Mc

Tuesday, April 25, 2017 3:54 PM

Printout

Tuesday, April 25, 2017 3:54 PM

Applications of Electrochemistry

Biberdorf

Unit 4 Electrochemistry

Important Information

Due Today: HW10 and LE39

Due Tuesday: LE40 and HW11

Exam 4 is on Wednesday (5/3) at 7 PM!

CIS

Question

spontaneous $\Delta G = -$ $E_{cell} = (+)$

Given the below half-reactions, calculate the standard potential of the galvanic electrochemical cell.

$Cu^{2+} + 2e^- \rightarrow Cu$ $E° = +0.34$ V

$Al^{3+} + 3e^- \rightarrow Al$ $E° = -1.66$ V

$Cu^{2+} + 2e^- \rightarrow Cu$ $E° = +0.34V$

$Al \rightarrow Al^{3+} + 3e^-$ $E° = +1.66V$

2V

Question

$W = \Delta G^\circ = -nFE^\circ = \text{charge} \times \text{voltage} = E$

Assuming E_{cell}° = 2V, what is the maximum amount of electrical work that can be extracted from running this cell under standard conditions?

$Cu^{2+} + 2e^- \rightarrow Cu$ $E^\circ = +0.34$ V
$Al^{3+} + 3e^- \rightarrow Al$ $E^\circ = -1.66$ V

A. 2316 kJ/mol
B. 1158 kJ/mol
C. 579 kJ/mol
D. 239 kJ/mol

$\Delta G^\circ = -nFE^\circ = -1157.8$ kJ/mol

$= -(6)\left(\frac{96{,}485\ C}{mole^-}\right)(2V)$

mole⁻

Question

$[Cu^{2+}] = 1M$

Given the below half-reactions, calculate the standard potential of the electrochemical cell.

$Cu^{2+} + 2e^- \rightarrow Cu$ $E° = +0.34$ V

$Cu^{2+} + 2e^- \rightarrow Cu$ $E° = +0.34$ V

$Cu^{2+} + 2e^- \rightarrow Cu$ $+0.34V$

$Cu \rightarrow Cu^{2+} + 2e^-$ $-0.34V$

$0V$

$E° = 0V$ * equilibrium *

$G_{reactant} = G_{product}$

Question

Calculate the emf of the following electrochemical cell.

anode / ox　　　　cathode / red

$Cu(s)|Cu^{2+}(0.001M)||Cu^{2+}(1M)|Cu(s)$

A. 0.176 V
B. – 0.176 V
C. 0.088 V
D. – 0.088 V
E. 0 V

$Cu(s) \rightarrow Cu^{2+}_{ox} + 2e^-$ (0.001)

$Cu^{2+}_{red} + 2e^- \rightarrow Cu(s)$ (1M)

$Cu^{2+}_{red} + Cu(s) \rightarrow Cu^{2+}_{(ox)} + Cu(s)$

$Q = \frac{[Cu^{2+}_{ox}]}{[Cu^{2+}_{red}]}$

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

$E = 0 - \frac{0.0591}{2} \log \frac{(0.001M)}{(1M)} = 0.08865V$

Question

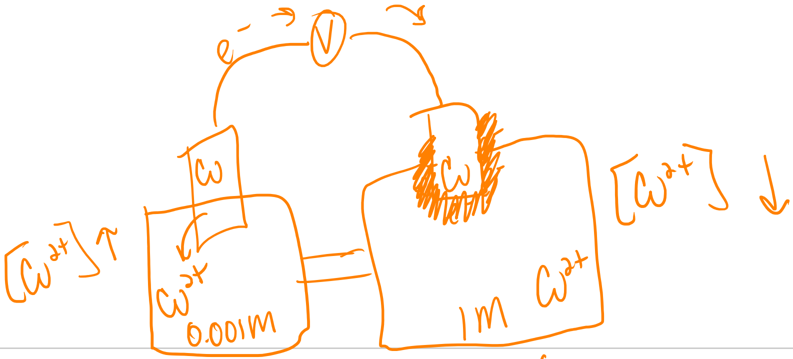
How does this cell produce a voltage?

