PH 122  Homework #3  Solutions

**Topic #1**

Q24) Resistivity is a material property, but resistance depends on dimensions.

\[ R = \frac{\rho L}{A} \], so \( \neq \ 0 \).

Q30) The overall resistance will decrease - greater area of fat, some area of muscle.

P4) Prepare: \( I = \frac{\Delta Q}{\Delta t}, \quad \Delta Q = 9.0 \times 10^{-12} \text{C}, \quad \Delta t = 0.50 \times 10^{-3} \text{s} \)

Solve: \( I = \frac{9.0 \times 10^{-12}}{0.50 \times 10^{-3}} = 1.8 \times 10^{-8} \text{A} = 18 \text{nA} \)

Assess: It's a small current - which we'd expect for a single cell.

P58) Prepare: we can rearrange our current equation as:

\( \Delta Q = I \cdot \Delta t \)

Solve: \( \Delta Q = (1.8 \times 10^{-12} \text{C/s})(1.0 \times 10^{-3} \text{s}) = 1.8 \times 10^{-15} \text{C} \)

each ion has charge \( +e = 1.6 \times 10^{-19} \text{C}, \) so:

\( \# \text{ ions} = \frac{1.8 \times 10^{-15} \text{C}}{1.6 \times 10^{-19} \text{C/ion}} = 1.1 \times 10^4 \text{ ions} \) \( \approx 11,000 \text{ ions} \)

Assess: That's enough to make a difference, but not a huge \#. Reasonable.

P54) Prepare: This looks like so:

\[ \Delta V \quad \frac{\sim I}{\sim R} \]

\[ R = \frac{\Delta V}{I} = \frac{0.06 \text{V}}{230 \times 10^{-4} \text{A}} = 3.91 \times 10^4 \Omega \]

\[ L = 0.050 \text{ m} \]

\[ A = \pi (0.0015/2)^2 = 1.77 \times 10^{-6} \text{m}^2 \]

Solve: \( \rho = \frac{RA}{L} \)

\( = \frac{(3.91 \times 10^4 \Omega)(1.77 \times 10^{-6} \text{m}^2)}{0.050 \text{m}} \)

\( = 14 \text{ S/m} \)

Assess: This is close to the table value, which is reasonable.
P56) Prepare: \[ \frac{I}{\Delta V} \rightarrow \Delta V = I \cdot R \]

Solve: \[ R = \frac{1.7 \times 10^{-8} \text{ S} \cdot \text{m}}{\pi (0.0013 \text{ m})^2} = 0.195 \text{ \Omega} \]

\[ \Delta V = (10 \text{ A})(0.195 \text{ \Omega}) = 1.9 \text{ V} \]

Assess: This is small compared to the 120 V operating voltage, but not trivial. Seems reasonable!

P68) Prepare: Household electricity is AC, with max 5 mA safe amnt. In both cases:

\[ \frac{\Delta V}{R} \rightarrow I = \frac{\Delta V}{R} \]

Solve: a) \[ I = \frac{120 \text{ V}}{500 \times 10^3 \text{ \Omega}} = \frac{0.24 \text{ mA}}{} \sim \text{ safe!} \]

b) \[ I = \frac{120 \text{ V}}{1 \times 10^3 \text{ \Omega}} = \frac{120 \text{ mA}}{} \sim \text{ dangerous!} \]

Assess: It's safe if your hands are dry, not if they are wet. Matches what we expect; extra safety features are in places your hands might be wet.

TOPIC 2

Q28) It does use energy to maintain a potential, so yes - it's an emf!

