UNIT8-DAY4-LaB1230

Monday, April 22, 2013
3:35 PM

Thinking Like a Chemist
About Electrochemistry III

Potential, Free Energy & K

UNIT8 DAY4

ke Spring 2012

IMPORTANT INFORMATION

Last LM

LM's 37 & 38 due Th 9 AM

Course Instructor Surveys NOW OPEN!

online only

CH302 Vanden Bout/LaBrake Spring 2013

What are we going to learn today?

Determine Voltage in Electrochemical Cells Containing Different Concentrations of Reactants

Relationship between ΔG, E and K

Quiz: Clicker Question 1

1 Ampere is the same as:

A. 1 Joule/Coulomb — Volt
B. 1 Joule/second — Watt
C. 1 Coulomb/second
D. 1 Coulomb/mole e^-

Principles of Chemistry II
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Quiz: Clicker Question 2

Faraday's Law of electrolysis: The amount of product formed or reactant consumed by an electric current is stoichiometrically equivalent to the amount of electrons supplied.

$Al^{+3} + 3e^- \rightarrow Al(s)$ (+3)

How many moles of Al (s) can be produced from Al_2O_3 if 5.0 mol of e^- are supplied?

a) 1.0
b) 1.7
c) 3.0
d) 5.3

$$5\ mole^- \left| \frac{Al^{3+}}{3e^-} \right| \frac{Al}{Al^{3+}} = 1.7\ Al$$

Quiz: Clicker Question 3

Given: 1 mol e^- = 96,485 Coulombs AND 1 Amp = 1 Coulomb/sec

Cu 63.5 g/mol

How many hours is required to plate 35.0 g of copper metal from 0.5 M $CuSO_4$(aq) by using a current of 3.0 A?

a) 3.5 hr
b) 7.0 hr
c) 10 hr
d) 13 hr

Given: 35 g Cu
Wanted: time

gCu → mol Cu → mole e^- → Coulomb → time
molar mass | stoichiometry | Faraday | Amp

$$35\ g\ Cu \left| \frac{mol\ Cu}{63.5\ g} \right| \frac{mol\ Cu^{2+}}{mol\ Cu} \left| \frac{2\ mole^-}{1\ mol} \right| \frac{96485\ C}{1\ mole^-} \left| \frac{1\ s}{3\ C} \right| \frac{1\ min}{60\ sec} \left| \frac{1\ hr}{60\ min} \right.$$

WORK ON Learning ACTIVITY.....

$$35\,g\,Cu \left|\frac{mol\,Cu}{63.5\,g}\right|\frac{mol\,Cu^{2+}}{mol\,Cu}\left|\frac{2\,mole^-}{1\,mol}\right|\frac{96485\,C}{1\,mole^-}\left|\frac{1\,s}{3\,C}\right|\frac{1\,min}{60\,sec}\left|\frac{1\,hr}{60\,min}\right.$$

WORK ON Learning ACTIVITY.....

Relationship between E and ΔG

ΔG is energy
E is electrical potential

Electric work (energy) = -(charge X potential)

work = -charge X E

$\Delta G = work_{max}$ $\Delta G = -$ charge X E_{max}

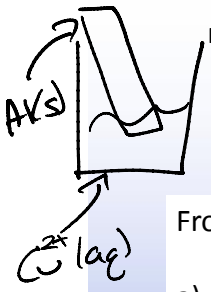
From now on we'll know the Potential we calculate is the theoretical maximum
Real world never actually that good

Relationship between E and ΔG

ΔG = - charge X E

What is the charge?
charge = n X F
n is number of moles of electrons (per mole rxn)
F is the charge of one mole of electrons
F = 96,485 C (Faraday's Constant)

$\Delta G = - nFE$



Poll: Clicker Question 3

$\Delta G^\circ_{Rxn} = \sum \Delta G^\circ_{fP} - \sum \Delta G^\circ_{fR}$

From the given thermo data, what is the value of ΔG° ?

a)-416 kJ/mol
b)+416 kJ/mol
c)-1159 kJ/mol
d)+1159 kJ/mol

$2Al(s) + 3Cu^{2+} \rightarrow 3Cu(s) + 2Al^{3+}$ ← spontaneous!

