Useful Constants:

1 calorie = 4.186 J
Latent heat of vaporization of water = 539 cal/g = 2256 kJ/kg
Latent heat of fusion of water = 79.5 cal/g = 333 kJ/kg
Specific heat of water = 1 cal/g = 4.19 kJ/kg
1 atmosphere = 1.01E5 Pa
Universal Gas Constant, R = 8.31 J/mol.K
Boltzmann's constant, k = 1.38E-23 J/K
Stefan-Boltzmann constant, σ = 5.67E-8 W/m^2K^4
Avogadro's number, N_A = 6.02E23 mol^{-1}
Coulomb's constant, $(1/4\pi\varepsilon_0)$ = 8.99E9 $N.m^2/C^2$
Speed of light, c = 3.00E8 m/s
Charge of an electron, -e = -1.6E-19 C
Mass of the electron, m_e = 9.1E-31 kg = 511 keV/c^2 = 5.49E-4 u
Mass of the proton, m_p = 1.67E-27 kg = 938.3 MeV/c^2 = 1.00728 u
Mass of the neutron, m_n = 1.675E-27 kg = 939.6 MeV/c^2 = 1.00866 u
Mass of the α particle, m_α = 3727.4 MeV/c^2 = 4.00151 u
Planck's constant, h = 6.63E-34 J.s = 4.14E-15 eV.s
Planck's <u>reduced</u> constant, $\hbar = h/2\pi$ = 1.05E-34 J.s = 6.58E-16 eV.s
Compton Wavelength of the electron, $\lambda_c = h/m_ec$ = 2.4263E-12 m
The Bohr Magneton, μ_B = 5.79E-5 eV/T
Atomic mass unit, u = 1.66E-27 kg = 931.5 MeV/c^2
1 Curie = 3.7E10 Bq

Useful Formulae

$\Delta Q = mc\Delta T$ where m = mass, c = specific heat.

Heat conduction, $I = \Delta T/R$ in Watts where R = thermal resistance = $\Delta x/kA$ and Δx = thickness, A = area and k = thermal conductivity of the material.

$P_{RAD} = \sigma\varepsilon AT^4$ where ε = emissivity and A = area.

1st Law of Thermodynamics: $\Delta Q = \Delta W + \Delta U$

Ideal gas law: $PV = nRT$ Work done, $\Delta W = \int PdV$ $v_{rms} = \sqrt{(3RT/M)}$

Molar specific heats: $C_V = \Delta U/n\Delta T$ $C_P = \Delta Q/n\Delta T$ $C_P = C_V + R$ $\gamma = C_P/C_V$

$\Delta Q = nC\Delta T$

Adiabatic ==> $\Delta Q = 0$, and PV^γ = constant. Entropy change: $\Delta S = \int dQ/T$

Carnot engine efficiency, $\varepsilon_C = 1 - Q_C/Q_H = 1 - T_C/T_H$

Potential energy lost by a charge q in traversing a potential difference of V is U = qV

Wave relation: $v = \nu\lambda$ where v = velocity, ν = frequency, λ = wavelength.

$\beta = v/c$ $\gamma = 1/\sqrt{(1-\beta^2)}$ Length Contraction: $L' = L/\gamma$ Time Dilation, $T' = \gamma T$

Addition of Velocities: $v' = (v + u)/(1 + vu/c^2)$ Relativistic Doppler Effect: $\nu' = \frac{\sqrt{(1-\beta)}}{\sqrt{(1+\beta)}}\nu$

Momentum – Energy relations: $E^2 = p^2c^2 + m^2c^4$

$E = \gamma mc^2$ $p = \gamma mv$ $K = E - mc^2$

Planck's Relation: $E = h\nu$ Einstein's Photoelectric Law: $h\nu = K + \phi$

Compton Effect: $\Delta\lambda = \lambda' - \lambda = (1 - \cos\theta)h/m_e c$

Electrostatic potential at a distance R from a charge Q: $V = (1/4\pi\varepsilon_0)Q/R$

Bohr Quantization Relation: $L = mvr = n\hbar$

Atomic Radii: $r_n = n^2 a_0/Z$ where $a_0 = 5.29\text{E-}11$ m

Atomic Energies: $E_n = -Z^2E_0/n^2$ where $E_0 = 13.6$ eV

Impact parameter: $b = \dfrac{Z_1 Z_2 e^2}{8\pi\varepsilon_0 K}\cot(\theta/2)$ $\quad n = \rho N_A/A$

Fraction of α's scattered through θ or greater: $f = \pi b^2 nt$

Rutherford Scattering: $$N(\theta) = \frac{N_i\, n\, t\, e^4\, Z_1^2\, Z_2^2}{16\,(4\pi\varepsilon_0)^2\, r^2\, K^2 \sin^4(\theta/2)}$$

de Broglie wavelength: $\lambda = h/p$ Bragg's Law: $n\lambda = 2d\sin\theta$

Heisenberg Uncertainty Principle: $\Delta p_x \Delta x \geq \hbar/2$ $\quad \Delta E \Delta t \geq \hbar/2$

Probability = ψ^2 Normalization condition: $\int \psi^2 dx = 1$

Infinite Square Well Potential in 1-dim: $\psi = \sqrt{2/L}\,\sin(n\pi x/L)$ $\quad E_n = n^2\pi^2\hbar^2/2mL^2$

Infinite Square Well Potential in 3-dims: $E = \dfrac{\pi^2\hbar^2}{2m}(n_1^2/L_1^2 + n_2^2/L_2^2 + n_3^2/L_3^2)$

Simple Harmonic Oscillator: $V = \frac{1}{2}kx^2$ $\quad \omega^2 = k/m$ $\quad E_n = (n+\frac{1}{2})\hbar\omega$

Quantum number relations: $n > 0$ $\quad l < n$ $\quad \mathbf{L} = \sqrt{l(l+1)}\,\hbar$ $\quad |m_l| \leq l$ $\quad L_z = m_l\hbar$

$s = \pm\frac{1}{2}$ $\quad \mathbf{S} = \sqrt{s(s+1)}\,\hbar$ $\quad \mathbf{J} = \mathbf{L} + \mathbf{S}$ $\quad j = l \pm s$

	S	P	D	F	G
L =	0	1	2	3	4

Spectroscopic Notation: $n^{2s+1}L_j$

Zeeman Effect: $V_B = -\boldsymbol{\mu}\cdot\mathbf{B} = \mu_B B m_l$ or $2\mu_B B m_s$

Anomalous Zeeman Effect: $V_B = \mu_B B g m_j$ where g = Landé g-factor $= 1 + \dfrac{J(J+1)+S(S+1)-L(L+1)}{2J(J+1)}$

Radioactive decay law: $N = N_o e^{-\lambda t}$ with $t_{1/2} = 0.693/\lambda$

Activity: $R = \lambda N$ $\quad$ 1 Becquerel (Bq) = 1 decay/s

Q-value: $Q = (M_x + M_X - M_y - M_Y)c^2$