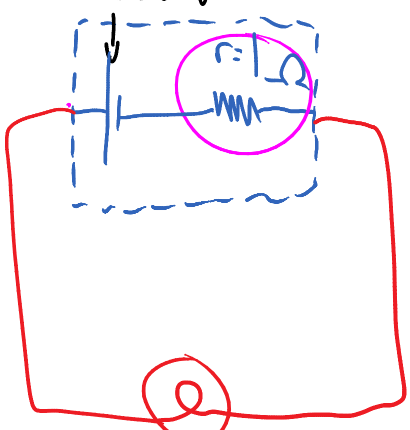
Terminal Voltage and Charging cells

Thursday, April 08, 2010
8:02 PM

All cells have an internal resistance to current flow. We call this the INTERNAL RESISTANCE. A cell is then drawn as

ends of a cell

$\mathcal{E} = 3.0V$



caused by chemistry in cells

$R_1 = 8\Omega$

$\mathcal{E}$ = source voltage
= EMF

$\mathcal{E} = Ir + V_T$

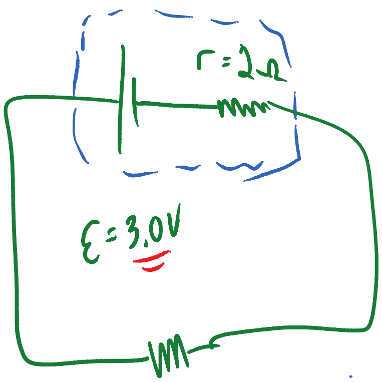
$\mathcal{E} - Ir = V_T$

Total CURRENT

① Find $I_{TOT} = \dfrac{\mathcal{E}}{R_{TOT}} = \dfrac{3}{9} = 0.33A$

$V_T = 3 - (.33)1 = 2.67V$

② find terminal voltage $V_T = \mathcal{E} - Ir$



What is the V_T?

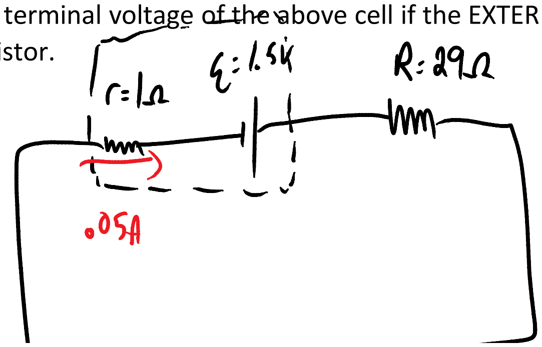
① $I_{TOT} = \dfrac{\mathcal{E}}{R_{TOT}} = \dfrac{3}{30} = 0.100\ A$

② $\mathcal{E} - Ir = V_T = 3 - (.100)2 = 2.67V$

2.8V

$\mathcal{E} = V_T$ when $I = 0$ ← cell not in use

Recalculate the terminal voltage of the above cell if the EXTERNAL resistor is replaced with a 29 Ω resistor.



$I_0 = \dfrac{\mathcal{E}}{R_{TOT}}$

$= 1.5$

R_{TOT}

$= \frac{1.5}{30} = .05\,A$

$V = Ir$

$= (.05)(1) = .05\,V$

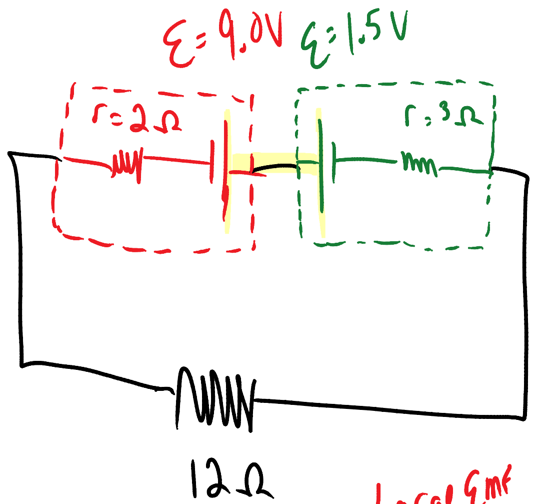
$V_T = \mathcal{E} - \cancel{Ir}$

$V_T = 1.5 - \cancel{.05} = 1.45\,V$

What I would allow $V_T = \mathcal{E}$?!!

