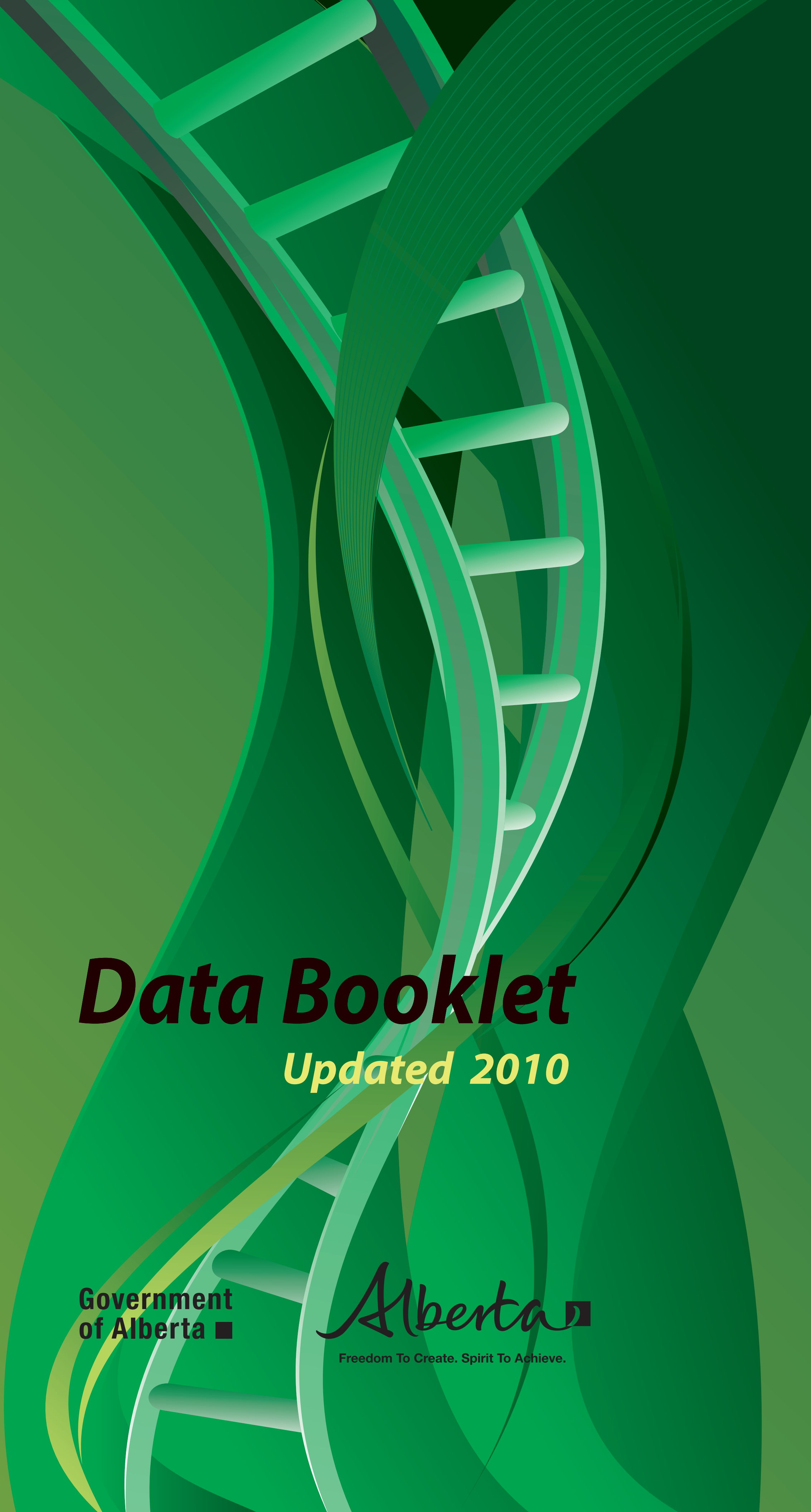
SCIENCE



Data Booklet

Updated 2010

Government
of Alberta ■

Alberta
Freedom To Create. Spirit To Achieve.

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Cover design interpretation of DNA in the presence of electromagnetic energy by Nathan A. Smith of Alberta Education.

General Formulas and Data

Formulas and Data

$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$\begin{matrix}\text{percent difference} \\ \text{from theoretical value}\end{matrix} = \frac{|\text{experimental value} - \text{theoretical value}|}{|\text{theoretical value}|} \times 100\%$$

$$\text{percent efficiency} = \left(\frac{\text{output}}{\text{input}}\right) \times 100\%$$

$$\text{magnification} = \left(\begin{matrix}\text{power of} \\ \text{ocular lens}\end{matrix}\right) \times \left(\begin{matrix}\text{power of} \\ \text{objective lens}\end{matrix}\right)$$

Distilled Water at Room Temperature (25°C) and Standard Pressure (101.325 kPa)

Volume	Mass	Density
1.0 mL or 1.0 cm^3	1.0 g	1.0 g/cm^3
1.0 L or 1.0 dm^3	1.0 kg	1.0 kg/dm^3

Units and Prefixes

Prefix	Symbol	Factor by Which Base Unit Is Multiplied	
tera	T	1 000 000 000 000	$= 10^{12}$
giga	G	1 000 000 000	$= 10^{9}$
mega	M	1 000 000	$= 10^{6}$
kilo	k	1 000	$= 10^{3}$
hecto	h	100	$= 10^{2}$
deca	da	10	$= 10^{1}$
Common Base Units*		1	$= 10^{0}$
deci	d	0.1	$= 10^{-1}$
centi	c	0.01	$= 10^{-2}$
milli	m	0.001	$= 10^{-3}$
micro	μ	0.000 001	$= 10^{-6}$
nano	n	0.000 000 001	$= 10^{-9}$
pico	p	0.000 000 000 001	$= 10^{-12}$

*metre (m), gram (g), litre (L), mole (mol)

Some Non-SI Units Used with SI

Quantity	Unit Name	Symbol	Definition
Time	minute	min	1 min = 60 s
	hour	h	1 h = 3 600 s
	day	d	1 d = 86 400 s
	year (annum)	a	1 a = 31 557 600 s
Area	hectare	ha	1 ha = 1 hm^2 = 10 000 m^2
Volume	litre	L	1 L = 1 000 cm^3
Mass	metric ton or tonne	t	1 t = 1 000 kg = 1 Mg
Pressure	standard atmosphere	atm	1 atm = 101.325 kPa

