

PHY 212 General Physics II - Electricity, Magnetism and Light  
Summer 2007

Quiz 4 Thursday, July 19

Name:

1. (6 points) The transport of electrons in large molecules has many significant applications. For example, light stimulates the transport of electrons through chlorophyll, the molecule intimately connected to photosynthesis. The conduction of up to  $10^6$  electrons per second along the axis of segments of the DNA double helix molecule is stimulated by the presence of ruthenium, which binds to ribose, one of the components of the helical DNA strands. What current does this electron transport represent? It is hoped that the development of ways to stimulate electron transport in DNA can lead to the detection of genetic defects and ways of detecting killer viruses, such as the HIV and Ebola viruses. (Hint: charge of an electron is  $1.602 \times 10^{-19}\text{C}$ .)

Ans: The current  $I$  is the product of the number of electrons per unit time and the magnitude of charge on each, so

$$\begin{aligned} I &= (10^6 \text{ electrons/s})(1.602 \times 10^{-19} \text{ C/electron}) \\ &= 1.6 \times 10^{-13} \text{ C/s} \\ &= 0.15 \text{ pA} \end{aligned}$$

2. (9 points) A wire of length  $l$  and cross-sectional area  $A$  is melted and recast into a wire of length  $3l$  using the same mass of material. (i) What is the new cross-sectional area of the wire? (ii) How is the resistivity  $\rho$  of the wire affected by the change (iii) How is the resistance  $R$  of the wire affected by the change? (Hint:  $R = \rho l/A$ .)

Ans : (i) The old and new wires have the same volume because they have the same density and the same mass. Let  $A'$  be the new cross-sectional area of the wire. Then

$$Al = A'(3l) \Rightarrow A' = \frac{A}{3} \quad (1)$$

(ii) Resistivity is a property of the material itself, not its geometrical shape. Therefore the resistivity is unaffected by the change in shape of the wire.

(iii) The resistance of the original wire is given by

$$R = \frac{\rho l}{A} \quad (2)$$

so resistance of the new wire is

$$R' = \frac{\rho(3l)}{A'} = \frac{\rho(3l)}{A/3} = 9\left(\frac{\rho l}{A}\right) = 9R \quad (3)$$

Therefore , the resistance increases by a factor of 9.