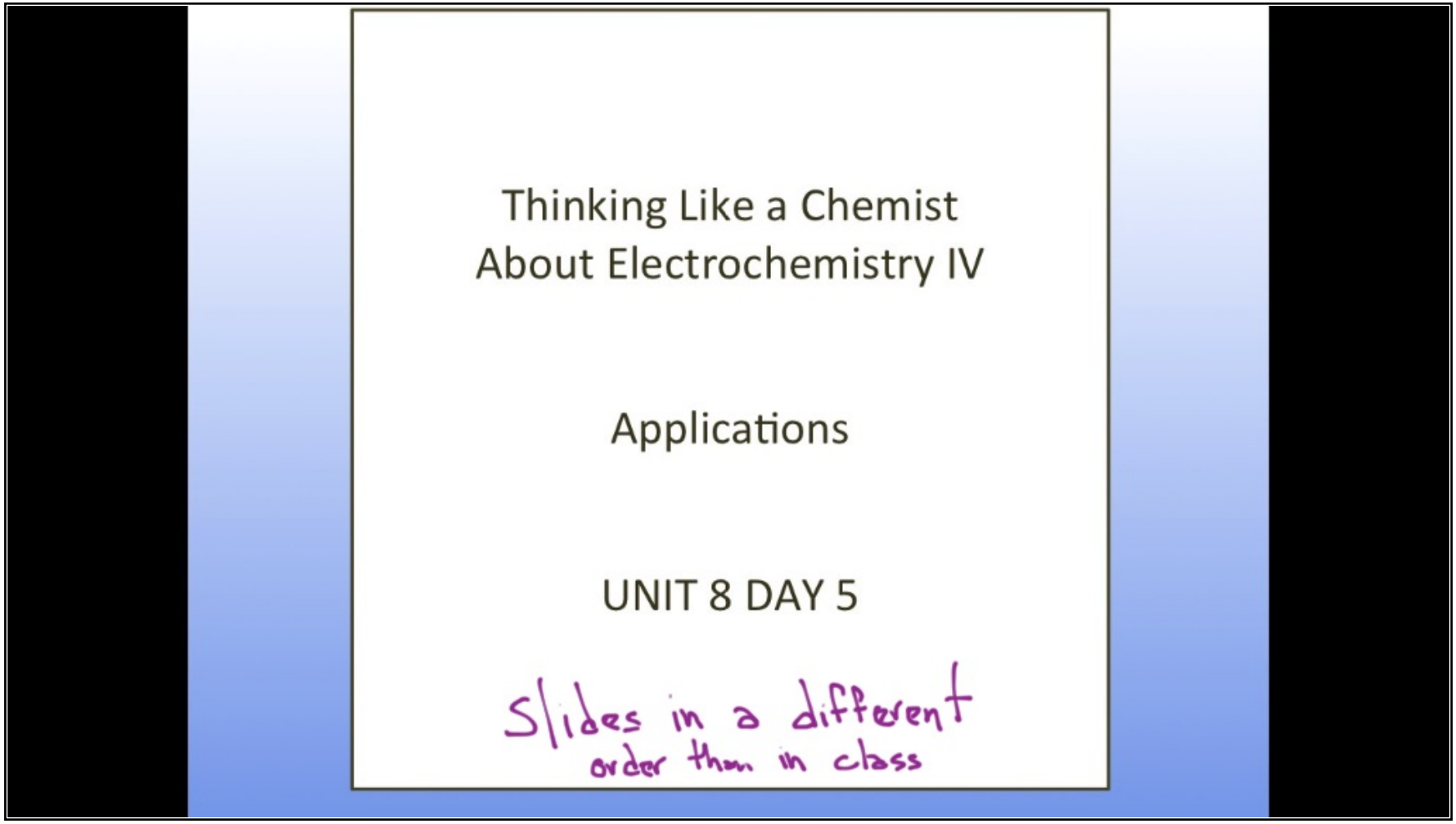
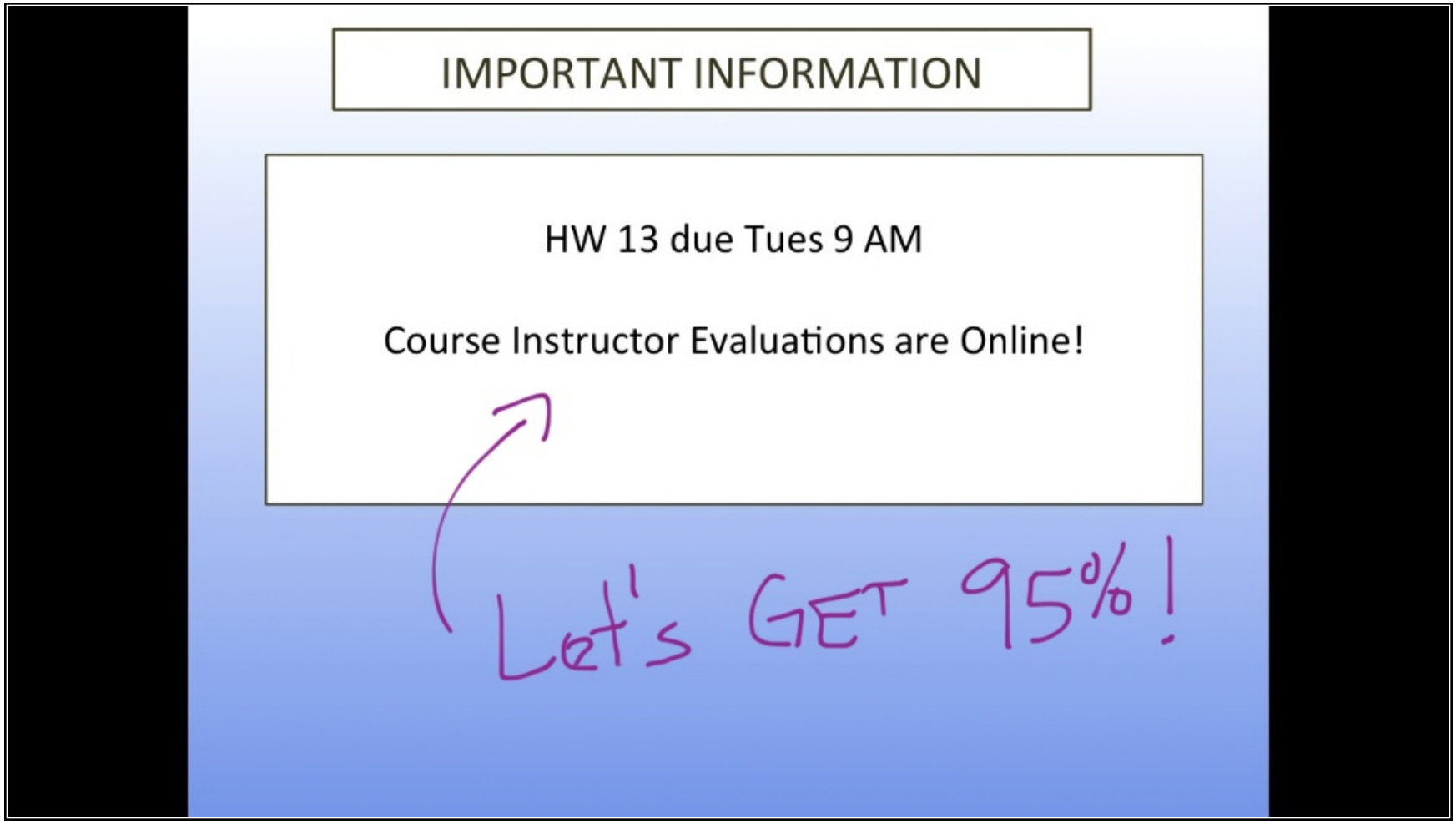
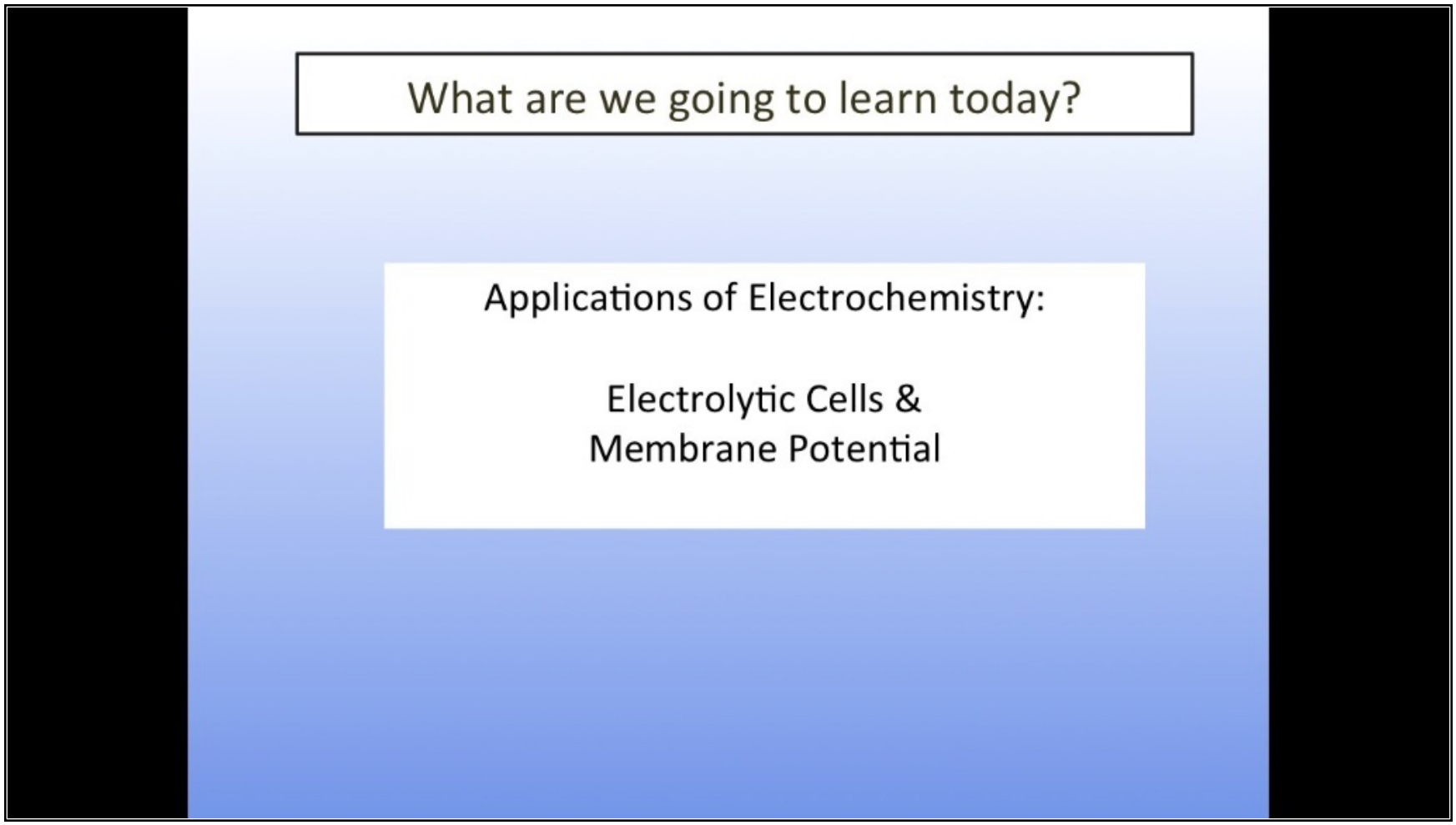
