GENERAL CIRCUIT ELEMENT

**Active**  
+ IV: PROVIDE POWER  
DEFINES POSITIVE CURRENT

**Passive**  
PASSIVE REF CONVENTION  
+ IV: DISSIPATE/ABSORB

TERMINALS

V_{ab}

CONSTANT V, I

CHARACTERIZE BY DC PLOT IN THE V-I PLANE

V_{ab}

i_{a}

TELLS HOW V_{ab}, i_{a}
"GO TOGETHER" FOR CIRCUIT ELEMENT

Textbook: Ch. 1  
Handouts:  
One-Minute Quiz  
KVL, KCL slides

Online:  
Lab Information  
Lab 1
CIRCUIT ELEMENTS  IDEAL SOURCES

DC VOLTAGE SOURCE

12V

SAME VOLTAGE, ANY CURRENT

CONDUCTOR

OV DROP FOR ANY CURRENT
SAME VOLTAGE EVERYWHERE ON AN IDEAL CONDUCTOR

DC CURRENT SOURCE

2A

OPEN CIRCUIT

OCURRENT FOR ANY VOLTAGE
ECE2019 One-Minute Quiz: Charge, Current, Voltage, Energy, Power

A fully charged N-700AAC battery (see data below) is used in a lighting application.

1. Determine the initial amount of charge (in both coulombs and number of electrons) and energy stored in the battery.

   \[ \text{CAPACITY: } 700 \text{ mAh} \times \left( \frac{1 \text{ A} \cdot \text{h}}{1000 \text{ mAh}} \right) \times \left( \frac{60 \text{ min}}{1 \text{ h}} \right) \times \left( \frac{60 \text{ sec}}{1 \text{ min}} \right) = 2.52 \times 10^3 \text{ A} \cdot \text{sec} \Rightarrow 2.52 \times 10^3 \text{ Coul} \]

   \[ \text{# of } e^- \times 2.52 \times 10^3 \text{ Coul} \times \left( \frac{1 \text{ e}^-}{1.6 \times 10^{-19} \text{ Coul}} \right) = 1.58 \times 10^{22} \text{ e}^- \]

   \[ \text{ENERGY: } 1.2 \text{ V} \times \left( \frac{1.2 \text{ Jou}}{1 \text{ Coul}} \right) \times (2.52 \times 10^3 \text{ Coul}) = 3.02 \times 10^3 \text{ Joule} \]

   The battery is used to power an LED which draws 35 mA of current at 1.2V. Idealizing the battery to be a voltage source that can provide 1.2V until the battery is completely discharged:

   \[ \text{20 hrs} \times 7.2 \times 10^4 \text{ sec} = 20 \times 3600 \text{ sec/hr} \]

   \[ p = iv \]

   \[ = 42 \text{ mW} \]

2. Determine how long the battery can drive the LED until discharged

3. Determine the power supplied by the battery while the LED is operating.

4. Integrate power vs. time as a check that the total energy supplied to the LED is equal to the total energy initially stored in the battery.

\[ (35 \text{ mA}) \times 2.52 \times 10^3 \text{ Coul} \]

\[ T_d = \frac{2.52 \times 10^3 \text{ Coul}}{0.035 \text{ Coul/sec}} = 7.2 \times 10^4 \text{ sec} = 20 \text{ hrs} \]

\[ p = iv \times (35 \text{ mA})(1.2 \text{ V}) = 42 \text{ mW} \]

\[ (42 \text{ mW}) \times (7.2 \times 10^4 \text{ sec}) = 3.02 \times 10^3 \text{ Joule} \]

