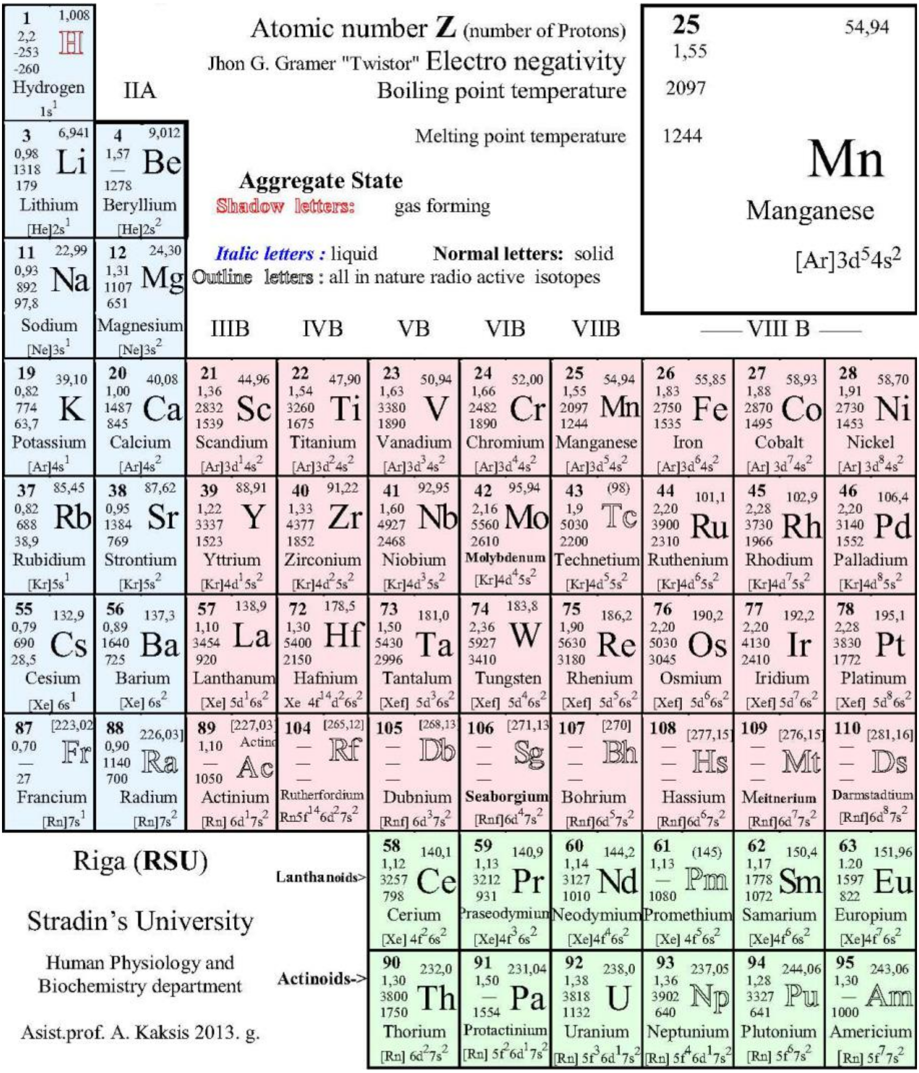
A.Kaksis

DATA BOOKLET
FOR MEDICAL CHEMISTRY

CONTENT

RSU
2023

Periodic Table of ELEMENTS



Atomic number **Z** (number of Protons)
Jhon G. Gramer "Twistor" Electro negativity
Boiling point temperature
Melting point temperature

Aggregate State
Shadow letters: gas forming
Italic letters : liquid **Normal letters:** solid
Outline letters : all in nature radio active isotopes

25
54,94
1,55
2097
1244
Mn
Manganese
$[Ar]3d^5 4s^2$

1 1,008 2,2 -253 -260 H Hydrogen $1s^1$	IIA								
3 6,941 0,98 1318 179 Li Lithium $[He]2s^1$	4 9,012 1,57 — 1278 Be Beryllium $[He]2s^2$								
11 22,99 0,93 892 97,8 Na Sodium $[Ne]3s^1$	12 24,30 1,31 1107 651 Mg Magnesium $[Ne]3s^2$	IIIB	IVB	VB	VIB	VIIB	—— VIII B ——		
19 39,10 0,82 774 63,7 K Potassium $[Ar]4s^1$	20 40,08 1,00 1487 845 Ca Calcium $[Ar]4s^2$	21 44,96 1,36 2832 1539 Sc Scandium $[Ar]3d^1 4s^2$	22 47,90 1,54 3260 1675 Ti Titanium $[Ar]3d^2 4s^2$	23 50,94 1,63 3380 1890 V Vanadium $[Ar]3d^3 4s^2$	24 52,00 1,66 2482 1890 Cr Chromium $[Ar]3d^4 4s^2$	25 54,94 1,55 2097 1244 Mn Manganese $[Ar]3d^5 4s^2$	26 55,85 1,83 2750 1535 Fe Iron $[Ar]3d^6 4s^2$	27 58,93 1,88 2870 1495 Co Cobalt $[Ar]\ 3d^7 4s^2$	28 58,70 1,91 2730 1453 Ni Nickel $[Ar]\ 3d^8 4s^2$
37 85,45 0,82 688 38,9 Rb Rubidium $[Kr]5s^1$	38 87,62 0,95 1384 769 Sr Strontium $[Kr]5s^2$	39 88,91 1,22 3337 1523 Y Yttrium $[Kr]4d^1 5s^2$	40 91,22 1,33 4377 1852 Zr Zirconium $[Kr]4d^2 5s^2$	41 92,95 1,60 4927 2468 Nb Niobium $[Kr]4d^3 5s^2$	42 95,94 2,16 5560 2610 Mo **Molybdenum** $[Kr]4d^4 5s^2$	43 (98) 1,9 5030 2200 Tc Technetium $[Kr]4d^5 5s^2$	44 101,1 2,20 3900 2310 Ru Ruthenium $[Kr]4d^6 5s^2$	45 102,9 2,28 3730 1966 Rh Rhodium $[Kr]4d^7 5s^2$	46 106,4 2,20 3140 1552 Pd Palladium $[Kr]4d^8 5s^2$
55 132,9 0,79 690 28,5 Cs Cesium $[Xe]\ 6s^1$	56 137,3 0,89 1640 725 Ba Barium $[Xe]\ 6s^2$	57 138,9 1,10 3454 920 La Lanthanum $[Xe]\ 5d^1 6s^2$	72 178,5 1,30 5400 2150 Hf Hafnium $Xe\ 4f^{14} d^2 6s^2$	73 181,0 1,50 5430 2996 Ta Tantalum $[Xef]\ 5d^3 6s^2$	74 183,8 2,36 5927 3410 W Tungsten $[Xef]\ 5d^4 6s^2$	75 186,2 1,90 5630 3180 Re Rhenium $[Xef]\ 5d^5 6s^2$	76 190,2 2,20 5030 3045 Os Osmium $[Xef]\ 5d^6 6s^2$	77 192,2 2,20 4130 2410 Ir Iridium $[Xef]\ 5d^7 6s^2$	78 195,1 2,28 3830 1772 Pt Platinum $[Xef]\ 5d^8 6s^2$
87 [223,02 0,70 — 27 Fr Francium $[Rn]7s^1$	88 226,03] 0,90 1140 700 Ra Radium $[Rn]7s^2$	89 [227,03] 1,10 — 1050 Actin Ac Actinium $[Rn]\ 6d^1 7s^2$	104 [265,12] — — — Rf Rutherfordium $Rn5f^{14} 6d^2 7s^2$	105 [268,13 — — — Db Dubnium $[Rnf]\ 6d^3 7s^2$	106 [271,13 — — — Sg **Seaborgium** $[Rnf]6d^4 7s^2$	107 [270] — — — Bh Bohrium $[Rnf]6d^5 7s^2$	108 [277,15] — — — Hs Hassium $[Rnf]6d^6 7s^2$	109 [276,15] — — — Mt **Meitnerium** $[Rnf]6d^7 7s^2$	110 [281,16] — — — Ds **Darmstadtium** $[Rnf]6d^8 7s^2$
			Lanthanoids>	58 140,1 1,12 3257 798 Ce Cerium $[Xe]\ 4f^2 6s^2$	59 140,9 1,13 3212 931 Pr Praseodymiun $[Xe]4f^3 6s^2$	60 144,2 1,14 3127 1010 Nd Neodymium $[Xe]4f^4 6s^2$	61 (145) 1,13 — 1080 Pm Promethium $[Xe]\ 4f^5 6s^2$	62 150,4 1,17 1778 1072 Sm Samarium $[Xe]4f^6 6s^2$	63 151,96 1.20 1597 822 Eu Europium $[Xe]4f^7 6s^2$
			Actinoids->	90 232,0 1,30 3800 1750 Th Thorium $[Rn]\ 6d^2 7s^2$	91 231,04 1,50 — 1554 Pa Protactinium $[Rn]\ 5f^2 6d^1 7s^2$	92 238,0 1,38 3818 1132 U Uranium $[Rn]\ 5f^3 6d^1 7s^2$	93 237,05 1,36 3902 640 Np Neptunium $[Rn]\ 5f^4 6d^1 7s^2$	94 244,06 1,28 3327 641 Pu Plutonium $[Rn]\ 5f^6 7s^2$	95 243,06 1,30 — 1000 Am Americium $[Rn]\ 5f^7 7s^2$