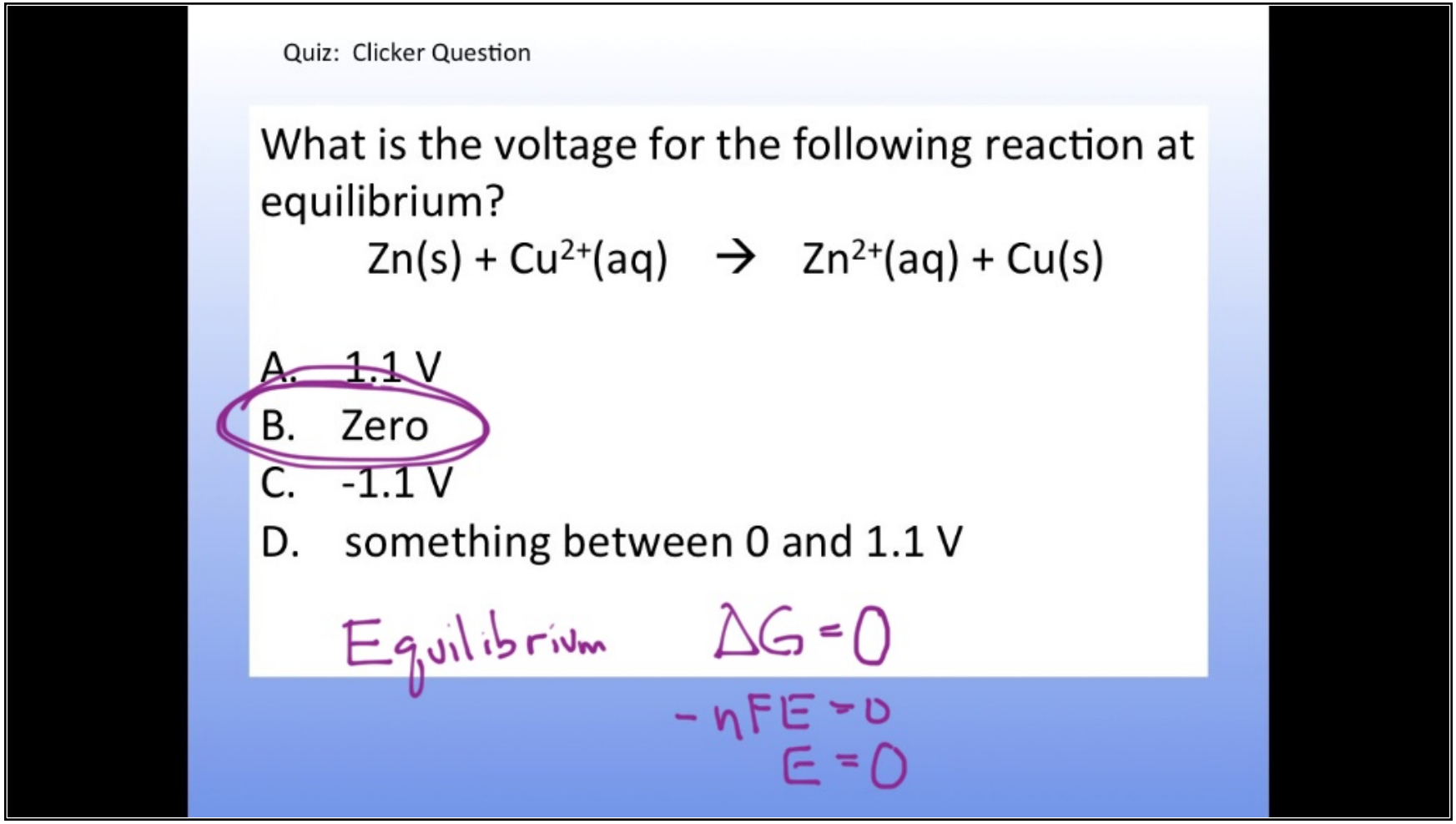
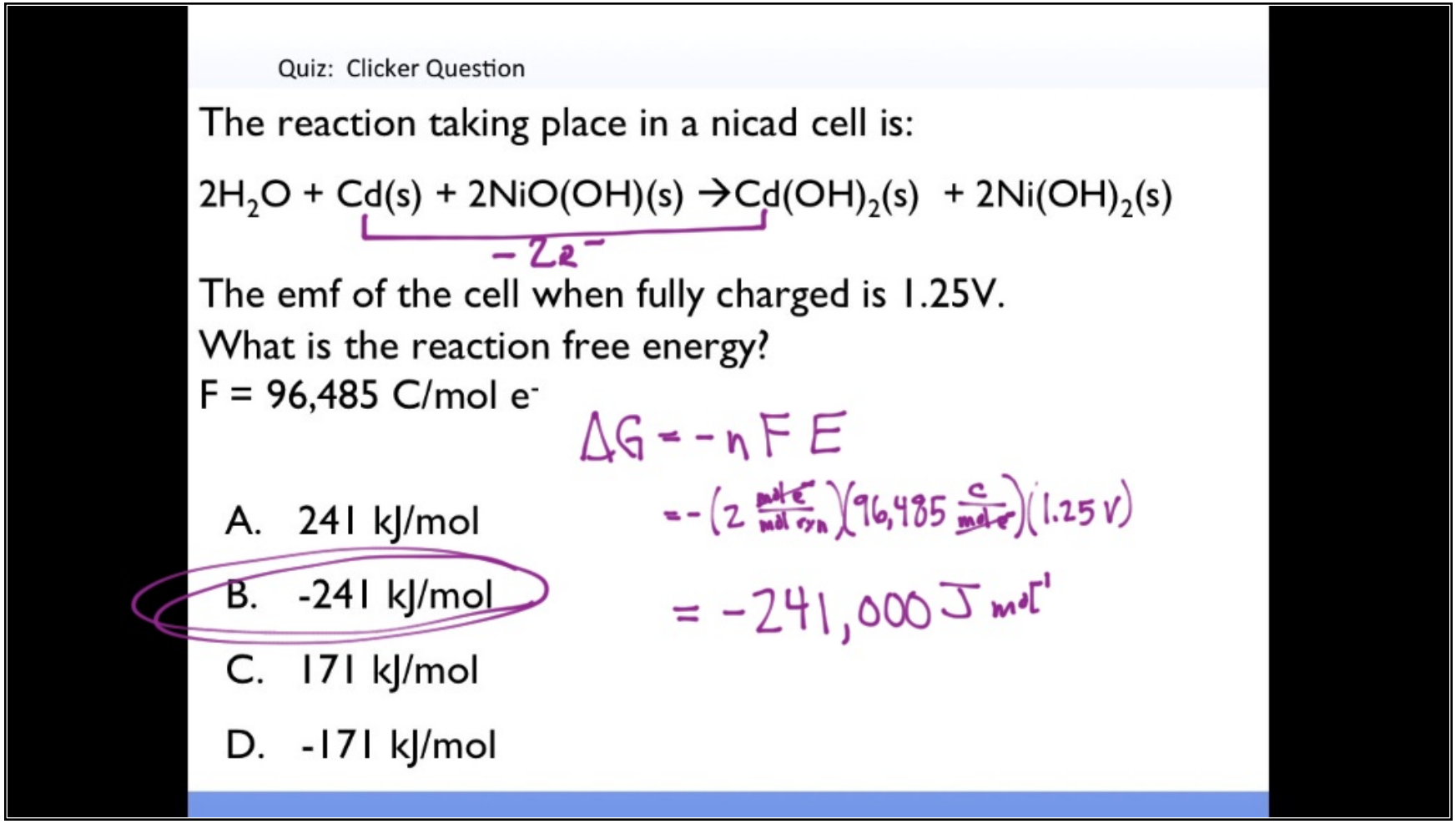
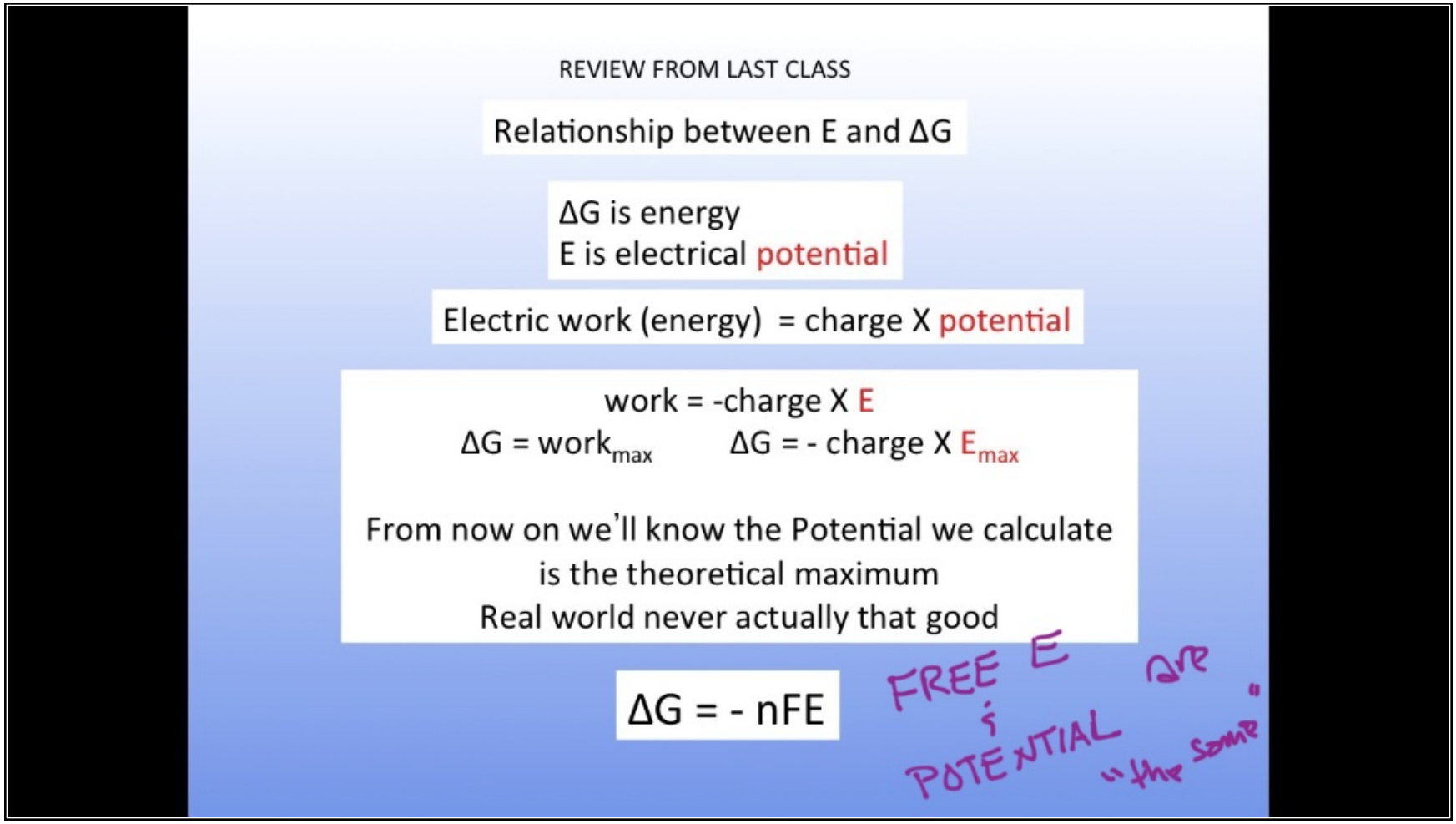

