20.4.

Read 20.2 and 20.3, problems. #12, 29

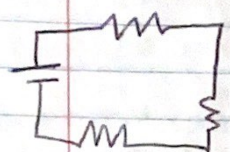
Power Dissipated by a Resistor

$V = I \cdot R$
$P = IV$ >> $\therefore P = I^2 R$ (J/s) (W)

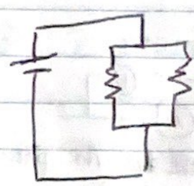
$P = IV$
$I = \frac{V}{R}$ >> $\therefore P = \frac{V^2}{R}$ (J/s) (W)

→ Circuit Analysis

- Series Circuit :



- Parallel Circuit



- In Parallel Circuits :

$V_T = V_1 = V_2$

$I_T = I_1 + \cdots I_2$

- In a Series circuit.

$V_T = V_1 + \cdots V_2$

$I_T = I_1 = I_2$

→ Rules for R_T

- Series : $V_T = V_1 + V_2 + V_3$

$\therefore \frac{V_T}{I_T} = \frac{V_1}{I_1} + \frac{V_2}{I_2} + \frac{V_3}{I_3}$

(note $I_T = I_1 = I_2 = I_3$)

$\therefore R_T = R_1 + R_2 + R_3$

(sum of Resistance)

- Parrallel : $I_T = I_1 + I_2 + I_3$

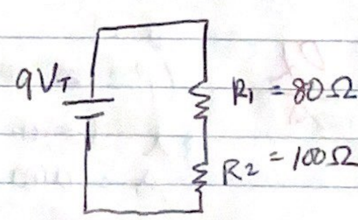
$\frac{I_T}{V_T} = \frac{I_1}{V_1} + \frac{I_2}{V_2} + \frac{I_3}{V_3}$

(note : $V_T = V_1 = V_2 = V_3$)

$\therefore \frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

VIR chart

V		I		R	
V_T	9.0	I_T	0.05	R_T	180Ω
V_1	4.0	I_1	0.05	R_1	80Ω
V_2	5.0	I_2	0.05	R_2	100Ω

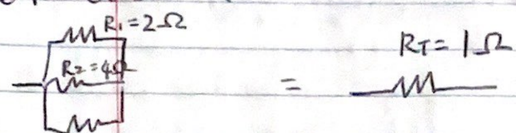


More Sophisticated Circuit Analysis.

Equivalent Resistance : R_{EQ} or R_T.
The one resistor that can replace a network of resistors.

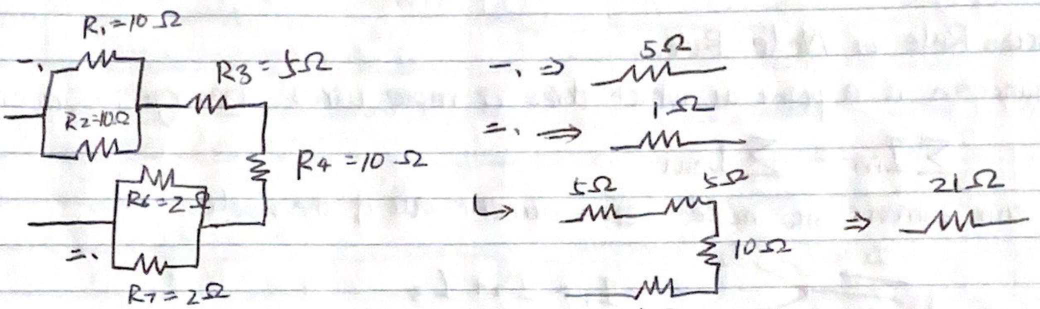
Ex ①

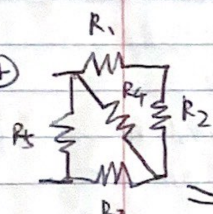
$R=10\Omega$ $R=20\Omega$ $R=15\Omega$ = $R=45\Omega$

② Parallel Circuit :


$$\frac{1}{R_T}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$$

$$R_T=\frac{1}{\frac{1}{2}+\frac{1}{2}+\frac{1}{4}}=1\Omega$$

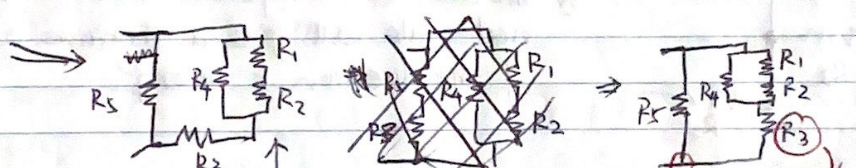
③ Network :


④


All Rs are 2Ω.

