

SCIENCE

Data Booklet *Updated 2010*

Government
of Alberta ■

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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.

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General Formulas and Data

Formulas and Data

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

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

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

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

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

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

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

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$$

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

$$\vec{F}_{\text{net}} = \vec{F}_a + \vec{F}_f$$

$$W = F\Delta d$$

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

$$\Delta \vec{d} = \vec{v}_i \Delta t + \frac{1}{2} \vec{a} (\Delta t)^2$$

$$\Delta \vec{d} = \left(\frac{\vec{v}_i + \vec{v}_f}{2} \right) \Delta t$$

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

$$\Delta \vec{p} = \vec{F} \Delta t, \Delta \vec{p} = \vec{p}_f - \vec{p}_i$$

$$\vec{F} = \frac{m(\vec{v}_f - \vec{v}_i)}{\Delta t}$$

$$E_p = mgh$$

$$E_k = \frac{1}{2}mv^2$$

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/s²)
 \vec{F} = force (kg·m/s² or N)
 \vec{F}_{net} = net force (N)
 \vec{F}_a = applied force (N)
 \vec{F}_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/s²)
 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

$$\vec{F}_g = m\vec{g}$$

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

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

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

Astronomy Data

Mass of Earth = 5.98×10^{24} kg	Average acceleration due to gravity on surface of Earth = 9.81 m/s^2
Radius of Earth = 6.37×10^6 m	
Mass of sun = 1.99×10^{30} kg	Average gravitational field strength on surface of Earth = 9.81 N/kg
1 light-year = 9.47×10^{15} m	
1 AU (astronomical unit) = 1.50×10^{11} m	

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

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

Ideal Transformers

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

R = resistance (Ω)

P = power (W)

I = current (A)

V = voltage (V)

E = energy (J)

t = time elapsed (s)

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

$$v = f\lambda$$

$$c = f\lambda$$

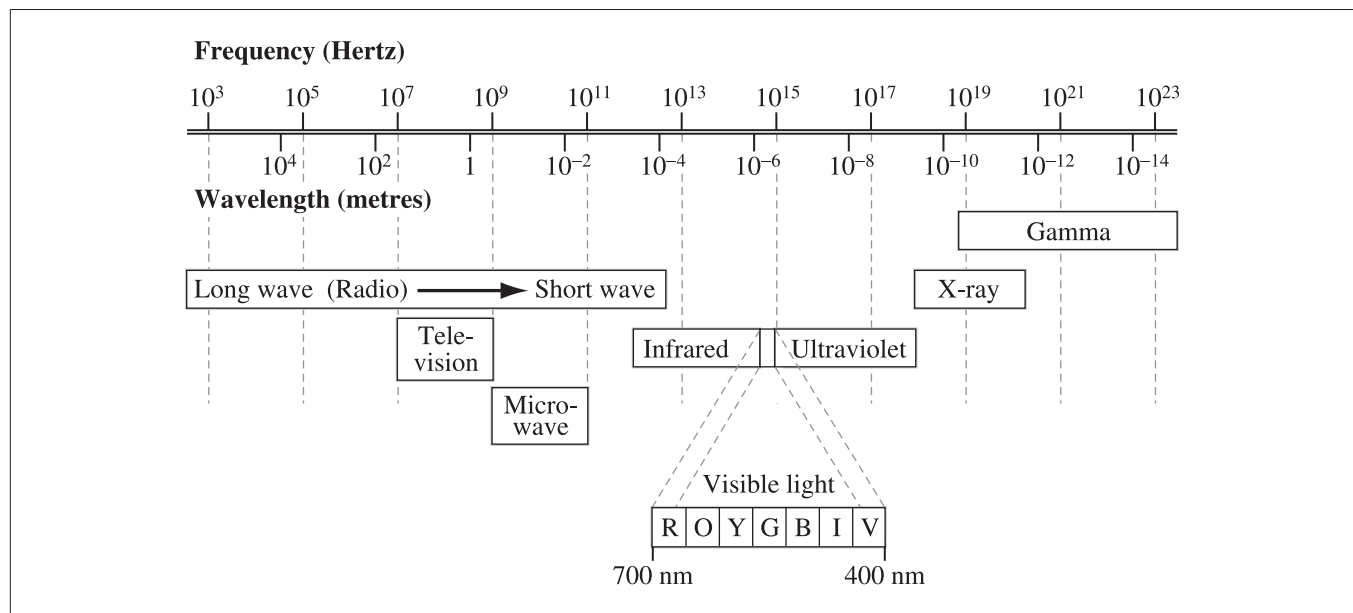
v = speed of wave (m/s)

