Clicker Question #27

- A lead-acid battery is not connected to a load. The electric potential difference between the positive and negative terminals is 2.0 Volts. Which of these statements describes the spatial dependence of the concentration of negative SO_4^- ions in the electrolyte:

    A. The concentration is uniform.
    B. The concentration drops near the - electrode
    C. The concentration increases near the - electrode
    D. The concentration drops near both electrodes
    E. The concentration increases near both electrodes

Answer: B. The reaction $Pb + SO_4^- \rightarrow PbSO_4 + 2e^-$ depletes SO_4^- ions near the - electrode.

Clicker Question #28

- According to the previous answer, the concentration of SO_4^- ions drops near the – battery electrode. That means that the total chemical potential of SO_4^- ions drops near that electrode.

A. True
B. False

Answer: B. The internal chemical potential drops, but there is an electrostatic potential step that opposes the drop, so that the total chemical potential is constant. In equilibrium, the total chemical potential must be constant.

Clicker Question #29

- The battery is now attached to a load (which could be the starter motor of your car). What happens to the total chemical potential near the – electrode?

A. It is still constant, since the system is in equilibrium.
B. It rises slightly near the – electrode.
C. It drops slightly near the – electrode.

Answer: C. The electrostatic potential step decreases slightly, so there is now a gradient of the total chemical potential pushing SO_4^- ions toward the - electrode. The chemical reaction resumes while the battery is supplying current.

Clicker Question #30

- The battery is now being charged. What happens to the total chemical potential near the – electrode?

A. It is still constant, since the system is in equilibrium.
B. It rises slightly near the – electrode.
C. It drops slightly near the – electrode.

Answer: B. The charging circuit adds electrons to the – electrode. That forces the reverse reaction to take place: $PbSO_4 + 2e^- \rightarrow Pb + SO_4^-$. That increases the concentration of SO_4^- ions, and hence the internal chemical potential, near the - electrode. SO_4^- ions will diffuse away from the electrode back into the solution.