1.1 The original "International Ampere" was defined electrochemically as the current required to deposit 1.118 mg of silver per second from a solution of silver nitrate. Using this definition, how does the international ampere compare to the SI version? (Note that the SI version is based on the Ampere force law).

$$\frac{1.118 \times 10^{-3} \text{g Ag}}{\text{s}} \left| \frac{\text{mol Ag}}{107.8682 \text{ g Ag}} \right| \frac{96485.33 \text{ C}}{\text{equivalent}} \right| \frac{1 \text{ equivalent}}{\text{mol Ag}} = 1.00022 \text{ A}$$

The international Ampere is slightly larger than the SI one, which is the current required to create a force of 2×10^{-7} N for two parallel wires separated by a distance of 1 m.



File:problem 1-2.EES 2/9/2015 7:50:28 AM Page 1 EES Ver. 9.724: #2355: For use only by students and faculty in Chemical and Biological Engineering Georgia Tech.

Chapter 1, problem 2

deposition of Mo from molten salt

MW = 95.94 [g/mol]

F = 96485 [coulomb/mol]

m = 12.85 [g]

I = 7 [coulomb/s]

t = 3600 [s]

$$m = I \cdot t \cdot \frac{MW}{F \cdot z}$$

SOLUTION **Unit Settings: SI C kPa kJ mass deg** F = 96485 [coulomb/mol] m = 12.85 [g] t = 3600 [s]

No unit problems were detected.

I = 7 [coulomb/s] MW = 95.94 [g/mol] z = 1.95 File:problem 1-3.EES

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Chapter 1, problem 3

amount of hydrogen needed to run fuel cell

F = 96485 [coulomb/mol]

Power = 50000 [W]

V = 0.7 [V] cell voltage

Power = $I \cdot V$

t = 3600 · 3 · 1 [s]

MW = 0.002 [kg/mol] molecular weight of hydrogen

n = 2

 $m = I \cdot t \cdot \frac{MW}{F \cdot n}$

SOLUTION	
Unit Settings: SI C kPa kJ mass deg	
F = 96485 [coulomb/mol]	
m = 7.995 [kg]	
n = 2	
t = 10800 [s]	

I = 71429 [coulomb/s] MW = 0.002 [kg/mol] Power = 50000 [W] V = 0.7 [V]

File:problem 1-4.EES 2/9/2015 7:52:00 AM Page 1 EES Ver. 9.724: #2355: For use only by students and faculty in Chemical and Biological Engineering Georgia Tech.

Chapter 1, problem 4

Al production from Electrolysis

MW = 26.982 [g/mol]

- F = 96485 [coulomb/mol]
- I = 200000 [coulomb/s]
- t = 24 · 3600 [S]

 $\eta = 0.95$

$$m = \eta \cdot I \cdot t \cdot \frac{MW}{F \cdot z}$$

cf1 = 1000 [g/kg]

 $prod_{rate} = \frac{m}{cf1}$

SOLUTION Unit Settings: SI C kPa kJ mass deg cf1 = 1000 [g/kg] F = 96485 [coulomb/mol] m = 1.530E+06 [g] prodrate = 1530 [kg] z = 3

 $\begin{array}{l} \eta \ = 0.95 \\ I \ = 200000 \ [coulomb/s] \\ MW \ = 26.98 \ [g/mol] \\ t \ = 86400 \ [s] \end{array}$

File:problem 1-5.EES 2/9/2015 7:52:36 AM Page 1 EES Ver. 9.724: #2355: For use only by students and faculty in Chemical and Biological Engineering Georgia Tech.

"!Chapter 1, problem 5"

"Power for Chlor-alkali process"

MW=70.9052[g/mol]; "molecular weight of Cl2"

F=96485 [coulomb/mol]

m=I*MW/(F*z)

z=2

cf1=24*365*3600 [s/year]

prod_rate=45e12 [g/year]

m=prod_rate/cf1

V=3.4 [V]

P=I*V

SOLUTION **Unit Settings: SI C kPa kJ mass deg** cf1 = 3.154E+07 [s/year] I = 3.883E+09 [coulomb/s] MW = 70.91 [g/mol] prod_{rate} = 4.500E+13 [g/year] z = 2

No unit problems were detected.

F = 96485 [coulomb/mol] m = 1.427E+06 [g/s] P = 1.320E+10 [W] V = 3.4 [V] File:problem 1-6.EES

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"!Chapter 1, problem 6"

"deposition of Fe from molten salt"

MW=55.845[g/mol]

F=96485 [coulomb/mol]

m=50 [g]

I=25 [coulomb/s]

m=I*t*MW/(F*z)

z=3

"calculate the volume of chlorine gas" MWg=70.9052 [g/mol] R=8.314 [J/mol-K] Tk=273 [K] p=1e5 [N/m^2]

"from stoichiometry, get moles of Cl2"

n=(m/MW)*(3/2)

p*V=n*R*Tk

SOLUTION	
Unit Settings: SI C kPa kJ mass deg	
F = 96485 [coulomb/mol]	l = 25 [C
m = 50 [g]	MW = 5
MWg = 70.91 [g/mol]	n = 1.34
$p = 100000 [N/m^2]$	R = 8.31
t = 10366 [s]	Tk = 273
$V = 0.03048 \ [m^3]$	z = 3

No unit problems were detected.

