

Energy, Power and Resistance

Question Paper 7

Level	A Level
Subject	Physics
Exam Board	OCR
Topic	Electrons , waves and photons
Sub-Topic	Energy, power and resistance
Booklet	Question Paper 7

Time Allowed: 51 minutes

Score: / 42

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

- 1 (a) Define *resistance*.

.....
 [1]

- (b) The smallest conductor within a computer processing chip can be represented as a rectangular block that is one atom high, four atoms wide and twenty atoms long. One such block is shown in Fig. 3.1.

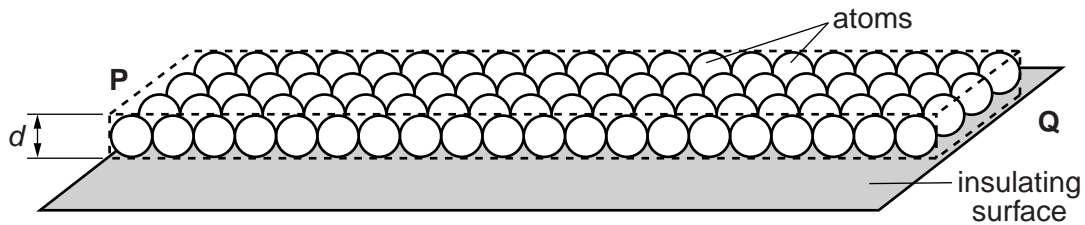


Fig. 3.1

The block is made from phosphorus atoms of diameter $d = 3.8 \times 10^{-10} \text{ m}$. The atoms are deposited on an insulating surface. This ensures that the atoms touch each other.

- (i) Show that the resistance between the ends **P** and **Q** of this block is greater than 200Ω .
 The resistivity of phosphorus is $1.7 \times 10^{-8} \Omega \text{ m}$.

[3]

- (ii) Show that the number density of free electrons within the block is about $2 \times 10^{28} \text{ m}^{-3}$.
 Assume that each phosphorus atom contributes one free electron.

[1]

- (iii) Calculate the current between **P** and **Q** when the mean drift velocity of free electrons in the block is $1.9 \times 10^{-5} \text{ m s}^{-1}$.

current = A [2]

- (iv) There are about 10^9 of these tiny conductors in a single chip each carrying the current calculated in (iii). Estimate the total power dissipated in these conductors in a single chip.

power = W [3]

- (c) It takes about $4 \times 10^{-4} \text{ s}$ for an electron to pass from **P** to **Q** but the electrical signal, an electromagnetic wave, is transmitted across the block in about $3 \times 10^{-17} \text{ s}$. Explain why these times are so different.

.....
.....
.....
..... [2]

[Total: 12]

- 2 Fig. 3.1 shows a circuit consisting of a battery of electromotive force 16.0V and negligible internal resistance, two resistors and a thermistor.

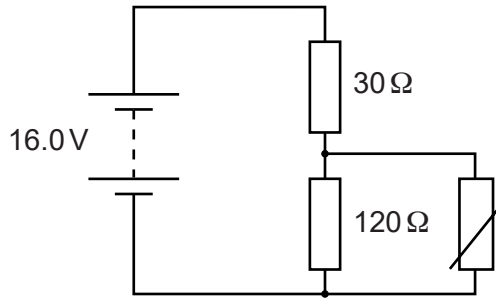


Fig. 3.1

- (a) (i) Define the term *electromotive force (e.m.f.)*.

.....

 [2]

- (ii) Explain the meaning of the term *internal resistance*.

.....

 [1]

- (b) The thermistor has a resistance of 360 Ω at 20 °C. Calculate

- (i) the total resistance R of the thermistor and the resistor of resistance 120 Ω at 20 °C

$R = \dots\dots\dots \Omega$ [2]

- (ii) the potential difference V across the thermistor.

$V = \dots\dots\dots V$ [3]

3 (a) A 12V 36W lamp is lit to normal brightness using a 12V car battery of negligible internal resistance. The lamp is switched on for one hour (3600s). For the time of 1 hour, calculate

(i) the energy supplied by the battery

energy =J [2]

(ii) the charge passing through the lamp

charge =unit.....[3]

(iii) the total number of electrons passing through the lamp.

number of electrons = [2]

(b) The wires connecting the 36W lamp to the 12V battery are made of copper. They have a cross-sectional area of $1.1 \times 10^{-7} \text{ m}^2$. The current in the wire is 3.0A. The number n of free electrons per m^3 for copper is $8.0 \times 10^{28} \text{ m}^{-3}$.

(i) Describe what is meant by the term *mean drift velocity* of the electrons in the wire.

.....
.....
..... [2]

(ii) Calculate the mean drift velocity v of the electrons in this wire.

$v = \dots\dots\dots\text{ms}^{-1}$ [3]

[Total: 12]