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**SANYO Cadnica**

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**Cell Type N-700AAC**

**Specifications**

<table>
<thead>
<tr>
<th>Nominal Capacity</th>
<th>700mAh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Voltage</td>
<td>1.2V</td>
</tr>
<tr>
<td>Charging Current</td>
<td>Standard: 70mA</td>
</tr>
<tr>
<td></td>
<td>Quick: 210mA</td>
</tr>
<tr>
<td></td>
<td>Fast: 1050mA</td>
</tr>
<tr>
<td>Charging Time</td>
<td>Standard: 14 to 16 hrs</td>
</tr>
<tr>
<td></td>
<td>Quick: 4 to 6 hrs</td>
</tr>
<tr>
<td></td>
<td>Fast: about 1 hr</td>
</tr>
<tr>
<td>Ambient Temperature</td>
<td>Standard: 0°C to +5°C [-32°F to 113°F]</td>
</tr>
<tr>
<td></td>
<td>Quick: 10°C to +5°C [-14°F to 113°F]</td>
</tr>
<tr>
<td></td>
<td>Fast: 0°C to +5°C [-4°F to 113°F]</td>
</tr>
<tr>
<td></td>
<td>Discharge: -20°C to +60°C [-4°F to 140°F]</td>
</tr>
<tr>
<td></td>
<td>Storage: -30°C to +50°C [-22°F to 122°F]</td>
</tr>
<tr>
<td>Internal Impedance (Av)</td>
<td>16.0mΩ</td>
</tr>
<tr>
<td>(at 50% discharge)</td>
<td>(at 1000Hz)</td>
</tr>
<tr>
<td>Weight</td>
<td>23g/8.6oz</td>
</tr>
<tr>
<td>Dimensions(D)x(H)</td>
<td>14.3 × 50.2 mm</td>
</tr>
<tr>
<td>(with tube)</td>
<td>0.58 × 1.98 inch</td>
</tr>
<tr>
<td>H</td>
<td>49.5 mm</td>
</tr>
<tr>
<td>D</td>
<td>13.6 × 0.540 mm</td>
</tr>
<tr>
<td>d</td>
<td>0.76 mm</td>
</tr>
<tr>
<td>H</td>
<td>1.94 × 0.020 inch</td>
</tr>
<tr>
<td>D</td>
<td>7.6 × 0.025 inch</td>
</tr>
<tr>
<td>d</td>
<td>0.276 inch</td>
</tr>
</tbody>
</table>
Cell Type N-700AAC

**Specifications**

- **Nominal Capacity**: 700mAh
- **Nominal Voltage**: 1.2V
- **Charging Current**
  - Standard: 70mA
  - Quick: 210mA
  - Fast: 1050mA
- **Charging Time**
  - Standard: 14 to 16 Hrs.
  - Quick: 4 to 6 Hrs.
  - Fast: about 1 Hr.
- **Ambient Temperature**
  - Charge: Standard 0°C to +45°C (+32°F to 113°F)
  - Quick 10°C to +45°C (+50°F to 113°F)
  - Fast 0°C to +45°C (+32°F to 113°F)
  - Discharge: -20°C to +60°C (-4°F to 140°F)
  - Storage: -30°C to +50°C (-22°F to 122°F)
- **Internal Impedance (A.V.)**
  - (at 50% discharge) 16.0mΩ (at 1000Hz)
- **Weight**: 23g/0.81oz
- **Dimensions**
  - (D)x(H) 14.3 x 50.2 mm
  - (with tube) 0.56 x 1.98 x 0.04 inch

**Typical Characteristics**

- **Charge**
  - Cell Voltage (V) vs. Charge Time (Hrs.)
  - Charge: 70mA
  - Temperature: 20°C/68°F
- **Discharge (at high rate)**
  - Cell Voltage (V) vs. Discharge Time (Mins)
  - Charge: 70mA/16Hrs.
  - Temperature: 20°C/68°F
- **Discharge (at low rate)**
  - Cell Voltage (V) vs. Discharge Time (Hrs.)
  - Charge: 70mA/16Hrs.
  - Temperature: 20°C/68°F
- **Temperature (Charge & Discharge)**
  - Available Capacity (%)
  - Operating Temperature
ELEMENTS IN SERIES

CONSEQUENCE OF KCL

\[ \begin{align*}
    \text{Series: Only 2 Paths at this node} \\
    \text{Supernode \( i_a \) out} \\
    \text{All have same current} \\
    \text{Shortcut: Define only one \( i \)}
\end{align*} \]

ELEMENTS IN PARALLEL

CONSEQUENCE OF KVL:

\[ \begin{align*}
    \text{All have same voltage} \\
    \text{Define only one \( V \)}
\end{align*} \]