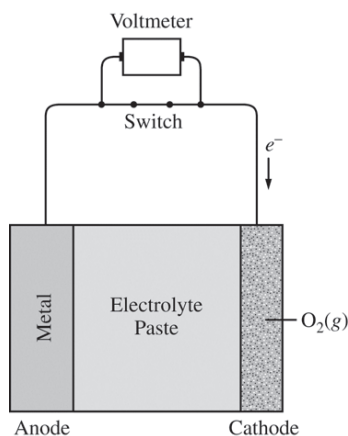


**CHEMISTRY****Section II****7 Questions****Time—1 hour and 45 minutes****YOU MAY USE YOUR CALCULATOR FOR THIS SECTION.**

**Directions:** Questions 1–3 are long free-response questions that require about 23 minutes each to answer and are worth 10 points each. Questions 4–7 are short free-response questions that require about 9 minutes each to answer and are worth 4 points each.

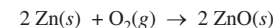
Write your response in the space provided following each question. Examples and equations may be included in your responses where appropriate. For calculations, clearly show the method used and the steps involved in arriving at your answers. You must show your work to receive credit for your answer. Pay attention to significant figures.



1. Metal-air cells are a relatively new type of portable energy source consisting of a metal anode, an alkaline electrolyte paste that contains water, and a porous cathode membrane that lets in oxygen from the air. A schematic of the cell is shown above. Reduction potentials for the cathode and three possible metal anodes are given in the table below.

| Half Reaction                                                                                           | $E$ at pH 11 and 298 K (V) |
|---------------------------------------------------------------------------------------------------------|----------------------------|
| $\text{O}_2(g) + 2 \text{H}_2\text{O}(l) + 4 e^- \rightarrow 4 \text{OH}^-(aq)$                         | +0.34                      |
| $\text{ZnO}(s) + \text{H}_2\text{O}(l) + 2 e^- \rightarrow \text{Zn}(s) + 2 \text{OH}^-(aq)$            | –1.31                      |
| $\text{Na}_2\text{O}(s) + \text{H}_2\text{O}(l) + 2 e^- \rightarrow 2 \text{Na}(s) + 2 \text{OH}^-(aq)$ | –1.60                      |
| $\text{CaO}(s) + \text{H}_2\text{O}(l) + 2 e^- \rightarrow \text{Ca}(s) + 2 \text{OH}^-(aq)$            | –2.78                      |

- (a) Early forms of metal-air cells used zinc as the anode. Zinc oxide is produced as the cell operates according to the overall equation below.



- (i) Using the data in the table above, calculate the cell potential for the zinc-air cell.
- (ii) The electrolyte paste contains  $\text{OH}^-$  ions. On the diagram of the cell above, draw an arrow to indicate the direction of migration of  $\text{OH}^-$  ions through the electrolyte as the cell operates.
- (b) A fresh zinc-air cell is weighed on an analytical balance before being placed in a hearing aid for use.
- (i) As the cell operates, does the mass of the cell increase, decrease, or remain the same?
- (ii) Justify your answer to part (b)(i) in terms of the equation for the overall cell reaction.
- (c) The zinc-air cell is taken to the top of a mountain where the air pressure is lower.
- (i) Will the cell potential be higher, lower, or the same as the cell potential at the lower elevation?
- (ii) Justify your answer to part (c)(i) based on the equation for the overall cell reaction and the information above.
- (d) Metal-air cells need to be lightweight for many applications. In order to transfer more electrons with a smaller mass, Na and Ca are investigated as potential anodes. A 1.0 g anode of which of these metals would transfer more electrons, assuming that the anode is totally consumed during the lifetime of a cell? Justify your answer with calculations.
- (e) The only common oxide of zinc has the formula  $\text{ZnO}$ .
- (i) Write the electron configuration for a Zn atom in the ground state.
- (ii) From which sublevel are electrons removed when a Zn atom in the ground state is oxidized?