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Human Physiology and
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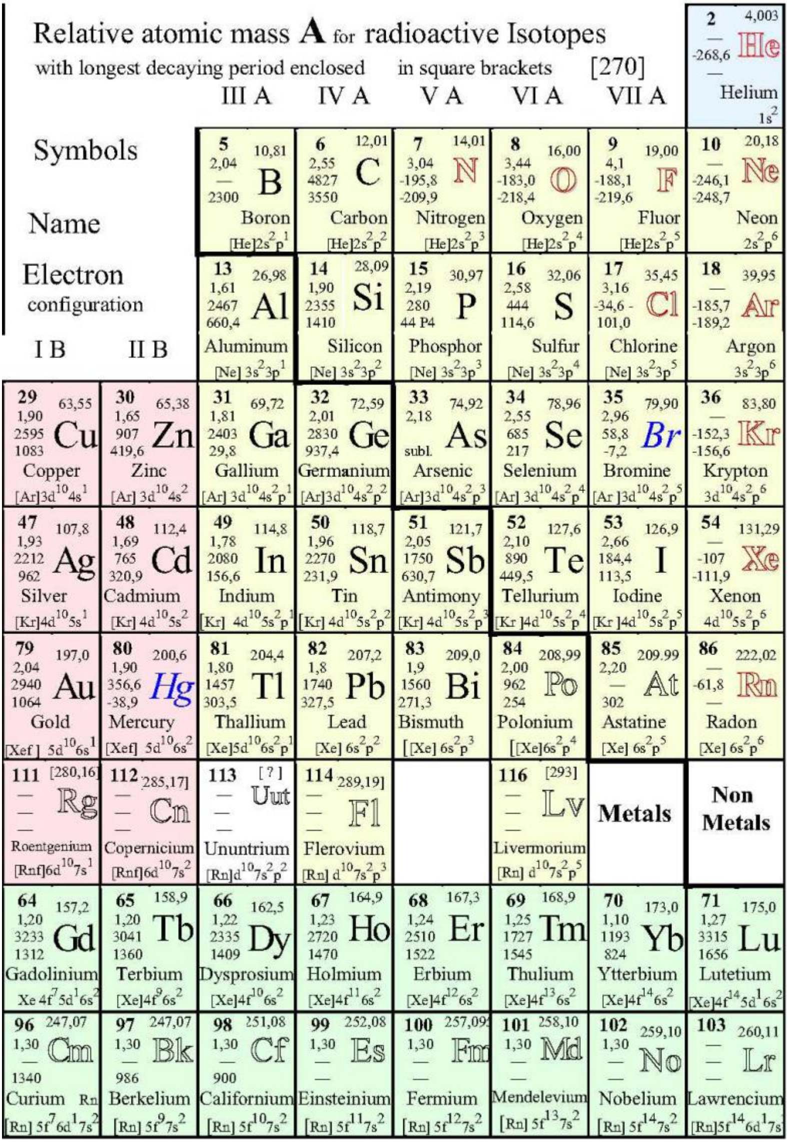
Periodic Table of ELEMENTS



Relative atomic mass A for radioactive Isotopes with longest decaying period enclosed in square brackets [270]							2 4,003 — -268,6 — He Helium $1s^{2}$
		III A	IV A	V A	VI A	VII A	
Symbols Name		5 10,81 2,04 — 2300 B Boron $[He]2s^{2}p^{1}$	6 12,01 2,55 4827 3550 C Carbon $[He]2s^{2}p^{2}$	7 14,01 3,04 -195,8 -209,9 N Nitrogen $[He]2s^{2}p^{3}$	8 16,00 3,44 -183,0 -218,4 O Oxygen $[He]2s^{2}p^{4}$	9 19,00 4,1 -188,1 -219,6 F Fluor $[He]2s^{2}p^{5}$	10 20,18 — -246,1 -248,7 Ne Neon $2s^{2}p^{6}$
Electron configuration I B	II B	13 26,98 1,61 2467 660,4 Al Aluminum $[Ne]\ 3s^{2}3p^{1}$	14 28,09 1,90 2355 1410 Si Silicon $[Ne]\ 3s^{2}3p^{2}$	15 30,97 2,19 280 44 P4 P Phosphor $[Ne]\ 3s^{2}3p^{3}$	16 32,06 2,58 444 114,6 S Sulfur $[Ne]\ 3s^{2}3p^{4}$	17 35,45 3,16 -34,6 - 101,0 Cl Chlorine $[Ne]\ 3s^{2}3p^{5}$	18 39,95 — -185,7 -189,2 Ar Argon $3s^{2}3p^{6}$
29 63,55 1,90 2595 1083 Cu Copper $[Ar]3d^{10}4s^{1}$	30 65,38 1,65 907 419,6 Zn Zinc $[Ar]\ 3d^{10}4s^{2}$	31 69,72 1,81 2403 29,8 Ga Gallium $[Ar]\ 3d^{10}4s^{2}p^{1}$	32 72,59 2,01 2830 937,4 Ge Germanium $[Ar]3d^{10}4s^{2}p^{2}$	33 74,92 2,18 subl. As Arsenic $[Ar]3d^{10}4s^{2}p^{3}$	34 78,96 2,55 685 217 Se Selenium $[Ar]\ 3d^{10}4s^{2}p^{4}$	35 79,90 2,96 58,8 -7,2 Br Bromine $[Ar\ ]3d^{10}4s^{2}p^{5}$	36 83,80 — -152,3 -156,6 Kr Krypton $3d^{10}4s^{2}p^{6}$
47 107,8 1,93 2212 962 Ag Silver $[Kr]4d^{10}5s^{1}$	48 112,4 1,69 765 320,9 Cd Cadmium $[Kr]\ 4d^{10}5s^{2}$	49 114,8 1,78 2080 156,6 In Indium $[Kr]\ 4d^{10}5s^{2}p^{1}$	50 118,7 1,96 2270 231,9 Sn Tin $[Kr]\ 4d^{10}5s^{2}p^{2}$	51 121,7 2,05 1750 630,7 Sb Antimony $[Kr]\ 4d^{10}5s^{2}p^{3}$	52 127,6 2,10 890 449,5 Te Tellurium $[Kr\ ]4d^{10}5s^{2}p^{4}$	53 126,9 2,66 184,4 113,5 I Iodine $[Kr\ ]4d^{10}5s^{2}p^{5}$	54 131,29 — -107 -111,9 Xe Xenon $4d^{10}5s^{2}p^{6}$
79 197,0 2,04 2940 1064 Au Gold $[Xef\ ]\ 5d^{10}6s^{1}$	80 200,6 1,90 356,6 -38,9 Hg Mercury $[Xef]\ 5d^{10}6s^{2}$	81 204,4 1,80 1457 303,5 Tl Thallium $[Xe]5d^{10}6s^{2}p^{1}$	82 207,2 1,8 1740 327,5 Pb Lead $[Xe]\ 6s^{2}p^{2}$	83 209,0 1,9 1560 271,3 Bi Bismuth $[[Xe]\ 6s^{2}p^{3}$	84 208,99 2,00 962 254 Po Polonium $[[Xe]6s^{2}p^{4}$	85 209.99 2,20 — 302 At Astatine $[Xe]\ 6s^{2}p^{5}$	86 222,02 — -61,8 — Rn Radon $[Xe]\ 6s^{2}p^{6}$
111 [280,16] — — — Rg Roentgenium $[Rnf]6d^{10}7s^{1}$	112 285,17] — — — Cn Copernicium $[Rnf]6d^{10}7s^{2}$	113 [?] — — — Uut Ununtrium $[Rn]d^{10}7s^{2}p^{2}$	114 289,19] — — — Fl Flerovium $[Rn]\ d^{10}7s^{2}p^{3}$		116 [293] — — — Lv Livermorium $[Rn]\ d^{10}7s^{2}p^{5}$	**Metals**	**Non Metals**
64 157,2 1,20 3233 1312 Gd Gadolinium $Xe\ 4f^{7}5d^{1}6s^{2}$	65 158,9 1,20 3041 1360 Tb Terbium $[Xe]4f^{9}6s^{2}$	66 162,5 1,22 2335 1409 Dy Dysprosium $[Xe]4f^{10}6s^{2}$	67 164,9 1,23 2720 1470 Ho Holmium $[Xe]4f^{11}6s^{2}$	68 167,3 1,24 2510 1522 Er Erbium $[Xe]4f^{12}6s^{2}$	69 168,9 1,25 1727 1545 Tm Thulium $[Xe]4f^{13}6s^{2}$	70 173,0 1,10 1193 824 Yb Ytterbium $[Xe]4f^{14}6s^{2}$	71 175,0 1,27 3315 1656 Lu Lutetium $[Xe]4f^{14}5d^{1}6s^{2}$
96 247,07 1,30 — 1340 Cm Curium Rn $[Rn]\ 5f^{7}6d^{1}7s^{2}$	97 247,07 1,30 — 986 Bk Berkelium $[Rn]\ 5f^{9}7s^{2}$	98 251,08 1,30 — 900 Cf Californium $[Rn]\ 5f^{10}7s^{2}$	99 252,08 1,30 — — Es Einsteinium $[Rn]\ 5f^{11}7s^{2}$	100 257,09 1,30 — — Fm Fermium $[Rn]\ 5f^{12}7s^{2}$	101 258,10 1,30 — — Md Mendelevium $[Rn]\ 5f^{13}7s^{2}$	102 259,10 1,30 — — No Nobelium $[Rn]\ 5f^{14}7s^{2}$	103 260,11 — — — Lr Lawrencium $[Rn]5f^{14}6d^{1}7s$