anode

$Cu(s)|Cu^{2+}(0.001M)||Cu^{2+}(1M)|Cu(s)$

A. More concentrated cell, lower free energy
B. Less concentrated cell, lower free energy

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



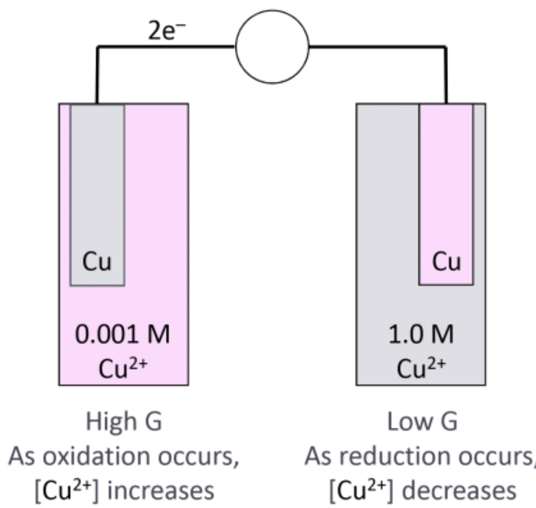
high G — low G

$Cu \rightarrow Cu^{2+} + 2e^-$ — $Cu^{2+} + 2e^- \rightarrow Cu$

Explanation

A more concentrated cell has a lower free energy.

Cu(s) | Cu^{2+}(0.001M) | | Cu^{2+}(1M) | Cu(s)



*will continue to react until

$[Cu^{2+}]_{ox} = [Cu^{2+}]_{red}$

OR

run out of electrode (reactant)

Batteries

Biberdorf

Unit 4 Electrochemistry

Key Characteristics of Batteries: Potential (E)

* amount of work needed to move charge
* unit = $V = \frac{J}{C}$
* large E, good battery
* we can string batteries together to overcome a low potential

$$E_{cell} = E_{cathode} - E_{anode}$$

Key Characteristics of Batteries: Capacity (Q)

↳ charge

* value of charge the system can generate at a specific voltage

* "total Energy"

* unit = C (coulomb)

$$Q = I \cdot t$$

Key Characteristics of Batteries: Current (I)

* how fast battery can generate charge
* provide a time factor
* unit = A = $\frac{C}{s}$ $\frac{\text{charge}}{\text{time}}$ $I = \frac{Q}{t}$

Key Characteristics of Batteries: Power (P)

* rate of doing work per unit time
* unit = Watts (W) = $\frac{J}{s}$

$$P = \frac{V \cdot Q}{t} = V \cdot I$$

$$\left(\frac{J}{\cancel{C}}\right)\left(\frac{\cancel{C}}{s}\right) = \frac{J}{s}$$

Key Characteristics of Batteries: Cycle Life

* how well the battery recharges

Question

Which of the following terms is the most important thing to consider when creating a new battery application?

A. Power
B. Potential
C. Capacity
D. Current
E. Cycle Life

"efficiency"

how fast charge can be generated

Optimal Battery Characteristics

* perfect combination of energy density & power density

light
cheap
nontoxic
solid

efficient
long-lasting
SMALL

Battery Type: Primary

* dry cells - paste in battery

↳ not reversible

↳ not rechargeable

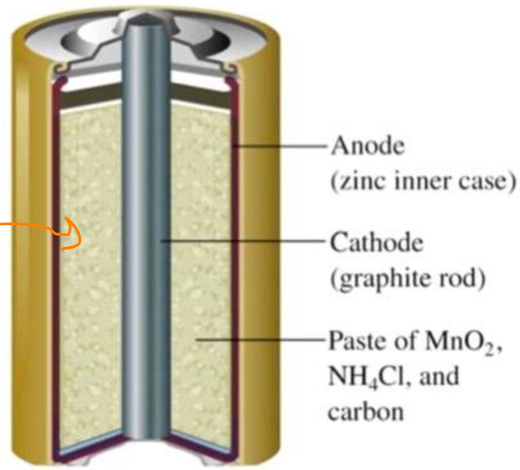
↳ alkaline batteries (1.5V)

