

Physical Constants and Conversion Factors

© M. Ragheb

8/14/2010

Physical Constants

c = speed of light = $(2.99793 \pm 0.00001) \times 10^{10}$ [cm/s] = 186,284 [mi/s]

e = elementary (electron) charge = $(1.60207 \pm 0.00007) \times 10^{-19}$ [abs coulombs] = $(4.80288 \pm 0.00021) \times 10^{-10}$ [esu]

r_0 = classical electron radius = $e^2 / m_0 c^2 = 2.818 \times 10^{-13}$ [cm]

e/m = specific elementary charge = $(1.75888 \pm 0.00005) \times 10^{11}$ [abs coulombs/kg]

g = acceleration due to gravity (standard) = 32.174 [ft/s²] = 980.665 [cm/s²] = 386.09 [in/s²] = 21.94 [mi/h-s]

N_a = Avogadro's number = $(6.02472 \pm 0.00036) \times 10^{23}$ [molecules/g-mole] (physical scale) = $(6.02308 \pm 0.00040) \times 10^{23}$ [molecules/g-mole] (chemical scale)

k = Boltzmann's constant = $(1.38042 \pm 0.00010) \times 10^{-16}$ [ergs/⁰K]

h = Planck's constant = $(6.6262 \pm 0.00005) \times 10^{-27}$ [erg.s]

$hc = 12.4$ [keV.Å]

$h/2\pi = \hbar = 1.0544 \times 10^{-27}$ [erg.sec] = 0.6582×10^{-15} [eV.sec]

σ = Stefan-Boltzmann Law (for blackbody) = $(5.6686 \pm 0.0005) \times 10^{-5}$ [erg/cm² s(⁰K)⁴]

F = Faraday constant = (96.520 ± 3) [abs coulombs/g equivalent]

ϵ_0 = permittivity of free space = $1/\mu_0 c^2 = (8.8542 \pm 0.0001) \times 10^{-12}$ [farad/m]

μ_0 = permeability of free space = 12.5664×10^{-7} [henry/m]

$\alpha_0 = h^2/4\pi m e^2$ = first Bohr's radius = $(5.29171 \pm 0.00006) \times 10^{-9}$ [cm]

R_0 = gas constant per mole = $(8.31662 \pm 0.00038) \times 10^7$ [erg/⁰K-mole] (physical scale) = $(8.20545 \pm 0.00037) \times 10^2$ [liter atm/⁰K-mole] (chemical scale)

Fine structure constant = $e^2/\hbar c = 2\pi e^2/\hbar c = 1/137$

Conversions

1 [barn (b) cross section] = 10^{-24} [cm²]

1 [Curie (Ci) activity] = 3.7×10^{10} [transformations/s] = 3.7×10^{10} [Becquerel (Bq)] = 2.22×10^{12} [transformations/min] = 3.7×10^4 [Rutherford]

1 [Bq] = 1 [transformation/s]

1 [Röntgen of exposure] = ionization by x or gamma rays resulting in 1 esu of charge in 1 cm³ of air (STP) = 1.61×10^{12} [ion pairs/gm of air]

STP = standard temperature and pressure = 0 ⁰C and 760 [mm Hg]

Rest energy of the electron = 0.51098 [MeV]

Electron mass = $m_e = (9.1085 \pm 0.0006) \times 10^{-28}$ [g] = 0.51098 [MeV] = 5.48760×10^{-4} [amu]

Proton mass = $(1.67243 \pm 0.00010) \times 10^{-24}$ [g] = 938.232 [MeV] = 1.00727 [amu]

Neutron mass = $(1.67474 \pm 0.00010) \times 10^{-24}$ [g] = 939.526 [MeV] = 1.00866 [amu]

Alpha particle mass = $(6.6442 \pm 0.0012) \times 10^{-24}$ [g] = 3727.377 [MeV] = 4.00260 [amu]

Hydrogen atomic mass = $(1.67335 \pm 0.00010) \times 10^{-24}$ [g] = 938.743 [MeV] = 1.00782 [amu]

1 [amu (Atomic Mass Unit)] = 1.6605×10^{-27} [kg] = 1.6605×10^{-24} [gm] = 931.48 [MeV]

M = mass of the earth = 5.983×10^{24} [kg] = 6.595×10^{21} [tons]

