ECE 398GG Prof. George Gross
Spring 2023

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.

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

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 combusts. **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.