9. Electricity

9.1 Electric current

Paper 1

Question Paper

1 A cylindrical wire has cross-sectional area A and number density of free electrons n.
The wire has current I and the free electrons have average drift speed v.

A second cylindrical wire has cross-sectional area $0.5A$ and number density of free electrons $2n$.
In this wire, the free electrons have average drift speed $2v$.

What is the current in the second wire?

A $0.5I$ **B** I **C** $2I$ **D** $4I$

2 An electric current is formed by moving charge carriers.

What is **not** a possible charge on a charge carrier?

A -4.8×10^{-19} C

B -2.4×10^{-19} C

C $+1.6 \times 10^{-19}$ C

D $+3.2 \times 10^{-19}$ C

3 There is a current in a resistor for a short time interval.

Which statement about the total charge that passes through the resistor is correct?

A It can take any value.

B It is an integer multiple of the elementary charge.

C It is the elementary charge.

D It is the rate of flow of the current.

4 An electric current of 12 A is in a wire of length 0.35 m.

The average drift speed of the free electrons (charge carriers) in the wire is 5.0×10^{-4} m s^{-1}.

How many free electrons are in the wire?

A 1.3×10^{16} **B** 5.3×10^{22} **C** 1.5×10^{23} **D** 4.3×10^{23}

5 The electric current in a metal wire is 4.0 mA.

How many electrons pass a fixed point in the wire in a time of 10 hours?

A 2.5×10^{17} **B** 2.5×10^{20} **C** 9.0×10^{20} **D** 9.0×10^{23}

6 Which charge can be carried by a charge carrier?

A 1.1×10^{-19} C

B 4.0×10^{-19} C

C 4.8×10^{-19} C

D 9.1×10^{-19} C

7 The current I in a conductor is given by the equation shown.

$$I = Anvq$$

What does the letter *n* represent in this equation?

A charge carried per charge carrier

B number of charge carriers per unit area

C number of charge carriers per unit volume

D total mass of charge carriers per unit volume

8 A fine mist of oil droplets is sprayed into air. As the oil droplets leave the nozzle of the spraying device they can become electrically charged.

What is **not** a possible value for the charge on an oil droplet?

A zero

B 1.0×10^{-19} C

C 4.8×10^{-19} C

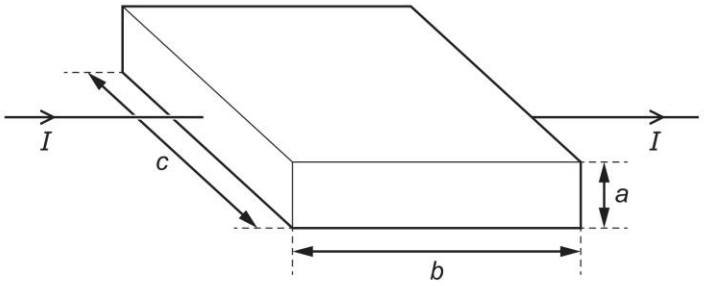
D 8.0×10^{-19} C

9 A straight copper wire of diameter 0.42×10^{-3} m has a number density of free electrons of 8.5×10^{28} m^{-3}. In a given time interval, a charge of 0.15 C moves through the wire.

What is the average displacement of the free electrons along the wire in this time interval?

A 3.3×10^{-8} m **B** 2.0×10^{-5} m **C** 8.0×10^{-5} m **D** 2.5×10^{-4} m

10 The diagram shows a metal block.



The block has sides of length *a*, *b* and *c* as shown, and its volume is *V*. Each charge carrier has a charge –*q* and the number density of the charge carriers in the metal is *n*. It takes each charge carrier an average time of *t* to pass through the block.

What is an expression for the current I?

A $I = nqabc$ **B** $I = \frac{nqV}{t}$ **C** $I = \frac{nqbc}{t}$ **D** $I = nqaV$

11 A length of wire RS has a circular cross-section.



At end R of the wire, the cross-sectional area is *A*.

At end S of the wire, the cross-sectional area is $\frac{A}{2}$.

Charge *Q* takes time *t* to pass through end R of the wire. There is a constant electric current in the wire.

How much charge will pass through end S in a time interval of $\frac{t}{4}$?

A $\frac{Q}{8}$ **B** $\frac{Q}{4}$ **C** $\frac{Q}{2}$ **D** Q

12 A nichrome wire has a resistance of 15 Ω and a diameter of 3.0 mm. The number density of the free electrons in nichrome is $9.0 \times 10^{28}\,m^{-3}$.

A potential difference (p.d.) of 6.0 V is applied between the ends of the wire.

What is the average drift speed of the free electrons in the wire?