Thinking Like a Chemist
About Electrochemistry IV
Applications
UNIT 8 DAY 5
Slides in a different
order than in class

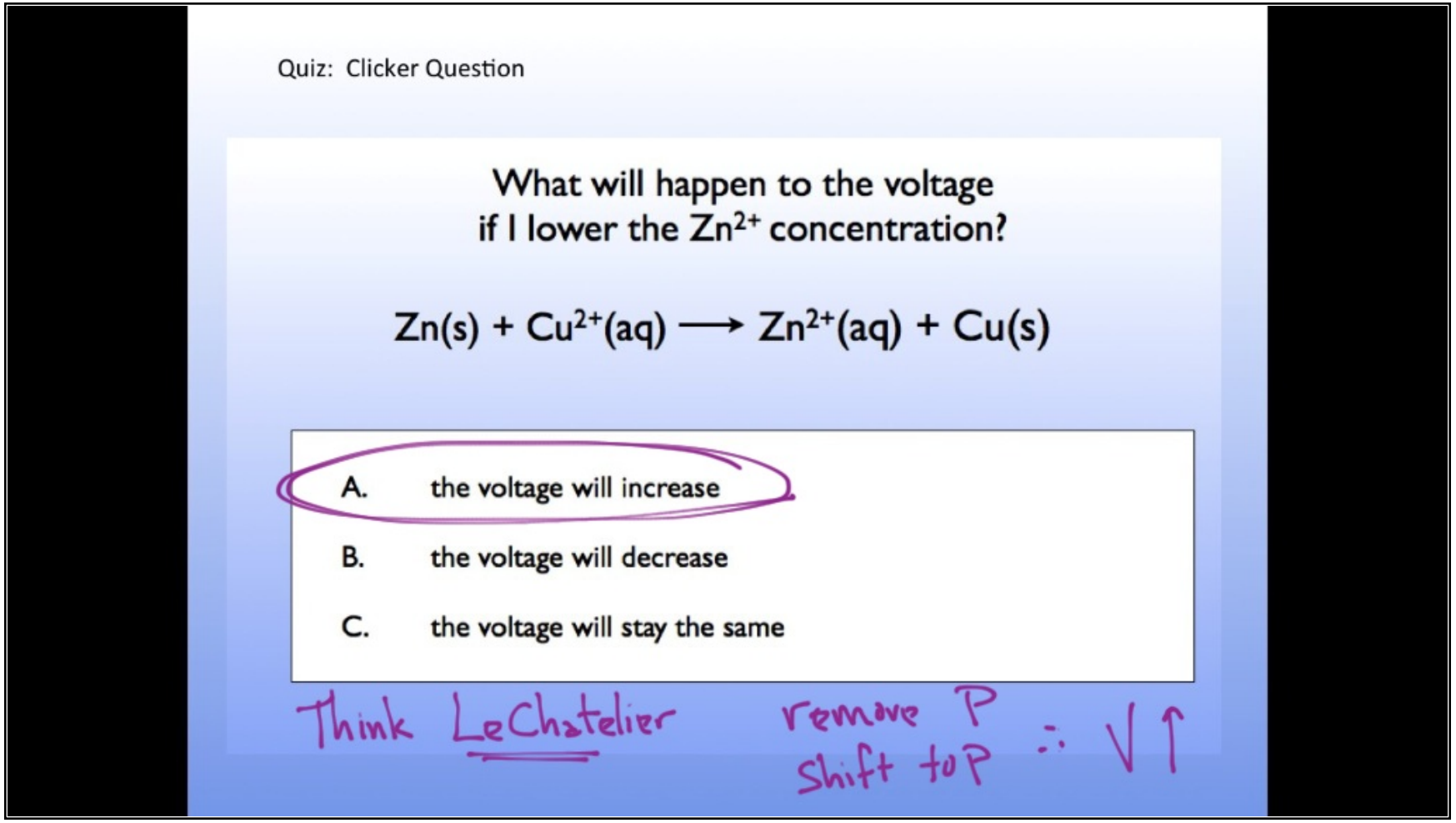

IMPORTANT INFORMATION
HW 13 due Tues 9 AM
Course Instructor Evaluations are Online!
Let's GET 95%!

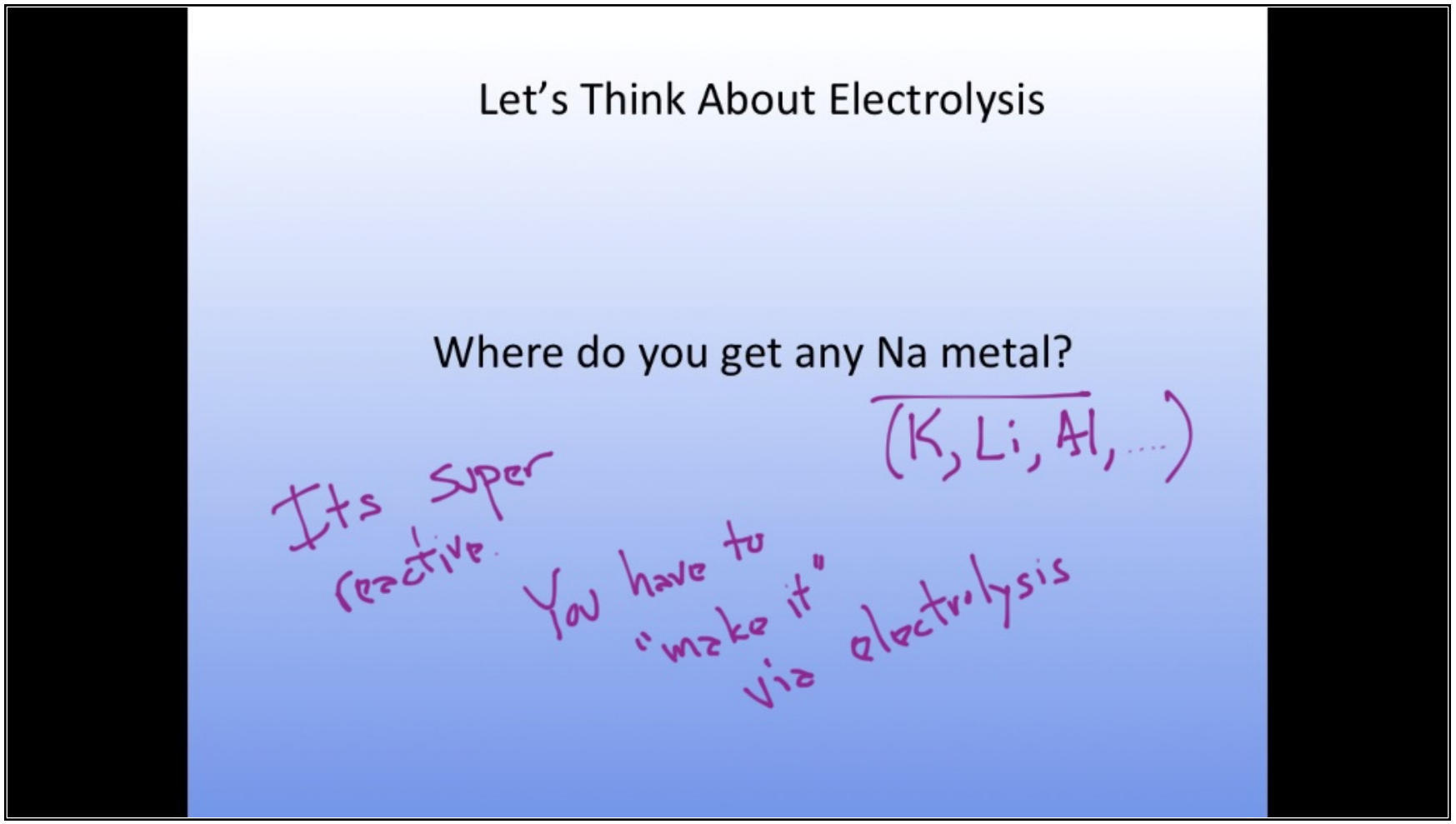

What are we going to learn today?
Applications of Electrochemistry:
Electrolytic Cells &
Membrane Potential


