma T^4, \quad \lambda_{\max} T = 0.2898\,\mathrm{cmK}, \quad E(T) = \frac{3}{2} k_B T,$$

$$hf = \Phi + K_e,$$

$$E = \sqrt{p^2c^2 + m^2c^4} = mc^2 + K, \quad K = \frac{1}{2}mv^2 = \frac{p^2}{2m},$$

$$E = hf = \hbar\omega, \quad p = h/\lambda,$$

$$\Delta\lambda = \lambda' - \lambda = \lambda_c(1 - \cos\theta), \quad \lambda_c = h/mc,$$

$$a_o = \hbar^2/km_e e^2 = 0.529 \text{ Å} \approx 0.5 \text{ Å}, \quad r_n = n^2 a_o/Z, \quad v_n = \frac{kZe^2}{\hbar}\frac{1}{n} = Z\alpha c/n,$$

$$\alpha = ke^2/\hbar c = 1/137, \quad l_n = nh, \quad E_n = -\frac{m_e Z^2 k^2 e^4}{2\hbar^2}\frac{1}{n^2} = -13.6\, Z^2/n^2 \text{ eV},$$

$$\psi_n(x) = \sqrt{2/L}\sin(n\pi x/L), \quad E_n = \frac{\hbar^2\pi^2}{2mL^2}\, n^2,$$

$$\psi_n(x) = H_n(x)\, e^{-x^2/2a^2}, \quad E_n = (n + 1/2)\hbar\omega, \quad a = \sqrt{\hbar/m\omega},$$

$$T \approx \mathrm{e}^{-2\gamma L}, \quad \gamma = \sqrt{2m(V - E)/\hbar^2},$$

$$L = \sqrt{l(l+1)}\hbar, \quad L_z = m_l\hbar, \quad \cos\theta = m_l/\sqrt{l(l+1)},$$

$$(\Delta x)(\Delta p_x) \approx \hbar, \quad (\Delta A)^2 = < A^2 > - < A >^2$$

$$\Delta l = \pm 1, \quad \Delta m = 0, \pm 1,$$

$$E_J^{\mathrm{rot}} = \frac{\hbar^2}{2I}J(J+1), \quad E_\nu^{\mathrm{vibr}} = (\nu + \frac{1}{2})\hbar\omega, \quad E_{J,\nu}^{\mathrm{rot-vibr}} = \frac{\hbar^2}{2I}J(J+1) + (\nu + \frac{1}{2})\hbar\omega,$$

$$I_{cm} = \mu R^2, \quad \mu^{-1} = m_1^{-1} + m_2^{-1},$$

$$\int_{-\infty}^{+\infty} x^{2n}\mathrm{e}^{-ax^2}dx = \frac{1\cdot 3\cdot 5\ldots(2n-1)}{(2a)^n}\sqrt{\frac{\pi}{a}}, \quad \int_{-\infty}^{+\infty}\mathrm{e}^{-ax^2}dx = \sqrt{\frac{\pi}{a}}, \quad \int_0^\infty r^n\mathrm{e}^{-\gamma r}dr = \frac{n!}{\gamma^{n+1}}$$