Charging Cells: this is done by reversing the chemical reactions in the cell. Only certain cells may be recharged. In order to reverse the chemical reactions the current through the cell must be driven backwards from the usual direction. How could this be accomplished?

Connect the cell to be Recharged backward to a larger EMF



Find V_T for each cell

$I_{TOT} = \frac{\mathcal{E}_{TOT}}{R_{TOT}} = \frac{9-1.5}{17} = 0.44A$

Large Emf is same

$V_T = \mathcal{E} - Ir$

$= 9 - .44(2) = 8.12V$

$V_T = \mathcal{E} - Ir$

$1.5 \cancel{-} + (.44)(3)$ ← small emf

$= 2.8V$

$I = -I$ means $\mathcal{E} + Ir = V_T$

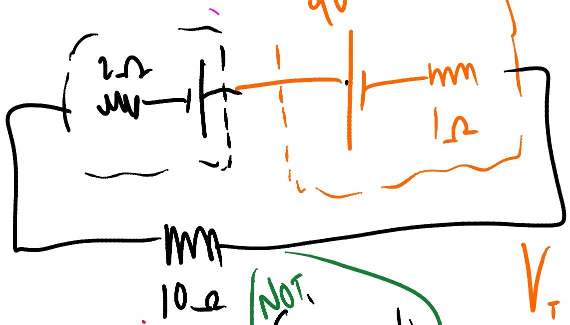
$V_T = \mathcal{E} \, {}^{-}_{+} \, Ir$ ← discharging ← recharging

9V EMF

Example: A 9.0 V transformer is used to charge a 1.5 V cell. If the cell has internal resistance 2.0 Ω and the transformer has internal resistance 1.0

recharging

Example: A 9.0 V transformer is used to charge a 1.5 V cell. If the cell has internal resistance 2.0 Ω and the transformer has internal resistance 1.0 Ω, what current flows through the cell and what is the terminal voltage of the cell and transformer. There is a 10 Ω resistor in the circuit.



$I_{TOT} = \frac{\mathcal{E}_{TOT}}{R_{TOT}} = \frac{7.5}{13} = .58\,A$

$V_T = 9 - .58(1) = 8.42\,V$

$V_T = 1.5 - (-.58)2$

$1.5 + 1.16$

$= 2.66\,V$

Booklet completed

NOT Giancoli Ch 6

Text stuff done

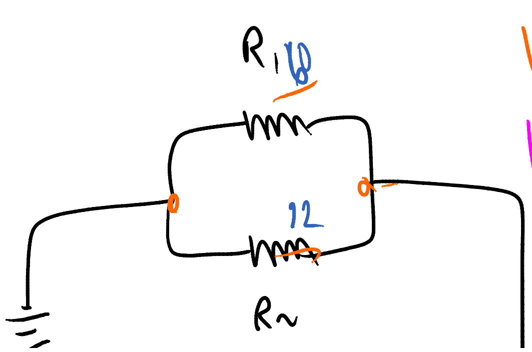
#5 and 6 page 192 as well as
2, 3, 7, 8, 11 – 16, 19, 21 – 24, 25 page 197

Charging cells changes the terminal voltage equation. $\mathcal{E} - (I)\,r = V_T$
Because current is a vector, and reversing a vector's direction is symbolized by making it negative, the terminal voltage formula for a charging cell is:

Ω $C_6H_{12}O_6$ Ω

$\mathcal{E} - (-I)\,r = V_T$ or $\mathcal{E} + Ir = V_T$ (charging)