$G = \text{Newton's gravity constant} = (6.670 \pm 0.005) \times 10^{-8} \text{ [cm}^3/\text{g.s]}$
 $1 \text{ [kWh]} = 4.2 \times 10^{-5} \text{ g U}^{235} \text{ fission}$
 $= 6.4 \times 10^{-6} \text{ g T in DT fusion reaction}$
 $= \text{Average noon insolation in 1 h on horizontal plane of } 1 \text{ m}^2 \text{ area}$
 $= 0.74 \text{ lb (highest power station efficiency on 12,500 [Btu/lb] coal)}$
 $1 \text{ eV} = 1.61 \times 10^{-12} \text{ [erg]}$
 $\pi = 3.1415926535$
 $e = 2.7182818284$
 $\log_e n = \log_e 10 \times \log_{10} n = 2.3026 \log_{10} n$

Time (T)

$1 \text{ [week]} = 7 \text{ [days]} = 168 \text{ [h]} = 10,080 \text{ [min]} = 604,800 \text{ [s]}$
 $1 \text{ [mean solar day]} = 1440 \text{ [min]} = 86,400 \text{ [s]}$
 $1 \text{ [calendar year]} = 365 \text{ [days]} = 8760 \text{ [h]} = 5.256 \times 10^5 \text{ [min]} = 3.1536 \times 10^7 \text{ [s]}$
 $1 \text{ [sidereal year]} = 365.256 \text{ [days (mean solar)]} = 8766.14 \text{ [h (mean solar)]}$

Mass (M)

$1 \text{ [gram (g)]} = 2.20462 \times 10^{-3} \text{ [lb (av)]} = 0.03527 \text{ [oz (av)]} = 15.4324 \text{ [grains]}$
 $1 \text{ [pound (lb) avoirdupois (av)]} = 16 \text{ [oz (av)]} = 7,000 \text{ [grains]} = 256 \text{ [drams (av)]} = 453.5924 \text{ [g]}$
 $1 \text{ [ounce (oz) (av)]} = 16 \text{ [drams (av)]} = 437.5 \text{ [grains]} = 28.34953 \text{ [g]}$
 $1 \text{ [short ton]} = 2,000 \text{ [lb (av)]} = 907.185 \text{ [kg]} = 20 \text{ [hundredweight (long)]}$
 $1 \text{ [long ton]} = 2,240 \text{ [lb (av)]} = 1,016.0470 \text{ [kg]} = 20 \text{ [hundredweight (long)]}$
 $1 \text{ [metric tonne]} = 1,000 \text{ [kgs]}$
 $1 \text{ [kg]} = 1,000 \text{ [gms]}$

Density (ML⁻³)

$1 \text{ [lb/ft}^3\text{]} = 5.787 \times 10^{-4} \text{ [lb/in}^3\text{]} = 16.018 \text{ [kg/m}^3\text{]} = 1.6018 \times 10^2 \text{ [g/cm}^3\text{]}$
 $1 \text{ [g/cm}^3\text{]} = 0.03613 \text{ [lb/in}^3\text{]} = 64.23 \text{ [lb/ft}^3\text{]}$

Pressure (ML⁻¹T⁻²)

$1 \text{ [atmosphere (atm)]} = 1.0133 \text{ [bar]} = 14.696 \text{ [lb/in}^2\text{]} = 1.013246 \times 10^6 \text{ [dyn/cm}^2\text{]} = 760 \text{ [Torr]} =$
 $1033.2 \text{ [g/cm}^2 \text{ (0 } ^\circ\text{C)}] = 760 \text{ [mm Hg (0 } ^\circ\text{C)}] = 29.921 \text{ [in Hg (0 } ^\circ\text{C)}] = 33.903 \text{ [ft water (0 } ^\circ\text{C)}]$
 $1 \text{ [dyn/cm}^2\text{]} = 1.01971 \times 10^{-3} \text{ [g/cm}^2\text{]} = 1.4504 \times 10^{-5} \text{ [lb/in}^2\text{]}$
 $1 \text{ [bar]} = 1.0 \times 10^6 \text{ [dyn/cm}^2\text{]} = 0.98692 \text{ [atm]}$
 $1 \text{ [lb wt/ in}^2\text{]} = 70.307 \text{ [g/cm}^2\text{]} = 68.947 \text{ [dyn/cm}^2\text{]}$

Speed (LT⁻¹)