Kinematics and Dynamics Formulas

$$v = \frac{\Delta d}{\Delta t}$$

$$\vec{v} = \frac{\Delta \vec{d}}{\Delta t}$$

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v}_{\text{f}} - \vec{v}_{\text{i}}}{\Delta t}$$

$$\vec{F}_{\text{net}} = m\vec{a}$$

$$\vec{F}_{\text{net}} = \vec{F}_{\text{a}} + \vec{F}_{\text{f}}$$

$$W = F\Delta d$$

$$P = \frac{W}{t}$$

$$\Delta \vec{d} = \vec{v}_{\text{i}}\Delta t + \tfrac{1}{2}\vec{a}(\Delta t)^2$$

$$\Delta \vec{d} = \left(\frac{\vec{v}_{\text{i}} + \vec{v}_{\text{f}}}{2}\right)\Delta t$$

$$\vec{p} = m\vec{v}$$

$$\Delta \vec{p} = \vec{F}\Delta t,\ \ \Delta \vec{p} = \vec{p}_{\text{f}} - \vec{p}_{\text{i}}$$

$$\vec{F} = \frac{m(\vec{v}_{\text{f}} - \vec{v}_{\text{i}})}{\Delta t}$$

$$E_{\text{p}} = mgh$$

$$E_{\text{k}} = \tfrac{1}{2}mv^2$$

v = average speed (m/s)
$\vec{v}$ = average velocity (m/s)
d = distance (m)
$\vec{d}$ = displacement (m)
t = time elapsed (s)
$\vec{a}$ = acceleration (m/s^2)
$\vec{F}$ = force (kg•m/s^2 or N)
$\vec{F}_{\text{net}}$ = net force (N)
$\vec{F}_{\text{a}}$ = applied force (N)
$\vec{F}_{\text{f}}$ = force of friction (N)
F = magnitude of a force (N)
m = mass (kg)
W = work (N•m or J)
P = power (J/s or W)
Δ = change in
$\vec{F}\Delta t$ = impulse
$\vec{p}$ = momentum (kg•m/s)
E_{p} = gravitational potential energy (J)
g = magnitude of acceleration due to gravity (m/s^2)
E_{k} = kinetic energy (J)

Collisions

Hit and rebound:

$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}\,'_1 + m_2\vec{v}\,'_2$$

Hit and stick:

$$m_1\vec{v}_1 + m_2\vec{v}_2 = (m_1 + m_2)\vec{v}\,'_{1\text{ and }2}$$

Explosion:

$$(m_1 + m_2)\vec{v}_{1\text{ and }2} = m_1\vec{v}\,'_1 + m_2\vec{v}\,'_2$$

Gravitational and Electric Fields

$$\vec{F}_{\text{g}} = m\vec{g}$$

$$g = \frac{Gm}{r^2}$$

$$\left|\vec{E}\right| = \frac{kq}{r^2}$$

$\vec{F}_{\text{g}}$ = force due to gravity (N)
m = mass (kg)
G = gravitational constant = 6.67×10^{-11} N•m^2/kg^2
r = radius or centre-to-centre distance (m)
g = magnitude of gravitational field strength (N/kg)
k = Coulomb's law constant = 8.99×10^{9} N•m^2/C^2
q = electrostatic charge in coulombs (C)
$\left|\vec{E}\right|$ = electric field strength (N/C)

Astronomy Data

Mass of Earth = 5.98×10^{24} kg
Radius of Earth = 6.37×10^{6} m
Mass of sun = 1.99×10^{30} kg
1 light-year = 9.47×10^{15} m
1 AU (astronomical unit) = 1.50×10^{11} m

Average acceleration due to gravity on surface of Earth = 9.81 m/s^2

Average gravitational field strength on surface of Earth = 9.81 N/kg

Electricity Formulas

$P = IV, \quad P = I^2R$

$V = IR$

$E = Pt$

For resistances connected in series

$$R_T = R_1 + R_2 + R_3 + \dots R_n$$

For resistances connected in parallel

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots \frac{1}{R_n}$$

R = resistance (Ω)

P = power (W)

I = current (A)

V = voltage (V)

E = energy (J)

t = time elapsed (s)

Ideal Transformers

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}, \quad \frac{N_p}{N_s} = \frac{I_s}{I_p}, \quad \frac{V_p}{V_s} = \frac{I_s}{I_p}$$

N = number of turns

p = primary

s = secondary

Related value: 1.00 kilowatt hour = 1.00 kW•h = 3.60×10^6 J

Wave Formulas

$v = f\lambda$

$c = f\lambda$

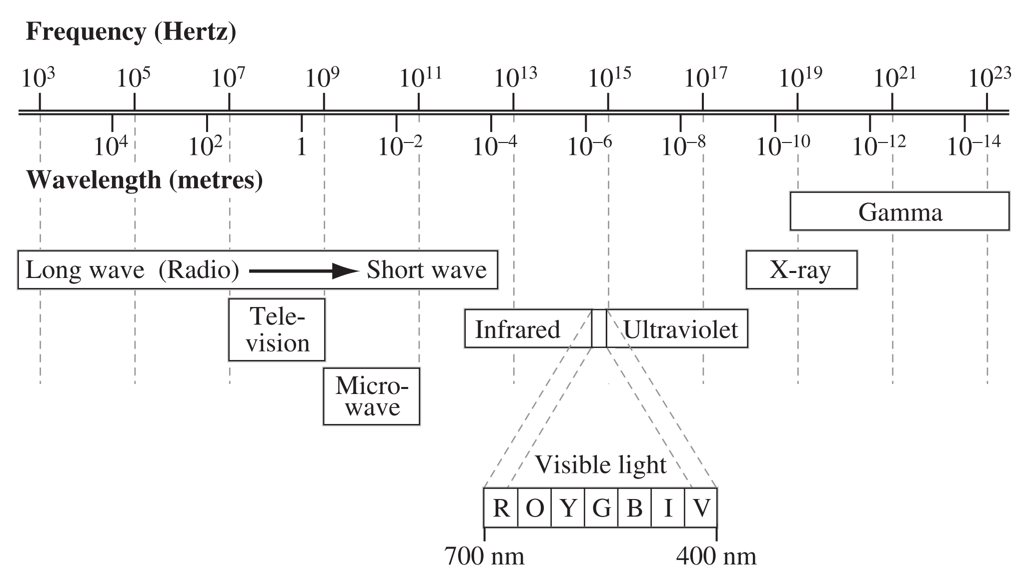
v = speed of wave (m/s)

c = speed of electromagnetic radiation in air or vacuum (3.00×10^8 m/s)

f = frequency (Hz or 1/s)