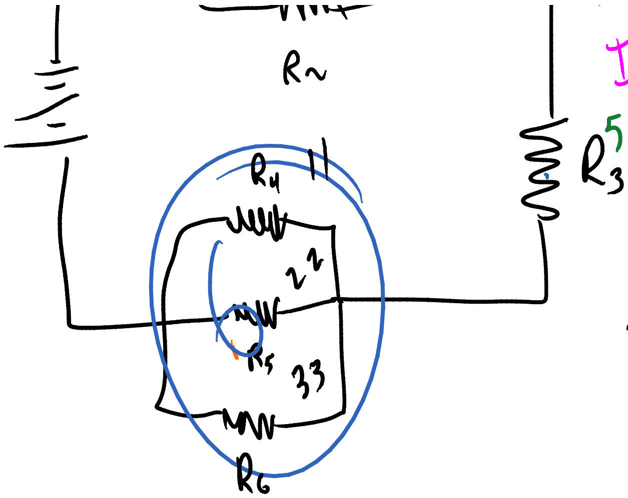
A 1.5 V cell with internal resistance 1.0 Ω is charged by a 3.0 V battery with internal resistance 2.0 Ω. If the circuit has an additional 10 Ω resistor draw the circuit and find the terminal voltage of each cell.



$V_1 = V_2$

$\frac{I_1 60}{12} = I_2$

$I_1 = 5 I_2$



$I_1 = 5 I_2$

$5 I_2 + I_2 = 6A$

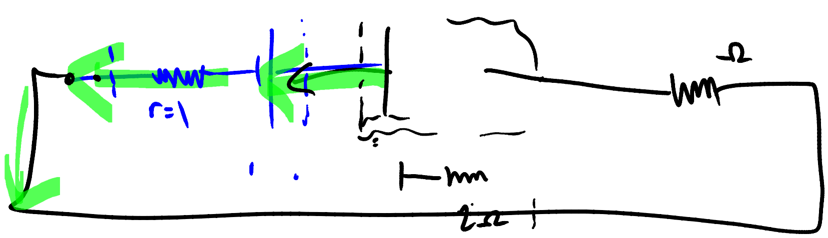
$\frac{6}{66} + \frac{3}{\cancel{22}} + \frac{2}{33} = \frac{11}{66}$

