<u>**CONCEPT:** THERMODYNAMICS OF MEMBRANE DIFFUSION: CHARGED ION</u>

●When ________ diffuse across a membrane, the *transmembrane potential/voltage* (______) must be considered.

□ Recall: *Transmembrane Potential/Voltage* ($\Delta\Psi$): the difference in *electrical* ___________ across the membrane.

●$\Delta G_{transport}$ of ions due to *only* the transmembrane potential (____________ *gradient*) *alone* is given as: $\Delta G_{transport} = zF\Delta\Psi$.

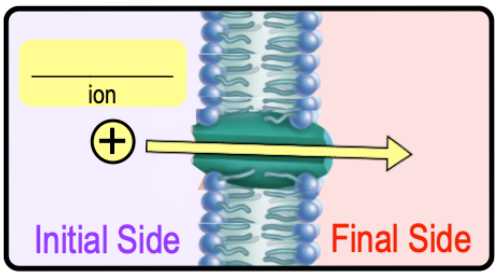
□ _____: net charge of the diffusing ion.

□ _____ (*Faraday constant*): charge of 1 mole of electrons = 96,485 JV^{-1}/mole (Coulombs/mole).

●HOWEVER, recall: *ion* diffusion depends on ________________ gradient (combination of *chemical* & *electrical* gradients).

EXAMPLE: $\Delta G_{transport}$ for Membrane Diffusion of Charged Ions.

R = 8.315 J/mol˚K
T = Degrees Kelvin (K)

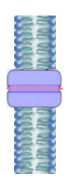


$$\Delta G_{transport} = \underbrace{RT \ln\left(\frac{[C_{final\ side}]}{[C_{initial\ side}]}\right)}_{\text{Chemical Gradient}} + \underbrace{\_\_\_\ \mathscr{F}\ \Delta\_\_\_}_{\_\_\_\_\_\_\_\_\_\_\ \text{Gradient}}$$

EXAMPLE: Calculate the energy cost ($\Delta G_{transport}$) of pumping Ca^{2+} from the cytosol to the extracellular space if the temperature is 37˚C, $\Delta\Psi$ = 0.05 V (inside negative), cytosolic [Ca^{2+}] = 1.0×10^{-7} M, & extracellular [Ca^{2+}] = 1.0×10^{-3} M.

STEP 1: Determine *net charge* of diffusing molecule: ☐ Uncharged. ☐ Charged (+/–): _______.

STEP 2: Determine *direction* of diffusion (establish *initial* & *final* sides). Determine *sign* of $\Delta\Psi$ (+ or –). Draw a sketch.



STEP 3: Check *units* on all numbers & if necessary, *convert* units to ensure *compatibility*. (Ex. Temp. = *Kelvin* ; $\Delta\Psi$ = Volts).

STEP 4: *Plug in* all given values (with *appropriate units*) into the *correct equation* & *algebraically solve* for missing variable.

CONCEPT: THERMODYNAMICS OF MEMBRANE DIFFUSION: CHARGED ION

PRACTICE: Calculate the free energy change ($\Delta G_{transport}$) for the movement of Na^+ into a cell when its concentration outside is 150 mM and its cytosolic concentration is 10 mM. Assume that T = 20°C and $\Delta\Psi$ = **–**50 mV (inside negative).

a) **–**1.7 KJ/mol.
b) **–**11.4 KJ/mol.
c) **–**11,600 KJ/mol.
d) 11.4 KJ/mol.
e) 14.3 KJ/mol.

PRACTICE: Calculate the $\Delta G_{transport}$ required to move 1 mole of Na^+ ions from inside the cell ($[Na^+]$ inside = 5 mM) to the outside of the cell ($[Na^+]$ outside = 150 mM) when $\Delta\Psi$ = **–**70 mV (inside negative) & the temperature is 37°C.

a) **–**15.5 KJ/mol.
b) 2.0 KJ/mol
c) 15.5 KJ/mol.
d) **–**2.0 KJ/mol.

PRACTICE: Calculate the $\Delta G_{transport}$ when Ca^{2+} ions move from the endoplasmic reticulum ($[Ca^{2+}]$ = 1 mM) to the cytoplasm ($[Ca^{2+}]$ = 0.1 μM). Assume that $\Delta\Psi$ = 0 and T = 25°C.

a) 23 KJ/mol.
b) **–**23 KJ/mol.
c) **–**17 KJ/mol.
d) 17 KJ/mol.