* different sizes for different electric current (I)

D battery = max I

Dry Cells

Salt bridge



anode: $Zn + 2OH^- \rightarrow ZnO + H_2O + 2e^-$

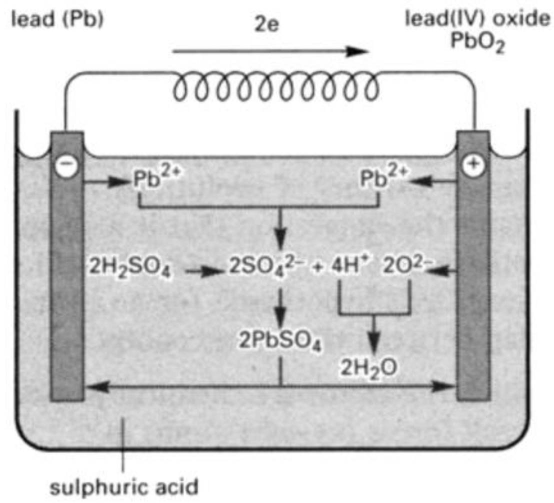
cathode: $2MnO_2 + H_2O + 2e^- \rightarrow Mn_2O_3 + 2OH^-$

*slow reactions, constant V (1.5V), low I

Battery Type: Secondary

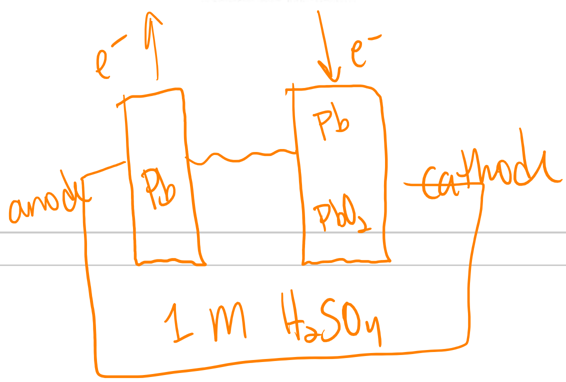
* reversible
  - ↳ rechargable
* NiCd (toxic)
* Li-ion
* Pb-storage (car battery)

Lead Storage Battery



(*) $\overset{0}{Pb}$, $\overset{+2}{PbSO_4}$, $\overset{+4}{PbO_2}$

(*) no salt bridge needed



Lead Storage Battery (*) discharge (*)

anode: $\overset{0}{Pb}_{(s)} + SO_4^{2-}{}_{(aq)} \rightarrow \overset{+2}{PbSO_4}{}_{(s)} + 2e^-$

cathode: $\overset{+4}{PbO_2}{}_{(s)} + 4H^+{}_{(aq)} + SO_4^{2-}{}_{(aq)} + 2e^- \rightarrow \overset{+2}{PbSO_4}{}_{(s)} + 2H_2O_{(l)}$

Overall: $Pb_{(s)} + PbO_{2(s)} + 2H_2SO_{4(aq)} \rightarrow 2PbSO_{4(s)} + 2H_2O_{(l)}$

$E_{cell} = 2V$

(*) 6 cells in a battery

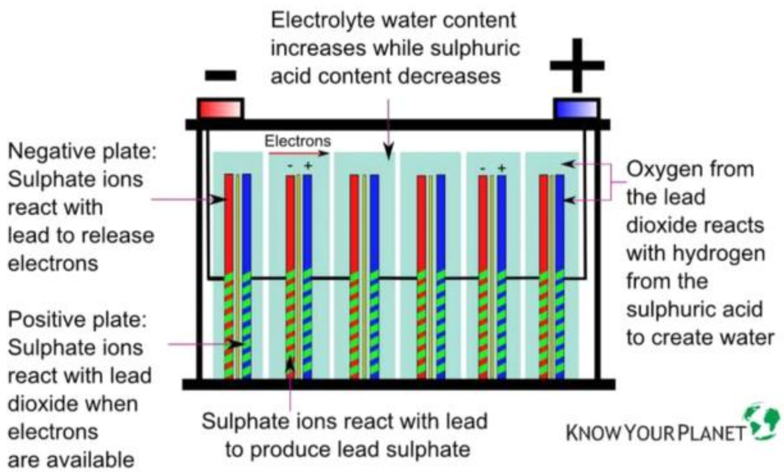
$2V \times 6 = 12V$

discharge	recharge
* voltaic cell	* electrolytic cell
* start the car	* car is on