H = 25 [coulomb/s] WW = 55.85 [g/mol] h = 1.343 [mol] R = 8.314 [J/mol-K] Tk = 273 [K] r = 3 File:problem 1-7.EES 2/9/2015 7:53:47 AM Page 1 EES Ver. 9.724: #2355: For use only by students and faculty in Chemical and Biological Engineering Georgia Tech.

"!Chapter 1, problem 7"

"Al production from Electrolysis"

MW=26.982[g/mol]

F=96485 [coulomb/mol]

I=150000 [coulomb/s] t=24*(3600 [s])

eta=0.89

m=eta*I*t*MW/(F*z)

z=3

cf1=1000 [g/kg]

prod_rate=m/cf1

SOLUTION **Unit Settings: SI C kPa kJ mass deg** cf1 = 1000 [g/kg] F = 96485 [coulomb/mol] m = 1.075E+06 [g] prod_{rate} = 1075 [kg] z = 3

η = 0.89 I = 150000 [coulomb/s] MW = 26.98 [g/mol] t = 86400 [s]

"!Chapter 1, problem 8"

"Electrodeposition of copper" "use a basis of 1 m2" A=1 [m^2]

MW=0.063546[kg/mol] rho=8930 [kg/m^3]

F=96485 [coulomb/mol]

cd=1750 [A/m^2] I=cd*A loading=1.22 [kg/m^2] m=loading*A angle=165/360

d=loading/rho; "desired thickness of deposit"

eta=0.95

m=eta*I*t*MW/(F*z)

z=2 cf=3600 [s/h]

t=angle*cf/rotationrate

SOLUTION	
$A = 1 \text{ [m}^2\text{]}$	angle = 0.4583
$r_{1} = 1750 [\Lambda/m^{2}]$	cf = 3600 [c/b]
d = 0.0001366 [m]	η = 0.95
F = 96485 [coulomb/mol]	I = 1750 [coulomb/s]
loading = $1.22 [kg/m^2]$	m = 1.22 [kg]
MW = 0.06355 [kg/mol]	$\rho = 8930 \ [kg/m^3]$
rotationrate = 0.7404 [1/h]	t = 2228 [s]
z = 2	

File:problem 1-9.EES

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Chapter 1, problem 9

amount of lithium in battery

MW = 6.941 [g/mol] molecular weight of Li

Cap = 1.32 [A-h]

- cf1 = 3600 [coulomb/A-h]
- F = 96485 [coulomb/mol]

$$m = Cap \cdot cf1 \cdot \frac{MW}{F \cdot z}$$

SOLUTION	
Unit Settings: SI C kPa kJ mass deg	
Cap = 1.32 [A-h]	cf1 = 3600 [coulomb/A-h]
F = 96485 [coulomb/mol]	m = 0.3419 [g]
MW = 6.941 [g/mol]	z = 1

problem 1-10

corrosion of steel plate

m = 50 [g]

n = 2

F = 96485.33 [Coulomb/mol]

 $m = I \cdot t \cdot \frac{MW}{n \cdot F}$

t = 3600 · 24 · 365 [s]

MW = 55.845 [g/mol]

SOLUTION	
Unit Settings: SI C kPa kJ mass deg	
F = 96485 [Coulomb/mol]	I = 0.005479 [A]
m = 50 [g]	MW = 55.85 [g/mol]
n = 2	t = 3.154E+07 [s]

File:problem 1-11.EES

PROBLEM 1-11

accelerated corrosion

$$i = 0.14 [A/m^2]$$

n = 2

F = 96485.33 [Coulomb/mol]

$$m = i \cdot t \cdot A \cdot \frac{MW}{n \cdot F}$$

t = 360000 [s]

 $A = 0.01 [m^2]$

MW = 55.845 [g/mol] molecular weight of iron

mr = 0.11 [g]

 $\eta = \frac{mr}{m} \text{ faradaic efficiency}$

$$cur = i \cdot A$$

oxygen evolved

n1 = 4

mo = i · t · A ·
$$\left[\frac{1 - \eta}{n1 \cdot F}\right]$$

SOLUTION Unit Settings: SI C kPa kJ mass deg $A = 0.01 [m^2]$ η = 0.7542 $i = 0.14 [A/m^2]$ mo = 0.000321 [mol] MW = 55.85 [g/mol] n1 = 4

cur = 0.0014 [A] F = 96485 [Coulomb/mol] m = 0.1459 [g] mr = 0.11 [g] n = 2 t = 360000 [s]

File:problem 1-12.EES 8/6/2015 12:28:28 PM Page 1 EES Ver. 9.724: #2355: For use only by students and faculty in Chemical and Biological Engineering Georgia Tech.

"!PROBLEM 1-12"

r= 1e-9 [m]

eo=8.854e-12 [farad/m]

q=1.602e-19 [coulomb]

W=q*q/(4*pi*eo*r)

phi=W/q

SOLUTION **Unit Settings: SI C kPa kJ mass deg** eo = 8.854E-12 [farad/m] q = 1.602E-19 [coulomb] W = 2.307E-19 [J]

 ϕ = 1.44 [V] r = 1.000E-09 [m]