Solubility Table

SOLUBILITY OF ACIDS, BASES AND SALTS IN WATER

	H^+	NH_4^+	K^+	Na^+	Li^+	Ba^{2+}	Sr^{2+}	Ca^{2+}	Mg^{2+}	Al^{3+}
OH^-	H_2O	s	s	s	s	s	m	m	n	n
F^-	s	s	s	s	n	m	n	n	m	m
Cl^-	s	s	s	s	s	s	s	s	s	s
Br^-	s	s	s	s	s	s	s	s	s	s
I^-	s	s	s	s	s	s	s	s	s	s
S^{2-}	s	s	s	s	s	s	s	+	n	+
SO_3^{2-}	s↑	s	s	s	s	n	n	n	m	+
SO_4^{2-}	∞	s	s	s	s	n	n	m	s	s
PO_4^{3-}	s	s	s	s	m	n	n	n	n	n
CO_3^{2-}	s↑	s	s	s	s	n	n	n	n	+
SiO_3^{2-}	n	-	s	s	s	n	n	n	n	n
NO_3^-	∞	s	s	s	s	s	s	s	s	s
CH_3COO^-	s	s	s	s	s	s	s	s	s	s

s – soluble; **m** – slightly soluble; n – **insoluble**; ∞-unlimited solubility;
s↑ - decomposes in water with gas emission; **+** - reacts with water;
– - substance does not exist

	Zn^{2+}	Fe^{2+}	Fe^{3+}	Mn^{2+}	Pb^{2+}	Cu^{2+}	Hg^{2+}	Ag^+	Cr^{3+}
OH^-	n	n	n	n	n	n	-	-	n
F^-	m	m	n	s	m	s	+	s	m
Cl^-	s	s	s	s	m	s	s	n	s
Br^-	s	s	s	s	m	s	m	n	s
I^-	s	s	-	s	n	-	n	n	s
S^{2-}	n	n	+	n	n	n	n	n	-
SO_3^{2-}	n	n	+	n	n	-	-	n	-
SO_4^{2-}	s	s	s	s	n	s	+	m	s
PO_4^{3-}	n	n	n	n	n	n	n	n	n
CO_3^{2-}	N	n	+	n	n	-	-	n	-
SiO_3^{2-}	N	n	n	n	n	n	-	-	-
NO_3^-	S	s	s	s	s	s	s	s	s
CH_3COO^-	S	s	s	s	s	s	s	s	s

Physical Constants and Unit Conversions

	Sign	***Unit***	***Examples***
Number of moles Amount of substance	**n**	mol	$n(H_2SO_4) = 0.5$ *mol*
Count of equivalents for reaction of compound	**z**	eq	*Two valent acid* $z(H_2SO_4) = 2$ *eq*
Number of equivalent moles for reaction	**n^z**	eq·mol	$n^z(H_2SO_4) = 1.0$ *eq·mol*
Mass of substance	**m**	g, kg, t	$m(H_2SO_4) = 49$ *g* $m = 0.049$ *kg*; $m = 1.03$ *t*
Mass of solution	**m(solution)** , g		$m(H_2O$ *1liter*$) = 1000$ *g*
Volume of solution	**V**	L mL, m^3	*V (NaCl sol.)* $= 0.174$ *L* $V = 174$ *mL*, $V = 0.000174\ m^3$
Density	**ρ**	g/mL kg/ m^3	*ρ(NaOH sol.)* $= 1.04$ *g/mL* $\rho = 1.78\ kg/m^3$
Molar mass	**M**	g/mol	$M(H_2SO_4) = 98$ *g/mol*
Mass fraction	**w**	Unit less no $0 < w < 1$	$w(H_2SO_4) = 0.243$
Mass fraction,%	**w%**	% , ***procentum*** $0\% < w\% < 100\%$	$w\%(H_2SO_4) = 24.3\ \%$
parts per million	**ppm**	Unit less $0 < ppm < 1\,000\,000$	$ppm(H_2SO_4) = 243\,000$ *ppm*
Promill alcohol in blood	**pml**	Unit less $0 < pml < 5$	$pml(H_3CCH_2OH) = 0.1$ *pml*
Molar concentration	**c_M**	mol/L = M olarity	$c_M(H_2SO_4) = 2.5$ *mol/L* $c_M(H_2SO_4) = 2.5$ *M* *[2.5 molar solution of* H_2SO_4*]*
Normal concentration	**c_N**	eq·mol/L = = Normality	$c_N(H_2SO_4) = 5.0$ eq·mol/L $c_N(H_2SO_4) = 5.0$ *N* *[5.0 normal solution of* H_2SO_4*]*
temperature	**t**	**° C , Celsius**	$t = 25°\ C$
Absolute Temperature	**T**	**K , Kelvin**	$T = 298.15$ *K*
Atomic size distance units	**l**	**Å , angstrem**	$1Å = 10^{-8}$ *cm*$= 10^{-10}$ *m*$= 0.1$ *nm*

Universal gas constant *R* = 8.3144 $J \cdot K^{-1} \cdot mol^{-1}$

Molar volume V_o of an ideal gas at 273 K and $1.01 \cdot 10^5$ Pa $V_o = 2.24 \times 10^{-2}\ m^3 \cdot mol^{-1}$

(V_o=22.4 L·mol^{-1})

Specific heat capacity C_p of water = $4.18\ kJ \cdot kg^{-1} \cdot K^{-1}$ (= $4.18\ J \cdot g^{-1} \cdot K^{-1}$)

Ionic product constant for water $K_w = 1.00 \cdot 10^{-14}$ at 298 K

Temperature conversation from °C to K T [K] = t [°C] + 273.15

1 atm = $1.013 \cdot 10^5$ Pa = 760 mm Hg

1 dm^3 = 1 litre = $1 \times 10^{-3}\ m^3 = 1 \times 10^3\ cm^3$

Table of chemical and physical values

	Basic Formula	***expression I***	***expression II***
Substance amount n *&* *mass* m	$n = \frac{m}{M}$	$m = n \cdot M$	$M = \frac{m}{n}$
Density ρ *of solution*	$\rho = \frac{m(solution)}{V}$	$m(solution) = \rho \cdot V$	$V = \frac{m(solution)}{\rho}$
Mass fraction (from mass) $w_{\%} = \frac{m \bullet 100\%}{m(solution)}$		$m = \frac{w\% \bullet m(solution)}{100\%}$ $m(solution) = \frac{m \bullet 100\%}{w\%}$	
Molar concentration molarity	$c_M = \frac{n}{V}$	$n = c_M \cdot V$	$V = \frac{n}{c_M}$
Molar concentration molarity (from mass)	$c_M = \frac{m}{M \bullet V}$	$m = c_M \cdot M \cdot V$	$M = \frac{m}{c_M \bullet V}$
Normal concentration normality	$c_N = c_M \cdot z$	$z = \frac{c_N}{c_M}$	$c_M = \frac{c_N}{z}$
Dilution	$c_{M1} \cdot V_1 = c_{M2} \cdot V_2$	$V_1 = \frac{c_{M2} \bullet V_2}{c_{M1}}$	$c_{M2} = \frac{c_{M1} \bullet V_1}{V_2}$
Water addition $\Delta V_{H2O} = V_2 - V_1$	$c_{M1} \cdot V_1 = c_{M2} \cdot (V_1 + \Delta V_{H2O})$ $V_2 = \frac{c_{M1} \bullet V_1}{c_{M2}}$		$\Delta V_{H2O} = V_2 - V_1$

