

26-3

PASSIVE & Active TRANSPORT

All living cells



0.1M Na^+ 10 times more Na^+ outside cell
0.1M Cl^- 10 times more Cl^- outside cell
0.01M K^+ 10 times more K^+ inside cell

Also: All living cells are more
negative inside by ~ 0.06 Volts

Electrical Potential Energy = Charge \times Voltage
difference

1 Volt = 1 Joule / Coulomb

= electric potential

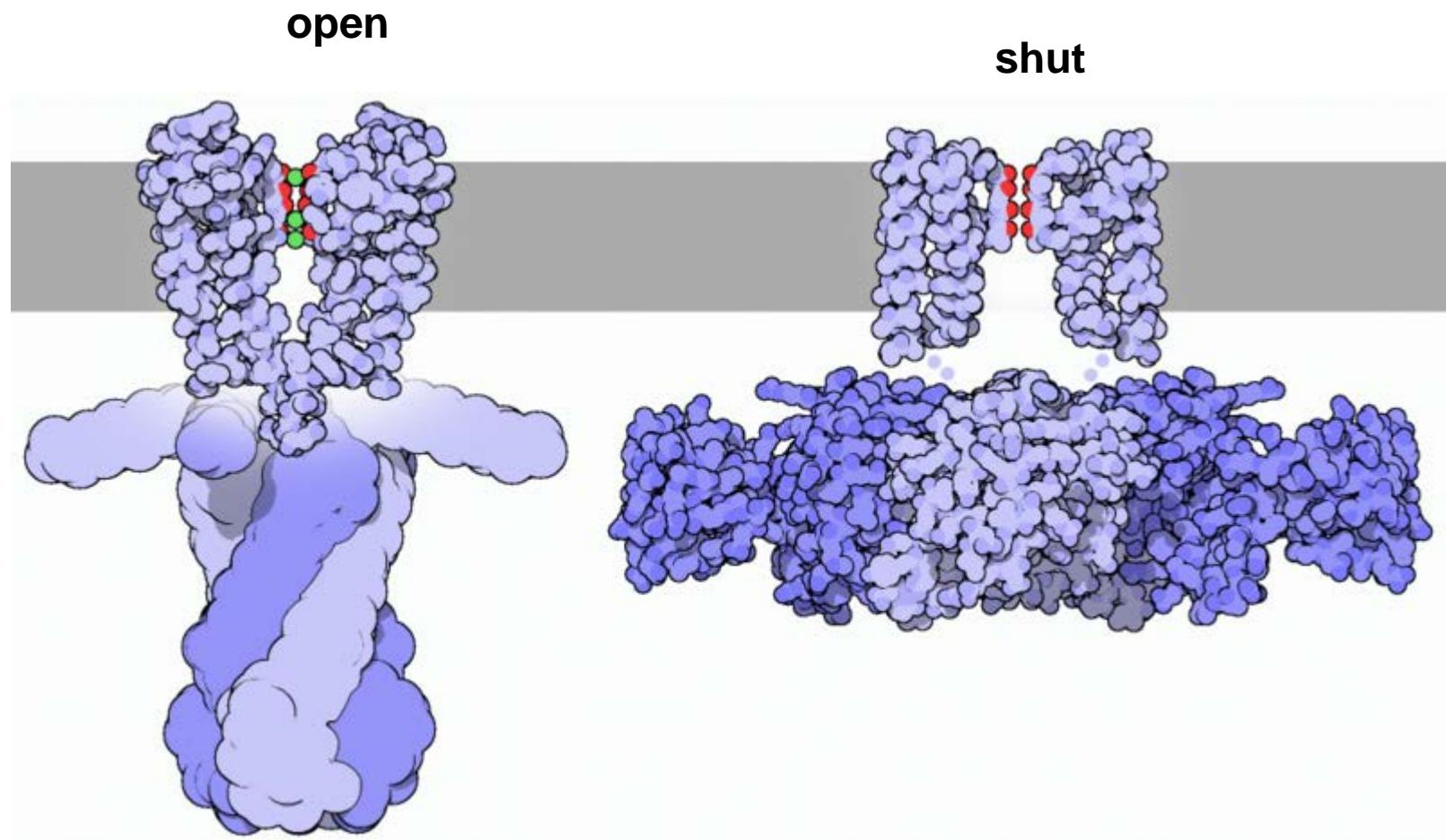
gravitational potential = $(g h) \frac{\text{J}}{\text{kg}}$
" energy = $m(g h)$

electrical energy = $\nexists \uparrow \Delta \phi (\text{Volts}) = nF (\xi_{\text{final}} - \xi_{\text{initial}})$