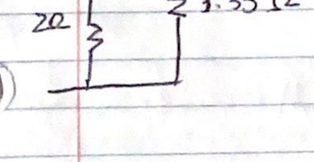
∴ combine R_1 and R_2 ⇒ 4Ω

∴ combine R_3 and R_5 ⇒ 4Ω ✗



you can connect R_1, R_2 because they are directly connected, in series.

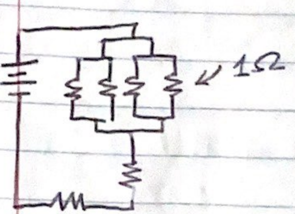
we can only put R_3 in parallel of R_5 because there is a third wire, not in series.



$$\therefore R_T=\left(\frac{1}{2}+\frac{1}{3.33}\right)^{-1}=1.25\,\Omega$$

Reversed

$R_T = 9\Omega$, Build a network of 4Ω resistors such that R_T or $R_{EQ} = 9\Omega$.



Trick: To build one 1Ω resistance, we use the same # of the resistors's resistance, in parallel
ex. 4 4Ωs in parallel.

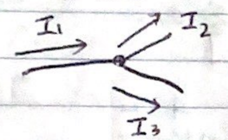
Kirchoff's Laws

- Junction Rule or Node Rule:

A junction is a point at which three or more wires converge in a circuit.

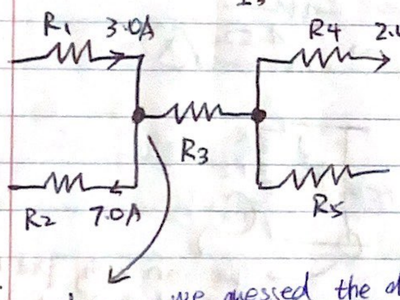
$$\sum I_{in} = \sum I_{out}.$$

sum current into node = sum current out of the node.



$I_1 = I_2 + I_3$

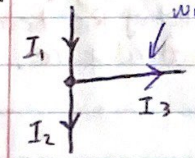
ex.



※ The direction is important, however, the node rule will give a negative answer if the direction is wrong.

work:

we guessed the direction



$\sum I_{in} = \sum I_{out}$

$I_1 = I_2 + I_3$

$\therefore I_3 = I_1 - I_2$

$\therefore I_3 = 3.0 - 7.0 = \ominus 4.0$

negative means direction guessed is wrong, thus is 4Amps to the left.

- The Loop Rule : Based on Law of conservation of Energy

A loop is defined as any closed conducting path in a circuit. If the charges in potential across all circuit elements in the loop are summed, the sum will be zero

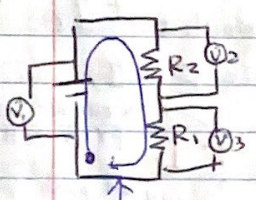
$$\Sigma \Delta V_{loop} = 0$$

$$\Sigma V_{rises} = \Sigma V_{drops}.$$

What is a Rise or Drop : conventional current direction

	travel →	travel →
Resistor	high V a → I low V b; $\Delta V = V_b - V_a = -IR$	low a ← I high b; $\Delta V = V_b - V_a = +IR$
emf source (battery)	low → high b; $\Delta V = V_b - V_a = +\mathcal{E}$	high → $\mathcal{E}$ low; $\Delta V = V_b - V_a = -\mathcal{E}$
capacitor	low a − + high b; $\Delta V = V_b - V_a = +q$	high a + − b low; $\Delta V = V_b - V_a = -q/c$

ex.



conventional direction

- starting point

V1 rise

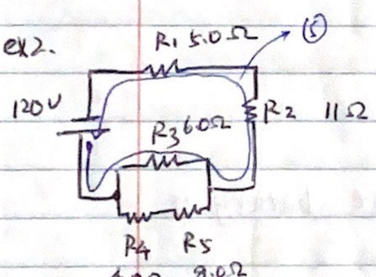
V2 = drop

V3 = drop

$\Sigma V_{rise} = \Sigma V_{drops}$

$\therefore V_T = V_2 + V_3$

ex2.



what is V_4 ?