Quiz: Clicker Question
What is the voltage for the following reaction at equilibrium?
Zn(s) + Cu2+(aq) → Zn2+(aq) + Cu(s)
A. 1.1 V
B. Zero
C. -1.1 V
D. something between 0 and 1.1 V
Equilibrium ΔG = 0
-nFE = 0
E = 0


Quiz: Clicker Question
The reaction taking place in a nicad cell is:
$2H_2O + Cd(s) + 2NiO(OH)(s) \rightarrow Cd(OH)_2(s) + 2Ni(OH)_2(s)$
$-2e^-$
The emf of the cell when fully charged is 1.25V.
What is the reaction free energy?
F = 96,485 C/mol e⁻
$\Delta G = -nFE$
$= -(2 \frac{mole^-}{mol\ rxn})(96{,}485 \frac{C}{mole^-})(1.25\ V)$
$= -241{,}000\ J\ mol^{-1}$
A. 241 kJ/mol
B. -241 kJ/mol
C. 171 kJ/mol
D. -171 kJ/mol


REVIEW FROM LAST CLASS
Relationship between E and ΔG
ΔG is energy
E is electrical potential
Electric work (energy) = charge X potential
work = -charge X E
ΔG = work$_{max}$
ΔG = - charge X E$_{max}$
From now on we'll know the Potential we calculate
is the theoretical maximum
Real world never actually that good
ΔG = - nFE
FREE E
&
POTENTIAL are "the same"


Quiz: Clicker Question
What will happen to the voltage if I lower the Zn^{2+} concentration?
$Zn(s) + Cu^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Cu(s)$
A. the voltage will increase
B. the voltage will decrease
C. the voltage will stay the same
Think LeChatelier
remove P
shift to P
∴ V ↑

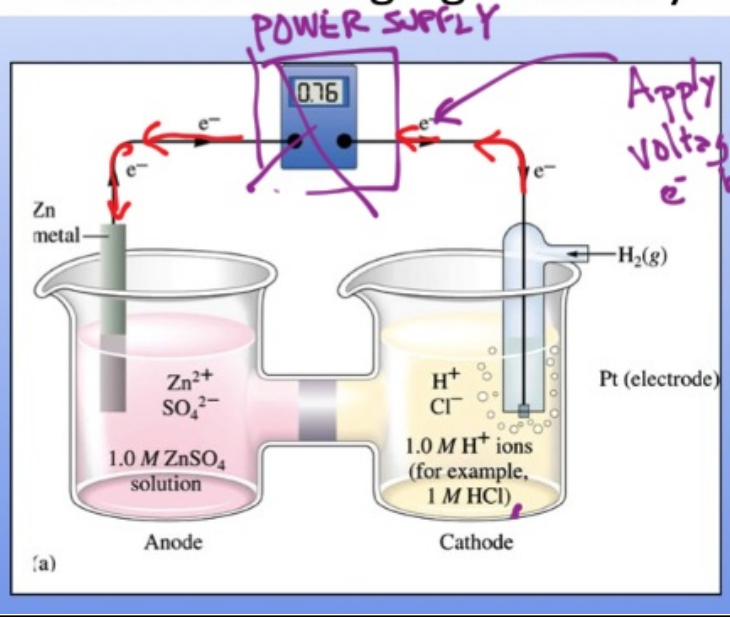

Let's Think About Electrolysis
Where do you get any Na metal?
(K, Li, Al, ...)
Its super reactive.
You have to "make it" via electrolysis

Electrolytic Cells

Version 1

Just a voltaic cell backwards

This is recharging a battery



Apply opposite voltage ; force e⁻ backward

$H_2 \rightarrow 2H^+ + 2e^-$

$Zn^{2+} + 2e^- \rightarrow Zn$

Electrolytic Cells

Version 2

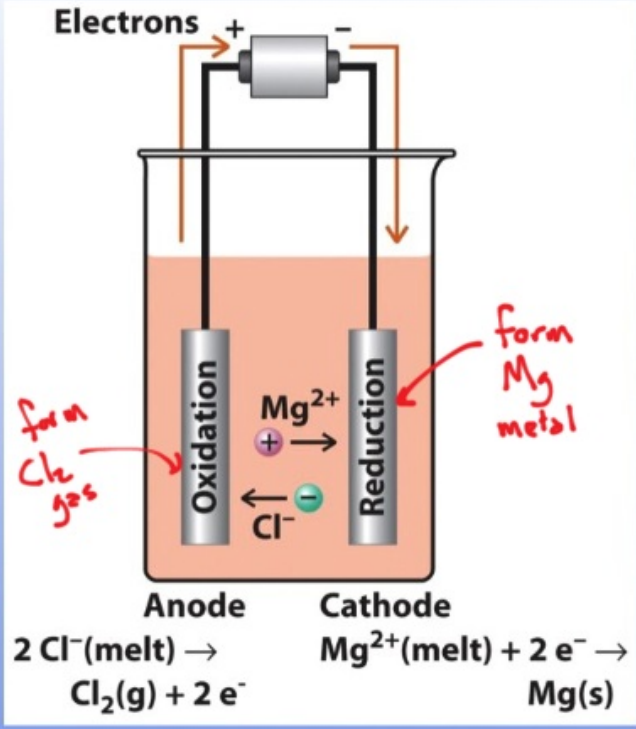
Make Reactive Species from Stable Compounds