λ = wavelength (m)

Electromagnetic Spectrum



Electrochemistry

Activity Series for 1.0 mol/L Solution at 25 °C and 101.325 kPa

Increasing strength of reactant as an oxidizing agent ↑

Reduction Half-Reaction				
$Au^{3+}(aq)$	+	$3e^-$	→	$Au(s)$
$Hg^{2+}(aq)$	+	$2e^-$	→	$Hg(l)$
$Ag^+(aq)$	+	e^-	→	$Ag(s)$
$Cu^{2+}(aq)$	+	$2e^-$	→	$Cu(s)$
$2H^+(aq)$	+	$2e^-$	→	$H_2(g)$
$Pb^{2+}(aq)$	+	$2e^-$	→	$Pb(s)$
$Sn^{2+}(aq)$	+	$2e^-$	→	$Sn(s)$
$Ni^{2+}(aq)$	+	$2e^-$	→	$Ni(s)$
$Cd^{2+}(aq)$	+	$2e^-$	→	$Cd(s)$
$Fe^{2+}(aq)$	+	$2e^-$	→	$Fe(s)$
$Zn^{2+}(aq)$	+	$2e^-$	→	$Zn(s)$
$Cr^{2+}(aq)$	+	$2e^-$	→	$Cr(s)$
$Al^{3+}(aq)$	+	$3e^-$	→	$Al(s)$
$Mg^{2+}(aq)$	+	$2e^-$	→	$Mg(s)$
$Na^+(aq)$	+	e^-	→	$Na(s)$
$Ca^{2+}(aq)$	+	$2e^-$	→	$Ca(s)$
$Li^+(aq)$	+	e^-	→	$Li(s)$

Increasing strength of reactant as a reducing agent ↓

Thermodynamics

Heat Capacities of Selected Substances at 25°C

Compound		Specific Heat Capacity (J/g·°C) or (kJ/kg·°C)
water	$H_2O(l)$	4.19
ice (at 0 °C)	$H_2O(s)$	2.10
water vapour (at 100 °C)	$H_2O(g)$	2.08
methanol	$CH_3OH(l)$	2.53
ethanol	$C_2H_5OH(l)$	2.44
hexane	$C_6H_{14}(l)$	2.27
toluene	$C_7H_8(l)$	1.71
air	mixture of $N_2(g)$, $O_2(g)$, $CO_2(g)$, and trace gases	1.01

Thermodynamic Properties of Selected Compounds

Compound		Melting Point (°C)	Boiling Point (°C)	Heat of Fusion (kJ/mol)	Heat of Vaporization (kJ/mol)
water	$H_2O(l)$	0.00	100.00	6.01	40.66
hexane	$C_6H_{14}(l)$	–95.35	68.73	13.08	28.85
ethanol	$C_2H_5OH(l)$	–114.14	78.29	4.93	38.56
methanol	$CH_3OH(l)$	–97.53	64.6	3.22	35.21
toluene	$C_7H_8(l)$	–94.95	110.63	6.64	33.18

Geological Time-Line

Millions of Years Ago	Era	Period	Epoch
	Cenozoic	Quaternary	Holocene Pleistocene
1.7		Tertiary	
65	Mesozoic	Cretaceous	
140		Jurassic	
210		Triassic	
250	Paleozoic	Permian	
290		Carboniferous	
360		Devonian	
410		Silurian	
440		Ordovician	
500		Cambrian	
590	Precambrian		
4 600			

*Current research suggests that the start of the Quaternary period is earlier.

Standard Heats of Formation of Selected Compounds at 25°C

Compound	Formula	$\Delta_f H°$(kJ/mol)
ammonia	$NH_3(g)$	−45.9
benzene	$C_6H_6(l)$	+49.1
butane	$C_4H_{10}(g)$	−125.7
calcium carbonate	$CaCO_3(s)$	−1 207.6
calcium hydroxide	$Ca(OH)_2(s)$	−985.2
carbon dioxide	$CO_2(g)$	−393.5
carbon monoxide	$CO(g)$	−110.5
ethane	$C_2H_6(g)$	−84.0
ethanoic acid (acetic acid)	$CH_3COOH(l)$	−484.3
ethanol	$C_2H_5OH(l)$	−277.6
ethene (ethylene)	$C_2H_4(g)$	+52.4
ethyne (acetylene)	$C_2H_2(g)$	+227.4
glucose	$C_6H_{12}O_6(s)$	−1 273.3
hydrogen sulfide	$H_2S(g)$	−20.6
methane	$CH_4(g)$	−74.6
methanol	$CH_3OH(l)$	−239.2
nitrogen dioxide	$NO_2(g)$	+33.2
nitrogen monoxide	$NO(g)$	+91.3
octane	$C_8H_{18}(l)$	−250.1
pentane	$C_5H_{12}(l)$	−173.5
propane	$C_3H_8(g)$	−103.8
sucrose	$C_{12}H_{22}O_{11}(s)$	−2 226.1
sulfur dioxide	$SO_2(g)$	−296.8
sulfur trioxide	$SO_3(g)$	−395.7
water (liquid)	$H_2O(l)$	−285.8
water (gas)	$H_2O(g)$	−241.8

Note: Elements are given a value of zero.
Negative sign (–) denotes exothermic change.
Positive sign (+) denotes endothermic change.