Best choice of volume is one liter that V=1 L =>1000 mL

$$c_M = \frac{m}{M \bullet V} \; ; \; c_M = \frac{m}{M \bullet 1 Liter} = \frac{m}{M}$$

and using density ρ for m(solution) calculation V=1000 mL

$m(solution) = \rho \cdot V = \rho \cdot 1000$ mL (units of m(solution) is in grams)

Standard Electrode Potentials

El	Red. form=Oxidized form+n**e**⁻	H_2O classic E_o	Thermodyn. H_2O account	Absolute -0.3982 V
H	$\underline{\mathbf{H}(\mathrm{Pt})}+H_2O=H_3O^{+}+(\mathrm{Pt})+\mathbf{e}^{-}$	classic **0**	**0.10166**	-0,2965
	$\underline{\mathbf{H}(\mathrm{Pt})}+OH^{-}=H_2O+(\mathrm{Pt})+\mathbf{e}^{-}$	-0.932195	-0.93268	-1.33088
O	$6H_2O=O_2^{(g)} + 4\ H_3O^{+}+4e^{-}$	1.2288	+1.48466	1.0865
	$H_2O_2+2H_2O=O^{-}_{2aqua}+2H_3O^{+}+e^{-}$	1.2764	+1.58416	1.0829
	$4H_2O=H_2O_2+2\ H_3O^{+}\ +2e^{-}$	1.776	+2.08366	1.6855
	$H_2O_{2aqua}+2H_2O=O_{2aq}+2H_3O^{+}+2e^{-}$	0.6945	0.8477	0.4495
N	$NO_2^{-}+2OH^{-}=NO_3^{-}+H_2O+2e^{-}$	0.01	0.0602	-0.3380
	$HNO_2+4H_2O=NO_3^{-}+3H_3O^{+}+2e^{-}$	0.94	1.2477	0.8495
	$NO_{aq}+6H_2O=NO_3^{-}+4H_3O^{+}+3e^{-}$	0.96	1.2677	0.8695
	$NH_4^{+}+13H_2O=NO_3^{-}+10H_3O^{+}+8e^{-}$	0.87	1.4180	1.0198
Br	$2Br^{-}=Br_2(aq)+2e^{-}$	1.0873	1.18896	0.79076
Bi	$BiO^{+}+6H_2O=BiO_3^{-}+4H_3O^{+}+2e^{-}$	1.80	2.210645	1.812445
Mn	$Mn^{2+}+12H_2O=MnO_4^{-}+8H_3O^{+}+5e^{-}$	1.51	1.8588	1.4506
	$\underline{MnO_2}+4OH^{-}=MnO_4^{-}+2H_2O+3e^{-}$	0.603	0.6360	0.2378
	$MnO_4^{2-}=MnO_4^{-}+e^{--}$	0.558	0.6597	0.2615
Pb	$Pb^{2+}+6H_2O=\underline{PbO_2}(s)+4H_3O^{+}+2e^{-}$	1.455	1.8656	1.4674
	$Pb+H_2O = Pb^{2+}\ \ +2e^{-}$	-0.126	0.0272	-0.3710
S	$H_2SO_3+4H_2O=HSO_4^{-}+3H_3O^{+}+2e^{-}$	0.172	0.47965	0.08145
	$HSO_3^{-}+4H_2O=SO_4^{2-}+3H_3O^{+}+2e^{-}$	0.172	0.47965	0.08145
	$SO_3^{2-}+2OH^{-}=SO_4^{2-}+H_2O+2e^{-}$	-0.93	-0.87984	-1.27804
	$S^{2-}=S_{rombic}+H_2O + 2\ e^{-}$	-0.4763	-0.4261	-0.8243
	$HS^{-}+OH^{-}=S_{rombic}+2H_2O+2e^{-}$	-0.478	-0.4793	-0.8775
	$H_2S_{aq}+2H_2O=S_{rombic}+2H_3O^{+}+2e^{-}$	0.142	0.3467	-0.0515
	$2S_2O_3^{2-}=S_4O_6^{2-}+2e^{-}$	0.08	0.18166	-0.2165
Fe	$Fe^{2+}=Fe^{3+}+e^{-}$	0.769	0.8717	0.4735
	$Fe(s)+ H_2O =Fe^{2+}+2e^{-}$	-0.4402	-0.2870	-0.6852
Ag	$Ag+ H_2O=Ag^{+}+e^{-}$	0.7994	1.0041	0.6059
	$Ag(s)+Cl^{-} =AgCl(s)+H_2O+e^{-}$	0.2223	0.2210	-0.1772
	$Ag+2NH_{3(aq)}=Ag(NH_3)_2^{+}+e^{-}$	0.373	0.4747	0.0765
	$2Ag+2OH^{-} =Ag_2O(s)+ H_2O+2e^{-}$	0.345	0.3952	-0.0030
I	$3I^{-}=I_3^{-}+2e^{-}$	0.6276	0.72926	0.33106
Cu	$Cu(Hg)+H_2O=Cu^{2+}+(Hg)+2e^{-}$	0.3435	0.4967	0.0985
F	$2F^{-}=F_2(g)+2e^{-}$	2.87	2.97166	2.5735
Cl	$2Cl^{-}=Cl_2(g)+2e^{-}$	1.358	1.45966	1.06146
	$Cl_2(g)+4H_2O=2HOCl+2H_3O^{+}+2e^{-}$	1.63	1.93765	1.53945
Cr	$2Cr^{3+}+21H_2O=Cr_2O_7^{2-}+14H_3O^{+}+6e^{-}$	1.33	1.7921	1.3939
	$Cr^{3+}+11H_2O=HCrO_4^{-}+7H_3O^{+}+3e^{-}$	1.20	1.6793	1.2811
C	$H_2C_2O_4+2H_2O=2CO_2+2H_3O^{+}+2e^{-}$	-0.49	-0.28534	-0.6835
Cr	$Cr+H_2O=Cr^{3+}+3e^{-}$	-0.744	-0.6080	-1.0062
Zn	$Zn+H_2O=Zn^{2+}+2e^{-}$	-0.7628	-0.6096	-1.0078
Al	$\underline{Al}+ H_2O=Al^{3+}+3e^{-}$	-1.662	-1.5260	-1.9242
Al	$\underline{Al}+4OH^{-}= H_2AlO_3^{-}+H_2O+3e^{-}$	-2.33	-2.2627	-2.6609

Ist type **Electrode potential E**

Red(Me)↔ Ox(Me^{n+}) + ne^-, n=3, E_{oCr}=-1.3939 V (classic E_o=-0,744 V)

Cr+**H_2O**$=$**Cr^{3+}**+$3e^-$; n = 3; **Cr**Cl_3 salt is conc. of ion [**Cr^{3+}**]=0.03 M

E = E^o+0.0591/n•lg[Me^{n+}] ; E=E_o+0.0591/3•log([**Cr^{3+}**]/[**Cr**])

Red-Ox **Electrode potential E** ; E=E_{oH2O}+0.0591/n•lg([**Ox**]/[**Red**]);

E= E_{oH2O} +0.0591/5log([**MnO_4^{2-}**][H_3O^+]^8/[**Mn^{2+}**]/[H_2O]^{12});

Mn^{2+}+12$H_2O$$=$$MnO_4^-$+8$H_3O^+$**+5$e^-$**; E_{oH2O}=1,4506 V (classic E_o+1,51 V)

|——Ox form —| ↔ |—Red form—| if ([**MnO_4^{2-}**][H_3O^+]^8=[**Mn^{2+}**][H_2O]^{12};

E = E_{oH2O} =1.86+log(1) =1,86 +0 = 1,86 V

Ostwald's dilution law

$$K_{dis.} = \frac{\alpha^2 \cdot c_M}{1-\alpha}$$

For weak acid $\alpha=\sqrt{\frac{K_{dis.}}{c_M}}$;

$$C=\frac{[H^+]^2}{K_a}=\frac{10^{-pH\bullet 2}}{K_a}$$

$K_{a.}$ = 1.75·10^{-5} ; c_M = 0,01 M ; pH = 3.3785

$$\alpha=\sqrt{\frac{1.75\cdot 10^{-5}}{0.01\text{ M}}}=0.0418=4.18\%$$

$$K_a=\frac{[H^+]^{-pH\bullet 2}}{1\cdot 0.01\,M}=\frac{10^{-3.3785\bullet 2}}{0.01}=\frac{10^{-6.757}}{0.01}=1.75\cdot 10^{-5}$$

