B CONSTANT & CONVERSION FACTORS

B.1. UNIVERSAL CONSTANTS
[from US National Institute of Standards and Technology (NIST), based on 2014 CODATA]

- $c_0 = 2.99792458 \times 10^8 \text{ m} \cdot \text{s}^{-1}$ = speed of light in a vacuum
- $c_1 = 3.741771790 \times 10^8 \text{ W} \cdot \text{m}^{-2} \cdot \text{um}^4$ = first radiation constant (in Planck’s law)
- $c_{1B} = 1.191042953 \times 10^8 \text{ W} \cdot \text{m}^{-2} \cdot \text{um}^4 \cdot \text{sr}^{-1}$ = first radiation constant for spectral radiance
- $c_2 = 1.43877736 \times 10^4 \text{ um} \cdot \text{K}$ = second radiation constant (in Planck’s law)
- $G = 6.67408 \times 10^{-11} \text{ m}^3 \cdot \text{s}^{-2} \cdot \text{kg}^{-1}$ = Newtonian gravitational constant
- $h = 6.62607004 \times 10^{-34} \text{ J} \cdot \text{s}$ = Planck constant
- $k_B = 1.38064852 \times 10^{-23} \text{ J} \cdot \text{K}^{-1} \cdot \text{molecule}^{-1}$ = Boltzmann constant
- $N_A = 6.022140857 \times 10^{23} \text{ mol}^{-1}$ = Avogadro constant
- $\sigma_{SB} = 5.670367 \times 10^{-8} \text{ W} \cdot \text{m}^{-2} \cdot \text{K}^{-4}$ = Stefan-Boltzmann constant
- $T = -273.15^\circ\text{C} = 0 \text{ K}$ = absolute zero (not considered a true universal constant)

B.2. MATH CONSTANTS
[from CRC Handbook of Chemistry and Physics]
- $e = 2.718281828459$ = base of natural logarithms
- $1/e = 0.367879441$ = e-folding ratio
- $\pi = 3.141592653589793238462643$ = pi
- $\sqrt{2} = 1.414213562373095$

B.3. EARTH CHARACTERISTICS

1° latitude = 111 km = 60 nautical miles (nm) [Caution: This relationship does NOT hold for degrees longitude.]
- $a = 149.598 \text{ Gm}$ = semi-major axis of Earth orbit
- $A = 0.306$ = Bond albedo (NASA 2015)
- $A = 0.367$ = visual geometric albedo (NASA 2015)
- $b = 149.090 \text{ Gm}$ = semi-minor axis of Earth orbit
- $d = 149.5978707 \text{ Gm}$ = average sun-Earth distance
- $d_{ap} = 152.10 \text{ Gm}$ = furthest sun-Earth distance, which occurs about 4 July (NASA 2015)
- $d_{pe} = 147.09 \text{ Gm}$ = closest sun-Earth distance, which occurs about 3 January (NASA 2015)
- $d_e = 173$ = 22 June = approx. day of summer solstice
- $e = 0.0167$ = eccentricity of Earth orbit around sun
- $g = -9.80665 \text{ m} \cdot \text{s}^{-2}$ = average gravitational acceleration on Earth at sea level (negative = downward) (from 2014 CODATA)

- $|g| = g_0 \cdot [1 + A \sin^2(\phi) - B \sin^2(2\phi)] - CH$
- $M = 5.9726 \times 10^{24} \text{ kg}$ = mass of Earth (NASA 2015)
- $P_{earth} = 365.256 \text{ days}$ = Earth orbital period (2015)
- $P_{moon} = 27.3217 \text{ days}$ = lunar orbital period (2015)
- $P_{sidereal} = 23.9344696 \text{ h}$ = sidereal day = period for one revolution of the Earth about its axis, relative to fixed stars
- $R_{earth} = 6371.0 \text{ km}$ = volumetric average Earth radius (from NASA 2015)
- $R_{equator} = 6378.1 \text{ km}$ = Earth radius at equator
- $R_{poles} = 6356.8 \text{ km}$ = Earth radius at poles
- $S = 1367.6 \text{ W} \cdot \text{m}^{-2}$ = solar irradiance (solar constant)
- $T_r = 254.3 \text{ K}$ = effective radiation emission black-body temperature of Earth system (NASA 2015)
- $\Phi_r = 23.44^\circ = 0.4091$ radians = tilt of Earth axis = obliquity relative to the orbital plane (2015)
- $\Omega = 0.7292107 \text{ x}10^{-4} \text{ s}^{-1}$ = sidereal rotation frequency of Earth (NASA 2015)
- $2\Omega = 1.458421 \text{ x}10^{-4} \text{ s}^{-1}$ = Coriolis factor
- $2\Omega / R_{earth} = 2.289 \times 10^{-11} \text{ m}^{-1} \cdot \text{s}^{-1}$ = beta factor