A $9.8 \times 10^{-7}\,m\,s^{-1}$

B $3.9 \times 10^{-6}\,m\,s^{-1}$

C $6.1 \times 10^{-6}\,m\,s^{-1}$

D $2.5 \times 10^{-5}\,m\,s^{-1}$

13 Which two units are used to define the coulomb?

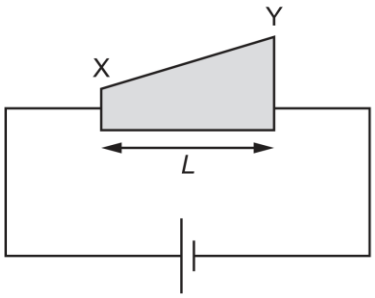
A ampere and second

B ampere and volt

C volt and ohm

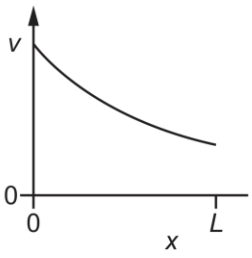
D volt and second

14 A wedge-shaped metal conductor of length *L*, varying width and uniform thickness is connected to a cell, as shown.

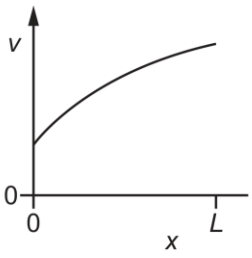


Which graph best shows how the average drift velocity *v* of electrons in the conductor varies with distance *x* from end X?

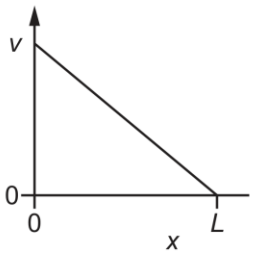
A



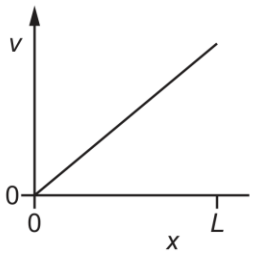
B



C



D



15 The current I in a wire is given by the equation

$$I = nAvq$$

where n is the number density of the free electrons, A is the cross-sectional area of the wire, v is the average drift velocity of the free electrons and q is the charge of an electron.

Which relationship is **not** used in the derivation of this equation?

A charge = current × time

B distance = speed × time

C number = number density × area

D volume = length × area

16 What is a description of the coulomb?

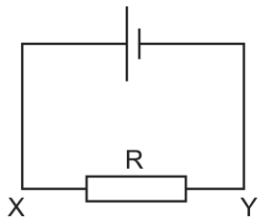
A the electric charge of one electron

B the electric charge transferred by a current of one ampere in one second

C the kinetic energy gained by an electron accelerated through a potential difference of one volt

D the kinetic energy of an electron moving at a speed of one metre per second

17 The current in the circuit shown is 3.2 mA.



What are the direction of flow and the rate of flow of electrons through the resistor R?

	direction of flow	rate of flow / s^{-1}
A	X to Y	2.0×10^{16}
B	X to Y	5.1×10^{-22}
C	Y to X	2.0×10^{16}
D	Y to X	5.1×10^{-22}

18 The number density of free electrons in copper is $8.0 \times 10^{28}\,\text{m}^{-3}$.

A copper wire has diameter 0.42 mm.

What is the average drift speed of the free electrons in the wire when the current in the wire is 0.57 A?

A $8.0 \times 10^{-11}\,\text{m s}^{-1}$

B $3.2 \times 10^{-10}\,\text{m s}^{-1}$

C $8.0 \times 10^{-5}\,\text{m s}^{-1}$

D $3.2 \times 10^{-4}\,\text{m s}^{-1}$

19 Free electrons flow along a copper wire X of radius $5.0 \times 10^{-5}\,\text{m}$ with an average drift speed of $2.8 \times 10^{-2}\,\text{m s}^{-1}$. The current in the wire is 3.0 A.

There is a current of 2.0 A in a copper wire Y of radius $1.0 \times 10^{-4}\,\text{m}$.

What is the average drift speed of the free electrons in copper wire Y?

A $4.7 \times 10^{-3}\,\text{m s}^{-1}$

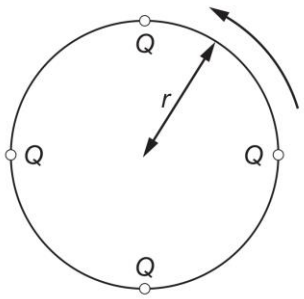
B $9.3 \times 10^{-3}\,\text{m s}^{-1}$

C $1.1 \times 10^{-2}\,\text{m s}^{-1}$

D $1.9 \times 10^{-2}\,\text{m s}^{-1}$

20 Four point charges, each of charge Q, are placed on the edge of an insulating disc of radius r.

The disc rotates at a rate of n revolutions per unit time.



