NERNST EQUATION with GOLDMAN EXTENTION

Total Force on an ion, say K^+ = Electrical Force + Concentration (Chemical) Force.

Putting in units of Voltage, the total electrochemical force =

$DV[K^+] = ZFE + RT \ln (K^+_i/K^+_o)$
(Z= charge/mole, F= valence, E=membrance potential in voltage units, R= gas constant, T= temperature(absolute), $\ln$ = log to base e, K^+_i = inside Potassium concentration, K^+_o = outside Pot. Conc.)

When K^+ is at electrochemical equilibrium, $DV[K^+] = 0 = C1E + C2 \ln (K_i^+ /K^+_o)$, where C1,C2....(all C) are constants.

So

$C1E = - C2 \ln (K^+_i/K^+_o) = C3 \ln (K^+_o/K^+_i)$, and dividing both sides by C1 yields
$E=C3/C1 \ln (K^+_o/K^+_i) = C4 \ln (K^+_o/K^+_i) =C5 \log_{10} (K^+_o/ K^+_i)$. C5= about 60, so

NERNST EQUATION: $E =60 \log (K^+_o/K^+_i)$ [Note: $\log (x)$ = Log to base 10]

It is noted that this applies when **only** permeable ion is K^+ . Otherwise, one uses the Goldman equation (of which the Nernst is seen to be a special case).

$E= 60 \log (Pk\ K_o+ Pna\ Na_o+Pcl\ Cl_i.......)/(Pk\ K_i + Pna\ Na_i + Pcl\ Cl_o.......)$

Pk= potassium permeability coefficient, Pna= perm coeff for Na, Pcl= perm coeff for Cl. Signs of ions omitted for clarity, but note, **cation** outside concentrations are in numerators, **anion** outside concentrations in denominator. Note what happens to equation if all coefficients but Pk go to zero.

Sample question: If $K^+_o = 10000$ and $K^+_i =10$, what is E if K^+ is sole permeable ion? In other words, what is the K^+ equilibrium potential?