Homework 4 on
Oliver Gross’ Lecture on Battery Hazards and Safety

Date due: Friday, February 24, 2023

1. Consider an EV battery pack made up of 108 prismatic can Li-ion cells connected in series. Each cell has the characteristics given in the table below. **Determine** both the cell and pack power, given that the fully charged pack is short circuited with a resistance equal to the pack resistance, *i.e.*, assume that the voltage is halved.

<table>
<thead>
<tr>
<th>feature</th>
<th>value and unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>rated discharge capacity</td>
<td>140 Ah</td>
</tr>
<tr>
<td>maximum voltage at full charge</td>
<td>4.2 V</td>
</tr>
<tr>
<td>nominal discharge voltage</td>
<td>3.7 V</td>
</tr>
<tr>
<td>nominal discharge resistance</td>
<td>0.5 mohm</td>
</tr>
<tr>
<td>cell mass</td>
<td>2.11 kg</td>
</tr>
<tr>
<td>cell dimensions (t x w x h)</td>
<td>31 mm x 230 mm x 91 mm</td>
</tr>
<tr>
<td>cell specific heat capacity</td>
<td>1 kJ/kg*K</td>
</tr>
</tbody>
</table>

2. **Evaluate** the discharge current for the pack under the assumption that there is a 10-s discharge. **Determine** the equivalent *C-rate.

3. **Calculate** the heating power generated by that cell, under the assumption above.
4. **Compute** the amount of heat energy generated in one cell in 10s under the assumption of a constant current during that time period.

5. **Estimate** the temperature rise that occurs in the cell under adiabatic conditions

6. Consider a discharge with an initial temperature of 35 °C, which was calculated based on the pulse temperature at the end of the discharge. **Identify** the likely cause of the cell failure.

7. **Repeat** for the case the cell is short circuited to 0.9 V. **Compute** the heat generation and expected temperature rise of the cell. **Identify** the cause of the cell failure.

8. We are told that a 140-Ah cell combuts. **Determine** the maximum additional amount of energy expected to be released from the anode alone.

9. Assume the cell skin reaches a maximum temperature of 600 °C. The two major cell faces (91mm x 230mm) are protected with a 2 mm thick piece of aerogel. **Calculate** the temperature at the end of 10 s seen by these two adjacent cells.

10. Assume the pack had been engineered to use a 600-A-rated thermal fuse. Use the plots below to **determine** whether the fuse would have activated within the 10 s, 2.1-V short circuit event and, if so, at what time. An additional bonus question is to **determine** the pack safe discharge power limit, given the 600-A fuse, so that the fuse would not activate over the life of the pack.