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

Reduction Half-Reaction	
Au ³⁺ (aq) + 3e ⁻ → Au(s)	Increasing strength of reactant as a reducing agent ↓ Increasing strength of reactant as an oxidizing agent
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)	

Thermodynamics

Heat Capacities of Selected Substances at 25 °C

Compound	Specific Heat Capacity (J/g·°C) or (kJ/kg·°C)
water	4.19
ice (at 0 °C)	2.10
water vapour (at 100 °C)	2.08
methanol	2.53
ethanol	2.44
hexane	2.27
toluene	1.71
air	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	0.00	100.00	6.01	40.66
hexane	-95.35	68.73	13.08	28.85
ethanol	-114.14	78.29	4.93	38.56
methanol	-97.53	64.6	3.22	35.21
toluene	-94.95	110.63	6.64	33.18

Geological Time-Line

Millions of Years Ago	Era	Period	Epoch
1.7	Cenozoic	Quaternary	Holocene
			Pleistocene
		Tertiary	
65	Mesozoic	Cretaceous	
140		Jurassic	
210		Triassic	
250		Permian	
290	Paleozoic	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	$\Delta_f H^\circ$ (kJ/mol)
ammonia	NH ₃ (g)	-45.9
benzene	C ₆ H ₆ (l)	+49.1
butane	C ₄ H 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 ₂ H ₆ (g)	-84.0
ethanoic acid (acetic acid)	CH ₃ COOH(l)	-484.3
ethanol	C ₂ H ₅ OH(l)	-277.6
ethene (ethylene)	C ₂ H ₄ (g)	+52.4
ethyne (acetylene)	C ₂ H ₂ (g)	+227.4
glucose	C ₆ H ₁₂ O ₆ (s)	-1 273.3
hydrogen sulfide	H ₂ S(g)	-20.6
methane	CH ₄ (g)	-74.6
methanol	CH ₃ OH(l)	-239.2
nitrogen dioxide	NO ₂ (g)	+33.2
nitrogen monoxide	NO(g)	+91.3
octane	C ₈ H ₁₈ (l)	-250.1
pentane	C ₅ H ₁₂ (l)	-173.5
propane	C ₃ H 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 ₂ O(l)	-285.8
water (gas)	H ₂ O(g)	-241.8

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

Energy Formulas

$$Q = mc\Delta t$$

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

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

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

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)

Σ = the sum of

$\Delta_f H^\circ$ = standard molar heat (enthalpy) of formation (kJ/mol)

Periodic Chart of the Elements and Ions

1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---

1 H hydrogen 1.01
H ⁺ hydrogen

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
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Table of Polyatomic Ions

Polyatomic ions									
acetate	CH ₃ COO ⁻	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 ₆ H ₅ COO ⁻	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 ₂ PO ₄ ⁻	hydrogen sulfite	HSO ₃ ⁻
carbonate	CO ₃ ²⁻	dichromate	Cr ₂ O ₇ ²⁻	oxalate	OOCOO ²⁻	silicate	SiO ₃ ²⁻	thiocyanate	SCN ⁻
hydrogen carbonate	HCO ₃ ⁻	cyanide	CN ⁻	hydrogen oxalate	HOOCOO ⁻	sulfate	SO ₄ ²⁻	thiosulfate	S ₂ O ₃ ²⁻
perchlorate	ClO ₄ ⁻	hydroxide	OH ⁻						

3 Li lithium 6.94	4 Be beryllium 9.01
Li ⁺ lithium	Be ²⁺ beryllium
11 Na sodium 22.99	12 Mg magnesium 24.31
Na ⁺ sodium	Mg ²⁺ magnesium

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

Key

Atomic number →	91	Pa	← Symbol of the element
Name of the element →	protactinium		
Atomic mass →	231.04		
	Pa ⁵⁺		← Ion charge
	protactinium(V)		← Stock name (IUPAC)
	Pa ⁴⁺		
	protactinium(IV)		

Based on ¹²₆C
Most stable or common ion is listed above dotted line. Atomic mass in parentheses indicates mass of the most stable isotope.

