Oxford Cambridge and RSA

A level Physics B

H557/02 Scientific literacy in physics

Question Set 12

1 This question is about conduction in metals and in semiconductors.

(a) A copper wire of length 1.5 m and radius 2.5×10^{-4} m has a resistance of 0.13 Ω at 20 °C.

Calculate the conductivity of copper at this temperature.

conductivity at 20 °C =……S m^{-1} **[3]**

(b) A simple model of conduction suggests that each copper atom in the wire contributes one or more electrons to a cloud of free electrons that behave rather like particles in a gas. These electrons drift through the wire under the influence of an electric field.

The current I is given by the equation $I = nave$ where:

n is the number of free electrons in the material per m^3
a is the cross-sectional area of the wire
v is the drift velocity of the electrons
e is the electronic charge.

Calculate the drift velocity of the electrons when the copper wire in part **(a)** carries a current of 2.3A. The number of free electrons per m^3 in copper = 8.5×10^{28} m^{-3}

drift velocity =……..m s^{-1} **[2]**

(c)* The conductivity σ of semiconductors such as ntc thermistors increases dramatically with temperature T. The relationship is given by the equation

$$\sigma = C\, e^{-E/kT}$$

where C is a constant, k is the Boltzmann constant and E is the energy required to ionise an atom in the semiconductor.

Use the relationships given in the question to explain the effect of increasing temperature on the conductivity of metals and semiconductors, referring to the microscopic structure of the materials. No calculations are required.

[6]

Total Marks for Question Set 12: 11