Equations relevant to Membrane Transport: Geometry, Diffusion and Flux

Sphere Area: $4 \bullet \pi \bullet r^2$ Sphere Volume: $\frac{4}{3} \bullet \pi \bullet r^3$

Cylinder Area: $4 \bullet \pi \bullet r \bullet h$ Cylinder Volume: $\pi \bullet r^2 \bullet h$

Cube Area: $6 \bullet \mathrm{h}^2$ Cube Volume: h^3

Fick's Diffusion: $J = D \bullet \frac{dc}{dx}$ Fick's Diffusion: $\frac{dc}{dt} = D \bullet \frac{d^2c}{dx^2}$

Einstein's Random Walks: $D = \frac{1}{2} \bullet \frac{\Delta^2}{\tau}$, $\langle x^2 \rangle = 2 \bullet D \bullet t$, and $\langle r^2 \rangle = 6 \bullet D \bullet t$

Membrane Diffusion: $J = P \bullet \left(c_{outside} - c_{inside}\right)$

Membrane Diffusion: $J = -(uRT) \bullet \frac{dc}{dx} - (zFuc) \bullet \frac{d\Psi}{dx}$

Membrane Diffusion: $J = -P \bullet \left(\frac{zF\Psi}{RT}\right) \bullet \left(\frac{c_o - c_i \bullet e^{zF\Psi/RT}}{1 - e^{zF\Psi/RT}}\right)$

Nernst Equation: $\Psi = \left(\frac{RT}{zF}\right) \bullet \ln\left(\frac{c_o}{c_i}\right)$

Ohm's Law: $V = I \bullet R$, $I = g \bullet V$, $R = \rho \bullet \left(l/A\right)$, and $J = I/(zF)$

Radial Diffusion: $C(r) = C_\infty \bullet \left(1 - \frac{a}{r}\right)$, and $J(r) = -D \bullet C_\infty \bullet \left(\frac{a}{r^2}\right)$

Radial Currents: $I_m = 4 \bullet \pi \bullet a^2 \bullet \beta$, and $I_d = 4 \bullet \pi \bullet a \bullet D \bullet C_\infty$

Dimensionless relations $P_e = \frac{2 \bullet a \bullet \nu}{D}$ and $R_e = \frac{\rho \bullet \nu \bullet l}{\eta}$

Goldman - Hodgkin - Katz (GHK) equation

$$\Psi = \frac{RT}{F} \ln\left(\frac{P_H c_H^o + P_{Na} c_{Na}^o + P_K c_K^o + P_{Cl} c_{Cl}^i}{P_H c_H^i + P_{Na} c_{Na}^i + P_K c_K^i + P_{Cl} c_{Cl}^o}\right)$$

Equations relevant to membrane capacitance

$Q = C \cdot \Delta E$ (coulombs) = (coulombs/volt) (volt)

Charge (Q) for a spherical cell of radius r :

$Q = \frac{4}{3} \cdot \pi \cdot r^3 \cdot c \cdot F$

c is the concentration of net charge.

Capacitance of a spherical cell of radius r :

$C = 4 \cdot \pi \cdot r^2 \cdot C'$ C' is the capacitance per unit area (about 1 microFarad per square centimeter for cells).

Symbol	Value	Units	Comments
GAS CONSTANT			
R	8.314	J mol^{-1} K^{-1}	R is the Boltzmann constant times Avogadro's Number ($6.023 \cdot 10^{23}$)
	1.987	cal mol^{-1} K^{-1}	
	8.314	m^{-3} Pa mol^{-1} K^{-1}	
RT	$2.437 \cdot 10^3$	J mol^{-1}	At 20 ºC (293 ºK)
	$5.833 \cdot 10^2$	cal mol^{-1}	At 20 ºC (293 ºK)
	2.437	liter MPa mol^{-1}	At 20 ºC (293 ºK)
RT/F	25.3	mV	At 20 ºC (293 ºK)
2.303 • RT	5.612	kJ mol^{-1}	At 20 ºC (293 ºK)
	1.342	kcal mol^{-1}	At 20 ºC (293 ºK)
FARADAY CONSTANT			
F	$9.649 \cdot 10^4$	coulombs mol^{-1}	F is the electric charge times Avogadro's Number
	$9.649 \cdot 10^4$	J mol^{-1} V^{-1}	
	23.06	kcal mol^{-1} V^{-1}	
CONVERSIONS			
kcal	4.187	J (joules)	Joules is an energy unit (equal to 1 Newton•meter)
Watt	1	J sec^{-1}	
Volt	1	J $coulomb^{-1}$	
Amperes	1	coulomb sec^{-1}	
Pascal (Pa)	1	Newton $meter^{-2}$	Pascal is a pressure unit (equal to 10^{-5} bars)
Siemens	1	Ohm^{-1}	Siemens (S) is conductance, the inverse of resistance (Ohm)
PHYSICAL PROPERTIES			
η_w	$1.004 \cdot 10^{-3}$	Pa sec	viscosity of water at 20 ºC
ν_w	$1.004 \cdot 10^{-6}$	m^2 sec^{-1}	kinematic viscosity of water at 20 ºC (viscosity/density)

Source: Nobel, Park S (1991) Physicochemical and Environmental Physiology