Useful Constants (*For a more complete list, see Appendix D*)

Atomic mass unit	$1 \text{ amu} = 1.6606 \times 10^{-24}$ g
Avogadro's number	$N = 6.0221415 \times 10^{23}$ particles/mol
Electronic charge	$e = 1.60218 \times 10^{-19}$ coulombs
Faraday constant	$F = 96{,}485$ coulombs/equivalent
	$= 96{,}485$ coulombs/mol e^-
Gas constant	$R = 0.08206 \dfrac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} = 1.987 \dfrac{\text{cal}}{\text{mol} \cdot \text{K}}$
	$= 8.3145 \dfrac{\text{J}}{\text{mol} \cdot \text{K}} = 8.3145 \dfrac{\text{kPa} \cdot \text{dm}^3}{\text{mol} \cdot \text{K}}$
Ion product for water	$K_w = 1.0 \times 10^{-14}$
Pi	$\pi = 3.1416$
Planck's constant	$h = 6.6260693 \times 10^{-34}$ J · s
	$= 6.6260693 \times 10^{-27}$ erg · s
Speed of light (in vacuum)	$c = 2.99792458 \times 10^8$ m/s

Useful Relationships (*For a more complete list, see Appendix C*)

Mass and Weight

SI Base Unit: Kilogram (kg)

1 kilogram = 1000 grams = 2.205 pounds
1 gram = 1000 milligrams
1 pound = 453.59 grams
1 amu = 1.6606×10^{-24} grams
1 gram = 6.022×10^{23} amu
1 ton = 2000 pounds

Length

Si Base Unit: Meter (m)

1 inch = 2.54 centimeters (exactly)
1 meter = 100 centimeters = 39.37 inches
1 yard = 0.9144 meter
1 mile = 1.609 kilometers
1 kilometer = 1000 meters = 0.6215 mile
1 Ångstrom = 1.0×10^{-10} meters = 1.0×10^{-8} centimeters

Volume

SI Base Unit: Cubic Meter (m^3)

1 liter = 0.001 cubic meter
1 liter = 1000 cubic centimeters = 1000 mL
1 liter = 1.056 quarts
1 quart = 0.9463 liter
1 milliliter = 0.001 liter = 1 cubic centimeter
1 cubic foot = 7.475 gallons = 28.316 liters
1 gallon = 4 quarts

Energy

SI Base Unit: Joule (J)

1 calorie = 4.184 joules = 4.129×10^{-2} L · atm
1 joule = $1 \dfrac{\text{kg} \cdot \text{m}^2}{\text{s}^2} = 0.23901$ calorie
1 joule = 1×10^7 ergs
1 electron volt = 1.6022×10^{-19} joule
1 electron volt = 96.485 kJ/mol
1 L · atm = 24.217 calories = 101.325 joules

Pressure

SI Base Unit: Pascal (Pa)

1 pascal = $1 \dfrac{\text{kg}}{\text{m} \cdot \text{s}^2} = 1$ newton/m^2
1 atmosphere = 760 torr
= 760 millimeters of mercury
= 1.01325×10^5 pascals
= 1.01325 bar
= 14.70 pounds per square inch
1 torr = 1 millimeter of mercury

Temperature

SI Base Unit: Kelvin (K)

0 K = −273.15°C
?K = °C + 273.15°
?°F = 1.8(°C) + 32°
?°C = $\dfrac{°\text{F} - 32°}{1.8}$

Common Units, Equivalences, and Conversion Factors

APPENDIX C

C-1 Fundamental Units of the SI System

The metric system was implemented by the French National Assembly in 1790 and has been modified many times. The International System of Units, or *le Système International* (SI), represents an extension of the metric system. It was adopted by the eleventh General Conference of Weights and Measures in 1960 and has also been modified since. It is constructed from seven base units, each of which represents a particular physical quantity (Table I).

The first five units listed in Table I are particularly useful in general chemistry. They are defined as follows.

Alternatives for the standard mass have been proposed.

1. The *meter* is defined as the distance light travels in a vacuum in 1/299,792,458 second.
2. The *kilogram* represents the mass of a platinum–iridium block kept at the International Bureau of Weights and Measures at Sèvres, France.
3. The *second* was redefined in 1967 as the duration of 9,192,631,770 periods of a certain line in the microwave spectrum of cesium-133.
4. The *kelvin* is 1/273.16 of the temperature interval between absolute zero and the triple point of water.
5. The *mole* is the amount of substance that contains as many entities as there are atoms in exactly 0.012 kg of carbon-12 (12 g of ^{12}C atoms).

TABLE I SI Fundamental Units

Physical Quantity	Name of Unit	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
temperature	kelvin	K
amount of substance	mole	mol
electric current	ampere	A
luminous intensity	candela	cd

Prefixes Used with Metric Units and SI Units

Decimal fractions and multiples of metric and SI units are designated by the prefixes listed in Table II. Those most commonly used in general chemistry are underlined.

TABLE II Traditional Metric and SI Prefixes

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{12}	tera	T	10^{-1}	deci	d
10^{9}	giga	G	10^{-2}	centi	c
10^{6}	mega	M	10^{-3}	milli	m
10^{3}	kilo	k	10^{-6}	micro	μ
10^{2}	hecto	h	10^{-9}	nano	n
10^{1}	deka	da	10^{-12}	pico	p
			10^{-15}	femto	f
			10^{-18}	atto	a

C-2 Derived SI Units

In the International System of Units all physical quantities are represented by appropriate combinations of the base units listed in Table I. A list of the derived units frequently used in general chemistry is given in Table III.

