Useful data for chemistry students

Atomic weights based on $^{12}C=12$

(Numbers) = most stable isotope

s block | d block | p block

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1s	1 **H** 1.0079																	2 **He** 4.0026	
2s	3 **Li** 6.941	4 **Be** 9.0122											5 **B** 10.811	6 **C** 12.0107	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.9984	10 **Ne** 20.1797	2p
3s	11 **Na** 22.9898	12 **Mg** 24.305											13 **Al** 26.6815	14 **Si** 28.0855	15 **P** 30.9738	16 **S** 32.066	17 **Cl** 35.4527	18 **Ar** 39.948	3p
4s	19 **K** 39.0983	20 **Ca** 40.078	21 **Sc** 44.9559	22 **Ti** 47.867	23 **V** 50.9415	24 **Cr** 51.9961	25 **Mn** 54.938	26 **Fe** 55.845	27 **Co** 58.9332	28 **Ni** 58.6934	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.9216	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80	4p
5s	37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.9059	40 **Zr** 91.224	41 **Nb** 92.9064	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.9055	46 **Pd** 106.42	47 **Ag** 107.8682	48 **Cd** 112.411	49 **In** 114.818	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.9045	54 **Xe** 131.29	5p
6s	55 **Cs** 132.9055	56 **Ba** 137.327	57* **La** 138.9055	72 **Hf** 178.49	73 **Ta** 180.9479	74 **W** 183.84	75 **Re** 186.207	76 **Os** 190.23	77 **Ir** 192.217	78 **Pt** 195.078	79 **Au** 196.9666	80 **Hg** 200.59	81 **Tl** 204.3833	82 **Pb** 207.2	83 **Bi** 208.9804	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)	6p
7s	87 **Fr** (223)	88 **Ra** (226)	89# **Ac** (227)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (264)	108 **Hs** (265)	109 **Mt** (268)	110 **Ds** (271)	111 **Rg** (272)								

*Lanthanoid series

4f	58 **Ce** 140.116	59 **Pr** 140.9077	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.964	64 **Gd** 157.25	65 **Tb** 158.9253	66 **Dy** 162.50	67 **Ho** 164.9303	68 **Er** 167.26	69 **Tm** 168.9342	70 **Yb** 173.04	71 **Lu** 174.967

#Actinoid series

f block

5f	90 **Th** 232.0381	91 **Pa** 231.0359	92 **U** 238.0289	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

Physical Constants

Avogadro constant	$N_A = 6.022 \times 10^{23}$ mol^{-1}
Boltzmann constant	$k_B = 1.381 \times 10^{-23}$ J K^{-1}
Planck constant	$h = 6.626 \times 10^{-34}$ J s
Elementary charge	$e = 1.602 \times 10^{-19}$ C
Ideal gas constant	$R = 8.314$ J K^{-1} mol^{-1}
Vacuum permittivity	$\varepsilon_o = 8.854 \times 10^{-12}$ J^{-1} C^2 m^{-1}
Speed of light (vacuum)	$c = 2.998 \times 10^8$ m s^{-1}

SI Base Units

Quantity	Unit Name	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Derived Units

Property	Unit Name	Unit Symbols
Frequency	hertz	Hz = s^{-1}
Force	newton	N = kg m s^{-2}
Pressure	pascal	Pa = N m^{-2}
Energy	joule	J = N m = kg m^2 s^{-2}
Electric charge	coulomb	C = s A
Potential difference	volt	V = J C^{-1}
Power	watt	W = J s^{-1}

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Useful data for chemistry students

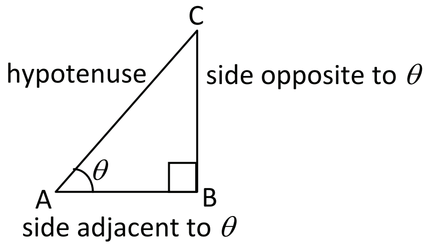
Algebra

Formula for solving a quadratic equation:

If $ax^2 + bx + c = 0$ then

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Trigonometry



$$\sin\theta = \frac{opposite}{hypotenuse} = \frac{BC}{AC}$$

$$\cos\theta = \frac{adjacent}{hypotenuse} = \frac{AB}{AC}$$

$$\tan\theta = \frac{opposite}{adjacent} = \frac{BC}{AB}$$

Logarithms

For any positive base *b* (with b≠1)

$\log_b A = c$ means $A = b^c$

$\log_b A + \log_b B = \log_b AB$

$\log_b A - \log_b B = \log_b \frac{A}{B}$

$n\log_b A = \log_b A^n$

$\log_b 1 = 0$

$\log_b b = 1$

Weights and conversions

%w/v = percentage weight per volume

%w/w = percentage weight for weight

	by parts		weight per volume
		1 g dm^{-3}	1 gram per litre
1ppm	1 part per million	mg dm^{-3}	milligrams per litre
1ppb	1 part per billion	µg dm^{-3}	micrograms per litre
1ppt	1 part per trillion	ng dm^{-3}	nanograms per litre

