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2.3 Conduction in gold Gold is in the same group as Cu and Ag. Assuming th at each Au atom donates one conduction electron, calculate the drift mobility of the e lectrons in gold at 22° C. What is the mean free path of the conduction electrons if their mean speed is 1.4×10^6 m s^{-1}? (Use ρ_o and α_o in Table 2.1.)

Table 2.1 at 0°C (273 K) is ρ_0 = 22.8 nΩ m, α_0 =1/251 K^{-1}

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2.4 Effective number of conduction electrons per atom

a. Electron drift mobility in tin (Sn) is 3.9 $cm^2\ V^{-1}\ s^{-1}$. The room temperature (20 °C) resistivity of Sn is about 110 nΩ m. Atomic mass M_{at} and density of Sn are 118.69 g mol^{-1} and 7.30 g cm^{-3}, respectively. How many "free" electrons are donated by each Sn atom in the crystal? How does this compare with the position of Sn in Group IVB of the Periodic Table?

b. Consider the resistivity of few selected metals from Groups I to IV in the Periodic Table in Table 2.7. Calculate the number of conduction electrons contributed per atom and compare this with the location of the element in the Periodic Table. What is your conclusion?

Table 2.7 Selection of metals from Groups I to IV in the Periodic Table

Metal	Periodic Group	Valency	Density ($g\ cm^{-3}$)	Resistivity (nΩ m)	Mobility ($cm^2\ V^{-1}s^{-1}$)
Na	IA	1	0.97	42.0	53
Mg	IIA	2	1.74	44.5	17
Ag	IB	1	10.5	15.9	56
Zn	IIB	2	7.14	59.2	8
Al	IIIB	3	2.7	26.5	12
Sn	IVB	4	7.30	110	3.9
Pb	IVB	4	11.4	206	2.3

NOTE: Mobility from Hall-effect measurements.

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2.12 Electrical and thermal conductivity of Ag The electron drift mobility in silver has been measured to be 56 $cm^2\ V^{-1}\ s^{-1}$ at 27 °C. The atomic mass and density of Ag are given as 107.87 amu or g mol^{-1} and 10.50 g cm^{-3}, respectively.

a. Assuming that each Ag atom contributes one conduction electron, calculate the resistivity of Ag at 27 °C. Compare this value with the measured value of $1.6 \times 10^{-8}\ \Omega$ m at the same temperature and suggest reasons for the difference.

b. Calculate the thermal conductivity of silver at 27 °C and at 0 °C.

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2.20 The Hall effect Consider a rectangular sample, a metal or an *n*-type semiconductor, with a length L, width W, and thickness D. A current I is passed along L, perpendicular to the cross-sectional area WD. The face $W \times L$ is exposed to a magnetic field density B. A voltmeter is connected across the width, as shown in Figure 2.40, to read the Hall voltage V_H.

a. Show that the Hall voltage recorded by the voltmeter is

$$V_H = \frac{IB}{Den} \qquad \textit{Hall voltage}$$

b. Consider a 1-micron-thick strip of gold layer on an insulating substrate that is a candidate for a Hall probe sensor. If the current through the film is maintained at constant 100 mA, what is the magnetic field that can be recorded per μV of Hall voltage?

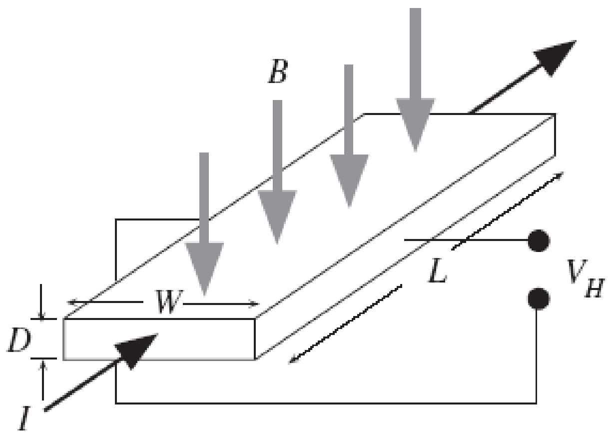

Figure 2.40 Hall effect in a rectangular material with length *L*, width *W*, and thickness *D*. The voltmeter is across the width *W*.

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