$R_p = \frac{66}{11} = 6$

1

Garden Ohm

10



$V_0 = 3 - 1.5 = 1.5V$

$R_0 = 13\,\Omega$

$I_0 = \frac{V_0}{R_0} = \frac{1.5}{13} = 0.115\,A$

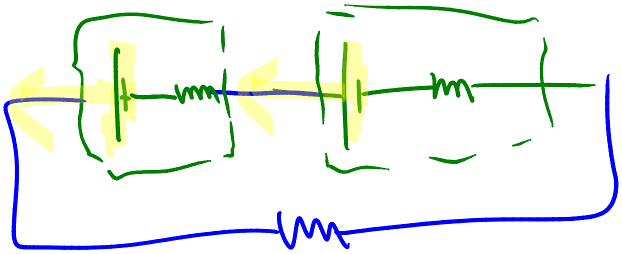
Voltage outside

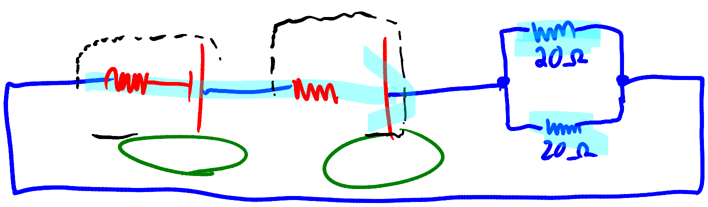
Vo
$R_0 = 13\,\Omega$ R_0 13

$\mathcal{E} - Ir = V_T$
$3 - (.115)(2) = 2.77\,V$

$\mathcal{E} - Ir = V_T$
$1.5 - (-.115)\,1 = V_T = 1.62\,V$

$R_1 \leftarrow$ Voltage outside cell used in circuit

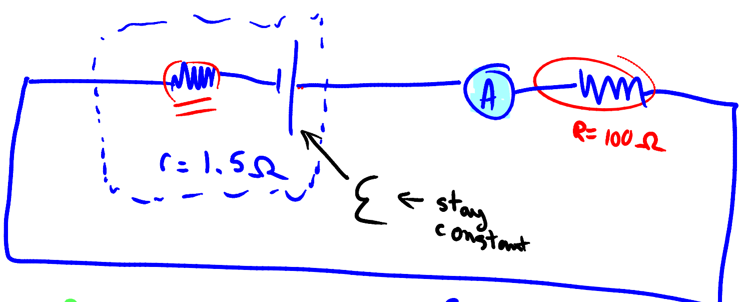




$\dfrac{\mathcal{E}_1 + \mathcal{E}_2}{R_{TOT}} = \dfrac{3}{\ }$

$= \dfrac{\mathcal{E}}{} = 0.26\,A$ R_0 11.6
.26 $R_1 = .8$
.26 $R_2 = .8$
$R_3 = 20$
.129 $R_4 = 20$

Finish Booklet



Use this

A reads 12 mA, find the terminal voltage
$\mathcal{E} = I\,R_{TOT}$ charging find V_T if the external resistor

$\varepsilon = I_{TOT} R_{TOT}$

A reads 12 mA, find the terminal voltage

find V_T if the external resistor is replaced with 50 Ω resistor

explain why V_T increased/decreased

$(.012)(101.5)$

$= 1.218V$

charging

$V_T = \varepsilon - Ir$

$1.218 - (.012)(1.5)$

$V_T = 1.20V$

12V

$V_T = \varepsilon - Ir$

$V_T = 1.218 - (.023)(1.5)$

$V_T = 1.18V$ ↓

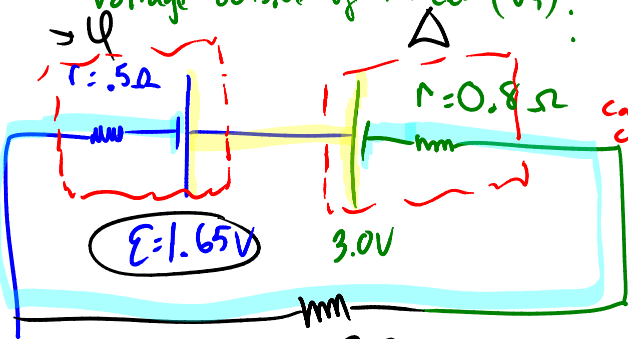
$\varepsilon = I_{TOT} R_{TOT}$

$1.218 = I_{TOT}\, 51.5$

$\frac{1.218}{51.5}$

$I_{TOT} = 0.023 A$

B/c I_{TOT} increases the voltage consumed in cell's internal resistance (Ir) increased. Resulting in less available voltage outside of the cell (V_T).



Describe how you can tell one cell is charging?

find V_T of each cell

Ir

which cell is being charged?

Cell's connected + to +

$V_T = \varepsilon \pm Ir$

charging: +

all others: −

$V_T = 1.65 + I(.5)$

$I_{TOT} = \frac{V_{TOT}}{R_{TOT}}$

$= \frac{3-1.65}{15}$

$1.65 + (.09)(.5)$

$= 1.7V$

$= \frac{1.35}{15} = .09A$

$V_T = \varepsilon - Ir$

$= 3 - (.09)(.8) = 2.93V$

φ is being charged, Δ is discharging

1-3, 5, 7, 8, 10-16,

18-22, 24,

25

26

P. 197

I_0 115↓ $R_0 = 13Ω$↑

I_1 $R_1 = 1$

I_2 $R_2 =$

I_3 $R_3 =$

1

10

2

10↑

2

10Ω

R_v

$\varepsilon_1 - \varepsilon_2 = 1.5$

R_2

$\mathcal{E}_1 - \mathcal{E}_2 = 1.5$ Black cell

V_1

V_2

V_3

2

Red cell $\mathcal{E} - Ir = V_T$

$3 - (.115)(2) = V_T = 2.77\,V$

$1.5 - (-.115)(1)$

$\mathcal{E} - Ir = V_T =$

$= 1.62\,V$

How does changing the external resistor affect the a) current flow ← current decrease if $R\uparrow$ increase if $R\downarrow$

b) terminal voltage of large cell increase if $R\uparrow$ decrease if $R\downarrow$

c) terminal voltage of charging cell decrease if $R\uparrow$ increase if $R\downarrow$

Do 4-6 p. 192

1-3 p. 191