↳ alternator turns ME into EE

↳ recharges the cell

12V Lead-Acid Battery (Discharge)



Question

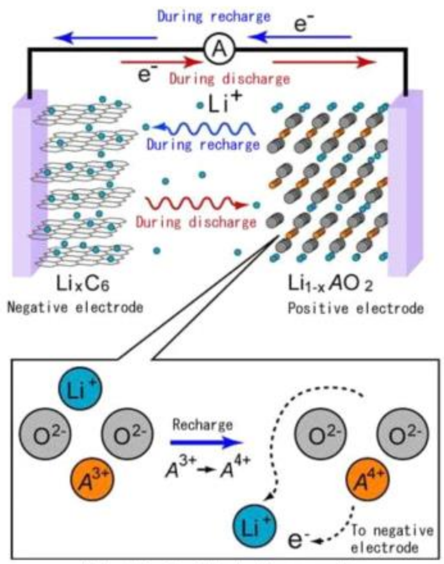
discharge

Which of the following species is the reducing agent in the Lead-Acid car battery?

oxidation

A. Pb (s)
B. PbO_2 (s)
C. $PbSO_4$ (s)
D. H_2O (l)

Li-Ion Battery



Schematic view illustrating operating principle of Li-ion secondary battery

portable electronic devices

anode: $LiC_6 \rightarrow C_6 + Li^+ + e^-$

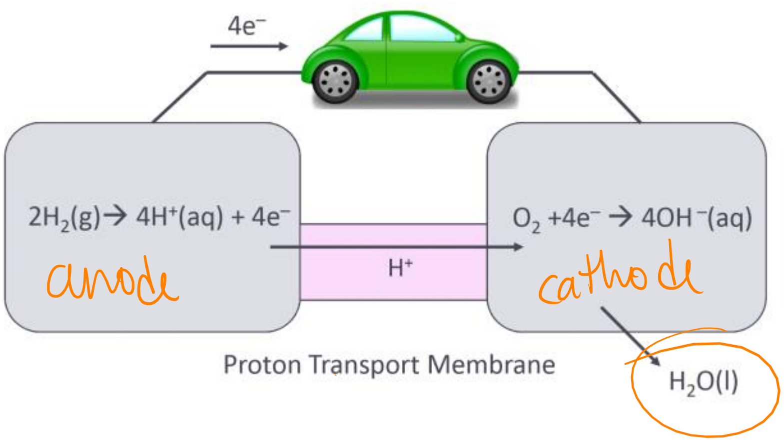
cathode: $CoO_2 + Li^+ + e^- \rightarrow LiCoO_2$

overall: $LiC_6 + CoO_2 \rightarrow C_6 + LiCoO_2$ $E_{cell} = 1.5V$

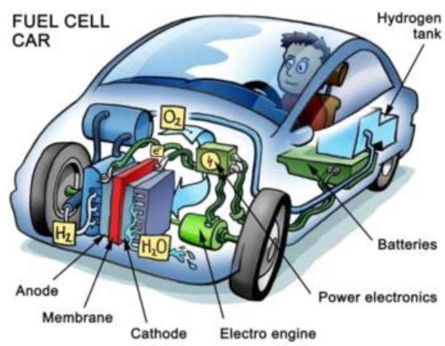
Battery Type: Fuel Cells

* voltaic cells where the fuel is continuously supplied
* not rechargeable
* refillable

Fuel Cells



4e⁻
2H₂(g) → 4H⁺(aq) + 4e⁻
O₂ +4e⁻ → 4OH⁻(aq)
H⁺
anode
cathode
Proton Transport Membrane
H₂O(l)



FUEL CELL CAR
Hydrogen tank
Batteries
Power electronics
Electro engine
Cathode
Membrane
Anode

Photovoltaic Cells