For strong electrolytes

$$\alpha=\frac{[H^+]}{z\cdot C}=\frac{10^{-pH}}{z\cdot C}$$

HCl strong acid pH = 2.4 ; c_M = 0,01 M

$$\alpha=\frac{[H^+]}{1\cdot 0.01\,M}=\frac{10^{-2.4}}{0.01}=0.3981=39.81\%$$

Isotonic coefficient

i=1+α·(m-1); 0 < α < 1

for total osmolarity Δc_{osm} is $i\cdot c_M$ total osmolar concentration $\Delta c_{osm}=i\cdot c_M$

Glucose as non electrolyte α=0

i=1+0·(1-1)=1 , $\Delta c_{osm}=1\cdot c_M$

Na_2SO_4 strong electrolyte 0.3<α< 0.999

$Na_2SO_4 \rightarrow 2Na^+ + SO_4^{2-}$

i=1+0,999·(3-1) = 2.998 , $\Delta c_{osm}=2.998\cdot c_M$

Osmotic pressure kPa on membrane is energy Jouls in cell volume liter

$\pi=\Delta c_{osm}\cdot R\cdot T$; $kPa=\frac{J}{L}$

$\Delta c_{osm}=i\cdot c_M\cdot$

At temperature 25 C or 298.15 K

0.2M glucose non-electrolyte, α=0; i = 1 sol.

$$\pi=1\cdot 0.2M\cdot 8.3144\frac{J}{K\cdot mol}\cdot 298.15\text{K}=495.79\text{ kPa}$$

0.2M Na_2SO_4 strong electrolyte, α=1; i = 3 sol.

$$\pi=3\cdot 0.2M\cdot 8.3144\frac{J}{K\cdot mol}\cdot 298.15\text{K}=1487.38\text{ kPa}$$

Ionic strength I or μ

$$I=\frac{1}{2}\sum\alpha\cdot c_i\cdot z_i^2$$

is total concentration of ions

$I=1/2\ (2\cdot 0.2M\cdot(+1)^2+0.2M\cdot(-2)^2$

0.2M Na_2SO_4solution $\alpha=1$

salt => sodium and sulfate ions

Na_2SO_4 => $2Na^+ + SO_4^{2-}$

$$=1\cdot\frac{1}{2}(2\cdot 0.2M\cdot 1+0.2M\cdot 4)=\frac{1}{2}(0.4+0.8)=0.6$$

Hess law and Prigogine Thermodynamics

Hess Enthalpy of reaction: $\Delta H_{Hess}=\sum\Delta H^{o}_{products}-\sum\Delta H^{o}_{reactants}$.

Dispersed (lost) heat in surrounding : $\Delta S_{heat\_dispersed} = -\Delta H_{Hess} / T$

Hess Entropy of reaction: $\Delta S_{Hess} = \sum\Delta S^{o}_{products}-\sum\Delta S^{o}_{reactants}$.

Hess Gibbs free energy of reaction $\Delta G_{Hess} = \Delta H_{Hess} - T\bullet\Delta S_{Hess}$

Negative Δ**G** means that the process (reaction) is **spontaneous** ($\Delta G<0$)

Positive Δ**G** means that the process is forbidden, **non-spontaneous** ($\Delta G>0$)

Prigogine attractor the Gibbs free energy change minimum ΔG_{min}**:**

$$|\Delta G_{Hess}|>|\Delta G_{min}|=|\Delta G_{equilibrium}|;\ \Delta G_{eq}=-R\bullet T\bullet\ln(K_{eq})\ .$$

$$\Delta G_{homeostasis}=\Delta G_{eq}+R\bullet T\bullet\ln(K_{homeostasis})\ .$$

Total energy dispersion entropy $\Delta S_{total}=\Delta S_{Hess}+\Delta S_{heat\_dispersed}$

Total entropy negative $T\bullet\Delta S_{total}<0$ tandem accumulate energy in products $\Delta G>0$,

Total entropy positive $T\bullet\Delta S_{total}>0$ spontaneous dispersed energy $\Delta G<0$.

Opposite singe with identical value ΔG for bound energy $\Delta G_{dispersed}=|T\bullet\Delta S_{total}|$

Combustion heat of reaction for food containing energy amount evaluation:

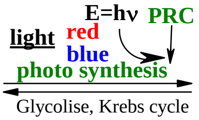
$$\Delta H_{Hess} = \Sigma\Delta H^{\textbf{combustions}}_{\textbf{reactants}} - \Sigma\Delta H^{\textbf{combustions}}_{\textbf{products}}$$

Photo Synthesis assimilate light **blue** **red** photon energy **E=hν**

Hydroxonium ions

$6HCO_3^-+6H_3O^++Q+\Delta G_{accumulate}$

Bicarbonate ions



$C_6H_{12}O_6+6O_{2aqua}+6H_2O$

glucose+oxygen

$$\Delta H_{Hess} = (\Delta H^\circ_{C6H12O} + 6\Delta H^\circ_{O2}) - (6\Delta H^\circ_{H2O} + 6\Delta H^\circ_{CO2})$$

$$\Delta S_{Hess} = (\Delta S^\circ_{C6H12O} + 6\Delta S^\circ_{O2}) - (6\Delta S^\circ_{H2O} + 6\Delta S^\circ_{CO2})$$

$$\Delta G_{Hess} = \Delta H_{Hess} - T\bullet\Delta S_{Hess}$$

$$\Delta S_{heat\_dispersed} = -\Delta H_{Hess} / T$$

$$\Delta S_{total} = \Delta S_{Hess} + \Delta S_{heat\_dispersed}$$

accumulate energy in products $C_6H_{12}O_6+6\ O_{2aqua}+6H_2O$

organisms by oxidation produce heat, energy, concentration gradients

for osmosis against and for transport down the concentration gradient:

$$C_6H_{12}O_6+6O_{2aqua}+6H_2O \Rightarrow 6HCO_3^-+6H_3O^+ + Q + \Delta G_{Hess}$$

Thermodynamic of equilibrium and homeostasis

Thermodynamic equilibrium constant K_{eq} is expressed as $K_{eq}=\mathbf{e}^{-\frac{\Delta G_{eq}}{RT}}$,
where <u>depends</u> on: R = 8.3144 **Universal gas constant** & **e**=2.7 natural number,
1) $\Delta G_{equilibrium}$ free energy change and on
2) temperature T

Equilibrium constant K <u>not depends</u> but **Homeostasis constant** depends on concentrations X_A, X_B, X_C, X_D for mixture of compounds A, B, C, D which ratio products over reactants for constant expression $K=\frac{\mathbf{X_C^c \bullet X_D^d}}{\mathbf{X_A^a \bullet X_B^b}}$

Reaction velocity temperature coefficient γ is average from range 2÷4

$\gamma=\frac{k_{T+10}}{k_T}=2\div4$ times greater velocity constant k_{T+10} as for k_T,

for experimentally example: $\gamma=\frac{k_{150^\circ}}{k_{140^\circ}}=3$ times greater at T=150ºC

Concentration decreases time and temperature iinfluence on time

$t=\frac{\ln\frac{C^\circ}{C}}{\vec{k}}$ time in which concentration decreases from C° > to > C .

Half life time or half reactant time $\tau_{½}=\frac{\ln 2}{\vec{k}}$,

In which concentration decreases per half $^{C^\circ}/_{C}=2$

$$t_{T_2}=\frac{t_{T_1}}{\gamma^{\frac{T_2-T_1}{10}}} \qquad t_{150^\circ\,C}=\frac{t_{140^\circ C}}{3^{\frac{150^\circ C-140^\circ C}{10}}}$$

If $t_{140^\circ\,C}$=900 s and $\gamma=\frac{k_{150^\circ C}}{k_{140^\circ C}}=3$

$$t_{150^\circ\,C}=\frac{\mathbf{900\ s}}{3^{\frac{150^\circ C-140^\circ C}{10}}}=\frac{900\ \mathbf{s}}{3^{\frac{10}{10}}}=\frac{900\ \mathbf{s}}{3^1}=\frac{900\ \mathbf{s}}{3}\mathbf{s}=300s$$

Strong Acid, Base protolytic dissociation **$pH+pOH=14$**

Formula	Example
$pH= -\log [H^+]= -\log(\alpha \cdot z \cdot c_M)$	What is the pH of 0.0850 M HNO_3 if **α** =1 **z** =1? $pH = -\lg (0.085) = 1.07$
$pOH= -\log [OH^-]=-\log(\alpha \cdot z \cdot c_M)$	What is the pH of 0.00765 KOH if **α** =1 **z** =1 $[KOH] = [OH^-]$
$pH + pOH = 14$	$pOH = 2.12$; $pH = 14 - pOH$ and $pH = 11.88$
$[H^+] = 10^{-pH}$	$pH=1$; $[H^+] =10^{-1} = 0.1$
$[OH^-] = 10^{-pOH}$	$pOH=1$; $[OH^-] =10^{-1} = 0.1$