1 million=10^6, 1 billion=10^9, 1 trillion=10^{12}

	weight per volume (w/v)	parts per million (ppm)	parts per billion (ppb)
1 g dm^{-3}	0.1% w/v	10^3 ppm	10^6 ppb
10 g dm^{-3}	1.0% w/v	10^6 ppm	10^9 ppb
100 dm^{-3}	10.0% w/v	10^9 ppm	10^{12} ppb

NOTE: Unit for volume is dm^{-3} which is equivalent to a litre

Prefixes (SI units)

y	z	a	f	p	n	µ	m	c	d
yocto	zepto	atto	femto	pico	nano	micro	milli	centi	deci
10^{-24}	10^{-21}	10^{-18}	10^{-15}	10^{-12}	10^{-9}	10^{-6}	10^{-3}	10^{-2}	10^{-1}

da	h	k	M	G	T	P	E	Z	Y
deca	hecto	kilo	mega	giga	tera	peta	exa	zetta	yotta
10	10^2	10^3	10^6	10^9	10^{12}	10^{15}	10^{18}	10^{21}	10^{24}

Greek Alphabet

α	alpha	ι	iota	ρ	rho
β	beta	κ	kappa	σ (Σ)	sigma
γ	gamma	λ (Λ)	lambda	τ	tau
δ (Δ)	delta	µ	mu	υ	upsilon
ε	epsilon	ν	nu	φ	phi
ζ	zeta	ξ	xi	χ	chi
η	eta	ο	omicron	ψ (Ψ)	psi
θ	theta	π	pi	ω (Ω)	omega

Indices

$a^m a^n = a^{m+n}$ $\quad \frac{a^m}{a^n} = a^{m-n}$

$(a^m)^n = a^{mn}$ $\quad a^0 = 1$

$a^{-m} = \frac{1}{a^m}$ $\quad a^{\frac{1}{n}} = \sqrt[n]{a}$

$a^{\frac{m}{n}} = (\sqrt[n]{a})^m$

Moles etc.

$c = \frac{n}{V}$ $\quad n = \frac{m}{M}$

$\rho = \frac{M}{V}$ $\quad \frac{n_A}{n_B} = \frac{c_A V_A}{c_B V_B}$

$$\%\ yield = \frac{\text{Mass obtained}}{\text{Theoretical yield}} \text{ x } 100$$

Useful data for chemistry students

Gases

Ideal Gas Law

$$pV = nRT$$

$$pV = \frac{1}{3}nMc^2$$

$$\frac{V_1}{V_2} = \frac{T_1}{T_2}$$

$$p_1V_1 = p_2V_2$$

$$p = \frac{RT}{V_m - b} - \frac{a}{{V_m}^2}$$

$$pV_m = RT(1 + \mathrm{B}p + \mathrm{C}p^2 + \cdots)$$

Phases

Clapeyron equation

$$\frac{\mathrm{d}p}{\mathrm{d}T} = \frac{\Delta H}{T\Delta V}$$

Clausius-Clapeyron

$$\ln\frac{p_1}{p_2} = -\frac{\Delta H}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

Gibbs phase rule

$$F = C - P + 2$$

Thermodynamics

First Law

$$\Delta U = q + w$$

$$H = U + pV$$

$$C_v = \frac{\Delta U}{\Delta T}$$

$$C_p = a + bT + \frac{c}{T^2}$$

$$C_p = \frac{\Delta H}{\Delta T}$$

Second Law

$$\Delta S = \frac{q_{rev}}{T}$$

$$S = k\ln W$$

$$A = U - TS$$

$$\Delta G = \Delta H - T\Delta S$$

$$\Delta S = nR\ln\left(\frac{V_{final}}{V_{initial}}\right)$$

Isothermal expansion of ideal gas

$$\left(\frac{\partial}{\partial T}\left(\frac{\Delta G}{T}\right)\right)_p = -\frac{\Delta H}{T^2}$$

Mixtures

$p_A = x_A p_A^*$ Raoult's law

$p_B = x_B K_B$ Henry's law

$$\mu_A(l) = \mu_A^*(l) + RT\ln x_A$$

$$V = \sum_i n_i V_{m,i}$$

$$G = \sum_i n_i \mu_i$$

Reactions

$\Delta_r G = \Delta_r G^\circ + RT\ln Q$ where

$$Q = \prod_J a_j^{v_j}$$

At equilibrium $Q = K$. If $\Delta_r G = 0$ then $-\Delta_r G^\circ = RT\ln K$ where