Number of
elementary charges
on ion

96,485 Coulombs/mol

Potassium channels

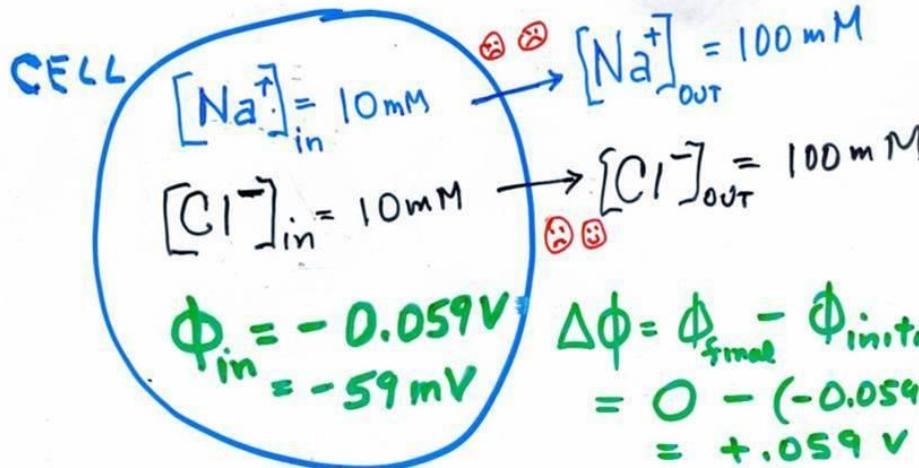


[File:Potassium channels shut and open.png](#)
From Wikipedia, the free encyclopedia

$$2.3R 298 / F = 0.059 V$$

ACTIVE TRANSPORT

Na^+, Cl^-



$$\begin{aligned}\Delta\phi &= \phi_{\text{final}} - \phi_{\text{initial}} = \xi_{\text{final}} - \xi_{\text{initial}} \\ &= 0 - (-0.059) \\ &= +0.059 \text{ V}\end{aligned}$$

For $\text{Na}^{\text{(in)}} \rightarrow \text{Na}^{\text{(out)}}$ final – initial volts

$$\begin{aligned}\Delta\mu_{\text{Na}^+} &= \Delta\mu_{\text{Na}^+}^0 + RT \ln\left(\frac{100}{10}\right) + (+1)F(0 - (-0.059)) \\ &= 0 + 5.7 + 5.7 = 11.4 \frac{\text{kJ}}{\text{mol}}\end{aligned}$$

For $\text{Cl}^-_{\text{in}} \rightarrow \text{Cl}^-_{\text{out}}$:

$$\begin{aligned}\Delta\mu_{\text{Cl}^-} &= \Delta\mu_{\text{Cl}^-}^0 + RT \ln\left(\frac{100}{10}\right) + (-1)F(0 - (-0.059)) \\ &= 0 + 5.7 - 5.7 = 0\end{aligned}$$

Na^+ Requires ACTIVE TRANSPORT (ATP)

Cl^- is close to equilibrium

Calculate the total ΔG for moving 1 mole of an ion out of the cell, i.e., $\Delta\mu$

What about $\text{K}^+??$

A common exam question

If $\Delta\mu = +11.4 \text{ kJ/mol}$ for moving Na⁺ from in ---> out

What is ΔG to move 2 moles of Na⁺ from in ---->out ?
(remember that $\Delta\mu$ is just **ΔG for 1 mol**)

Answer: 2 mol *11.4 kJ/mol = **22.8 kJ**

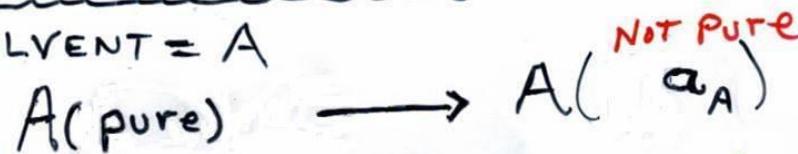
COLLIGATIVE PROPERTIES

Properties of LIQUID or SOLID that depend ONLY on X_{SOLID} or X_{LIQUID}

i.e. ON MOLES of SOLUTE

Not the identity of Solute

SOLVENT = A



α_A = activity in solution = $\gamma_A X_A = \text{less than } 1$

$$\Delta \mu_A = \Delta \bar{G}_A = \Delta \bar{G}^\circ + RT \ln \frac{\alpha_A}{1}$$

Osmotic Pressure. $A(l, \text{pure}) \rightarrow A(l, X_A < 1)$

Melting Point Depression $A(s, \text{pure}) \rightarrow A(l, X_A < 1)$

Boiling Point Elevation $A(l, X_A < 1) \rightarrow A(\text{gas})$

Vapor Pressure Depression " "

What do the following 4 processes have in common?

$A(\text{liq}, X_A=1) \longrightarrow A(\text{solid}, X_A=1)$ at melting point

$A(\text{liq}, X_A=1) \longrightarrow A(\text{gas}, P_A = \text{vap press})$ at any T

$A(\text{liq}, X_A=1) \longrightarrow A(\text{gas}, P_A=1)$ at boiling point

$A(\text{liq}, X_A=1) \longrightarrow A(\text{liq}, X_A=1)$ at any T

ALL at equilibrium

i.e., ALL have $\Delta G = 0$

which have $\Delta G^0 = 0$, i.e., $K = 1$?

all have $\Delta G^0 = 0$, except 2nd

What do the following 4 processes have in common?