Energy Formulas

$$Q = mc\Delta t$$

$$\Delta_{\text{fus}} H = \frac{Q}{n}$$

$$\Delta_{\text{vap}} H = \frac{Q}{n}$$

$$\Delta_r H = \sum n\Delta_f H° \text{ products} - \sum n\Delta_f H° \text{ reactants}$$

Q = quantity of heat energy (J or kJ)
m = mass (g or kg)
$\Delta_{\text{fus}} H$ = heat of fusion (kJ/mol)
$\Delta_{\text{vap}} H$ = heat of vaporization (kJ/mol)
c = specific heat capacity (J/g•°C or kJ/kg•°C)
Δt = change in temperature (°C)
n = amount in moles (mol)
$\Delta_r H$ = energy change of reaction (kJ)
$\sum$ = the sum of
$\Delta_f H°$ = standard molar heat (enthalpy) of formation (kJ/mol)

Periodic Chart of the Elements and Ions

Note: The legend at the right denotes the physical state of the elements at 101.325 kPa and 298.15 K (25°C).

Legend for the Elements

Solid	Liquid	Gas	Seldom forms ions

1	2	3	4	5	6	7	8	9
1 H hydrogen 1.01 H^+ hydrogen								
3 Li lithium 6.94 Li^+ lithium	4 Be beryllium 9.01 Be^{2+} beryllium							
11 Na sodium 22.99 Na^+ sodium	12 Mg magnesium 24.31 Mg^{2+} magnesium							
19 K potassium 39.10 K^+ potassium	20 Ca calcium 40.08 Ca^{2+} calcium	21 Sc scandium 44.96 Sc^{3+} scandium	22 Ti titanium 47.87 Ti^{4+} titanium(IV) Ti^{3+} titanium(III)	23 V vanadium 50.94 V^{5+} vanadium(V) V^{4+} vanadium(IV)	24 Cr chromium 52.00 Cr^{3+} chromium(III) Cr^{2+} chromium(II)	25 Mn manganese 54.94 Mn^{2+} manganese(II) Mn^{4+} manganese(IV)	26 Fe iron 55.85 Fe^{3+} iron(III) Fe^{2+} iron(II)	27 Co cobalt 58.93 Co^{2+} cobalt(II) Co^{3+} cobalt(III)
37 Rb rubidium 85.47 Rb^+ rubidium	38 Sr strontium 87.62 Sr^{2+} strontium	39 Y yttrium 88.91 Y^{3+} yttrium	40 Zr zirconium 91.22 Zr^{4+} zirconium	41 Nb niobium 92.91 Nb^{5+} niobium(V) Nb^{3+} niobium(III)	42 Mo molybdenum 95.94 Mo^{6+} molybdenum	43 Tc technetium (98) Tc^{7+} technetium	44 Ru ruthenium 101.07 Ru^{3+} ruthenium(III)	45 Rh rhodium 102.91 Rh^{3+} rhodium
55 Cs cesium 132.91 Cs^+ cesium	56 Ba barium 137.33 Ba^{2+} barium	57 La lanthanum 138.91 La^{3+} lanthanum	72 Hf hafnium 178.49 Hf^{4+} hafnium	73 Ta tantalum 180.95 Ta^{5+} tantalum	74 W tungsten 183.84 W^{6+} tungsten	75 Re rhenium 186.21 Re^{7+} rhenium	76 Os osmium 190.23 Os^{4+} osmium	77 Ir iridium 192.22 Ir^{4+} iridium
87 Fr francium (223) Fr^+ francium	88 Ra radium (226) Ra^{2+} radium	89 Ac actinium (227) Ac^{3+} actinium	104 Rf rutherfordium (261)	105 Db dubnium (262)	106 Sg seaborgium (266)	107 Bh bohrium (264)	108 Hs hassium (277)	109 Mt meitnerium (268)

Table of Polyatomic Ions

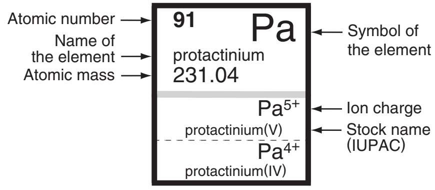
Polyatomic ions

acetate	CH_3COO^-	chlorate	ClO_3^-	iodate	IO_3^-	permanganate	MnO_4^-	sulfite	SO_3^{2-}
ammonium	NH_4^+	chlorite	ClO_2^-	nitrate	NO_3^-	phosphate	PO_4^{3-}	hydrogen sulfide	HS^-
benzoate	$C_6H_5COO^-$	hypochlorite	ClO^-	nitrite	NO_2^-	hydrogen phosphate	HPO_4^{2-}	hydrogen sulfate	HSO_4^-
borate	BO_3^{3-}	chromate	CrO_4^{2-}	methanoate	$CHOO^-$	dihydrogen phosphate	$H_2PO_4^-$	hydrogen sulfite	HSO_3^-
carbonate	CO_3^{2-}	dichromate	$Cr_2O_7^{2-}$	oxalate	$OOCCOO^{2-}$	silicate	SiO_3^{2-}	thiocyanate	SCN^-
hydrogen carbonate	HCO_3^-	cyanide	CN^-	hydrogen oxalate	$HOOCCOO^-$	sulfate	SO_4^{2-}	thiosulfate	$S_2O_3^{2-}$
perchlorate	ClO_4^-	hydroxide	OH^-						

Lanthanide and Actinide Series Begins

58 Ce cerium 140.12 Ce^{3+} cerium	59 Pr praseodymium 140.91 Pr^{3+} praseodymium	60 Nd neodymium 144.24 Nd^{3+} neodymium	61 Pm promethium (145) Pm^{3+} promethium	62 Sm samarium 150.36 Sm^{3+} samarium(III) Sm^{2+} samarium(II)
90 Th thorium 232.04 Th^{4+} thorium	91 Pa protactinium 231.04 Pa^{5+} protactinium(V) Pa^{4+} protactinium(IV)	92 U uranium 238.03 U^{6+} uranium(VI) U^{4+} uranium(IV)	93 Np neptunium (237) Np^{5+} neptunium	94 Pu plutonium (244) Pu^{4+} plutonium(IV) Pu^{6+} plutonium(VI)

Key



Based on $^{12}_{6}C$

Most stable or common ion is listed above dotted line. Atomic mass in parentheses indicates mass of the most stable isotope.