Weak acid protolytic equilibria buffer solution

Protolysis-dissociation weak acid deprotonation equilibrium: $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$	**$CH_3COOH+H_2O \Leftrightarrow H_3O^++CH_3COO^-$;** $K_a = \frac{[H^+] \cdot [CH_3COO^-]}{[CH_3COOH]_{nedis}} =10^{-pKa} =10^{-4,76}$
$pK_a = - \lg [K_a]$	$K_a= 1.745 \cdot 10^{-5}$; $pK_a = -\lg(1.745 \cdot 10^{-5})= 4.76$
$K_a=10^{-pKa}$	$pK_a = 9,25$; $K_a= 10^{-9,25} =5,618 \cdot 10^{-10}$
$NH_4^++H_2O \Leftrightarrow H_3O^++NH_{3\ aqua}$	**$K_a = \frac{[H^+] \cdot [NH_3]_{aqua}}{[NH_4^+]}$**$=10^{-pKa}=10^{-9,25}$
Weak acid protolysis deprotonation equilibrium buffer solution **$pH = pK_a + \lg \left(\frac{n_{base}}{n_{acid}} \right)$** **$pH = pK_a + \log \left(\frac{c_{base} \cdot v_{base}}{c_{acid} \cdot v_{acid}} \right)$**	Calculate **pH** of a formiate buffer **(HCOOH/HCOONa),** **$HCOOH + H_2O \Leftrightarrow H_3O^+ + HCOO^-$;** if the buffer is composed from **300** mL of **0.15** M **HCOOH** and **200** mL of **0.09** M **HCOONa** solutions, **$K_a=2 \cdot 10^{-4}$** **$pH=pK^a+\log$**$\frac{c_{base} \cdot v_{base}}{c_{acid} \cdot v_{acid}}$ **$= -\log 2 \cdot 10^{-4}+\log$**$\frac{200 \times 0.09}{300 \times 0.15} =$ **$= 3.7+\log$**$\frac{18}{45}$ **$= 3.7+\log$** $0.4= 3.7-0.398=3.3$
Weak acid protolysis **$NH_4^++H_2O \Leftrightarrow H^++NH_{3\ aqua}$** ammonium **$NH_4^+$** deprotonation equilibrium buffer solution **$pH = pK_a + \log \frac{n_{NH3}}{n_{NH4+}}$** **$pH = pK_a + \log \frac{c_{NH3} \cdot v_{NH3}}{c_{NH4+} \cdot v_{NH4+}}$**	**$NH_4^++H_2O \Leftrightarrow H_3O^++NH_{3\ aqua}$** ; Calculate buffer solution **pH**, that formed of **80** mL **0.1** M ammonia **$NH_{3\ aqua}$** and **120** mL **0.17** M **NH_4Cl** solution, **K_a**$=5,618*10^{-10}$. **$pH=pK^a+\log$**$\frac{c_{NH3} \cdot v_{NH3}}{c_{NH4+} \cdot v_{NH4+}}$ **$= -\log$**$5,62*10^{-10}$**$+\log$**$\frac{80 \times 0.1}{120 \times 0.17} =$ **$= 9,25+\log$**$\frac{8}{20.4}$ **$= 9,25+\log$** $0,392= 9,25-0,4065=8.844$

Weak acid protolytic equilibria buffer solution

Calculate, how many milliliters of 0,1 M $HCOOH$ and 0,2 M $HCOONa$ have to be taken to obtain a buffer, having pH=3,0 and
total volume 1 liter. $K_a=2\cdot10^{-4}$

$$\mathbf{pH = pK_a + log}\left(\frac{c_{base}\cdot v_{base}}{c_{acid}\cdot v_{acid}}\right)$$

$V_{salt}= x$; $V_{acid} = 1000 - x$

$$3{,}0 = -\log(2\cdot10^{-4)} + \log\left(\frac{0{,}2x}{0{,}1\cdot(1000-x)}\right)$$

$$3{,}0 = 3{,}7 + \log\left(\frac{0{,}2x}{0{,}1\cdot(1000-x)}\right)$$

$$-0{,}7=\log\left(\frac{0{,}2x}{0{,}1\cdot(1000-x)}\right)$$

$$10^{-0{,}7}=\left(\frac{0{,}2x}{0{,}1\cdot(1000-x)}\right)$$

$$0.199=\left(\frac{0{,}2x}{0{,}1\cdot(1000-x)}\right)$$

$0{,}199 \cdot (100 - 0{,}1x) = 0{,}2x$

$x = 90{,}6$ mL

$V_{salt}= 90{,}6$ mL; $V_{acid} = 1000 - 90{,}6$ mL$=909{,}5$ mL

Weak acid protolytic equilibria buffer solution

1. *Buffer solution to be composed of a weak acid and deprotonated weak acid salt as base form,*
2. *Buffer formed of protonated* $\mathbf{NH_4^+}$ *and deprotonated* $\mathbf{NH_3}$ *ammonia,*
3. *Buffer solution can be composed of a weak acid and strong base in limited supply,*
4. *Buffer formed of deprotonated base and strong acid in limited supply,*
5. *Buffer system can be composed of a weak bivalent acid and its acidic salt,*
6. *Buffer system can be composed of two salts of the same polyvalent acid, differing in **1** hydrogen ion*, where the salt containing greater number of hydrogen ions plays the role of acid and the salt, containing lower number of hydrogen ions plays the role of the base.
7. *Proteins* Buffers in human organism *are long amino acid polypeptide chains with four type protolytic weak acid groups* (see 14th page)

Complex compounds and light absorption

Charges and coordination numbers of some central ions.

Charge of central ion	*Coord. number by empiric rule*	*examples*
+1	2	Ag^{+}, Cu^{+}, Au^{+}
+2	4	Cu^{2+}, Hg^{2+}, Pt^{2+}, Ni^{2+}, Zn,$^{2+}$ Cd^{2+}, Co^{2+}, Pb^{2+},
+3	6	Fe^{3+}, Al^{3+}, Cr^{3+}, Co^{3+}

Other possible coord. numbers	*examples*
4	Li^{+}
6	Fe^{2+}
4	Au^{3+}

Outer sphere dissociation as strong electrolyte because complex compounds always are water soluble strong electrolytes like as salts, strong acids and strong bases:

$$[Cu(NH_3)_4]SO_4 \rightleftarrows [Cu(NH_3)_4]^{2+} + SO_4^{2-}$$

Instability constant $K_{inst..}$ ***of complex compound*** **$[Cu(NH_3)_4]^{2+}$ destruction**

in secondary *dissociation complex compound* **$[Cu(NH_3)_4]^{2+}$ equilibrium :**

$$[Cu(NH_3)_4]^{2+} \rightleftarrows Cu^{2+} + 4NH_3$$

$$K_{inst..} = \frac{\left[Cu^{2+}\right]\cdot\left[NH_3\right]^4}{\left[\left[Cu\left(NH_3\right)_4\right]^{2+}\right]};$$

Flip over reaction **to formation reaction equilibrium**

$$Cu^{2+} + 4NH_3 \rightleftarrows [Cu(NH_3)_4]^{2+}$$

$$K_{stab.} = \frac{1}{K_{instab.}} = \frac{\left[\left[Cu\left(NH_3\right)_4\right]^{2+}\right]}{\left[Cu^{2+}\right]\cdot\left[NH_3\right]^4}$$

Light absorption **$A=\log(Io/I)=a \bullet c_M \bullet l$**

Amino Acid	pKa-COOH	pKa-NH3+	pKa R group
Isoleucine	2.36	9.68	
Valine	2.32	9.62	
Leucine	2.36	9.60	
Phenylalanine	1.83	9.13	
Cysteine	1.96	10.28	8.18
Methionine	2.28	9.21	
Alanine	2.34	9.69	
Proline	1.99	10.96	
Glycine	2.34	9.60	
Threonine	2.11	9.62	
Serine	2.21	9.15	
Tryptophan	2.38	9.39	
Tyrosine	2.20	9.11	10.07
Histidine	1.82	9.17	6.00
Aspartate	1.88	9.60	3.65
Glutamate	2.19	9.67	4.25
Asparagine	2.02	8.80	
Glutamine	2.17	9.13	
Lysine	2.18	8.95	10.53
Arginine	2.17	9.04	12.48

Protein constitute amino acids protolytic equilibria average calculation expression for protolytic constant as well isoelectric point pK_{a_mean}=IEP value with total of NpK_a sum constants pK_a for molecule given in table includes the sum of: side groups $\Sigma pKa_{R\ group}$, N-terminus $pKa_{Nterminus}NH_3+$ and C-terminus $pKa_{Cterminus}COO^{-}$. In *Ostwald's dilution law* pH calculation is used pK_{a_mean} by concentration C logarithm

$$pH=\frac{pK_{a\_mean}-\log C}{2}=......$$

$$pK_{a\_mean}=IEP=(\Sigma pK_{aRside\_residue}+pK_{aNterminus}+pK_{aCterminus})/NpK_a$$

Amino acid or protein molecules have four type acidic functional groups: **-COOH** neutral, **-NH$_3^+$** positive charged, phenol **-OH** neutral, **-SH** neutral. At physiologic pH 7.36 groups exist prevailing: negative charged **R-COO**$^-$, positive charged amino groups **R-NH$_3^+$** , neutral group of Tyrosine phenol-**OH** and Cysteine sulfo hydrogen **R--SH**.