$A(\text{liq}, a_A < 1) \rightarrow A(\text{solid}, X_A=1)$ at melting point

$A(\text{liq}, a_A < 1) \rightarrow A(\text{gas}, P_A = \text{vap press})$ at any T

$A(\text{liq}, a_A < 1) \rightarrow A(\text{gas}, P_A = 1)$ at boiling point

$A(\text{liq}, a_A < 1) \rightarrow A(\text{liq}, X_A=1)$ at any T

**ALL spontaneous left
i.e., ALL have $\Delta G = +$**

which have $\Delta G^0 = 0$, i.e., $K = 1$?

all have $\Delta G^0 = 0$, except 2nd

same answer: changing conc. does not change ΔG^0



$$Q = X_{\text{H}_2\text{O}}(\text{liq})/X_{\text{H}_2\text{O}}(s) \text{ if ideal}$$

(when $X=1$, it is ideal)

$$\Delta G = \Delta G^0_{273} + RT \ln(Q/Q^0)$$

At melting point for pure solid and liquid:

Equilibrium

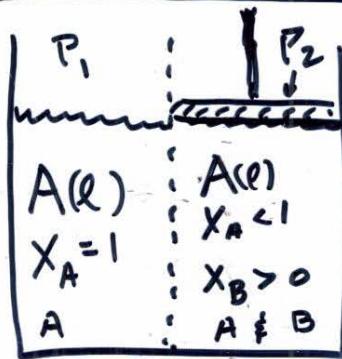
$$\Delta G = 0, Q/Q^0 = 1/1, K = 1$$

$$\Delta G^0_{273} = 0$$

$$\text{OSMOTIC PRESSURE} = \Pi$$

19-6
20-

$$= P_2 - P_1$$



Semi-permeable
passes A, Not B

$$A(l, x_A=1, P_1) \rightarrow A(r, x_A < 1, P_2)$$

$$\Delta \mu_A = \Delta \mu_A^{\circ} + RT \ln \frac{a_A}{1} + V_A(\Pi)$$

Recall $dG = -SdT + VdP$
 $\Delta G = VAP$ at const T

$\Delta \mu_A^{\circ} = 0$ $a_A < 1$ spontaneous unless
 Π very large.

(800 ft of H₂O if [B] = 1 M)

$$\text{EQUILIBRIUM: } \Delta \mu_A = 0$$

$$\text{So, } V_A \Pi_{eq} = -RT \ln \left(\frac{a_A}{1} \right)_{eq}$$

$$\ln a_A = -\frac{\Pi V_A}{RT}$$

partial molar
Volume of Solu.
~18ml for H₂O

$$\text{activity } a_A = e^{-\frac{\Pi V_A}{RT}}$$

at equil

Use this for Problem 6 of HW # 4 Due next Thursday

The “nice” thing about osmotic pressure is that you get activity directly from a Boltzmann-like (or equilibrium constant-like expression

$$a = e^{\frac{-\Pi V_{m,A}}{RT}}$$

$$a = e^y = 1 + y + \frac{y^2}{2} + \frac{y^3}{6} \dots \dots \frac{y^n}{n!}$$

Perhaps the most important power series on the Planet!

Constantly used in a process called LINEARIZATION
when y is small compared to 1, e.g., if $y = -0.02$

$$a = e^y \approx 1 + y$$

exponential power series

$$\alpha = e^{-\frac{\pi \bar{V}_A}{RT}} = e^y = 1 + y + \underbrace{\frac{y^2}{2} + \dots}_{\text{ignore if } y \ll 1} \frac{y^n}{n!}$$

this is known as "linearization"

Fact:

$$\alpha = \gamma_A X_A \approx X_A = 1 - X_B \leftarrow \text{solute}$$

$$1 - X_B = 1 - \frac{\pi \bar{V}_A}{RT} + \frac{\text{smaller stuff}}{\text{ignore.}}$$

$$X_B = \frac{\pi \bar{V}_A}{RT} = \frac{n_B}{n_A + n_B} \cong \frac{n_B}{n_A}$$

\uparrow
 $n_B \ll n_A$
(dilute solution)

$$\frac{\pi \bar{V}_A}{RT} = \frac{n_B}{n_A}$$

$$\pi \bar{V}_A n_A = n_B R T$$

$$\boxed{\pi V_{\text{solution}} = n_B R T}$$

$$\boxed{\Pi V_{\text{solution}} = n_B RT}$$

or $\Pi = \frac{n_B}{V_{\text{solution}}} RT = [B] RT$

$\downarrow [B] = 1 \text{ M}$ at 298 $RT = 0.082 \frac{\text{Latm}}{\text{mol K}} \times 298$

$$\Pi = 25 \text{ atm} \times \frac{2.5 \text{ ft Hg}}{\text{atm}} \times 13.6 \frac{\text{ft H}_2\text{O}}{\text{ft Hg}} = \underline{\underline{850 \text{ ft}_h}}$$

!!