10	11	12	13	14	15	16	17	18
							1 H hydrogen 1.01 H^- hydride	2 He helium 4.00 He helium
			5 B boron 10.81 B boron	6 C carbon 12.01 C carbon	7 N nitrogen 14.01 N^{3-} nitride	8 O oxygen 16.00 O^{2-} oxide	9 F fluorine 19.00 F^- fluoride	10 Ne neon 20.18 Ne neon
			13 Al aluminium 26.98 Al^{3+} aluminium	14 Si silicon 28.09 Si silicon	15 P phosphorus 30.97 P^{3-} phosphide	16 S sulfur 32.07 S^{2-} sulfide	17 Cl chlorine 35.45 Cl^- chloride	18 Ar argon 39.95 Ar argon
28 Ni nickel 58.69 Ni^{2+} nickel(II) Ni^{3+} nickel(III)	29 Cu copper 63.55 Cu^{2+} copper(II) Cu^+ copper(I)	30 Zn zinc 65.41 Zn^{2+} zinc	31 Ga gallium 69.72 Ga^{3+} gallium	32 Ge germanium 72.64 Ge^{4+} germanium	33 As arsenic 74.92 As^{3-} arsenide	34 Se selenium 78.96 Se^{2-} selenide	35 Br bromine 79.90 Br^- bromide	36 Kr krypton 83.80 Kr krypton
46 Pd palladium 106.42 Pd^{2+} palladium(II) Pd^{3+} palladium(III)	47 Ag silver 107.87 Ag^+ silver	48 Cd cadmium 112.41 Cd^{2+} cadmium	49 In indium 114.82 In^{3+} indium	50 Sn tin 118.71 Sn^{4+} tin(IV) Sn^{2+} tin(II)	51 Sb antimony 121.76 Sb^{3+} antimony(III) Sb^{5+} antimony(V)	52 Te tellurium 127.60 Te^{2-} telluride	53 I iodine 126.90 I^- iodide	54 Xe xenon 131.29 Xe xenon
78 Pt platinum 195.08 Pt^{4+} platinum(IV) Pt^{2+} platinum(II)	79 Au gold 196.97 Au^{3+} gold(III) Au^+ gold(I)	80 Hg mercury 200.59 Hg^{2+} mercury(II) Hg^+ mercury(I)	81 Tl thallium 204.38 Tl^+ thallium(I) Tl^{3+} thallium(III)	82 Pb lead 207.2* Pb^{2+} lead(II) Pb^{4+} lead(IV)	83 Bi bismuth 208.98 Bi^{3+} bismuth(III) Bi^{5+} bismuth(V)	84 Po polonium (209) Po^{2+} polonium(II) Po^{4+} polonium(IV)	85 At astatine (210) At^- astatide	86 Rn radon (222) Rn radon
110 Ds darmstadtium (271)	111 Rg roentgenium (272)							

Polyatomic Elements

Elements			
astatine	At_2	iodine	I_2
bromine	Br_2	nitrogen	N_2
chlorine	Cl_2	oxygen	O_2
fluorine	F_2	phosphorus	P_4
hydrogen	H_2	sulfur	S_8

* The isotopic mix of naturally occurring lead is more variable than that of other elements, preventing precision to greater than tenths of a gram per mole.

63 Eu europium 151.96 Eu^{3+} europium(III) Eu^{2+} europium(II)	64 Gd gadolinium 157.25 Gd^{3+} gadolinium	65 Tb terbium 158.93 Tb^{3+} terbium	66 Dy dysprosium 162.50 Dy^{3+} dysprosium	67 Ho holmium 164.93 Ho^{3+} holmium	68 Er erbium 167.26 Er^{3+} erbium	69 Tm thulium 168.93 Tm^{3+} thulium	70 Yb ytterbium 173.04 Yb^{3+} ytterbium(III) Yb^{2+} ytterbium(II)	71 Lu lutetium 174.97 Lu^{3+} lutetium
95 Am americium (243) Am^{3+} americium(III) Am^{4+} americium(IV)	96 Cm curium (247) Cm^{3+} curium	97 Bk berkelium (247) Bk^{3+} berkelium(III) Bk^{4+} berkelium(IV)	98 Cf californium (251) Cf^{3+} californium	99 Es einsteinium (252) Es^{3+} einsteinium	100 Fm fermium (257) Fm^{3+} fermium	101 Md mendelevium (258) Md^{2+} mendelevium(II) Md^{3+} mendelevium(III)	102 No nobelium (259) No^{2+} nobelium(II) No^{3+} nobelium(III)	103 Lr lawrencium (262) Lr^{3+} lawrencium

Nuclear Chemistry

Masses of Subatomic Particles and Radiation

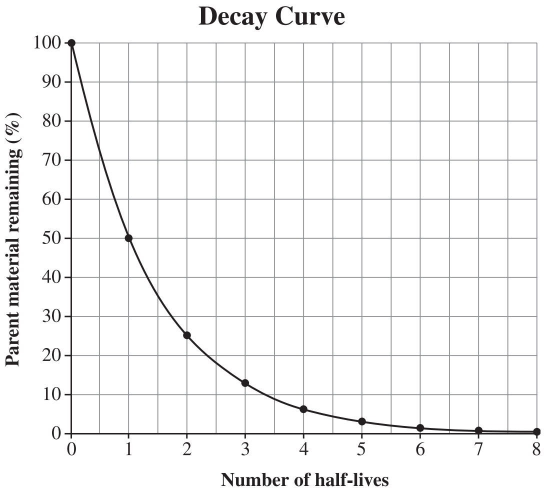
Subatomic Particle or Radiation	Mass (10^{-3} kg/mol)	Subatomic Particle or Radiation	Mass (10^{-3} kg/mol)
alpha particle (helium nucleus) $^{4}_{2}He$ or α	4.001 51	positron $^{0}_{+1}e$	0.000 549
		gamma radiation $^{0}_{0}\gamma$	—
beta particle (electron) $^{0}_{-1}e$ or β	0.000 549	neutron $^{1}_{0}n$	1.008 66
		proton $^{1}_{1}p$	1.007 28

