

Department of Mechanical Engineering
Birla Institute of Technology and Science, Pilani, Pilani campus
ME F414: Fuel Cell Science and Technology
Comprehensive Examination (13/12/2023)

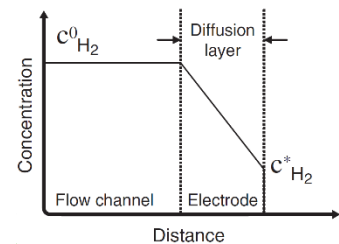
Time: 180 min; Max. Marks: 35

Note to Students:

1. Please follow all the *Instructions to Candidates* given on the cover page of the answer book.
2. This is an OPEN BOOK test; however, you are only allowed a **maximum of 10 (ten) A4** sheets with you.
3. You are not allowed to have photocopies of handwritten notes
4. Assumptions made, if any, should be stated clearly at the beginning of your answer.

1. Why does charge transport result in a voltage loss in fuel cells? Explain with a schematic. If a fuel cell's area is increased 10-fold and its resistance is decreased 9-fold, will the ohmic losses in the fuel cell increase or decrease (for a given current density, all else being equal)? Give reasons. 2+1 = 3

2. Figure shows the change in reactant concentration (c^*) in the diffusion layer. What happens if c^* reaches zero? How to avoid this condition?



- 2+2 = 4
3. Explain the working of a potentiostatic EIS vs galvanostatic EIS. What differences will you encounter in the Nyquist plots for each? 3+1 = 4
4. A 5-cm² fuel cell has $R_{elec} = 0.01 \Omega$ and $\sigma_{electrolyte} = 0.10 \Omega^{-1} \cdot \text{cm}^{-1}$. If the electrolyte is 100 μm thick, predict the ohmic voltage losses for this fuel cell at $j = 50 \text{ mA/cm}^2$. 4
5. You have fabricated identical PEMFC cells under the same environmental conditions. However, upon characterization, you found out that their electrochemical performance varies significantly. What characterization technique(s) did you use to arrive at this conclusion? Explain with schematics. 4
6. What are biological fuel cells? Explain the working of such a cell in detail. 1+3 = 4

7. A typical fuel cell will encounter losses such as ohmic losses, anode activation losses, cathode activation and mass transfer losses. Explain (with appropriate schematics) the process of measuring such losses using the concept of equivalent circuit models? What characterization technique is used for such purpose? 5 + 1 = **6**
8. Explain the effect of concentration on (a) reaction rate and (b) Nernst voltage. With appropriate schematic and nomenclature, explain the changes in j - V curve with respect to the ideal behaviour or no loss conditions. 2+2+2 = **6**

--X--