$1 \text{ m/s} = 3.6 \text{ km/h} = 2.237 \text{ mph} = 1.944 \text{ knots}$
 $1 \text{ knot} = 1 \text{ nautical mile per hour} = 0.5144 \text{ m/s} = 1.852 \text{ km/h} = 1.125 \text{ mph}$

Acceleration (LT⁻²)

$$1 \text{ [ft/s}^2\text{]} = 30.4801 \text{ [cm/s}^2\text{]} = 0.6818 \text{ [mi/h-s]}$$

Energy and Work (MLT⁻²)

$$1 \text{ atomic mass unit [amu]} = 931.494 \text{ [MeV]} = 1.66054 \times 10^{-24} \text{ [gm]}$$

$$1 \text{ electron volt [eV]} = 1.60207 \times 10^{-19} \text{ [J (abs)]}$$

$$1 \text{ [Joule (International)]} = 1.000165 \text{ [Joule (abs)]}$$

$$1 \text{ [absolute (abs) Joule (J)]} = 1 \text{ [N meter (N.m)]} = 1 \times 10^7 \text{ [ergs]} = 1 \times 10^7 \text{ [dyn.cm]} = 1 \text{ [W.s]} = 1 \text{ [V.coulomb]} = 0.73756 \text{ [ft.lb]} = 2.3889 \times 10^4 \text{ [kg.calorie (mean)]} = 9,4805 \times 10^4 \text{ [Btu (mean)]} = 23.730 \text{ [ft.poundal]} = 2.778 \times 10^{-7} \text{ [kWh]} = 3.725 \times 10^{-7} \text{ [hp.h]}$$

$$1 \text{ [g calorie]} = 4.186 \text{ [J (abs)]}$$

$$1 \text{ [g calorie (15 }^\circ\text{C)]} = 4.1855 \text{ [J (abs)]} = 0.003968 \text{ [Btu]}$$

$$1 \text{ [kWh]} = 3413.0 \text{ [Btu (mean)]} = 2.6552 \times 10^6 \text{ [ft.lb]} = 1.3410 \text{ [hp.h]}$$

$$1 \text{ [liter atm (normal)]} = 3.7745 \times 10^{-5} \text{ [hp.h]} = 24.206 \text{ [g cal (mean)]} = 101.328 \text{ [J (abs)]}$$

$$\text{J (Joule)} = 1 \text{ W.sec} = 0.2388 \text{ cal}$$

$$1\text{J} = 10^7 \text{ ergs}$$

$$1 \text{ GJ (Gigajoule)} = 10^9 \text{ J}$$

$$1 \text{ TJ (Terajoule)} = 10^{12} \text{ J}$$

$$1 \text{ PJ (Petajoule)} = 10^{15} \text{ J}$$

$$1 \text{ kWhr (kilo Watt hour)} = 3,600,000 \text{ Joules}$$

$$1 \text{ toe (tonne oil equivalent)}$$

$$= 7.4 \text{ barrels of crude oil, primary energy}$$

$$= 7.8 \text{ barrels, total final consumption}$$

$$= 1270 \text{ m}^3 \text{ of natural gas (methane)}$$

$$= 2.3 \text{ metric tonnes of coal}$$

$$1 \text{ Mtoe (Million metric tonnes oil equivalent)} = 41.868 \text{ PJ}$$

$$1 \text{ cal} = 4.12 \text{ J}$$

$$1 \text{ kilocalorie (1 Cal, the unit used in nutrition)} = 1 \text{ kcal} = 1,000 \text{ calories}$$

$$1 \text{ BTU} = 1055 \text{ J}$$

$$1 \text{ barrel of oil (42 gal)} = 6.12 \times 10^9 \text{ J} = 1.7 \times 10^3 \text{ kWh}$$

$$1 \text{ ton of coal} = 2.5 \times 10^7 \text{ BTU} = 2.2 \times 10^{10} \text{ J}$$

$$1 \text{ cubic foot of natural gas} = 1,000 \text{ BTU}$$

$$1 \text{ therm} = 10^5 \text{ BTU} = 100 \text{ cu ft of natural gas}$$

$$1 \text{ quad} = 10^{15} \text{ BTU}$$

$$1 \text{ kWh} = 3.6 \times 10^6 \text{ J} = 3.4 \times 10^3 \text{ BTU}$$

Power

$$1 \text{ horsepower} = 0.75 \text{ kW}$$

$$1 \text{ W (Watt)} = 1 \text{ J/sec}$$

$$1 \text{ kW} = 1.359 \text{ HP}$$