

HW Exam on Electrochemistry (due Mon. Nov 08, 2021)

(Each question carries equal weight)

1: Narrative on Comparing SOFCs and Li-ion Batteries

Write less than one page to compare the similarities and differences between a Solid Oxide Fuel Cell and a battery such as the lithium-ion batteries.

2. ASR

Give reasons why ASR (area specific resistance) has units of Ωcm^2 and not Ωcm^{-2} .

3. Temperature for SOFC Operation

Why does an SOFC be operated at elevated temperature?

Can you draw a sketch of competing parameters that lead to an optimum temperature for cell operation? (The term competing means that one increases the efficiency of the fuel cell while the other reduces the overall efficiency of the system)

4. Power Delivery from SOFCs

Explain, with elementary sketches and equations if you wish, why the curve for the power density vs. current density shows a maximum. (From my point of view the best answer would be if you can explain with words alone - with physical arguments).

5. Electrolyte Chemistry for SOFCs

Explain why yttria doped zirconia is the material of choice as the electrolyte for SOFCs.

6. Architecture of Li-ion batteries

Why are Li-ion batteries constructed from three layers - the anode, the electrolyte and the cathode. What are the functions of these three elements and what properties will you use for selecting the appropriate materials for them?

7. The Performance Parameters (units)

Give the units for the following

Charge capacity of the anode?

Energy density of a battery?

Capacity per unit area of the battery?

8. Overall Performance Parameters

Derive an equation that relates the gravimetric capacity of the battery to the charge capacity of the anode (assume that the weight of the anode constitutes one third of the total weight of the battery).

9. Lithium Metal Anodes

Derive the capacity of lithium metal anodes from first principles in units of mAh g⁻¹.

10. Building a Car Battery

- Explain why the specifications for EV-cars are given in terms of kWh.
- Look up the capacity and voltage of the battery in your own computer, and calculate how many such batteries would be needed to create a 75 kWh battery for a car.

11. Horse Power Equivalent for EV Batteries

Internal combustion engines are specified in terms of HP (1 HP = 746 Watts).

Assume that a car battery consists of 20 units connected in series, each with a voltage of 12 V, in order to run motors at a voltage of 240 V.

Calculate the total ASR value you would need in order for the 75 kWh battery to be equivalent to a 250 HP internal combustion engine?