

9. Answer the following questions in your own words. Direct quotes from the original article will not be awarded marks.

- (a) In your own words, describe the motion of electrons both with and without the application of an electric field (see paragraphs 2 and 6). [4]

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- (b) Calculate the temperature at which electrons are expected to have an rms speed of 100 km s^{-1} (see Equation 1). [2]

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- (c) Show that the acceleration of an electron in an electric field, of strength E , is:

$$a = \frac{eE}{m_e} \quad (\text{Equation 2}) \quad [2]$$

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- (d) Use a mean time of 40 fs to calculate the electric field strength, E , when the mean drift velocity of electrons is 0.25 mm s^{-1} (see Equation 4). [2]

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- (e) Explain briefly how the author can derive Equation 9 from Equation 8. [2]

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- (f) Copper has a resistivity of $1.68 \times 10^{-8} \Omega \text{ m}$ and has 8.5×10^{28} free electrons per m^3 . Use equation 9 to calculate the mean time between collisions for copper. [2]

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- (g) Explain why resistivity should be proportional to the square root of temperature (see paragraph 8 and Equation 9). [4]

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- (h) State and explain what charge you would expect a lattice vibration to carry (see paragraph 9). [2]

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END OF PAPER

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