

THERMODYNAMIC PROPERTIES

Table 2.1-1 Universal Constants

Ideal Gas Constant (\mathcal{R})	8.314 J/(mol-°K) or kPa-L/(mol-°K)
Avagadro's Number (\mathcal{A})	6.023×10^{23} molecules/mol
Boltzman Constant ($\mathcal{K} = \mathcal{R} / \mathcal{A}$)	1.380×10^{-23} J/(molecule-°K)
Gravitational Acceleration (\mathcal{G})*	9.80665 m/s ²
Planck Constant (\mathcal{H})	6.626×10^{-34} kg-m ² /s
Faraday Constant (\mathcal{F})	96,480 A-s/eq

*Standard magnitude for an object in a vacuum near the earth's surface

**Table A3-1. Partition Coefficients $\lambda_s^{A,B}$ of Liquid (l) and Solid (s) Solutes
Between Organic (A) and Aqueous (B) Solvents at 25°C
(Leib and Stein, 1986)**

Solutes \ Phases	A=Olive Oil B=Water	A=Octanol B=Water	A=Lipid B=Water
Erythritol (s)	3.0×10^{-5}	0.0012	0.026
Ethenediol (l)	4.9×10^{-4}	0.012	0.12
Ethanol (l)	3.6×10^{-2}	0.48	0.44
Glycerol (l)	7.0×10^{-5}	0.0028	0.050
Methanol (l)	9.5×10^{-3}	0.18	0.21
n-Hexanol (l)	7.6	110	--
n-Propanol (l)	1.4×10^{-1}	2.2	1.3
Sucrose (s)*	3.0×10^{-5}	---	---
Thiourea (s)	1.2×10^{-3}	0.072	--
Urea (s)	1.5×10^{-4}	0.0022	0.23
Water (l)	1.3×10^{-3}	0.041	--

*Davson (1964)

Table A3-2. Henry's Law Constant, h_s [10^9 Pa] of Gases in Water (Perry *et al.*, 1963)

Gas Solute s T(°C)	25	30	35	37	40	45
Acetylene (C ₂ H ₂)	0.135	0.148	---	0.166*	---	---
Air	7.29	7.81	8.34	8.53**	8.81	9.23
Carbon Dioxide (CO ₂)	0.166	0.188	0.212	0.221**	0.236	0.260
Carbon Monoxide (CO)	5.88	6.28	6.68	6.83**	7.05	7.39
Helium (He)	---	12.6	---	12.3**	12.2	---
Hydrogen (H ₂)	7.16	7.38	7.52	7.55**	7.61	7.70
Nitric Oxide (NO)	2.91	3.14	3.35	3.44**	3.57	3.77
Nitrogen (N ₂)	8.76	9.36	9.98	10.21**	10.54	11.04
Nitrous Oxide (N ₂ O)	0.228	0.262	0.306	0.325*	---	---
Oxygen (O ₂)	4.44	4.81	5.14	5.25**	5.42	5.70
Ozone	0.463	0.606	0.829	0.949**	1.216	---

* Extrapolated values. ** Interpolated values.

**Table A3-3. Bunsen Solubility Coefficients α_s of O₂ and CO₂
(Modified from Altman and Dittmer, 1971, p 20-21)**

Gas Solute	Oxygen ml gas(STP)/(dL liquid-kPa)			Carbon Dioxide ml(STP)/(dL-kPa)	
	Isotonic Saline*	Human Plasma	Human Blood**	Isotonic Saline*	Ox Plasma
20	0.0295	0.0273	0.0282	0.850	0.777
25	0.0268	0.0254	0.0261	0.732	0.672
30	0.0246	0.0235	0.0241	0.640	0.593
31	0.0243	0.0231	0.0238	0.625	0.579
32	0.0240	0.0227	0.0234	0.611	0.566
33	0.0236	0.0223	0.0231	0.596	0.553
34	0.0233	0.0220	0.0228	0.582	0.540
35	0.0230	0.0217	0.0225	0.568	0.528
36	0.0227	0.0214	0.0222	0.556	0.518
37	0.0224	0.0211	0.0219	0.543	0.508
38	0.0222	0.0209	0.0217	0.531	0.497
39	0.0219	0.0207	0.0214	0.516	0.486
40	0.0216	0.0205	0.0211	0.506	0.476

* Solution of 0.155 mol NaCl per liter.