$$K = \prod_e a_e^{v_j}$$

$$\Delta_r G^\circ = -RT\ln K$$

$$\frac{\mathrm{d}\ln K}{\mathrm{d}T} = \frac{\Delta_r H^\circ}{RT^2}$$

Kinetics

Order	Rate Law: Diff. form	Rate Law: Integrated form	Half-life	Units of k
0	$\frac{\mathrm{d}[\mathrm{A}]}{\mathrm{dt}} = -k$	$[\mathrm{A}]_0 - [\mathrm{A}] = kt$	$\frac{[\mathrm{A}]_0}{2k}$	mol dm^{-3} s^{-1}
1	$\frac{\mathrm{d}[\mathrm{A}]}{\mathrm{dt}} = -k[\mathrm{A}]$	$[A] = [A]_0 e^{-kt}$	$\frac{\ln 2}{k}$	s^{-1}
2	$\frac{\mathrm{d}[\mathrm{A}]}{\mathrm{dt}} = -k[\mathrm{A}]^2$	$\frac{1}{[\mathrm{A}]} - \frac{1}{[\mathrm{A}]_0} = kt$	$\frac{1}{\mathrm{k}[\mathrm{A}]_0}$	mol^{-1} dm^3 s^{-1}
2*	$\frac{\mathrm{d}[\mathrm{A}]}{\mathrm{dt}} = -k[\mathrm{A}][\mathrm{B}]$	$\frac{1}{[\mathrm{B}]_0 - [\mathrm{A}]_0}\ln\frac{[\mathrm{B}][\mathrm{A}]_0}{[\mathrm{A}][\mathrm{B}]_0} = kt$	-	mol^{-1} dm^3 s^{-1}

*A+B → P reaction **where** **[A]** = conc. reactant A at time ***t***

$[\mathrm{A}]_0$= initial conc. reactant A (t=0)

Useful data for chemistry students

Spectroscopy

$c = \nu\lambda$

$\tilde{\nu} = \frac{1}{\lambda}$

$\tilde{\nu} = \Re_{\mathrm{H}}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

Maxwell Distribution

$g = \left(\frac{m}{2\pi kT}\right)^{\frac{1}{2}} e^{-\frac{mv^2}{2kT}}$

Beer-Lambert Law

$A = \varepsilon cl$

$\log\frac{I_0}{I} = A$

$A = -\log T = \log\frac{1}{T}$

Boltzmann Distribution

$\frac{N_i}{N_j} = e^{-(E_i - E_j)/kT}$

Rotational levels of a diatomic molecule

$E_j = hcBJ(J+1)$ where $B = \frac{\hbar}{4\pi cI}$ and $J = 0,1,2 \ldots$

with a selection rule of $\Delta J = \pm 1$,

allowed absorptions occur at $\tilde{\nu} = 2B(J+1)$

Vibrational energy levels

$E_v = \left(v + \frac{1}{2}\right)\hbar\omega$ where $\omega = \left(\frac{k}{\mu}\right)^{\frac{1}{2}}$

with $v = 0,1,2 \ldots$

With a selection rule of $\Delta v \pm 1$ allowed absorptions

pH Equations

$\mathrm{pH} = -\log[\mathrm{H_3O^+}]$

$\mathrm{pOH} = -\log[\mathrm{OH^-}]$

for $\mathrm{HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)}$

$K_a = \frac{[\mathrm{H_3O^+}][\mathrm{A^-}]}{[\mathrm{HA}]}$ and $\mathrm{p}K_a = -\log K_a$

$K_W = [\mathrm{H_3O^+}][\mathrm{OH^-}] = 10^{-14}$ and $pK_w = -\log K_W$

Electrochemistry

$\Delta G^{\ominus} = -nFE^{\ominus}$

$\ln K = \frac{nFE^{\ominus}}{RT}$

$E = E^{\ominus} - \frac{RT}{nF}\ln Q$ Nernst Equation

Lattice Energies

Born-Mayer equation

$\Delta U(0K) = -\frac{LA|z_+||z_-|e^2}{4\pi\varepsilon_0 r_0}\left(1 - \frac{\rho}{r_0}\right)$

Born-Lande equation

$\Delta U(0K) = -\frac{LA|z_+||z_-|e^2}{4\pi\varepsilon_0 r_0}\left(1 - \frac{1}{n}\right)$

Kapustinskii equation

$\Delta U(0K) = \frac{(1.07\mathrm{x}10^5)v|z_+||z_-|}{r_+ + r_-}$

Quantum Theory

$E = h\nu$

$\lambda = \frac{h}{p}$

$\hbar = \frac{h}{2\pi}$

$-\frac{\hbar^2}{2m}\frac{d^2\Psi}{dx^2} + V(x)\Psi = E\Psi$

$\Psi = Ae^{ikx} + Be^{-ikx}$

with $E = \frac{\hbar^2 k^2}{2m}$ and $p = \hbar k$

$\Delta p \Delta x \geq \frac{1}{2}\hbar$

Magnetic moments

$\mu(spin - only) = \sqrt{n(n+2)}$

$\mu(spin - only) = 2\sqrt{S(S+1)}$

(μ is in μ_{BM} units)

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