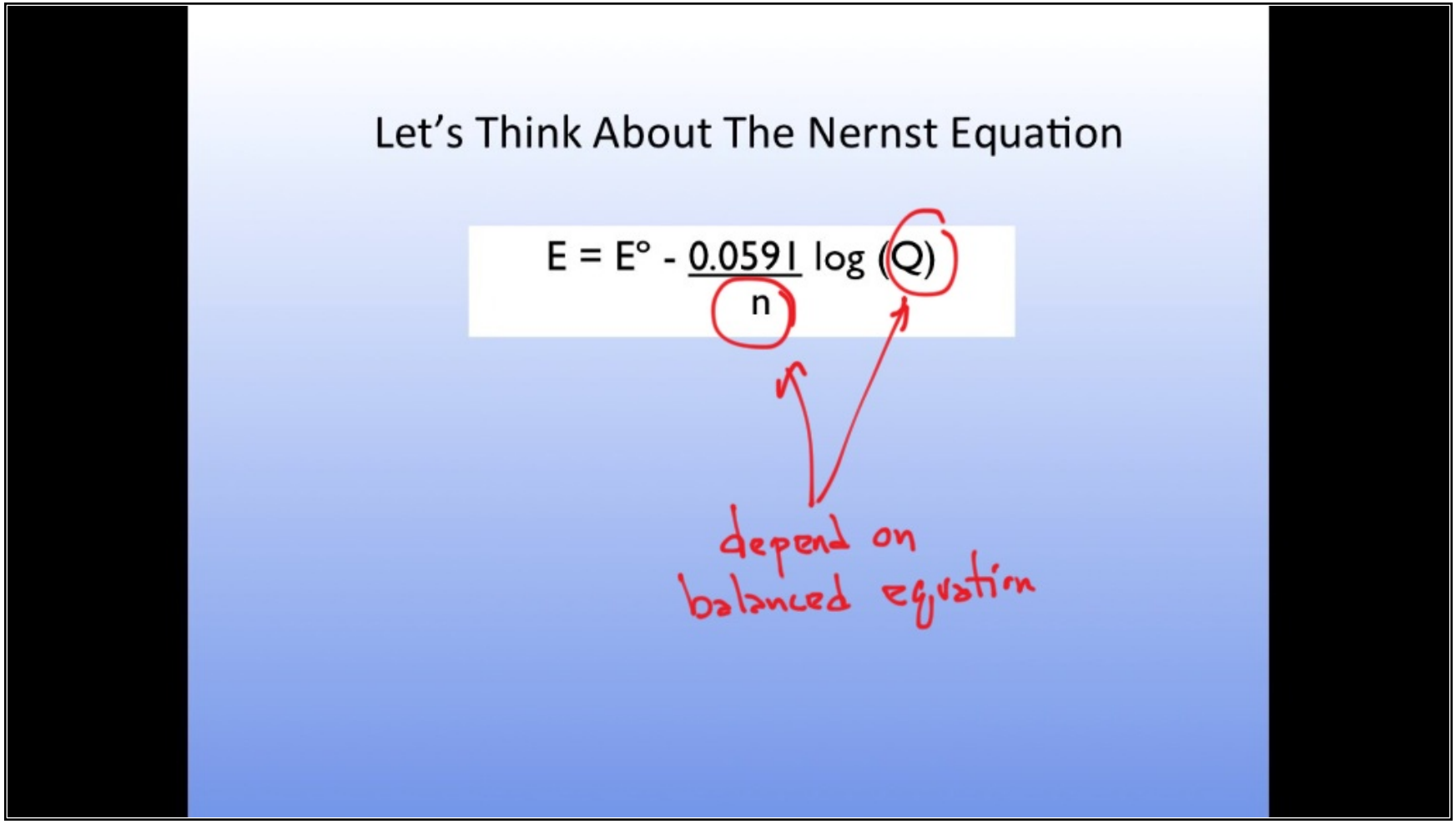
products highly reactive

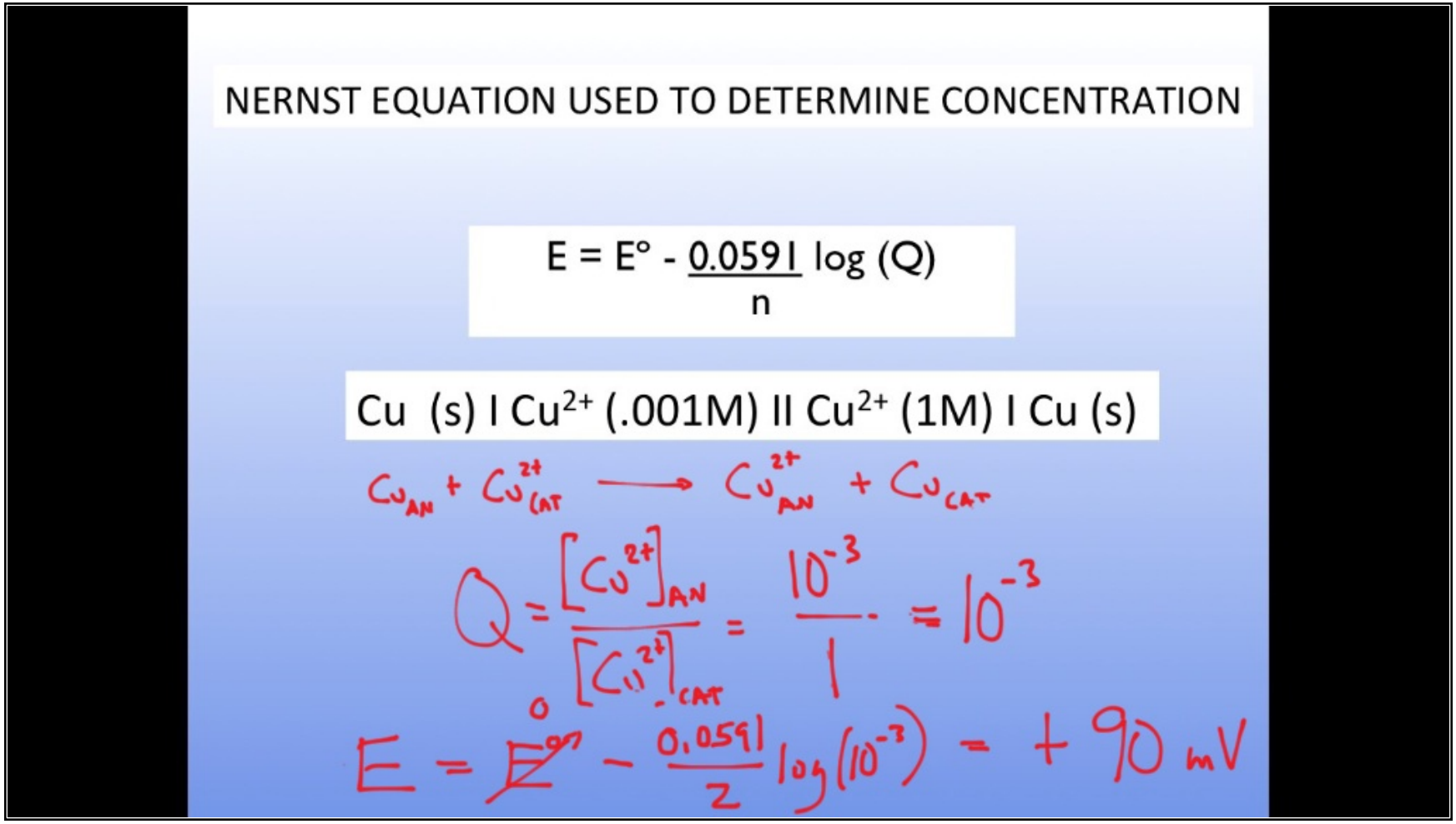
keep them separated

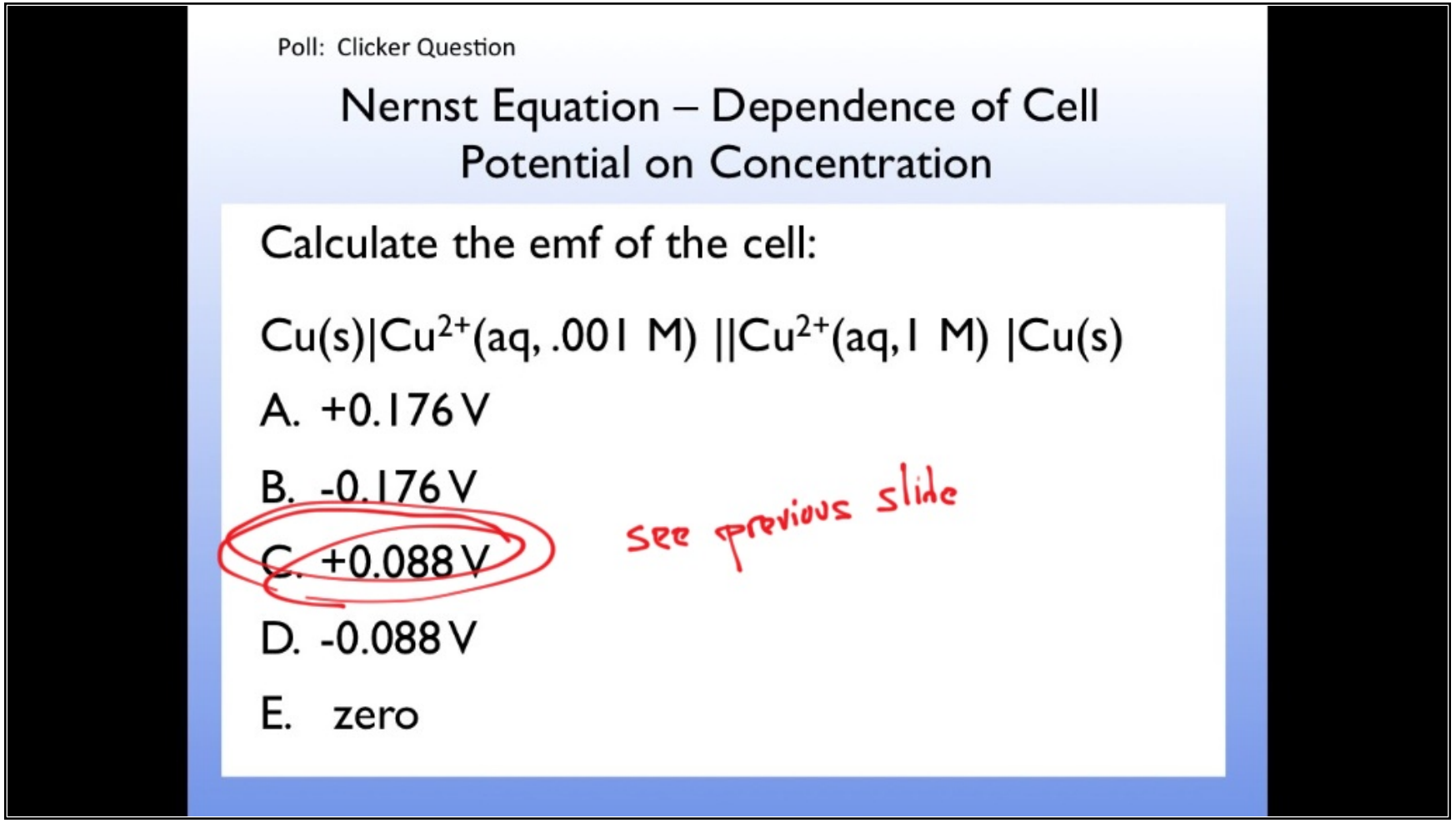
http://www.youtube.com/watch?v=i9xS9t-KMpc

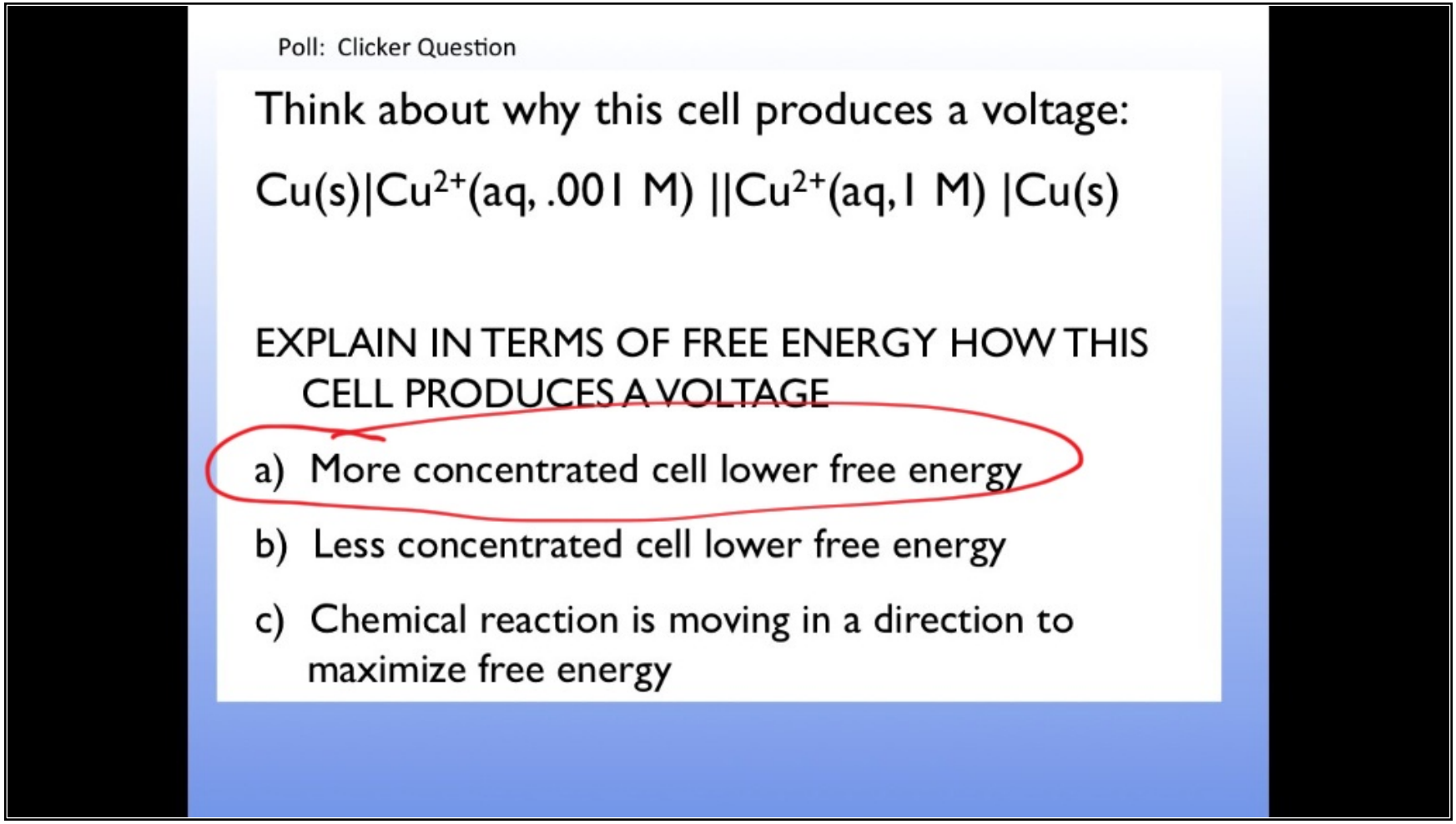
https://www.youtube.com/watch?v=Cf8zjla8euQ