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

10	11	12	13	14	15	16	17	18
----	----	----	----	----	----	----	----	----

1	H	2	He
hydrogen	1.01	helium	4.00
H ⁻ hydride		He helium	

5	B	6	C	7	N	8	O	9	F	10	Ne
boron	10.81	carbon	12.01	nitrogen	14.01	oxygen	16.00	fluorine	19.00	neon	20.18
B boron		C carbon		N ³⁻ nitride		O ²⁻ oxide		F ⁻ fluoride		Ne neon	

13	Al	14	Si	15	P	16	S	17	Cl	18	Ar
aluminium	26.98	silicon	28.09	phosphorus	30.97	sulfur	32.07	chlorine	35.45	argon	39.95
Al ³⁺ aluminium		Si silicon		P ³⁻ phosphide		S ²⁻ sulfide		Cl ⁻ chloride		Ar argon	

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

28	Ni	29	Cu	30	Zn	31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr
nickel	58.69	copper	63.55	zinc	65.41	gallium	69.72	germanium	72.64	arsenic	74.92	selenium	78.96	bromine	79.90	krypton	83.80
Ni ²⁺ nickel(II)		Cu ²⁺ copper(II)		Zn ²⁺ zinc		Ga ³⁺ gallium		Ge ⁴⁺ germanium		As ³⁻ arsenide		Se ²⁻ selenide		Br ⁻ bromide		Kr krypton	

46	Pd	47	Ag	48	Cd	49	In	50	Sn	51	Sb	52	Te	53	I	54	Xe
palladium	106.42	silver	107.87	cadmium	112.41	indium	114.82	tin	118.71	antimony	121.76	tellurium	127.60	iodine	126.90	xenon	131.29
Pd ²⁺ palladium(II)		Ag ⁺ silver		Cd ²⁺ cadmium		In ³⁺ indium		Sn ⁴⁺ tin(IV)		Sb ³⁺ antimony(III)		Te ²⁻ telluride		I ⁻ iodide		Xe xenon	

78	Pt	79	Au	80	Hg	81	Tl	82	Pb	83	Bi	84	Po	85	At	86	Rn
platinum	195.08	gold	196.97	mercury	200.59	thallium	204.38	lead	207.2*	bismuth	208.98	polonium	(209)	astatine	(210)	radon	(222)
Pt ⁴⁺ platinum(IV)		Au ³⁺ gold(III)		Hg ²⁺ mercury(II)		Tl ⁺ thallium(I)		Pb ²⁺ lead(II)		Bi ³⁺ bismuth(III)		Po ²⁺ polonium(II)		At ⁻ astatide		Rn radon	

110	Ds	111	Rg
darmstadtium	(271)	roentgenium	(272)

* 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	64	Gd	65	Tb	66	Dy	67	Ho	68	Er	69	Tm	70	Yb	71	Lu
europium	151.96	gadolinium	157.25	terbium	158.93	dysprosium	162.50	holmium	164.93	erbium	167.26	thulium	168.93	ytterbium	173.04	lutetium	174.97
Eu ³⁺ europium(III)		Gd ³⁺ gadolinium		Tb ³⁺ terbium		Dy ³⁺ dysprosium		Ho ³⁺ holmium		Er ³⁺ erbium		Tm ³⁺ thulium		Yb ³⁺ ytterbium(III)		Lu ³⁺ lutetium	

95	Am	96	Cm	97	Bk	98	Cf	99	Es	100	Fm	101	Md	102	No	103	Lr
americium	(243)	curium	(247)	berkelium	(247)	californium	(251)	einsteinium	(252)	fermium	(257)	mendelevium	(258)	nobelium	(259)	lawrencium	(262)
Am ³⁺ americium(III)		Cm ³⁺ curium		Bk ³⁺ berkelium(III)		Cf ³⁺ californium		Es ³⁺ einsteinium		Fm ³⁺ fermium		Md ²⁺ mendelevium(II)		No ²⁺ nobelium(II)		Lr ³⁺ lawrencium	

Organic Chemistry

Homologous Series of Alkanes at 25°C and 101.325 kPa

Name*	Formula	Name*	Formula
<i>meth</i> ane	CH ₄ (g)	<i>hex</i> ane	C ₆ H ₁₄ (l)
<i>eth</i> ane	C ₂ H ₆ (g)	<i>hept</i> ane	C ₇ H ₁₆ (l)
<i>prop</i> ane	C ₃ H ₈ (g)	<i>oct</i> ane	C ₈ H ₁₈ (l)
<i>but</i> ane	C ₄ H ₁₀ (g)	<i>non</i> ane	C ₉ H ₂₀ (l)
<i>pent</i> ane	C ₅ H ₁₂ (l)	<i>dec</i> ane	C ₁₀ H ₂₂ (l)

*Note: Italics indicate organic nomenclature prefixes.