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B.4. AIR AND WATER CHARACTERISTICS

\[ a = 0.0337 \text{ (mm/day)} \cdot \left(\frac{W}{m^2}\right)^{-1} = \text{water-depth evaporation per unit latent-heat flux} \]

\[ B = 3 \times 10^9 \text{ Vkm}^{-1} = \text{breakdown potential for dry air} \]

\[ C_{vd} = 717 \text{ Jkg}^{-1} \text{K}^{-1} = \text{specific heat for dry air at constant volume} \]

\[ C_{pd} = 1003 \text{ Jkg}^{-1} \text{K}^{-1} = \text{specific heat for dry air at constant pressure at } -23^\circ\text{C} \]

\[ = 1004 \text{ Jkg}^{-1} \text{K}^{-1} = \text{specific heat for dry air at constant pressure at } 0^\circ\text{C} \]

\[ = 1005 \text{ Jkg}^{-1} \text{K}^{-1} = \text{specific heat for dry air at constant pressure at } 27^\circ\text{C} \]

\[ C_{po} = 1850 \text{ Jkg}^{-1} \text{K}^{-1} = \text{specific heat for water vapor at constant pressure at } 0^\circ\text{C} \]

\[ = 1875 \text{ Jkg}^{-1} \text{K}^{-1} = \text{specific heat for water vapor at constant pressure at } 15^\circ\text{C} \]

\[ C_{liq} = 4217.6 \text{ Jkg}^{-1} \text{K}^{-1} = \text{specific heat of liquid water at } 0^\circ\text{C} \]

\[ C_{ice} = 2106 \text{ Jkg}^{-1} \text{K}^{-1} = \text{specific heat of ice at } 0^\circ\text{C} \]

\[ D = 2.11 \times 10^{-5} \text{ m}^2\text{s}^{-1} = \text{molecular diffusivity of water vapor in air in standard conditions} \]

\[ e_s = 0.611 \text{ kPa} = \text{reference vapor pressure at } 0^\circ\text{C} \]

\[ k = 0.0253 \text{ Wm}^{-1} \text{K}^{-1} = \text{molecular conductivity of air at sea level in standard conditions} \]

\[ L_d = 2.834 \times 10^6 \text{ Jkg}^{-1} = \text{latent heat of deposition at } 0^\circ\text{C} \]

\[ L_f = 3.34 \times 10^5 \text{ Jkg}^{-1} = \text{latent heat of fusion at } 0^\circ\text{C} \]

\[ L_v = 2.501 \times 10^6 \text{ Jkg}^{-1} = \text{latent heat of vaporization at } 0^\circ\text{C} \]

\[ n = 3.3 \times 10^{28} \text{ molecules m}^{-3} \text{ for liquid water at } 0^\circ\text{C} \]

\[ n_{air} = 1.00277 = \text{index of refraction for air} \]

\[ n_{water} = 1.336 = \text{index of refraction for liquid water} \]

\[ n_{ice} = 1.312 = \text{index of refraction for ice} \]

\[ P_{STP} = 101.325 \text{ kPa} = \text{standard sea-level pressure (STP = Standard Temperature & Pressure)} \]

\[ \mathcal{R}_d = 0.287053 \text{ kPaK}^{-1}\text{m}^{-3}\text{kg}^{-1} = C_{pd} - C_{vd} \]

\[ \mathcal{R}_v = 287.053 \text{ JK}^{-1}\text{kg}^{-1} = \text{gas constant for dry air} \]

\[ \mathcal{R}_d = 461.5 \text{ JK}^{-1}\text{kg}^{-1} = \text{water-vapor gas constant} \]

\[ = 4.61 \times 10^{-4} \text{ kPaK}^{-1}\text{m}^3\text{g}^{-1} \]

\[ R_i = 0.25 = \text{critical Richardson number (dimensionless)} \]

\[ s_o = 343.15 \text{ m} \text{s}^{-1} = \text{sound speed in standard, calm air} \]

\[ T_{STP} = 15^\circ\text{C} = \text{standard sea-level temperature} \]

\[ e_s = 0.622 \text{ gwaterkg}^{-1} = \mathcal{R}_d / \mathcal{R}_v = \text{gas constant ratio} \]

\[ \gamma = 0.0004 \text{ (gwaterkg}^{-1})^{-1}\text{K}^{-1} = C_v / L_v \]

\[ = 0.4 \text{ (gwaterkg}^{-1})^{-1}\text{K}^{-1} = \text{psychrometric constant} \]