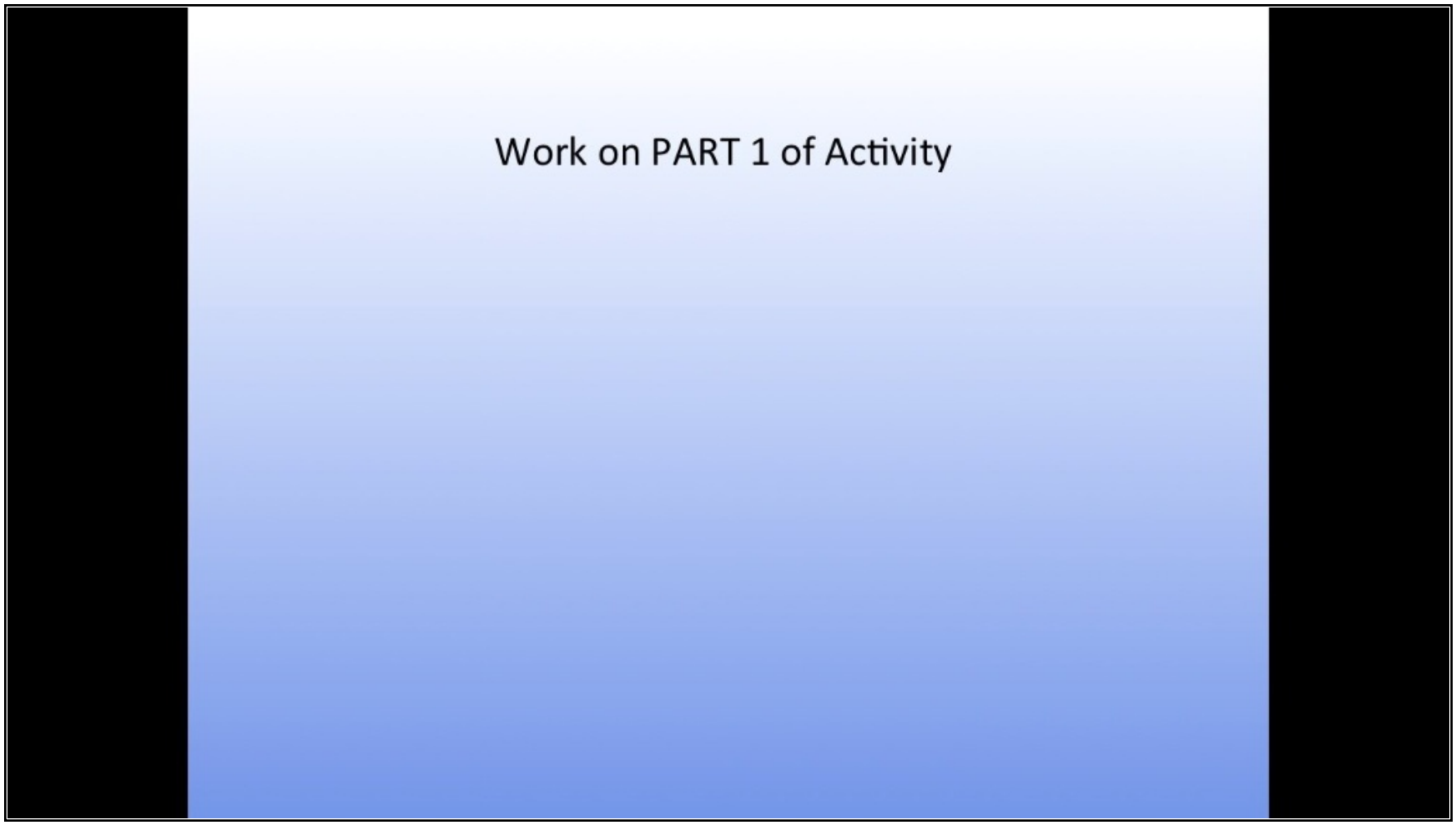


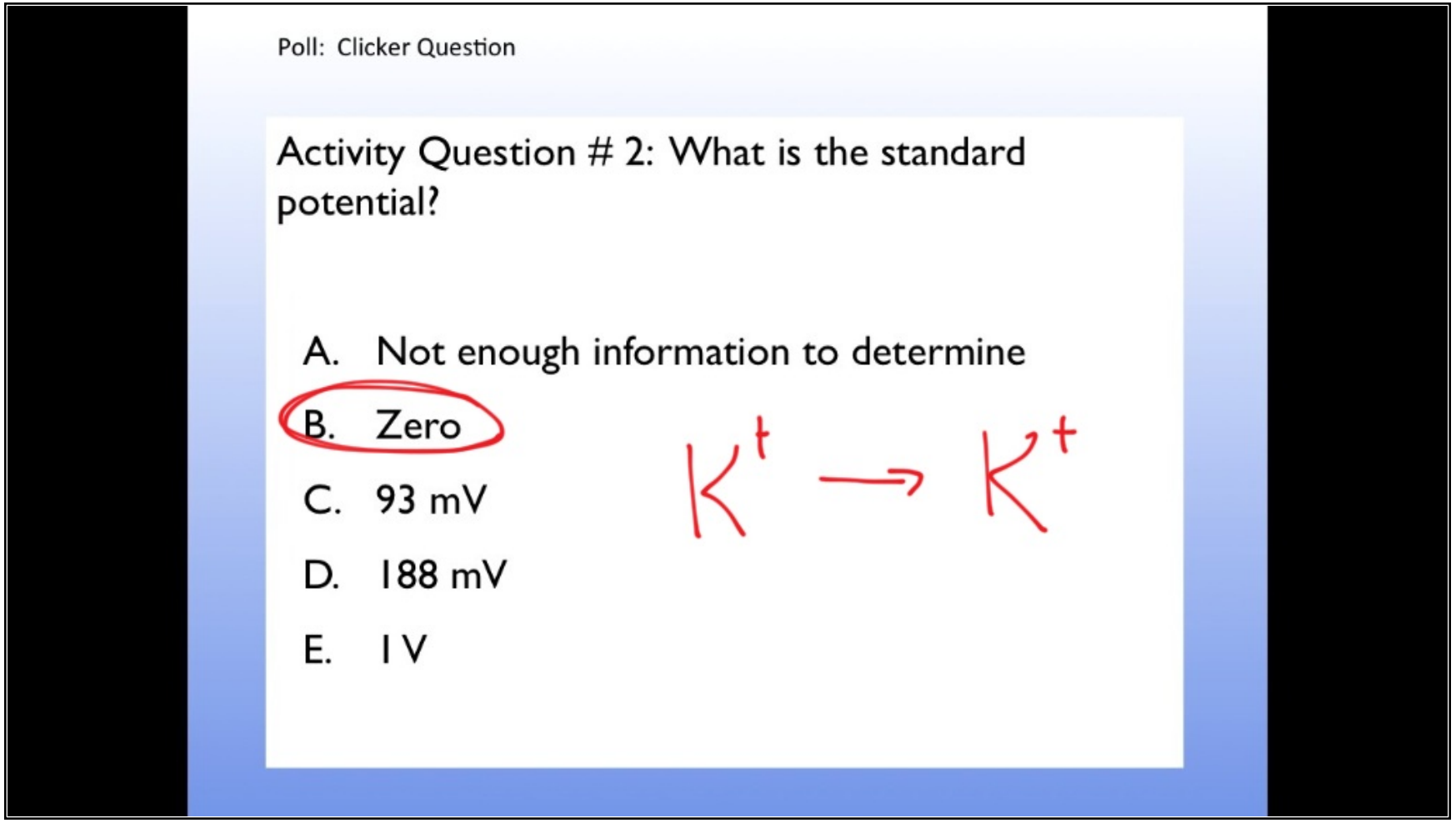

Let's Think About The Nernst Equation
E = E° - 0.0591 log (Q)
n
depend on
balanced equation