Prefixes for Molecular Compounds

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

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 _n H _(2n+2)	alkane	$\begin{array}{c} \text{H} & \text{H} \\ & \\ \text{H}-\text{C}- & \text{C}-\text{H} \\ & \\ \text{H} & \text{H} \end{array}$	ethane
C _n H _(2n)	alkene	$\begin{array}{c} \text{H} & & \text{H} \\ & \diagdown & / \\ & \text{C} = \text{C} & \\ & / & \diagdown \\ \text{H} & & \text{H} \end{array}$	ethene
C _n H _(2n-2)	alkyne	H - C ≡ C - H	ethyne
R - O - H	alcohol	$\begin{array}{c} \text{H} & \text{H} \\ & \\ \text{H}-\text{C}- & \text{C}-\text{O}-\text{H} \\ & \\ \text{H} & \text{H} \end{array}$	ethanol
$\begin{array}{c} \text{O} \\ // \\ \text{R}-\text{C} \\ \backslash \\ \text{O}-\text{H} \end{array}$	carboxylic acid	$\begin{array}{c} \text{H} & \text{O} \\ & // \\ \text{H}-\text{C}- & \text{C} \\ & \backslash \\ \text{H} & \text{O}-\text{H} \end{array}$	ethanoic acid
$\begin{array}{c} \text{O} \\ // \\ \text{R}-\text{C} \\ \backslash \\ \text{O}-\text{R}' \end{array}$	ester	$\begin{array}{c} \text{H} & \text{O} & \text{H} \\ & // & \\ \text{H}-\text{C}- & \text{C}-\text{O}- & \text{C}-\text{H} \\ & & \\ \text{H} & & \text{H} \end{array}$	methyl ethanoate
R - Q	halogenated hydrocarbon	$\begin{array}{c} \text{H} & \text{H} \\ & \\ \text{H}-\text{C}- & \text{C}-\text{Cl} \\ & \\ \text{H} & \text{H} \end{array}$	chloroethane
... [x - y] _n ...	polymer	$\left[\begin{array}{c} \text{H} & \text{H} \\ & \\ \text{---} \text{C} & - & \text{C} \text{---} \\ & \\ \text{H} & \text{H} \end{array} \right]_n \dots$	polyethene
R	usually represents a carbon group	x - y	represents the monomer unit
R'	usually represents a different carbon group	n	represents a whole number
Q	represents a halogen (fluoro-, chloro-, bromo-, iodo-)		

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 ₃ COO ⁻	F ⁻	Cl ⁻ Br ⁻ I ⁻	SO ₄ ²⁻	CO ₃ ²⁻ PO ₄ ³⁻ SO ₃ ²⁻	IO ₃ ⁻ OOC ₂ COO 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 (OOC ₂ COO) ₃	Group 1 ions NH ₄ ⁺
Solubility less than 0.1 mol/L (slightly soluble) (s)	RbClO ₄ CsClO ₄ AgCH ₃ COO	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

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

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

$$C_i V_i = C_f V_f$$

$$\frac{\text{coefficient}_r}{\text{coefficient}_g} = \frac{n_r}{n_g} \quad \text{or} \quad n_r = n_g \times \frac{\text{coefficient}_r}{\text{coefficient}_g}$$

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

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

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	$\text{CrO}_4^{2-}(\text{aq})$	yellow
chromium(III)	$\text{Cr}^{3+}(\text{aq})$	blue-green
chromium(II)	$\text{Cr}^{2+}(\text{aq})$	dark blue
cobalt(II)	$\text{Co}^{2+}(\text{aq})$	red
copper(I)	$\text{Cu}^+(\text{aq})$	blue-green
copper(II)	$\text{Cu}^{2+}(\text{aq})$	blue
dichromate	$\text{Cr}_2\text{O}_7^{2-}(\text{aq})$	orange
iron(II)	$\text{Fe}^{2+}(\text{aq})$	lime green
iron(III)	$\text{Fe}^{3+}(\text{aq})$	orange-yellow
manganese(II)	$\text{Mn}^{2+}(\text{aq})$	pale pink
nickel(II)	$\text{Ni}^{2+}(\text{aq})$	blue-green
permanganate	$\text{MnO}_4^-(\text{aq})$	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 <i>-ide</i>	<i>hydro-ic acid</i>	$\text{HCl}(\text{aq})$	hydrogen chlor <i>ide</i>	<i>hydrochloric acid</i>	aqueous hydrogen chloride
hydrogen <i>-ate</i>	<i>-ic acid</i>	$\text{H}_3\text{PO}_4(\text{aq})$	hydrogen phosph <i>ate</i>	<i>phosphoric acid</i>	aqueous hydrogen phosphate
hydrogen <i>-ite</i>	<i>-ous acid</i>	$\text{H}_3\text{PO}_3(\text{aq})$	hydrogen phosph <i>ite</i>	<i>phosphorous acid</i>	aqueous hydrogen phosphite