Poll: Clicker Question 4

From the given computed value of ΔG° , what is the value of K?

a)Enormous
b)Infinitely small
c)1

From the given computed value of ΔG° , what is the value of K?

a) Enormous
b) Infinitely small
c) 1

$\Delta G^\circ_{Rxn} = -RT \ln K$

VERY large negative number

super spontaneous

VERY Product favored

Poll: Clicker Question 5

From the given standard reduction potential data, what is the value of E_{cell}° ?

spontaneous reaction

"+" potential

a) -1 V
b) +1 V
c) -2 V
d) +2 V

work done by the system

$w = -1158$

Poll: Clicker Question 6

96485

Charge = (moles e⁻) F

What is the maximum amount of electrical work that can extracted from running this cell under standard conditions.

a) +2316 kJ/mol
b) +1158 kJ/mol
c) +579 kJ/mol
d) +239 kJ/mol

$\Delta G^\circ = -nFE^\circ = w$

What is n?

$n = 6$

a) 2316 kJ/mol
b) 1158 kJ/mol
c) 579 kJ/mol
d) 239 kJ/mol

What is n?

n = 6

based on BALANCED Rxn

Non Standard Conditions

DERIVE NERNST EQUATION

$$\Delta G = \Delta G^\circ + RT\ln Q$$

(at equilibrium $\Delta G^\circ = -RT\ln K$)

$$-nFE = -nFE^\circ + RT\ln Q$$

$$\frac{-nFE}{-nF} = \frac{-nFE^\circ}{-nF} + \frac{RT\ln Q}{-nF}$$

$$E = E^\circ - \frac{RT}{nF}\ln Q$$

Constants go to log

$$E = E^\circ - \frac{0.0591}{n}\log Q$$

memorize

$$E = E^\circ - \frac{0.0591}{n}\log(Q)$$

$$Q = \frac{[Al^{3+}]^2}{[Cu^{2+}]^3}$$

$$Q = \frac{(0.001)^2}{(0.01)^3} = \frac{1\times10^{-6}}{1\times10^{-6}} = 1$$

Calculate the emf of the cell:

<Al(s)|Al^{3+}(aq, .001 M) ||Cu^{2+}(aq, .01 M) |Cu(s)>

$\log 1 = 0$

$E = E^\circ$

a) 1.8 V
b) 1.9 V
c) 2 V
d) 2.1 V

b) 1.9 V
c) 2 V
d) 2.1 V

$$E = E^o - \frac{0.0591}{n} \log(Q)$$

$Q = \frac{(1)^2}{(1 \times 10^{-8})^3}$

$\log(1 \times 10^{24}) = 24$

Calculate the emf of the cell:

<Al(s)|Al^{3+}(aq, 1 M) ||Cu^{2+}(aq, 1 x 10^{-8} M) |Cu(s)>

↖ VERY Different from standard

a) 1.55 V
b) 1.76 V ← VERY Similar to standard voltage
c) 2 V
d) 2.24 V

This is great! batteries last the same until equilibrium

Nernst Equation – Dependence of Cell Potential on Concentration

$$E = E^o - \frac{0.0591}{n} \log(Q)$$

Think about what happens to the value of E when the value of Q changes!

What did we learn today?

Calculate the cell potential for a nonstandard cell.

Describe fully the relationship between the free energy and the cell potential.

Describe fully the relationship between cell potential and the equilibrium constant.

Explain thermodynamically the operation of a concentration cell, and be able to predict the concentration in the cell based on the cell potential.

Understand the relationship between charge delivered or produced and the amount of reactant used or product formed for both galvanic and electrolytic cells.