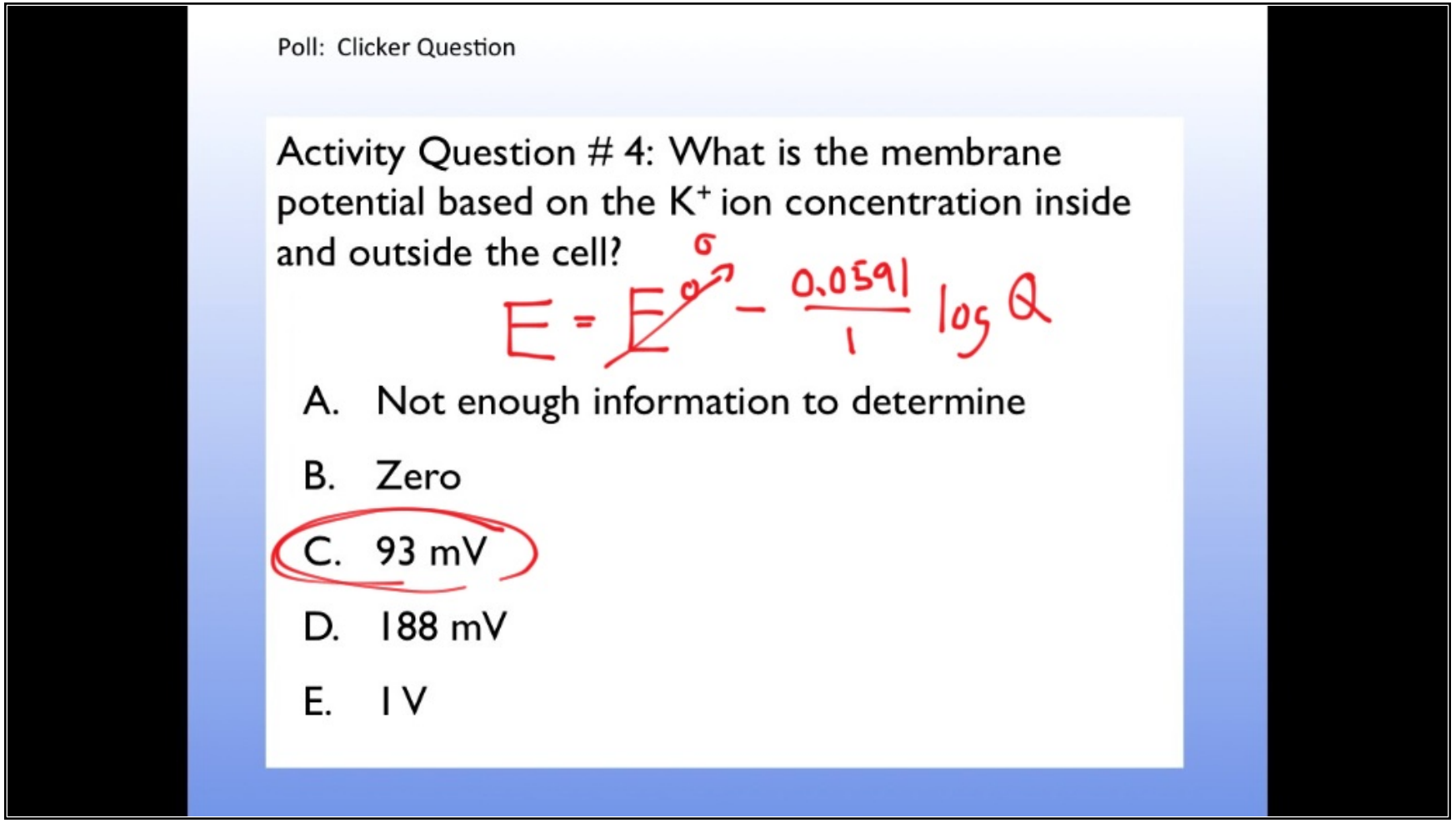

NERNST EQUATION USED TO DETERMINE CONCENTRATION
E = E° - 0.0591 log (Q)
n
Cu (s) I Cu2+ (.001M) II Cu2+ (1M) I Cu (s)
CuAN + Cu2+CAT → Cu2+AN + CuCAT
Q = [Cu2+]AN / [Cu2+]CAT = 10-3 / 1 = 10-3
E = E°cell - 0.0591 / 2 log(10-3) = + 90 mV


Poll: Clicker Question
Nernst Equation – Dependence of Cell Potential on Concentration
Calculate the emf of the cell:
Cu(s)|Cu2+(aq, .001 M) ||Cu2+(aq,1 M) |Cu(s)
A. +0.176 V
B. -0.176 V
C. +0.088 V
D. -0.088 V
E. zero
see previous slide


Poll: Clicker Question
Think about why this cell produces a voltage:
Cu(s)|Cu2+(aq, .001 M) ||Cu2+(aq,1 M) |Cu(s)
EXPLAIN IN TERMS OF FREE ENERGY HOW THIS CELL PRODUCES A VOLTAGE
a) More concentrated cell lower free energy
b) Less concentrated cell lower free energy
c) Chemical reaction is moving in a direction to maximize free energy


Work on PART 1 of Activity


Poll: Clicker Question
Activity Question # 2: What is the standard potential?
A. Not enough information to determine
B. Zero
C. 93 mV
D. 188 mV
E. 1 V
K+ → K+


Poll: Clicker Question
Activity Question # 4: What is the membrane potential based on the K+ ion concentration inside and outside the cell?
E = E° − 0.0591/1 log Q
A. Not enough information to determine
B. Zero
C. 93 mV
D. 188 mV
E. 1 V

Two "kinds" of electrochemical cells:

Galvanic (Voltaic): Reaction is spontaneous. We can use these to make a battery.

Electrolytic: Reaction is not spontaneous. We have to input work to get these reactions to proceed.


DEMONSTRATE THE REACTIVITY OF SODIUM METAL
HOW DOES ONE GET SODIUM METAL?
http://www.youtube.com/watch?v=i9xS9t-KMpc


DO PART II OF ACTIVITY

Poll: Clicker Question

Activity Part II question #1: What is happening at the cathode?