Four parallel protolytic equilibria:

Acid ⇔ base + **H**$^+$

1. **R-COOH** ⇔**R-COO**$^-$ +**H**$^+$,
2. **R-NH$_3^+$** ⇔**R-NH$_2$** + **H**$^+$
3. **Tyr**-phenol-**OH**⇔**Tyr**-phenol-**O**$^-$ +**H**$^+$,
4. **Cys--SH** ⇔**Cys—S**$^{—}$ + **H**$^+$

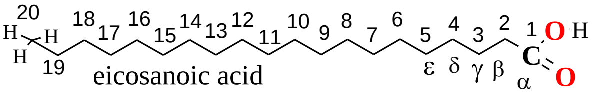
FATTY ACIDS

Saturated **name**	**C**	*Unsaturated*		**C:Double bonds**	
Caproic acid		**Common name**	**Name of salt**	**C : ?**	**ω ?**
Caprylic acid	8:0	Myristoleic acid	Myristoleate	14:1	**ω-5**
Capric acid	10:0	Palmitoleic acid	Palmitoleate	16:1	**ω-7**
Lauric acid	12:0	Sapienic acid	Sapienoate	16:1	**ω10**
Myristic acid	14:0	Oleic acid	Oleate	18:1	**ω-9**
Palmitic acid	16:0	Elaidic acid	Elaidinoate	18:1	trans
Stearic acid	18:0	Vaccenic acid	Vacceniate	18:1	trans
Arachidic acid	20:0	Linoleic acid	Linoleate	18:2	**ω-6**
Behenic acid	22:0	Linoelaidic acid	Linoelaidiate	18:2	trans
Lignoceric acid	24:0	α-Linolenic acid	α-Linolenate	18:3	**ω-3**
Cerotic acid	26:0	Arachidonic acid	Arachidonate	20:4	**ω-6**
		Eicosapentaenoic acid	Eicosapentaenoate	20:5	**ω-3**
		Erucic acid	Eruciate	22:1	**ω-8**
		Docosahexaenoic acid	Docosahexaenoate	22:6	**ω-3**

Saturated fatty acids

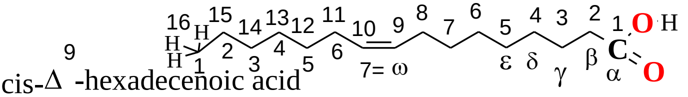
$CH_3(CH_2)_{14}CO_2H$ - hexadecanoic acid palmitic acid **C16**

$CH_3(CH_2)_{16}CO_2H$-octadecanoic acid stearic acid **C18**

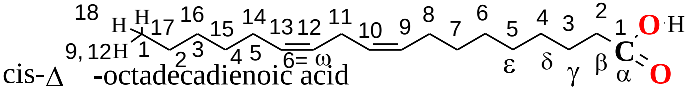


arachidic acid
C20:0

Unsaturated fatty acids

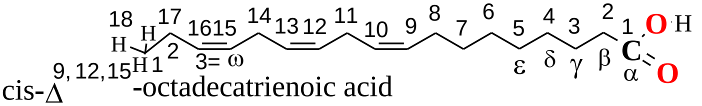


palmitoleic acid
C16:1 ; ω-7



linoleic acid
C18:2 ; ω-6

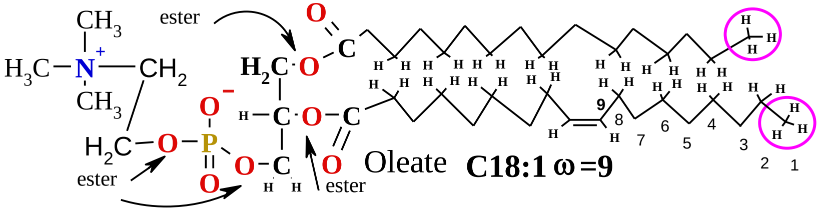
Essential ω-6,-3



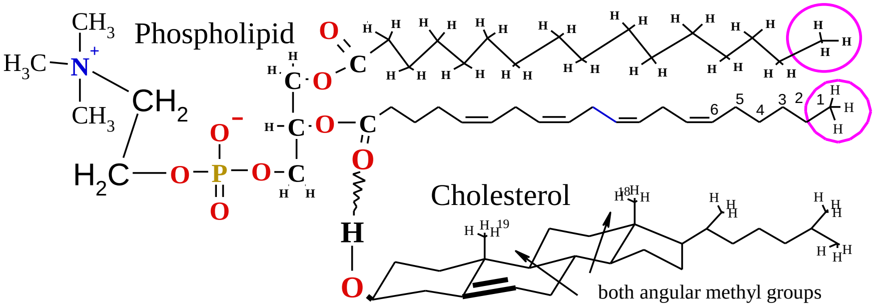
α-linolenic acid
C18:3 ; ω-3

Phosphatidyl **Choline** **Membrane** building molecular components

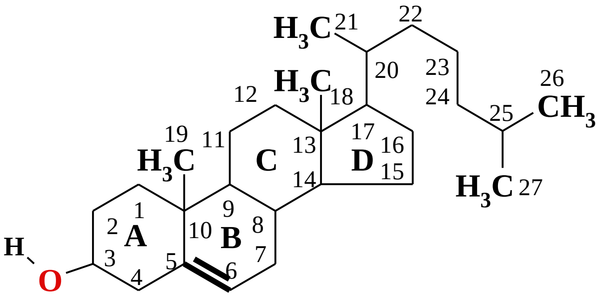
Phosphate ester of glycerol C3 **Palmitate** ester of glycerol C1



Choline **Glycerol** All atoms colored **CPK** labels

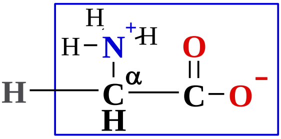
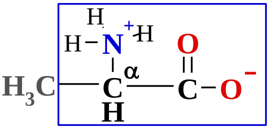
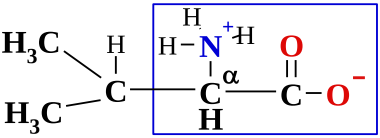
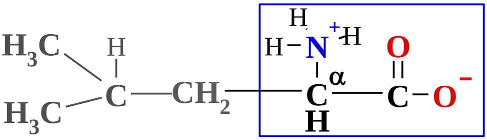


Phosphatidyl **Choline**/**Cholesterol** complex in cell **membranes**

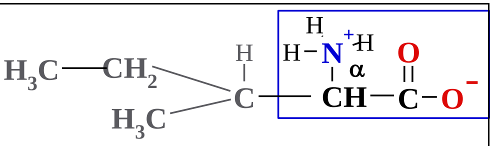
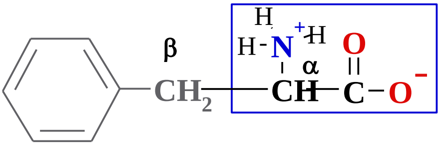
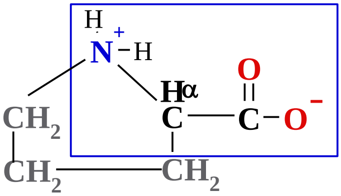
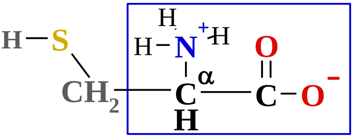
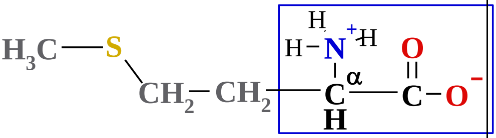


Cholesterol Steroid Lipid Rings are labeled **A**, **B**, **C** and **D**. Double bond between 5 and 6 >**C=C**< and alcohol **HO**- at carbon 3. Angular methyl groups **–CH_3** labeled 18, 19 or splinter 21, 26, 27 clutch fixing molecules in membrane stabile.