Q26) \[ P \propto (\Delta V)^2, \text{ so doubling } P \text{ means increasing } \Delta V \text{ by } \sqrt{2}, \text{ to } 7.1 \text{ V}. \]

P40) Prepare: \[ P = \Delta V \cdot I \]

\[ E = P \cdot \Delta t \]

\[ Q = I \cdot \Delta t \]

Solve: \[ P = (450 \text{ V})(0.80 \text{ A}) = \frac{360 \text{ W}}{} \]

\[ E = (360 \text{ J/s})(1.0 \times 10^{-3} \text{ s}) = \frac{0.36 \text{ J}}{} \]

\[ Q = (0.80 \text{ C/s})(1.0 \times 10^{-3} \text{ s}) = \frac{0.80 \text{ mC}}{} \]

Assess: Matches values we saw in class.
P46) Prepare: Let's use \[ P = \frac{(AV)^2}{R} \] \( \sim \) we know AV \& R.

\[ Q = mc \Delta T \text{ for the heating.} \]

Solve:
\[ Q = (0.060 \text{ kg})(2500 \text{ J/kg} \cdot \text{K})(60 \text{ K}) = 9.0 \times 10^3 \text{ J} \]
\[ P = \frac{(AV)^2}{R} = \frac{(120 \text{ V})^2}{150 \Omega} = 96 \text{ W} \]
\[ \Delta t = \frac{Q}{P} = 9.0 \times 10^3 \text{ J} / 96 \text{ J/s} = \boxed{94 \text{ s}} \sim 1 \frac{1}{2} \text{ minutes} \]

Assess: This seems reasonable \& pretty speedy.

P52) Prepare: The necessary current is:
\[ I = \frac{P}{AV} = \frac{1.5 \text{ W}}{1.5 \text{ V}} = 1.0 \text{ A} = 1000 \text{ mA} \]

Solve: The battery provides 1,000 mA, and can supply 15,000 mA·hr, so it runs for:
\[ 15,000 \text{ mA·hr} / 1000 \text{ mA} = \boxed{15 \text{ hr}} \]

Assess: Seems reasonable \& a few nights of steady use.

CHAPTER 23

Topic #1

P6) Prepare: There is 3.0 V across the resistor; the left side is positive.

Solve:
\[ I = \frac{\Delta V}{R} = \frac{3.0 \text{ V}}{30 \Omega} = \boxed{0.10 \text{ A}}, \text{ to the right} \]

Assess: The 9.0 V battery "wins," but the current is less than it would be for either battery alone \& reasonable.

P8) Prepare: The 10 \( \Omega \) + 20 \( \Omega \) are in series; total \( R = 30 \Omega \).

\[ I_{\text{total}} = \frac{15 \text{ V}}{30 \Omega} = 0.50 \text{ A} \]

Solve:
\[ \Delta V (10 \Omega) = I \cdot R = (0.50 \text{ A})(10 \Omega) = 5.0 \text{ V} \]
\[ \Delta V (20 \Omega) = I \cdot R = (0.50 \text{ A})(20 \Omega) = 10.0 \text{ V} \]
The graph is thus: 

Assess: This makes sense - smaller voltage across the smaller resistor, and the total $\Delta V$ for both is 15 V.

Ps2) Prepare: The total resistance is $R_{\text{total}} = R_1 + R_2 = 27 \Omega$

$I = \frac{\Delta V}{R} = \frac{9.0 \text{ V}}{27 \Omega} = 0.33 \text{ A}$

$P = I^2 \cdot R$ for each resistor.

Solve: $P_1 = (0.33 \text{ A})^2 (12 \Omega) = 1.33 \text{ W}$

$P_2 = (0.33 \text{ A})^2 (15 \Omega) = 1.66 \text{ W}$

Assess: The total power is $I \cdot \Delta V = (9.0 \text{ V}) (0.33 \text{ A}) = 3.0 \text{ W}$, which is the sum of the two powers we calculated. Snore!!

Exam Problem

Tuna Prepare: Top view: 

Perspective: 

Solve: If $E$ is constant, $E_{\text{tank}} = \frac{\Delta V}{\text{Ad}} = 100 \text{ V} \cdot 0.68 \text{ m}$

$\Delta V_{\text{fish}} = E_{\text{tank}} \cdot \Delta d_{\text{fish}} = (100 \text{ V} \cdot 0.68 \text{ m}) (0.34 \text{ m}) = 50 \text{ V}$

2x tank length: \( \frac{1}{2} \) the electric field

2x the resistance

\( \frac{1}{2} \) the current

Assess: $\Delta V_{\text{fish}} = \frac{1}{2} \Delta V_{\text{tank}}$, which makes sense - length is half. Doubling length of tank halves field, so should halve current too.