\[ \Gamma_d = 9.75 \text{ Kkm}^{-1} = \left|\frac{\gamma}{k}\right| = \text{dry adiabatic lapse rate} \]

\[ \rho_{STP} = 1.225 \text{ kgm}^{-3} = \text{standard sea-level air density} \]

\[ \rho_{avg} = 0.689 \text{ kgm}^{-3} = \text{air density averaged over the troposphere (over } z = 0 \text{ to } 11 \text{ km)} \]

\[ \rho_{liq} = 999.84 \text{ kgm}^{-3} = \text{density of liquid water at } 0^\circ\text{C} \]

\[ = 1000.0 \text{ kgm}^{-3} = \text{density of liquid water at } 4^\circ\text{C} \]

\[ = 998.21 \text{ kgm}^{-3} = \text{density of liquid water at } 20^\circ\text{C} \]

\[ = 992.22 \text{ kgm}^{-3} = \text{density of liquid water at } 40^\circ\text{C} \]

\[ = 983.20 \text{ kgm}^{-3} = \text{density of liquid water at } 60^\circ\text{C} \]

\[ = 971.82 \text{ kgm}^{-3} = \text{density of liquid water at } 80^\circ\text{C} \]

\[ = 958.40 \text{ kgm}^{-3} = \text{density of liquid water at } 100^\circ\text{C} \]

\[ \rho_{sea-water} = 1025 \text{ kgm}^{-3} = \text{avg. density of sea water} \]

\[ \text{(sea water contains 34.482 g of salt ions per kg of water, on average)} \]

\[ \rho_{ice} = 916.8 \text{ kgm}^{-3} = \text{density of ice at } 0^\circ\text{C} \]

\[ \sigma = 0.076 \text{ Nm}^{-1} = \text{surface tension of pure water at } 0^\circ\text{C} \]

B.5. CONVERSION FACTORS & COMBINED PARAMETERS

\[ C_{pd} / C_{vd} = k = 1.400 \text{ (dimensionless)} \]

\[ = \text{specific heat ratio} \]

\[ C_{pd} / \left|\gamma\right| = 102.52 \text{ mK}^{-1} \]

\[ C_{pd} / L_v = 0.0004 \text{ (gwaterkg}^{-1})^{-1}\text{K}^{-1} = \gamma \]

\[ = 0.4 \text{ (gwaterkg}^{-1})^{-1}\text{K}^{-1} = \text{psychrometric constant} \]

\[ C_{pd} / \mathcal{R}_d = 3.50 \text{ (dimensionless)} \]

\[ C_{vd} / C_{pd} = 1/k = 0.714 \text{ (dimensionless)} \]

\[ \left|\gamma\right| / C_{pd} = \Gamma_d = 9.8 \text{ Kkm}^{-1} = \text{dry adiabatic lapse rate} \]

\[ \left|\gamma\right| / \mathcal{R}_d = 0.0342 \text{ Kkm}^{-1} = 1/(\text{hypsomeric constant}) \]

\[ L_v / C_{pd} = 2.5 \text{ K/(gwaterkg}^{-1}) \]

\[ L_v / \mathcal{R}_d = 5423 \text{ K} = \text{Clausius-Clapeyron parameter for vaporization} \]

\[ \mathcal{R}_d / C_{pd} = 0.28571 \text{ (dimensionless)} \]

\[ \mathcal{R}_d / \left|\gamma\right| = \varepsilon = 0.622 \text{ gwaterkg}^{-1} = \text{gas constant ratio} \]

\[ \mathcal{R}_d / L_v = 29.29 \text{ mK}^{-1} \]

\[ \rho_{air} \cdot C_{pd air} = 1231 \text{ (Wm}^{-2}) / (\text{Km}^{-1}) \text{ at sea level} \]

\[ = 12.31 \text{ mbK}^{-1} \text{ at sea level} \]

\[ = 1231 \text{ kPaK}^{-1} \text{ at sea level} \]

\[ \rho_{air} \cdot \left|\gamma\right| = 12.0 \text{ kgm}^{-2} \text{K}^{-1} \text{ at sea level} \]

\[ = 0.12 \text{ mbm}^{-1} \text{ at sea level} \]

\[ = 0.012 \text{ kPa} \text{ at sea level} \]

\[ \rho_{air} \cdot L_v = 3013.5 \text{ (Wm}^{-2}) / [(\text{gwaterkg}^{-1}) \text{m}^{-3})] \text{ at sea level} \]

\[ \rho_{liq} \cdot C_{liq} = 4.295 \times 10^6 \text{ (Wm}^{-2}) / (\text{Km}^{-1}) \]

1 megaton nuclear explosion = 4x10^{15} J

2π radians = 360°

(1–ε)/ε = 0.61 = virtual temperature constant