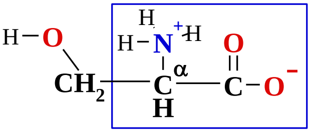
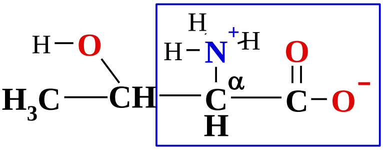
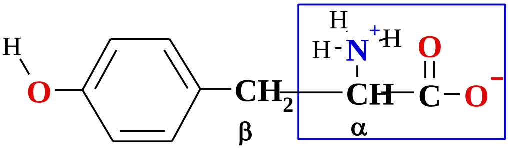
Lα-Amino Acids Non-polar, aliphatic, aromatic R groups left Cα

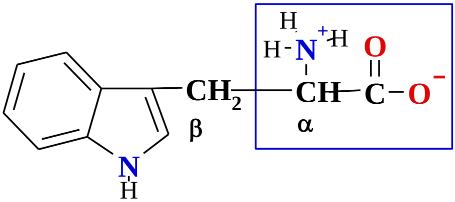
Nr.	Name	Three, one	Structural formula **pH=7.36**
1.	Glycine	Gly, G	
2.	Alanine	Ala, A	
3.	Valine	Val, V	
4.	Leucine	Leu, L	

Nr.	Name	Three, one	Structural formula **pH=7.36**

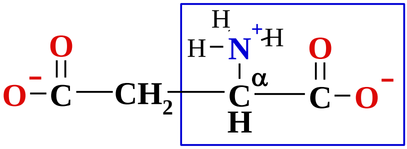
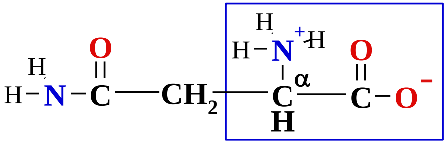
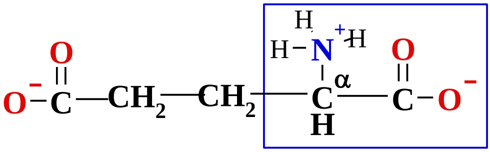
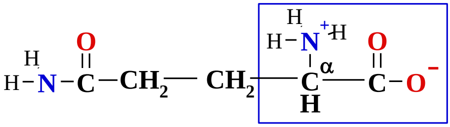
5.	Isoleucine	Ile, I	
17.	Phenylalanine	Phe, F	
20.	Proline	Pro, P	
8.	Cysteine **S sulfur** non-polar	Cys, C	
9.	Methionine **S sulfur** non-polar	Met, M	

Polar R groups pink colors due to oxygen **O** bluish colors of nitrogen **N**

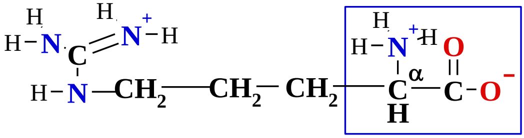
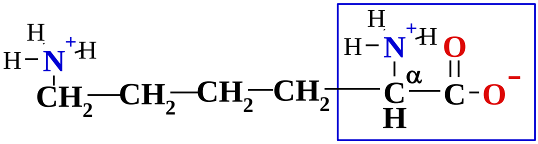
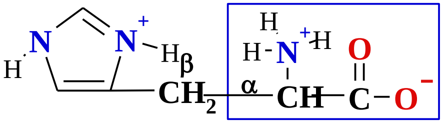
6.	Serine	Ser, S	
7.	Threonine	Thr, T	
18.	Tyrosine	Tyr, Y	

Nr.	Name	Three, one	Structural formula **pH=7.36**
19.	Tryptophan	Trp, W	

Acidic α-amino acids red colors of oxygen O

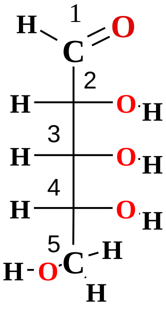
Nr. 10.	Aspartate Aspartic acid salt	Asp, D	
Nr. 11.	Asparagine	Asn, N	
12.	Glutamate Glutamic acid salt	Glu, E	
13.	Glutamine	Gln, Q	

Basic α-amino acids blue colors of nitrogen N pH=7.36

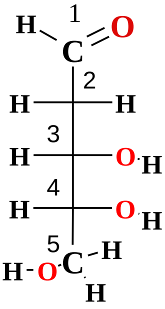
Nr. 14.	Arginine	Arg, R	
15.	Lysine	Lys, K	
16.	Histidine	His, H	

Structural Formulas of Carbohydrates The Fischer tree projections for open chain structures

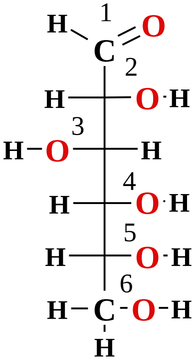
Pentoses–Aldoses: **Hexoses – Aldohexoses:**



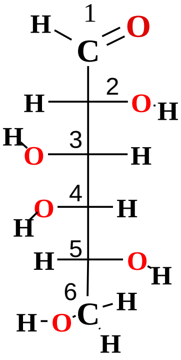
D-Ribose



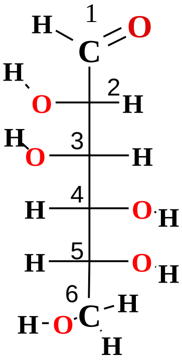
D-2-deoxy-ribose



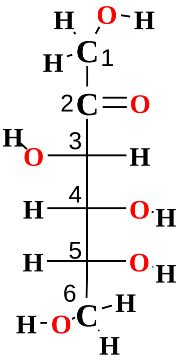
D-Glucose



D-Galactose



D-Mannose

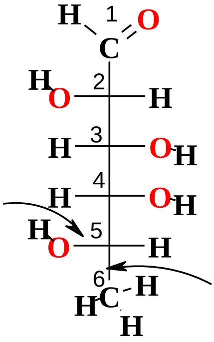


D-Fructose

Fisher projection

L-monosaccharide because **H**O- on carbon 5 is on the left

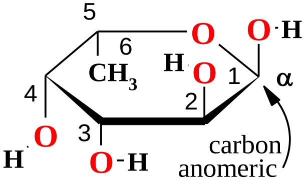
and is down carbon 6 6methyl –**CH_3**



Haworth projection

Cyclic α-L-Fucose

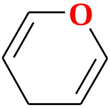
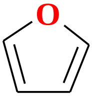
Hemi acetal ↓ oxygen



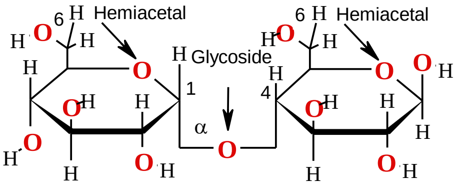
Carbon 6 is –**CH_3** rather than –**CH_2-OH**

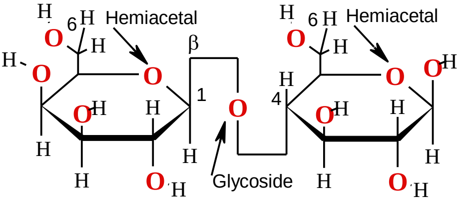
Cyclic Structure Haworth projections of Carbohydrates

Haworth projection uses the organic molecule frames

Pyranose six member cycle  and *Furanose*  cycle 5 atoms

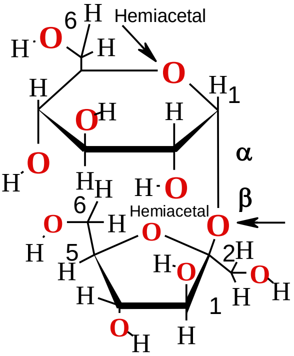
Disaccharides and polysaccharides





Maltose **Glc(α1→4)Glc-β**

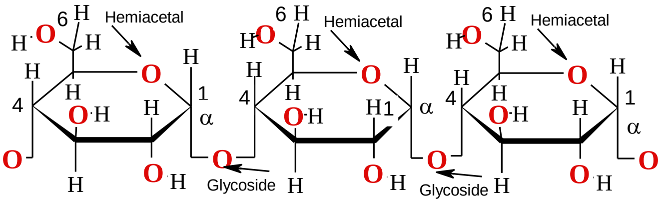
Lactose **Gal(β1→4)Glc-β**



	Sucrose
α-D-Glucose unit	*Pyranose six member* cycle
(α1→2β)	**Glc(α1→2)Fruc-β**
← Glycoside bond	
β-D-Fructose unit	*Furanose* five member cycle

Starch →4)Glc(α1→4)Glc(α1→4)Glc(α1→

Polysaccharides



Cellulose →4)Glc(β1→4)Glc(β1→4)Glc(β1→