SI Units, Conversion Factors, Formulas, Constants & Other Information

SI Base Units

Quantity	Symbol	Unit	Abbr.
length	l	meter	m
mass	m	kilogram	kg
volume	V	cubic meter	m^3
time	t	second	s
energy	E	Joule	J
pressure	P	Pascal	Pa
electric current	I	ampere	A
temperature	T	Kelvin	K
amount of substance	n	mole	mol
luminous intensity	I	candela	cd

Abbreviations and Symbols

_	alpha radiation	k	kilo–
_	beta radiation	L	liter
_	gamma radiation	_	azimuthal quantum #
Δ	change in, add heat	M	molarity, mega–
_	mole fraction	m	mass, meter, milli–, molality
_	wavelength		
_	frequency	mi	mile
_	micro-	min	minute
_	take the sum of	mol	mole
Å	Angstrom (length)	N	Newton (force)
C	Coulomb (charge)	N_A	Avogadro's number
c	speed of light, centi-	n	principle quantum #, number of moles, nano-
c_p	specific heat capacity		
D	density	P	pressure
d	orbital shape, deci-	Pa	Pascal (pressure)
E	energy	p	momentum, orbital shape, pico-
F	force, Faraday const.		
f	orbital shape	q	heat
G	free energy, giga–	R	gas constant
g	gram, gas	S	entropy
H	enthalpy	s	second, orbital shape, solid
Hz	hertz (frequency)		
h	Planck's const, hecto-	T	temperature, tera–
J	Joule	u	atomic mass unit
K	Kelvin (temperature)	V	volume
K_a	acid ionization const.	Z	atomic number
K_b	base ionization const.	_	"yields"
K_{eq}	equilibrium constant	–	forms a precipitate
K_{sp}	solubility product const.	–	gaseous product

Rules for Significant Digits

1. There is no uncertainty in counting or exact numbers.
2. The digits {1, 2, 3, 4, 5, 6, 7, 8, 9} are always significant.
3. Zeros are significant except in these two cases:
   a. at the end of a whole number that does not have a terminal decimal point (1200 has 2 s.d.).
   b. at the beginning of a decimal number that is less than one (0.0012 has 2 s.d.).
4. All digits written in scientific notation are significant.
4. In measurements, significant digits include all digits that are known with certainty plus one uncertain digit.
5. Significant digits in calculations:
   a. In addition & subtraction, significant digits are limited by the decimal place of the least precise number.
   b. In multiplication, division, roots and powers, significant digits are limited by the number with the least number of digits.

SI Prefixes

prefix	abbr.	means	multiplier*
tera-	T	trillion	10^{12}
giga-	G	billion	10^{9}
mega-	M	million	10^{6}
kilo-	k	thousand	10^{3}
hecto-	h	hundred	10^{2}
deka-	da	ten	10^{1}
…	…	base unit	10^{0}
deci-	d	1 tenth	10^{-1}
centi-	c	1 hundredth	10^{-2}
milli-	m	1 thousandth	10^{-3}
micro-	µ	1 millionth	10^{-6}
nano-	n	1 billionth	10^{-9}
pico-	p	1 trillionth	10^{-12}

(arrow down: indicates smaller units; arrow up: indicates larger units)

*replace prefix with multiplier, e.g. 5.92 µg = 5.92×10^{-6} g

English – Metric Equivalents

Length

1 mi = 5282 ft
1 in = 2.540 cm
1 ft = 30.48 cm
1 yd = 0.9144 m
1 mi = 1.609 km
1 Å = 10^{-10} m = 0.1 nm
1 cm = 0.3937 in
1 m = 39.37 in
1 m = 1.094 yd
1 km = 0.6214 mi

Mass or weight

1 lb = 16 oz
1 oz = 28.23 g
1 lb = 453.6 g
1 lb = 0.4536 kg
1 metric ton = 1000 kg
1 g = 0.03527 oz
1 kg = 35.27 oz
1 kg = 2.205 lb

Volume of solids

1 ft^3 = 1728 in^3
1 yd^3 = 27 ft^3 = 46656 in^3
1 in^3 = 16.39 cm^3
1 ft^3 = 28.32 dm^3
1 yd^3 = 0.7646 m^3
1 m^3 = 1 000 000 cm^3
1 cm^3 = 0.06102 in^3
1 dm^3 = 61.02 in^3
1 m^3 = 35.31 ft^3
1 m^3 = 1.3079 yd^3

Volume of liquids

NOTE: 1 L = 1 dm^3 = 10^3 cm^3 = 10^{-3} m^3 = 1000 mL
1 qt = 32 fl oz = 4 c
1 fl oz = 29.57 mL
1 qt = 946.3 mL
1 qt = 0.9463 L
1 mL = 1 cm^3
1 mL = 0.03381 fl oz
1 L = 33.81 fl oz
1 L = 1.057 qt

Energy

1 nutritional "calorie" = 1 kcal = 1000 cal = 4184 J
1 cal = 4.184 J = 0.04129 L·atm
1 J = 1 N-m = kg·m^2/sec^2 = 10^7 erg
1 J = 0.10197 kg·m = 0.009869 L·atm = 0.2390 cal
= 0.738 ft·lb = 9.478×10^{-4} BTU
1 L·atm = 101.3 J = 10.33 kg·m = 24.22 cal
1 eV = 1.602×10^{-19} J
1 u = 931.5 MeV (relativistic)

Pressure

1 atm = 760 mm Hg (torr) = 101.3 kPa = 14.70 lb/in^2 (psi)
= 1.013×10^5 N/m^2 = 33.9 ft water
1 Pa = 1 N/m^2 = 1 kg/m·s^2