What is the equivalent electric current at the edge of the disc?

A $4Qn$ **B** $\frac{4Q}{n}$ **C** $8\pi rQn$ **D** $\frac{2Qn}{\pi r}$

21 In an electrolyte, the electric current is carried by charged particles (ions) in solution.

What is **not** a possible value for the charge on an ion in solution?

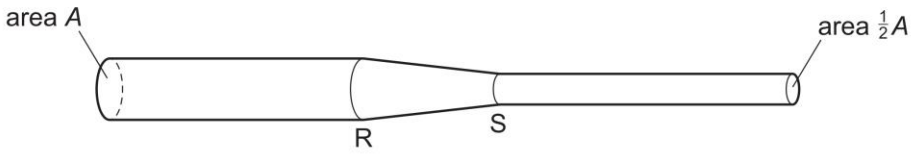
A -4.8×10^{-19} C

B $+1.6 \times 10^{-19}$ C

C $+3.2 \times 10^{-19}$ C

D $+4.0 \times 10^{-19}$ C

22 A length of wire is connected into a circuit.



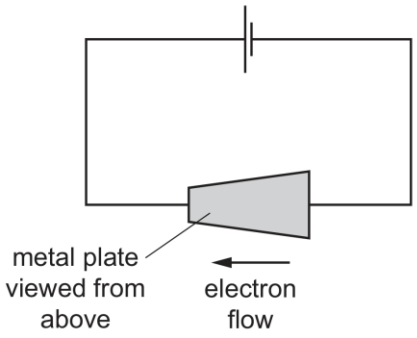
The area of the cross-section of the wire changes from A at R to $\frac{1}{2}A$ at S.

There is a constant current in the wire. Charge Q passes R in time t.

What is the charge passing point S in the same time t?

A $\frac{1}{2}Q$ **B** Q **C** $Q\sqrt{2}$ **D** $2Q$

23 A metal plate of uniform thickness is connected to a cell as shown.



Electrons move clockwise around the circuit.

Which statement about the metal plate is correct?

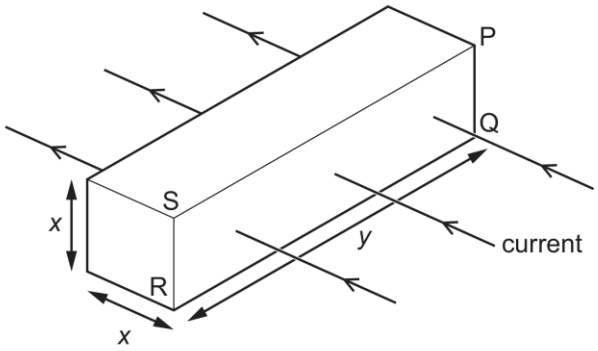
A The average drift speed of the conduction electrons decreases as they move from right to left through the plate.

B The average drift speed of the conduction electrons increases as they move from right to left through the plate.

C The number density of the conduction electrons decreases from right to left through the plate.

D The number density of the conduction electrons increases from right to left through the plate.

24 The diagram shows the direction of the current in a metal block. The charge carriers enter the block through the face PQRS and leave the block through the opposite face.



The number density of charge carriers is n. Each charge carrier has charge e. The average drift speed of the charge carriers is v.

Which expression gives the current in the block?

A $envx^2$ **B** $envxy$ **C** $envx^3y^2$ **D** $envx^4y$

25 When the current in a wire is 5.0 A, the average drift speed of the conduction electrons in the wire is $7.4 \times 10^{-4}\,\text{m s}^{-1}$.

Which row gives a possible cross-sectional area and number of conduction electrons per unit volume for this wire?

	cross-sectional area / m^2	number of conduction electrons per unit volume / m^{-3}
A	7.2×10^{-7}	1.2×10^{28}
B	7.2×10^{-7}	5.9×10^{28}
C	2.3×10^{-6}	7.3×10^{26}
D	2.3×10^{-6}	3.7×10^{27}

26 The current I in a metal wire is given by the expression shown.

$$I = Anvq$$

What does the symbol n represent?

A the number of atoms per unit volume of the metal

B the number of free electrons per atom in the metal

C the number of free electrons per unit volume of the metal

D the total number of electrons per unit volume of the metal

27 When there is a current of 5.0 A in a copper wire, the average drift velocity of the free electrons is $8.0 \times 10^{-4}\,m\,s^{-1}$.

What is the average drift velocity in a different copper wire that has twice the diameter and a current of 10.0 A?

A $4.0 \times 10^{-4}\,m\,s^{-1}$

B $8.0 \times 10^{-4}\,m\,s^{-1}$

C $1.6 \times 10^{-3}\,m\,s^{-1}$

D $3.2 \times 10^{-3}\,m\,s^{-1}$