Kirchhoff's Voltage and Current Law.
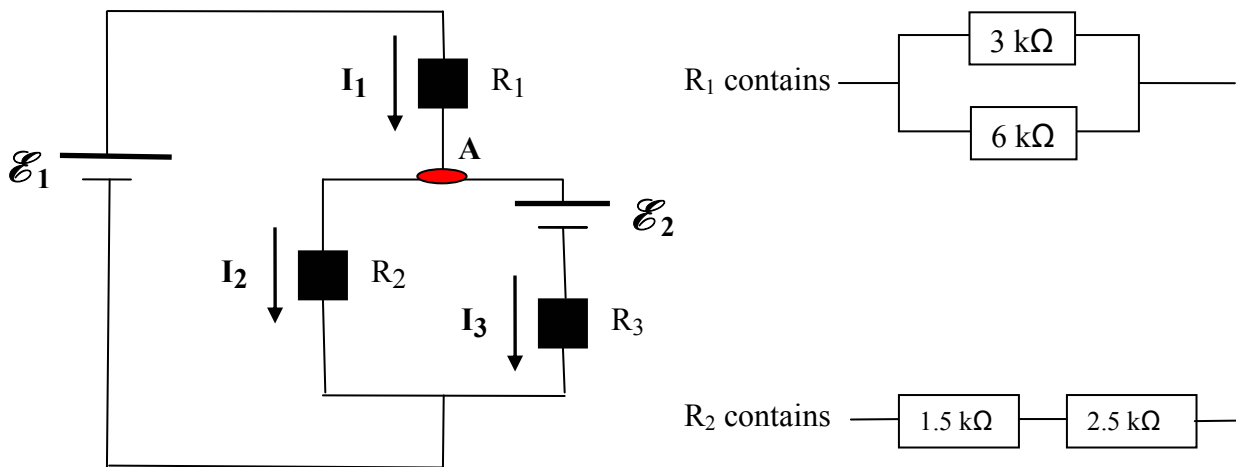
Kirchhoff's Voltage Law: around any closed electrical circuit loop,
KVL: the sum of the voltage drops is equal to the sum of the voltage rises.
Kirchhoff's Current Law: at any junction node in an electrical circuit,
KCL: the sum of the incoming currents equals the sum of the outgoing currents.

Apply these two circuit laws to the circuit shown and demonstrate conservation of energy.

Examine the 3 currents at node **A** and apply Kirchhoff's Current Law as stated above.
Similarly examine the two loops and apply Kirchhoff's Voltage Law as stated above.
Apply Ohm's rule (V=IR or I=GV) for the voltage drops across the energy sinks.

KCL at node A : $\qquad I_1 = I_2 + I_3$

KVL for loop with $\mathscr{E}_1$: $\quad \mathscr{E}_1 = I_1 R_1 + I_2 R_2$

KVL for loop with $\mathscr{E}_2$: $\quad \mathscr{E}_2 + I_3 R_3 = I_2 R_2$

Given: $\mathscr{E}_1 = 11$ volt $\qquad \mathscr{E}_2 = 33$ volt $\qquad G_3 = 1/6$ **mS**

Note: $R_1 = 2$ kΩ $\qquad R_2 = 4$ kΩ $\qquad R_3 = 6$ kΩ

With these given values, there results 3 equations in the 3 unknowns.
The reader should solve the mathematics for the three unknown currents:

Answer: $I_1 = -0.5$ **mA** $\qquad I_2 = +3.0$ **mA** $\qquad I_3 = -3.5$ **mA**

Having solved for the three unknown currents, we know everything that can be known about each individual device in this electrical circuit.

We fill in a table with the values pertaining to each device in the circuit:

Device ID	potential difference V volt	current I mA	resistance R kΩ	conductance G = 1/R mS	power IV mW
R_1	−1	−0.5	**2**	1/2	0.5
R_2	12	3.0	**4**	1/4	36
R_3	−21	−3.5	6	**1/6**	73.5
$\mathscr{E}_1$	**11**	−0.5			−5.5
$\mathscr{E}_2$	**33**	3.5			115.5

Bolded values are given or pre-determined values, all other values are derived with the 3 currents.

The total power consumed by the energy sinks is P_{total} = 0.5 + 36 + 73.5 = 110 mW.

The total power supplied by the energy sources is P_{total} = 115.5 + (-5.5) = 110 mW.

Thus the same net amount of energy per second is leaving the supply source(s) as is being consumed or entering the sinks, and we see that energy is indeed conserved.

Note that I_1 turned out to be a negative number, which really means the actual current is in the opposite direction of the arrow of I_1, (arrow direction is positive). The current in the loop containing $\mathscr{E}_1$ energy source is running counter-clockwise!

That current is **entering** the $\mathscr{E}_1$ energy source which means $\mathscr{E}_1$ is being charged using the energy from the second $\mathscr{E}_2$ energy source or power supply. $\mathscr{E}_2$ is being depleted at the rate of 115.5 milliJoules per second of which 110 are absorbed by the three energy sinks and 5.5 mW are being pumped into the first $\mathscr{E}_1$ power supply.