V	I	R
$V_T = 120$	$I_T = 6.0$	$R_T = 20$
$V_1 = 30$	$I_1 = 6.0$	$R_1 = 5.0$
$V_2 = 66$	$I_2 = 6.0$	$R_2 = 11$
$V_3 = 24$	$I_3 = 4.0$	$R_3 = 6.0$
$V_4 = 8$	$I_4 = 2.0$	$R_4 = 4.0$
$V_5 = 16$	$I_5 = 2.0$	$R_5 = 8.0$

① $R_T = R_1 + R_2 + \left(\frac{1}{R_3} + \frac{1}{R_4+R_5}\right)^{-1} = 20\Omega$

② $V_T = I_T \cdot R_T \quad \therefore I_T = V_T / R_T = 120/20 = 6.0A$

③ $V_1 = I_1 \cdot R_1 = 6 \times 5 = 30\ V$

④ $V_2 = I_2 \cdot R_2 = 6 \times 11 = 66\ V$

⑤ $\Sigma V_{rise} = \Sigma V_{drop}$

$V_T = V_3 + V_2 + V_1$

$\therefore V_3 = V_T - V_2 - V_1 \quad \therefore V_3 = 120 - 30 - 66$

$\therefore V_3 = 24\ V$

⑥ $V_3 = I_3 \cdot R_3 \therefore I_3 = V_3 / R_3 = 24/6 = 4.0$

⑦ $I_4 = I_5 \quad I_{in} = I_{out}$

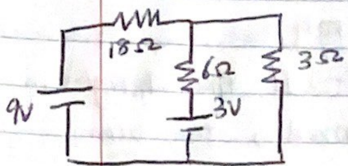
$\therefore I_T = I_3 + I_4$

$I_4 = 6.0 - 4.0 = 2.0A$

⑧ $V_4 = I_4 \cdot R_4 = 2.0 \times 4.0 = 8$

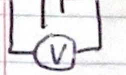
⑨ $V_5 = I_5 \cdot R_5 = 2.0 \times 8.0 = 16$

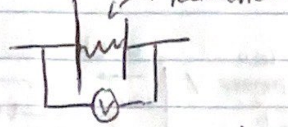
Two Cell Analysis.

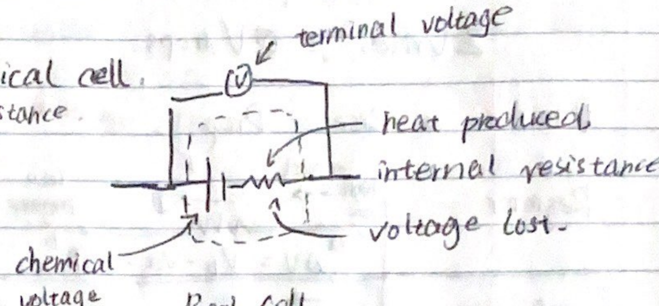


→ Terminal Voltage ←

- Voltage measured across terminals of chemical cell.



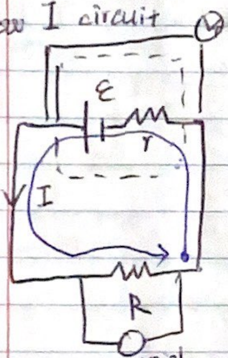




ideal cell
low I circuit

Real Cell
High I circuit

ex.



r = internal resistor

ε = chemical Emf

V_{Term} = Terminal Voltage

$\sum V_{rise} = \sum V_{drop}$

$\varepsilon = V_{termininal} + Ir$

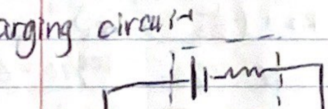
$\therefore V_{termial} = \varepsilon - Ir$

$V_{terminal} = \varepsilon \mp Ir$

current is drawn from cell (discharged)

current push backwards into cell (charging)

Charging circuit



the current is going to opposite direction, which entails the battery is being charaged, thus $\boxed{V_{terminal} = \varepsilon + Ir}$