Masses of Selected Nuclides

Nuclide		Mass (10^{-3} kg/mol)	Nuclide		Mass (10^{-3} kg/mol)
barium-141	$^{141}_{56}Ba$	140.914 41	nitrogen-15	$^{15}_{7}N$	15.000 11
beryllium-7	$^{7}_{4}Be$	7.016 93	oxygen-15	$^{15}_{8}O$	15.003 07
beryllium-8	$^{8}_{4}Be$	8.005 31	oxygen-16	$^{16}_{8}O$	15.994 91
boron-8	$^{8}_{5}B$	8.024 61	oxygen-18	$^{18}_{8}O$	17.999 16
carbon-14	$^{14}_{6}C$	14.003 24	phosphorus-31	$^{31}_{15}P$	30.973 76
cesium-144	$^{144}_{55}Cs$	143.932 02	plutonium-239	$^{239}_{94}Pu$	239.052 16
fluorine-17	$^{17}_{9}F$	17.002 10	polonium-210	$^{210}_{84}Po$	209.982 86
helium-3	$^{3}_{2}He$	3.016 03	polonium-218	$^{218}_{84}Po$	218.008 97
hydrogen-1	$^{1}_{1}H$	1.007 83	potassium-40	$^{40}_{19}K$	39.964 00
hydrogen-2 (deuterium)	$^{2}_{1}H$	2.014 10	radium-226	$^{226}_{88}Ra$	226.025 40
hydrogen-3 (tritium)	$^{3}_{1}H$	3.016 03	radon-222	$^{222}_{86}Rn$	222.017 57
krypton-92	$^{92}_{36}Kr$	91.926 11	rubidium-90	$^{90}_{37}Rb$	89.914 81
lanthanum-146	$^{146}_{57}La$	145.925 8	ruthenium-107	$^{107}_{44}Ru$	106.909 9
lead-206	$^{206}_{82}Pb$	205.974 5	strontium-95	$^{95}_{38}Sr$	94.919 31
lead-208	$^{208}_{82}Pb$	207.976 64	sulfur-31	$^{31}_{16}S$	30.979 56
neon-20	$^{20}_{10}Ne$	19.992 44	thorium-230	$^{230}_{90}Th$	230.033 13
nitrogen-13	$^{13}_{7}N$	13.005 74	uranium-235	$^{235}_{92}U$	235.043 92
nitrogen-14	$^{14}_{7}N$	14.003 07			

Elements for Radioactive Dating

Radioisotope (Parent Nuclide)		Final Decay Nuclide		Approximate Half-Life (annum—a)
carbon-14	$^{14}_{6}C$	nitrogen-14	$^{14}_{7}N$	5.73×10^{3}
potassium-40	$^{40}_{19}K$	argon-40	$^{40}_{18}Ar$	1.26×10^{9}
rubidium-87	$^{87}_{37}Rb$	strontium-87	$^{87}_{38}Sr$	4.88×10^{10}
uranium-235	$^{235}_{92}U$	lead-207	$^{207}_{82}Pb$	7.04×10^{8}
uranium-238	$^{238}_{92}U$	lead-206	$^{206}_{82}Pb$	4.47×10^{9}



Decay Curve

Energy Change Formula

$\Delta E = \Delta mc^2$

ΔE = change in energy (J)
Δm = mass converted to energy (kg)
c = speed of EMR (3.00×10^{8} m/s)

Organic Chemistry

Homologous Series of Alkanes at 25°C and 101.325 kPa

Name*	Formula	Name*	Formula
*meth*ane	$CH_4(g)$	*hex*ane	$C_6H_{14}(l)$
*eth*ane	$C_2H_6(g)$	*hept*ane	$C_7H_{16}(l)$
*prop*ane	$C_3H_8(g)$	*oct*ane	$C_8H_{18}(l)$
*but*ane	$C_4H_{10}(g)$	*non*ane	$C_9H_{20}(l)$
*pent*ane	$C_5H_{12}(l)$	*dec*ane	$C_{10}H_{22}(l)$

*Note: Italics indicate organic nomenclature prefixes.

Prefixes for Molecular Compounds

1 = *mono-*
2 = *di-*
3 = *tri-*
4 = *tetra-*
5 = *penta-*
6 = *hexa-*
7 = *hepta-*
8 = *octa-*
9 = *ennea- (nona-)*
10 = *deca-*

Types of Reactions

Formation (Synthesis)
element + element → compound

Decomposition
compound → element + element

Single Replacement
compound + element → new compound + new element

Double Replacement
compound + compound → new compound + new compound

Complete Hydrocarbon Combustion
hydrocarbon + oxygen → carbon dioxide + water

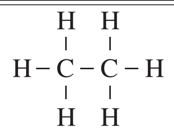
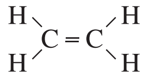
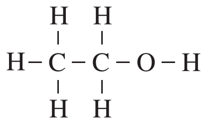
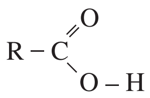
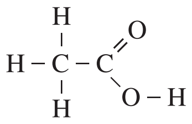
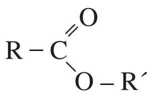
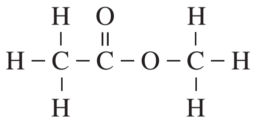
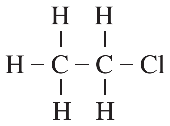
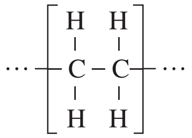
Addition
alkene or alkyne + excess hydrogen → alkane
alkene or alkyne + halogen → halogenated hydrocarbon

Cracking
large hydrocarbon → small hydrocarbons

Polymerization
monomer + monomer → polymer

Esterification
alcohol + carboxylic acid → ester + water

General Formulas and Names of Some Organic Compounds

General Formula	Classification	Example Formula	Example Name
$C_nH_{(2n+2)}$	alkane	 $\mathrm{H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-H}$	ethane
$C_nH_{(2n)}$	alkene	 $\mathrm{{}^{H}_{H}\!>C=C<{}^{H}_{H}}$	ethene
$C_nH_{(2n-2)}$	alkyne	$\mathrm{H-C\equiv C-H}$	ethyne
$\mathrm{R-O-H}$	alcohol	 $\mathrm{H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-O-H}$	ethanol
 $\mathrm{R-C\genfrac{}{}{0pt}{}{=O}{-O-H}}$	carboxylic acid	 $\mathrm{H-\underset{H}{\overset{H}{C}}-C\genfrac{}{}{0pt}{}{=O}{-O-H}}$	ethanoic acid
 $\mathrm{R-C\genfrac{}{}{0pt}{}{=O}{-O-R'}}$	ester	 $\mathrm{H-\underset{H}{\overset{H}{C}}-\overset{O}{\overset{\parallel}{C}}-O-\underset{H}{\overset{H}{C}}-H}$	methyl ethanoate
$\mathrm{R-Q}$	halogenated hydrocarbon	 $\mathrm{H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-Cl}$	chloroethane
$\cdots\!\left[\mathrm{x-y}\right]_n\!\cdots$	polymer	 $\cdots\!\left[\mathrm{\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}}\right]\!\cdots$	polyethene