** Based on a hemoglobin content of 15 g hemoglobin/dL (α_{O_2} increases by about 0.3% per increase of 1 g/dL blood in hemoglobin content).

**Table A3-4. Partition Coefficients of Gases at 37-38°C
(Altman and Dittmer, 1971, p 20-21)**

Gas Solute	Phases A:B	$\lambda_i^{A,B}$
Acetone	Blood:Gas	333.0
Acetylene	Water:Gas	0.850
	Blood:Gas	0.795
Argon	Water:Gas	0.0295
	Oil:Water	5.3
Chloroform	Water:Gas	4.6
	Blood:Gas	7.3
	Brain:Blood	1.1
	Liver:Blood	0.9
	Oil:Water	110.0
Ethylene	Water:Gas	0.089
	Blood:Gas	0.140
	Brain:Blood	1.2
	Heart:Blood	1.0
	Oil:Water	14.4
Ethyl ether	Water:Gas	15.5
	Blood:Gas	14.9
	Brain:Blood	1.14
	Oil:Water	3.2

Gas Solute i	Phases A:B	$\lambda_i^{A,B}$
Helium	Water:Gas	0.0097
	Blood:Gas	0.0098
	Oil:Water	1.7
Hydrogen	Water:Gas	0.018
	Oil:Water	3.1
Nitrogen	Water:Gas	0.0144
	Blood:Gas	0.0147
	Brain:Blood	1.1
	Liver:Blood	1.1
	Fat:Blood	5.2
	Oil:Water	5.2
Nitrous oxide	Water:Gas	0.440
	Blood:Gas	0.466
	Brain:Blood	1.0
	Heart:Blood	1.0
	Oil:Water	3.2
Sulfur Hexafluoride	Water: Gas	0.00437
Xenon	Water:Gas	0.097
	Oil:Water	20.0

**Table A3-5. Standard Free Energy of Reaction at T=37°C and P=101.3 kPa
(Snell *et al.*, 1965, p 255)**

Reaction	ΔG_r^* (kJ/mole substrate)	pH
Glucose \rightleftharpoons 2 Lactate ⁻ + 2H ⁺	-198	7.0
Glucose + ATP ⁴⁻ \rightleftharpoons Glucose 6P ²⁻ + ADP ³⁻ + H ⁺	-21	7.0
ATP ⁴⁻ + H ₂ O \rightleftharpoons ADP ³⁻ + HPO ₄ ²⁻ + H ⁺	-37	7.5
ADP ³⁻ + H ₂ O \rightleftharpoons AMP ²⁻ + HPO ₄ ²⁻ + H ⁺	-40	7.5
Enolpyruvate 2P ³⁻ + ADP ³⁻ + H ⁺ \rightleftharpoons Pyruvate + ATP ⁴⁻	-25	7.0
Pyruvate ⁻ + DPNH + H ⁺ \rightleftharpoons Lactate ⁻ + DPN ⁺	-23	7.0
Succinate ²⁻ + ½ O ₂ \rightleftharpoons Fumarate ²⁻ + H ₂ O	-151	7.0
DPNH + ½ O ₂ + H ⁺ \rightleftharpoons DPN ⁺ + H ₂ O	-219	7.0
Glucose + 6O ₂ \rightleftharpoons 6CO ₂ + 6H ₂ O	-2872	----
Glycylglycine + H ₂ O \rightleftharpoons 2 Glycine	-15	----

*T=37°C, P=101.3 kPa.

Table A3-6. Dissociation Equilibria of Some Common Amino Acids*
(Mahler and Cordes, 1968)

Amino Acid	pK ₁	pK ₂	pK ₃	pI
Glycine	2.34 (COOH)	9.60 (NH ₃ ⁺)	---	5.97
Aspartic acid	2.09 (COOH)	3.86 (COOH)	9.82 (NH ₃ ⁺)	2.97
Lysine	2.18 (COOH)	8.95 (NH ₃ ⁺)	10.53 (NH ₃ ⁺)	9.74
Tyrosine	2.20 (COOH)	9.11 (NH ₃ ⁺)	10.07 (OH)	5.65
Cysteine	1.71 (COOH)	8.33 (SH)	10.78 (NH ₃ ⁺)	5.02
Proline	1.99 (COOH)	10.6 (NH)	---	6.10

* Parenthesis contain the protonated form of the acid side group.