TABLE III Derived SI Units

Physical Quantity	Name of Unit	Symbol	Definition
area	square meter	m^2	
volume	cubic meter	m^3	
density	kilogram per cubic meter	kg/m^3	
force	newton	N	$kg \cdot m/s^2$
pressure	pascal	Pa	N/m^2
energy	joule	J	$kg \cdot m^2/s^2$
electric charge	coulomb	C	$A \cdot s$
electric potential difference	volt	V	$J/(A \cdot s)$

Common Units of Mass and Weight

1 pound = 453.59 grams

1 pound = 453.59 grams = 0.45359 kilogram
1 kilogram = 1000 grams = 2.205 pounds
1 gram = 10 decigrams = 100 centigrams
= 1000 milligrams
1 gram = 6.022×10^{23} atomic mass units
1 atomic mass unit = 1.6606×10^{-24} gram
1 short ton = 2000 pounds = 907.2 kilograms
1 long ton = 2240 pounds
1 metric tonne = 1000 kilograms = 2205 pounds

Common Units of Length

1 inch = 2.54 centimeters (exactly)

1 mile = 5280 feet = 1.609 kilometers
1 yard = 36 inches = 0.9144 meter
1 meter = 100 centimeters = 39.37 inches = 3.281 feet
= 1.094 yards
1 kilometer = 1000 meters = 1094 yards = 0.6215 mile
1 Ångstrom = 1.0×10^{-8} centimeter = 0.10 nanometer
= 1.0×10^{-10} meter = 3.937×10^{-9} inch

Common Units of Volume

1 quart = 0.9463 liter
1 liter = 1.056 quarts

1 liter = 1 cubic decimeter = 1000 cubic centimeters
= 0.001 cubic meter
1 milliliter = 1 cubic centimeter = 0.001 liter
= 1.056×10^{-3} quart
1 cubic foot = 28.316 liters = 29.902 quarts
= 7.475 gallons

Common Units of Force* and Pressure

1 atmosphere = 760 millimeters of mercury
= 1.01325×10^5 pascals
= 1.01325 bar
= 14.70 pounds per square inch
1 bar = 10^5 pascals = 0.98692 atm
1 torr = 1 millimeter of mercury
1 pascal = 1 $kg/m \cdot s^2$ = 1 N/m^2

*Force: 1 newton (N) = 1 $kg \cdot m/s^2$, i.e., the force that, when applied for 1 second, gives a 1-kilogram mass a velocity of 1 meter per second.

Common Units of Energy

1 joule = 1×10^7 ergs

1 thermochemical calorie* = 4.184 joules = 4.184×10^7 ergs
= 4.129×10^{-2} liter-atmospheres
= 2.612×10^{19} electron volts
1 erg = 1×10^{-7} joule = 2.3901×10^{-8} calorie
1 electron volt = 1.6022×10^{-19} joule = 1.6022×10^{-12} erg = 96.487 kJ mol†
1 liter-atmosphere = 24.217 calories = 101.325 joules = 1.01325×10^9 ergs
1 British thermal unit = 1055.06 joules = 1.05506×10^{10} ergs = 252.2 calories

*The amount of heat required to raise the temperature of one gram of water from 14.5°C to 15.5°C.

†Note that the other units are per particle and must be multiplied by 6.022×10^{23} to be strictly comparable.

Physical Constants

APPENDIX D

Quantity	Symbol	Traditional Units	SI Units
Acceleration of gravity	g	980.6 cm/s	9.806 m/s
Atomic mass unit ($\frac{1}{12}$ the mass of ^{12}C atom)	amu or u	1.6606×10^{-24} g	1.6606×10^{-27} kg
Avogadro's number	N	6.0221415×10^{23} particles/mol	6.0221415×10^{23} particles/mol
Bohr radius	a_0	0.52918 Å 5.2918×10^{-9} cm	5.2918×10^{-11} m
Boltzmann constant	k	1.3807×10^{-16} erg/K	1.3807×10^{-23} J/K
Charge-to-mass ratio of electron	e/m	1.75882×10^{8} coulomb/g	1.75882×10^{11} C/kg
Electronic charge	e	1.60218×10^{-19} coulomb 4.8033×10^{-10} esu	1.60218×10^{-19} C
Electron rest mass	m_e	9.10940×10^{-28} g 0.00054858 amu	9.10940×10^{-31} kg
Faraday constant	F	96,485 coulombs/eq 23.06 kcal/volt · eq	96,485 C/mol e^- 96,485 J/V · mol e^-
Gas constant	R	$0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$ $1.987 \frac{\text{cal}}{\text{mol} \cdot \text{K}}$	$8.3145 \frac{\text{kPa} \cdot \text{dm}^3}{\text{mol} \cdot \text{K}}$ 8.3145 J/mol · K
Molar volume (STP)	V_m	22.414 L/mol	22.414×10^{-3} m^3/mol 22.414 dm^3/mol
Neutron rest mass	m_n	1.67495×10^{-24} g 1.008665 amu	1.67495×10^{-27} kg
Planck constant	h	$6.6260693 \times 10^{-27}$ erg · s	$6.6260693 \times 10^{-34}$ J · s
Proton rest mass	m_p	1.6726×10^{-24} g 1.007277 amu	1.6726×10^{-27} kg
Rydberg constant	R_∞	3.289×10^{15} cycles/s 2.1799×10^{-11} erg	1.0974×10^{7} m^{-1} 2.1799×10^{-18} J
Speed of light (in a vacuum)	c	$2.99792458 \times 10^{10}$ cm/s (186,281 miles/second)	2.99792458×10^{8} m/s

$\pi = 3.1416$ $\quad$ $2.303\,R = 4.576$ cal/mol · K = 19.15 J/mol · K

$e = 2.71828$ $\quad$ $2.303\,RT$ (at 25°C) = 1364 cal/mol = 5709 J/mol

$\ln X = 2.303 \log X$