R usually represents a carbon group
R´ usually represents a different carbon group
Q represents a halogen (fluoro-, chloro-, bromo-, iodo-)
x–y represents the monomer unit
n represents a whole number

Solutions

Solubility of Selected Ionic Compounds in Aqueous Solutions at 25°C

Ion	**Group 1 ions** NH_4^+ NO_3^- ClO_3^- ClO_4^- CH_3COO^-	F^-	Cl^- Br^- I^-	SO_4^{2-}	CO_3^{2-} PO_4^{3-} SO_3^{2-}	IO_3^- $OOCCOO^{2-}$	OH^-
Solubility greater than or equal to 0.1 mol/L (very soluble) **(aq)**	most	most	most	most	Group 1 ions NH_4^+	Group 1 ions NH_4^+ $Co(IO_3)_2$ $Fe_2(OOCCOO)_3$	Group 1 ions NH_4^+
Solubility less than 0.1 mol/L (slightly soluble) **(s)**	$RbClO_4$ $CsClO_4$ $AgCH_3COO$	Li^+ Mg^{2+} Ca^{2+} Sr^{2+} Ba^{2+} Fe^{2+} Pb^{2+}	Cu^+ Ag^+ Pb^{2+} Tl^+	Ca^{2+} Sr^{2+} Ba^{2+} Ag^+ Pb^{2+} Ra^{2+}	most	most	most

Note: This solubility table is only a guideline that was established using the K_{sp} values. A concentration of 0.1 mol/L corresponds to approximately 10 g/L to 30 g/L, depending on molar mass.

Stoichiometry and Solution Formulas

$$n = \frac{m}{M}$$

$$C = \frac{n}{V}$$

$$C_iV_i = C_fV_f$$

$$\frac{coefficient_r}{coefficient_g} = \frac{n_r}{n_g} \quad \text{or} \quad n_r = n_g \times \frac{coefficient_r}{coefficient_g}$$

$$(\%\ V/V) = \frac{V_{solute}}{V_{solution}} \times 100\%$$

$$\text{parts per million} = \frac{m_{solute}}{m_{solution}} \times 10^6 \text{ ppm}$$

n = number of moles (mol)

m = mass (g)

M = molar mass (g/mol)

C = molar concentration (mol/L)

V = volume (L)

i = initial solution

f = final solution

r = required substance

g = given substance

% V/V = percent by volume concentration

Identification of Selected Ions in 1.0 mol/L Aqueous Solutions

Ion	Symbol	Colour in Solution
chromate	$CrO_4^{2-}(aq)$	yellow
chromium(III)	$Cr^{3+}(aq)$	blue-green
chromium(II)	$Cr^{2+}(aq)$	dark blue
cobalt(II)	$Co^{2+}(aq)$	red
copper(I)	$Cu^{+}(aq)$	blue-green
copper(II)	$Cu^{2+}(aq)$	blue
dichromate	$Cr_2O_7^{2-}(aq)$	orange
iron(II)	$Fe^{2+}(aq)$	lime green
iron(III)	$Fe^{3+}(aq)$	orange-yellow
manganese(II)	$Mn^{2+}(aq)$	pale pink
nickel(II)	$Ni^{2+}(aq)$	blue-green
permanganate	$MnO_4^{-}(aq)$	deep purple

Flame Colour of Elements

Element	Symbol	Colour
barium	Ba	yellowish-green
calcium	Ca	yellowish red
cesium	Cs	violet
copper	Cu	blue to green
lead	Pb	blue-white
lithium	Li	red
potassium	K	violet
rubidium	Rb	violet
sodium	Na	yellow
strontium	Sr	scarlet red

Note: The flame test can be used to determine the identity of a metal or a metal ion. Blue to green indicates a range of colours that might appear.

Acids and Bases

Rules for Naming Acids

Compound Name	Classical System Example				IUPAC System Example
	Acid Name	Formula	Compound Name	Acid Name	Acid Name
hydrogen *–ide*	*hydro–ic* acid	$HCl(aq)$	hydrogen chlor*ide*	*hydro*chlor*ic* acid	aqueous hydrogen chloride
hydrogen *–ate*	*–ic* acid	$H_3PO_4(aq)$	hydrogen phosph*ate*	phosphor*ic* acid	aqueous hydrogen phosphate
hydrogen *–ite*	*–ous* acid	$H_3PO_3(aq)$	hydrogen phosph*ite*	phosphor*ous* acid	aqueous hydrogen phosphite

IUPAC Rules for Naming Inorganic Bases

Base Name	Example	
	Formula	Base Name
cation + anion	$NaOH(aq)$	sodium hydroxide

pH Formulas

$pH = -\log_{10}[H_3O^{+}(aq)]$

$[H_3O^{+}(aq)] = 10^{(-pH)}$

[ ] = concentration (mol/L)