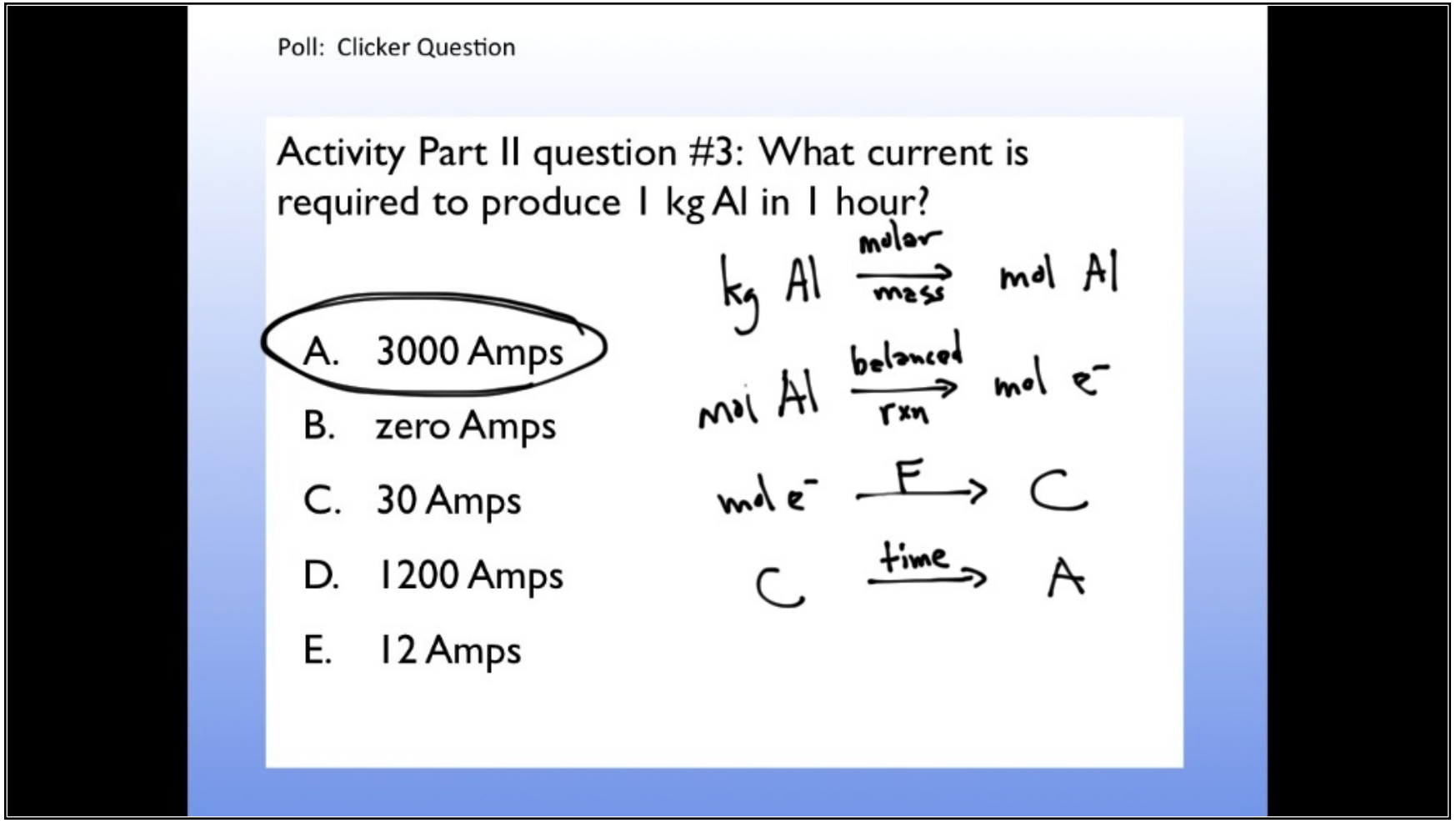
A. Not enough information to determine

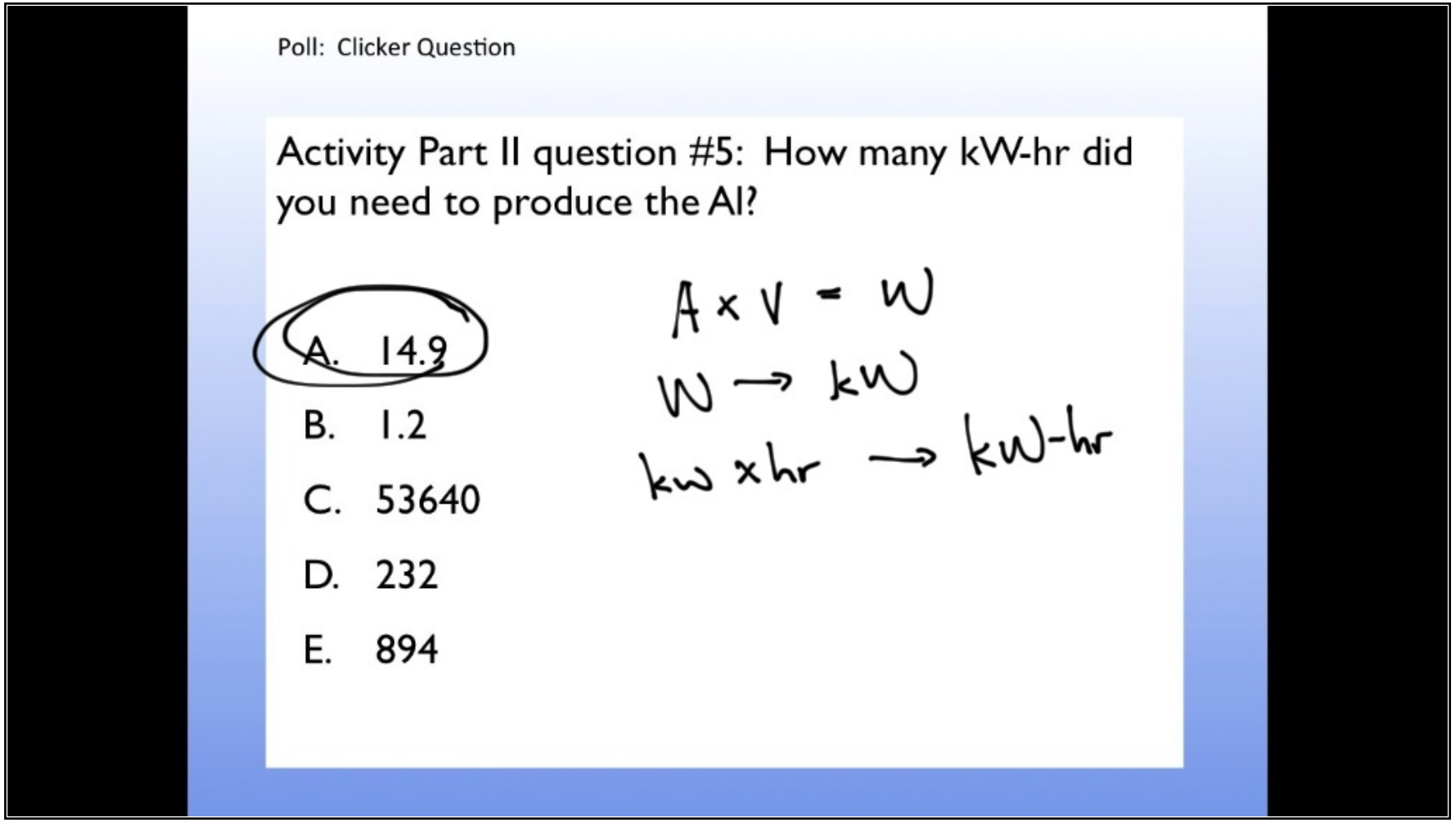
B. Aluminum is oxidized

C. Aluminum is reduced.

D. Carbon is oxidized.

E. Carbon is reduced.


Poll: Clicker Question
Activity Part II question #3: What current is required to produce 1 kg Al in 1 hour?
A. 3000 Amps
B. zero Amps
C. 30 Amps
D. 1200 Amps
E. 12 Amps
kg Al
molar mass
mol Al
mol Al
balanced rxn
mol e⁻
mol e⁻
F
C
C
time
A


Poll: Clicker Question
Activity Part II question #5: How many kW-hr did you need to produce the Al?
A. 14.9
B. 1.2
C. 53640
D. 232
E. 894
A x V = W
W → kW
kw x hr → kW-hr

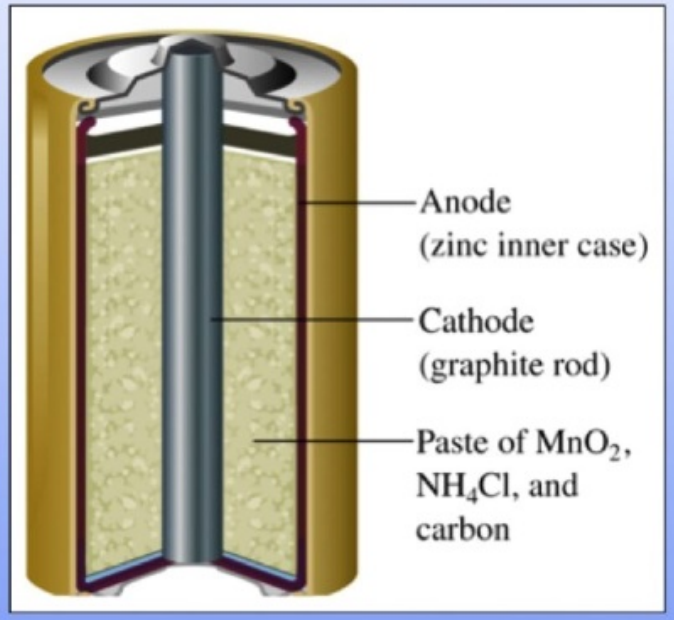
Batteries without liquids

Dry Cell

All solids!

$Q = 1$

$E = E^\circ$!



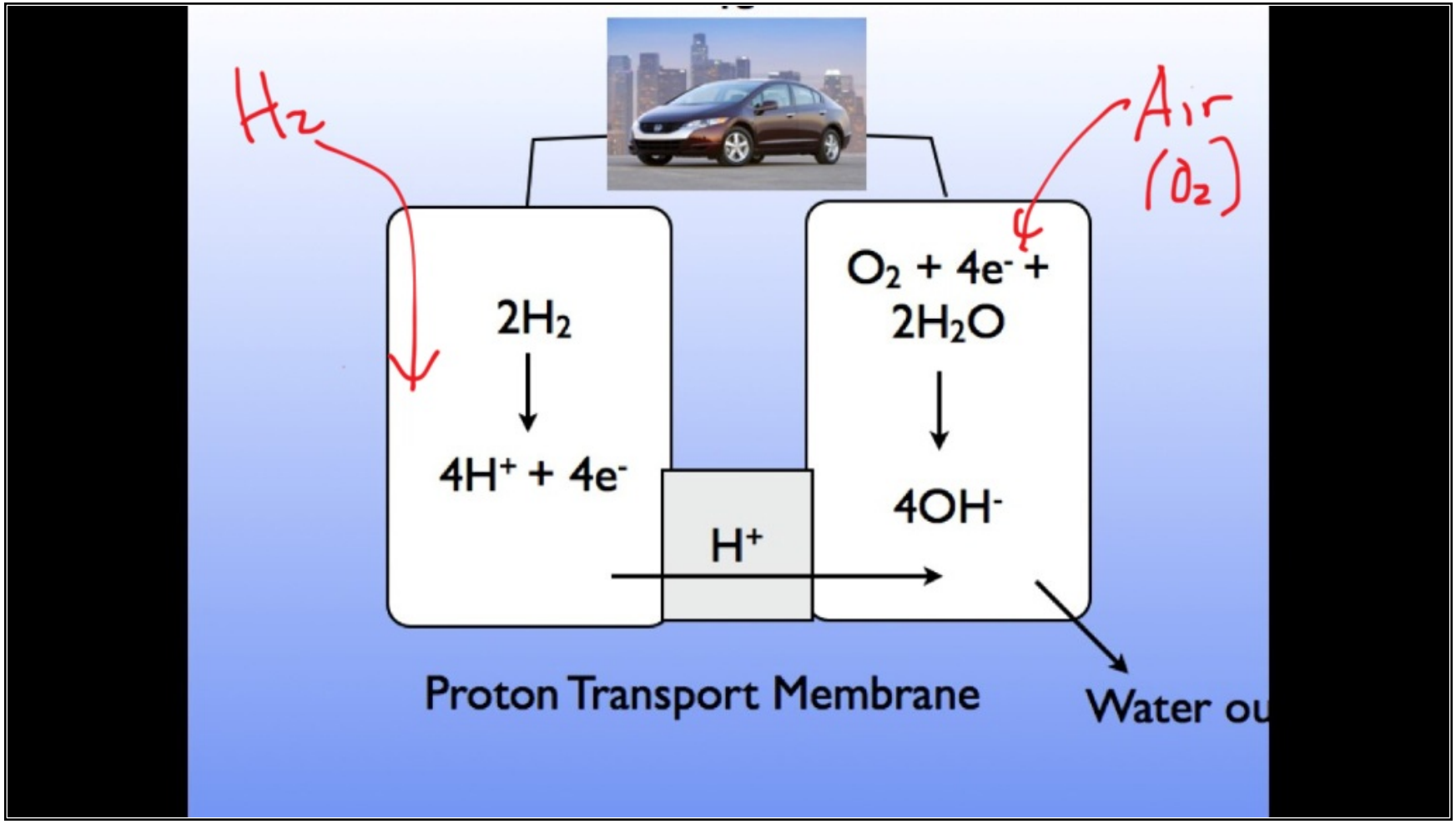
$Zn(s) \rightarrow Zn^{2+}(aq) + 2\ e^-$

$2MnO_2(s) + 2\ H^+(aq) + 2\ e^- \rightarrow Mn_2O_3(s) + H_2O$

The Key
Solid Electrolyte
Paste
NH_4^+, NH_3, H_2O

Carbon makes electrical connection

Very slow reaction. Constant V. Very low current


H2
Air
(O2)
2H2
4H+ + 4e-
O2 + 4e- +
2H2O
4OH-
H+
Proton Transport Membrane
Water ou