Physical Constants

absolute zero .... = 0 K or – 273.15 °C
atomic mass unit ....u = 1/12 mass of carbon-12 atom
= 1.6605×10^{-24} g
= 1.6605×10^{-27} kg
Avogadro number ....N_A = 6.0221×10^{23} particles/mole
Bohr radius ....a_o = 5.292×10^{-11} m
Boltzmann constant ......*k* = 1.381×10^{-23} J/K
electron charge ....– e = -1.602×10^{-19} C
electron rest mass.........m_e = 9.1096×10^{-28} g
= 0.00054580 u
Faraday constant..........*F* = 9.649×10^{4} C/mol e^-
gas constant ....R = 8.206×10^{-2} L·atm/mol·K
= 62.4 L·torr/mol·K
= 8.314 J/mol·K
= 8.314 L·kPa/mol·K
gravitational const. ....g = 9.807 m/sec^2
molar volume at STP ...V_m = 22.414 L/mol
neutron rest mass ....m_n = 1.67495×10^{-24} g
= 1.008665 u
Planck's constant ....h = 6.626×10^{-34} J·s
proton rest mass...........m_p = 1.67265×10^{-24} g
= 1.007277 u
speed of light ....c = 2.99792458×10^{8} m/s
= $2.99792458 \times 10^{10}$ cm/s

Selected Constants for H_2O

molar mass .... 18.0153 g/mol
normal freezing point.................... 0.00 °C
normal boiling point .... 100.00°C
average specific heat, c_p .... 2.06 J/g·°C, solid
4.18 J/g·°C, liquid
2.02 J/g·°C, gas
heat of fusion, ΔH_f .... 334 J/g
heat of vaporization, ΔH_v .... 2260 J/g
molal fp depression, K_f .... 1.853 kg·°C/mol
molal bp elevation, K_b .... 0.515 kg·°C/mol
critical temperature and pressure ..... 647.14 K, 21760 kPa
density and vapor pressure as a function of temperature

temperature, °C	density, g/mL*	vapor pressure, mm Hg
0	0.99987	4.579
10	0.99973	9.209
15	0.99913	12.788
20	0.99823	17.535
25	0.99707	23.756
30	0.99567	31.824
40	0.99224	55.324
50	0.98807	92.51
75	0.97489	289.1
95	0.96192	633.9

*density is at a maximum of 1.0000 g/mL at 3.98 °C

Fundamental Units of Science

1 Joule = 1 J = 1 kg·m^2/s^2 = 1 watt·s = 1 N·m
1 watt = 1 W = 1 J/s = 1 N·m/s = 1 kg·m^2/s^3
1 ampere = 1 A = C/s
1 volt = 1 V = kg·m^2/C·s^2
1 ohm = 1 _ = 1 kg·m^2/C^2·s
1 Newton = 1 N = kg·m/s^2 = 10^5 dyne
1 erg = 1 dyne·cm

Formulas and Laws

w Volumes of regular geometric solids
rectangular solid .... V = l w h
cylinder .... $V = \pi r^2 h$
sphere .... $V = {}^4/_3\, \pi r^3$

w Energy relationships
Einstein's Equation...... $E = m c^2$
heating .... $q = m \Delta T c_p$
Hess's Law .... $\Delta H = ´\sum H_{products} - \_\sum H_{reactants}$
kinetic energy .... $KE = {}^1/_2\, m v^2$
$KE = {}^3/_2\, R T$
light energy .... $E = h \lambda$ and $\lambda\nu = c$
potential energy .... PE = m g h

w Stoichiometry equations
percent composition .... $\dfrac{\text{mass of component}}{\text{molar mass}} \times 100\%$
percent yield.............. $\dfrac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$
molarity..................... $M = \dfrac{\text{moles solute}}{\text{liters solution}}$
mole fraction .... $\_ = \dfrac{\text{moles solute}}{\text{total moles}}$
molality..................... $m = \dfrac{\text{moles solute}}{\text{kg solvent}}$

w Gas laws
Boyle's Law...........PV = a constant or $P_1V_1 = P_2V_2$
Charles' Law .... $\dfrac{V}{T}$ = constant or $\dfrac{V_1}{T_1} = \dfrac{V_2}{T_2}$
Combined gas law ... $\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2}$
Dalton's Law..........$P_{total} = P_1 + P_2 + P_3 + \ldots$
density ....$D = \dfrac{\text{molar mass in g/mol}}{22.4\ \text{L/mol}}$ at STP
Graham's Law .... $\dfrac{rate_a}{rate_b} = \sqrt{\dfrac{mass_b}{mass_a}}$ (rate of diffusion)
Henry's Law...........concentration of gas in solution = k P
Ideal Gas Law.........P V = n R T
STP ....T = 0.00 °C, 273.15 K **or** 32.0 °F **and**
P = 1.00 atm, 760. torr **or** 101.3 kPa

w Colligative properties
boiling point elevation........... $\Delta T = K_b\, m_{solute}$
freezing point depression .... $\Delta T = K_f\, m_{solute}$
osmotic pressure.................. $\pi = M R T$
Raoult's Law .... $P_{soln} = \__{solvent}\, P^o_{solvent}$

w Miscellaneous equations
relative error......... $E_r = \dfrac{|O - A|}{A} \times 100\%$
O = observed
A = accepted
quadratic equation . $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
density .... density = $\dfrac{\text{mass}}{\text{volume}}$
temperature .... $\dfrac{°F - 32}{180} = \dfrac{°C}{100}$
$°C = {}^5/9\,(°F - 32)$ $°F = {}^9/5\,°C + 32$
K = °C + 273.15