IUPAC Rules for Naming Inorganic Bases

Base Name	Example	
	Formula	Base Name
cation + anion	$\text{NaOH}(\text{aq})$	sodium hydroxide

pH Formulas

$$\text{pH} = -\log_{10}[\text{H}_3\text{O}^+(\text{aq})]$$

$$[\text{H}_3\text{O}^+(\text{aq})] = 10^{(-\text{pH})}$$

[] = concentration (mol/L)

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

Acid Name	Acid Formula	Conjugate Base Formula
hydrochloric acid	HCl(aq)	Cl ⁻ (aq)
sulfuric acid	H ₂ SO ₄ (aq)	HSO ₄ ⁻ (aq)
nitric acid	HNO ₃ (aq)	NO ₃ ⁻ (aq)
hydronium ion	H ₃ O ⁺ (aq)	H ₂ O(l)
oxalic acid	HOOC ₂ COOH(aq)	HOOC ₂ COO ⁻ (aq)
sulfurous acid	H ₂ SO ₃ (aq)	HSO ₃ ⁻ (aq)
hydrogen sulfate ion	HSO ₄ ⁻ (aq)	SO ₄ ²⁻ (aq)
phosphoric acid	H ₃ PO ₄ (aq)	H ₂ PO 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 ₆ H ₅ COOH(aq)	C ₆ H ₅ COO ⁻ (aq)
ethanoic (acetic) acid	CH ₃ COOH(aq)	CH ₃ COO ⁻ (aq)
carbonic acid (CO ₂ (g) + H ₂ O(l))	H ₂ CO ₃ (aq)	HCO ₃ ⁻ (aq)
bromothymol blue	HBb(aq)	Bb ⁻ (aq)
hydrosulfuric acid	H ₂ S(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 ₂ O(l)	OH ⁻ (aq)

↑
Increasing strength of acid

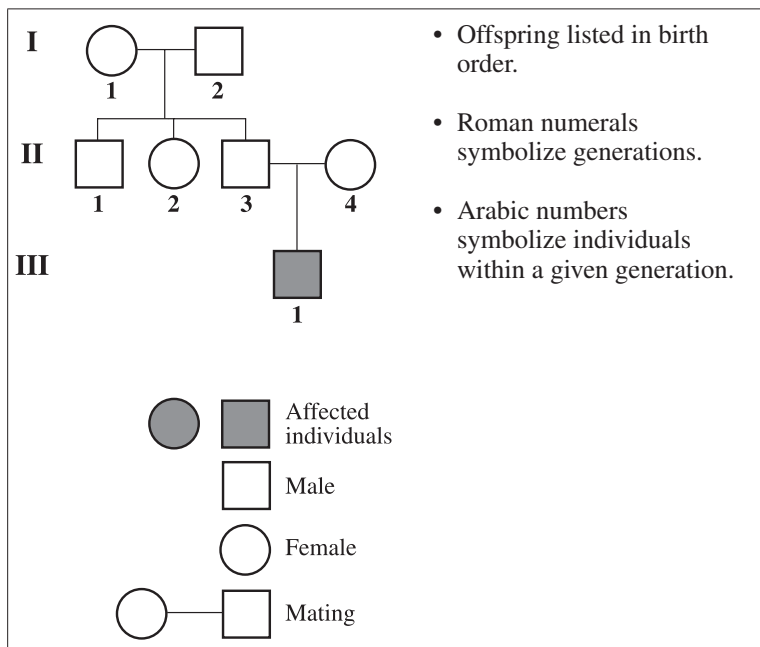
↓
Increasing strength of base

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 ₂ Tb(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



DNA Nitrogen Bases

Nitrogen Base	Abbreviation
adenine	A
cytosine	C
guanine	G
thymine	T

Alleles

Upper case—dominant
 Lower case—recessive
 Sex linked— X^2Y or X^2X^2

DNA Base Triplets and Their Corresponding Amino Acids

		S E C O N D B A S E					
		T	C	A	G		
F	T	TTT phenylalanine	TCT serine	TAT tyrosine	TGT cysteine	T	T
		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	
I	C	CTT leucine	CCT proline	CAT histidine	CGT arginine	T	H
		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	
B	A	ATT isoleucine	ACT threonine	AAT asparagine	AGT serine	T	B
		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	
S	G	GTT valine	GCT alanine	GAT aspartate	GGT glycine	T	E
		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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