Relative Strengths of Selected Acids and Bases for 0.10 mol/L Solution at 25°C

Increasing strength of acid

Increasing strength of base

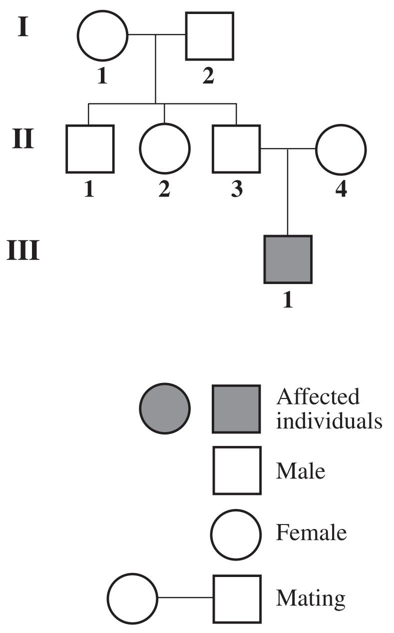
Acid Name	Acid Formula	Conjugate Base Formula
hydrochloric acid	HCl(aq)	Cl^-(aq)
sulfuric acid	H_2SO_4(aq)	HSO_4^-(aq)
nitric acid	HNO_3(aq)	NO_3^-(aq)
hydronium ion	H_3O^+(aq)	H_2O(l)
oxalic acid	$HOOCCOOH$(aq)	$HOOCCOO^-$(aq)
sulfurous acid	H_2SO_3(aq)	HSO_3^-(aq)
hydrogen sulfate ion	HSO_4^-(aq)	SO_4^{2-}(aq)
phosphoric acid	H_3PO_4(aq)	$H_2PO_4^-$(aq)
orange IV	HOr(aq)	Or^-(aq)
nitrous acid	HNO_2(aq)	NO_2^-(aq)
hydrofluoric acid	HF(aq)	F^-(aq)
methanoic (formic) acid	$HCOOH$(aq)	$HCOO^-$(aq)
methyl orange	HMo(aq)	Mo^-(aq)
benzoic acid	C_6H_5COOH(aq)	$C_6H_5COO^-$(aq)
ethanoic (acetic) acid	CH_3COOH(aq)	CH_3COO^-(aq)
carbonic acid (CO_2(g) + H_2O(l))	H_2CO_3(aq)	HCO_3^-(aq)
bromothymol blue	HBb(aq)	Bb^-(aq)
hydrosulfuric acid	H_2S(aq)	HS^-(aq)
phenolphthalein	HPh(aq)	Ph^-(aq)
ammonium ion	NH_4^+(aq)	NH_3(aq)
hydrogen carbonate ion	HCO_3^-(aq)	CO_3^{2-}(aq)
indigo carmine	HIc(aq)	Ic^-(aq)
water (55.5 mol/L)	H_2O(l)	OH^-(aq)

Acid–Base Indicators at 25°C

Indicator	Abbreviation (acid/conjugate base)	pH Range	Colour Change as pH Increases
methyl violet	HMv(aq) / Mv^-(aq)	0.0 – 1.6	yellow to blue
thymol blue	H_2Tb(aq) / HTb^-(aq)	1.2 – 2.8	red to yellow
thymol blue	HTb^-(aq) / Tb^{2-}(aq)	8.0 – 9.6	yellow to blue
orange IV	HOr(aq) / Or^-(aq)	1.4 – 2.8	red to yellow
methyl orange	HMo(aq) / Mo^-(aq)	3.2 – 4.4	red to yellow
bromocresol green	HBg(aq) / Bg^-(aq)	3.8 – 5.4	yellow to blue
litmus	HLt(aq) / Lt^-(aq)	4.5 – 8.3	red to blue
methyl red	HMr(aq) / Mr^-(aq)	4.8 – 6.0	red to yellow
chlorophenol red	HCh(aq) / Ch^-(aq)	5.2 – 6.8	yellow to red
bromothymol blue	HBb(aq) / Bb^-(aq)	6.0 – 7.6	yellow to blue
phenol red	HPr(aq) / Pr^-(aq)	6.6 – 8.0	yellow to red
phenolphthalein	HPh(aq) / Ph^-(aq)	8.2 – 10.0	colourless to pink
thymolphthalein	HTh(aq) / Th^-(aq)	9.4 – 10.6	colourless to blue
alizarin yellow R	HAy(aq) / Ay^-(aq)	10.1 – 12.0	yellow to red
indigo carmine	HIc(aq) / Ic^-(aq)	11.4 – 13.0	blue to yellow
1,3,5–trinitrobenzene	HNb(aq) / Nb^-(aq)	12.0 – 14.0	colourless to orange

Genetics

Pedigree Chart



- Offspring listed in birth order.
- Roman numerals symbolize generations.
- Arabic numbers symbolize individuals within a given generation.

DNA Nitrogen Bases

Nitrogen Base	Abbreviation
adenine	A
cytosine	C
guanine	G
thymine	T

Alleles

Upper case—dominant

Lower case—recessive

Sex linked—$X^?Y$ or $X^?X^?$

DNA Base Triplets and Their Corresponding Amino Acids

		SECOND BASE					
		T	C	A	G		
FIRST BASE	T	TTT phenylalanine	TCT serine	TAT tyrosine	TGT cysteine	T	THIRD BASE
		TTC phenylalanine	TCC serine	TAC tyrosine	TGC cysteine	C	
		TTA leucine	TCA serine	TAA STOP**	TGA STOP**	A	
		TTG leucine	TCG serine	TAG STOP**	TGG tryptophan	G	
	C	CTT leucine	CCT proline	CAT histidine	CGT arginine	T	
		CTC leucine	CCC proline	CAC histidine	CGC arginine	C	
		CTA leucine	CCA proline	CAA glutamine	CGA arginine	A	
		CTG leucine	CCG proline	CAG glutamine	CGG arginine	G	
	A	ATT isoleucine	ACT threonine	AAT asparagine	AGT serine	T	
		ATC isoleucine	ACC threonine	AAC asparagine	AGC serine	C	
		ATA isoleucine	ACA threonine	AAA lysine	AGA arginine	A	
		ATG methionine or START*	ACG threonine	AAG lysine	AGG arginine	G	
	G	GTT valine	GCT alanine	GAT aspartate	GGT glycine	T	
		GTC valine	GCC alanine	GAC aspartate	GGC glycine	C	
		GTA valine	GCA alanine	GAA glutamate	GGA glycine	A	
		GTG valine	GCG alanine	GAG glutamate	GGG glycine	G	

Note: This table uses base triplets from the “complementary” (5´ → 3´) strand of DNA.
*__Note:__ ATG is an initiator base triplet but also codes for the amino acid methionine.
**__Note:__ TAA, TAG, and TGA are terminator base triplets.

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