Charge and Current

1. This question is about investigations involving an electromagnetic wave.

A vertical transmitter aerial emits a **vertically polarised** electromagnetic wave which travels towards a vertical receiver aerial. The wavelength of the wave is 0.60 m.

Fig. 5.1 shows a short section of the oscillating electric field of the electromagnetic wave.

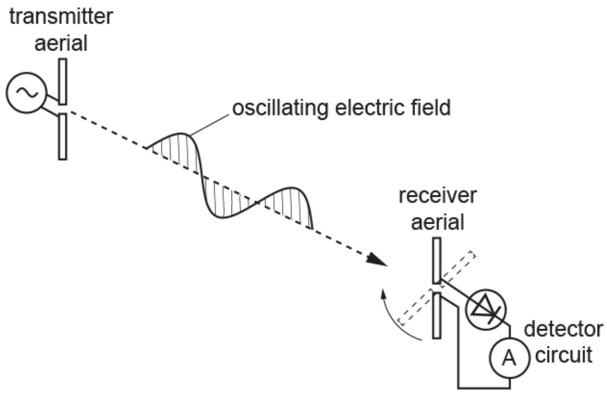
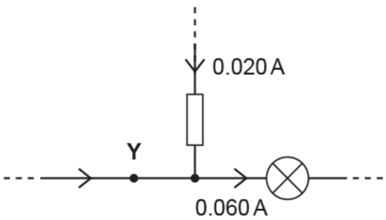


Fig. 5.1

Suggest why the diode in **Fig. 5.1** is necessary for an ammeter to detect a signal at the receiver aerial.

[1]

2. Part of an electric circuit is shown below.



The direction of all the currents and the magnitude of two currents are shown.

How many electrons pass through the point **Y** in 10 s?

A 1.25×10^{18}
B 2.50×10^{18}
C 3.75×10^{18}
D 5.00×10^{18}

Your answer

[1]

3. Name the charge carriers responsible for electric current

in a metal ....

and in an electrolyte ....

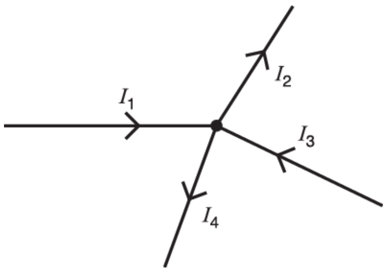
[1]

4. The intensity of light incident on a light–dependent resistor (LDR) is increased. Its resistance decreases. Which statement gives the correct reason for this behaviour?

A The cross–sectional area of the LDR decreases.
B The mean drift velocity of the charge carriers decreases.
C The number density of the charge carriers increases.
D The magnitude of the charge on the charge carriers increases.

Your answer ☐ **[1]**

5. The diagram shows the conventional currents entering and leaving a junction in an electric circuit. I_1, I_2, I_3 and I_4 are all positive.



Which statement is always true?

A $I_1 + I_2 = I_3 + I_4$
B $I_1 - I_2 + I_3 - I_4 = 0$
C $I_1 = I_2$ and $I_3 = I_4$
D $I_1 + I_2 + I_3 + I_4 = 0$

Your answer ☐

[1]

6. A copper wire is connected across a cell. The conduction electrons within the copper wire move.

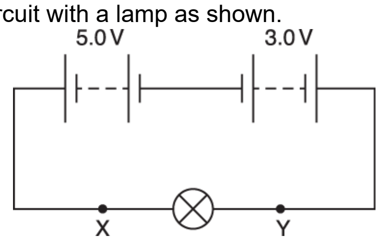
Which statement is correct about these electrons?

A. They drift towards the negative end of the cell.
B. They have random speeds because of collisions with other electrons.
C. They travel through the wire at the speed of light.
D. They collide with vibrating copper ions.

Your answer ☐

[1]

7. Two batteries are connected in a circuit with a lamp as shown.



The batteries have e.m.f. 5.0 V and 3.0 V.
Which row is correct?

	Direction of conventional current	Magnitude of current
A	clockwise	greater at Y than at X
B	clockwise	same at Y and X
C	anticlockwise	greater at X than at Y
D	anticlockwise	same at X and Y

Your answer

[1]

8. A small heater is connected to a power supply. The power supply is switched on for 100 s. The current in the heater is 3.0 A and it dissipates 1200 J of thermal energy.

What is the potential difference across the heater?

A 0.25V
B 4.0V
C 12V
D 300V

Your answer

[1]

9. The number density of charge carriers in material **X** is about $10^{28}m^{-3}$.
The number density of charge carriers in material **Y** is about $10^{5}m^{-3}$.

Which row of the table correctly classifies both materials?

	Material X	Material Y
A	conductor	insulator
B	insulator	conductor
C	insulator	semiconductor
D	semiconductor	conductor

Your answer

[1]

10. One million electrons travel between two points in a circuit.
The **total** energy gained by the electrons is 1.6×10^{-10} J.

What is the potential difference between the two points?

A 1.6×10^{-16} V

B 1.6×10^{-4} V

C 1.0×10^{3} V

D 1.0×10^{9} V

Your answer [1]

11. Which electrical quantity has S.I. units ampere-second (A s)?

A charge

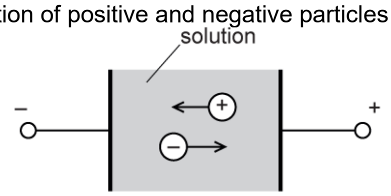
B current

C resistance

D potential difference

Your answer [1]

12. The diagram below shows the motion of positive and negative particles in a conducting solution.



Which statement is correct?

A The current in the solution is zero.

B The conventional current is to the left.

C The positive particles are always protons.

D The negative particles are always electrons.

Your answer [1]

13. Wires **P** and **Q**, made from the same metal, are connected in **parallel** across a cell of negligible internal resistance.

The table shows some data.

Wire	**Length of wire**	**Diameter of wire**	**Mean drift velocity of electrons in the wire / mm s^{-1}**
P	L	d	0.60
Q	$3L$	$2d$	v

What is the mean drift velocity v of the electrons in wire **Q**?

A 0.15 mm s^{-1}
B 0.20 mm s^{-1}
C 0.30 mm s^{-1}
C 0.60 mm s^{-1}

Your answer ☐ **[1]**

14. Which sequence shows the materials arranged in the order of increasing number density of charge carriers?

increasing number density ⟶

A conductor, insulator, semiconductor
B conductor, semiconductor, insulator
C insulator, semiconductor, conductor
D semiconductor, insulator, conductor

Your answer ☐ **[1]**

15. Which law indicates that charge is conserved?

A Lenz's law
B Coulomb's law
C Kirchhoff's first law
D Faraday's law of electromagnetic induction

Your answer ☐ **[1]**

16. The p.d. across a resistor is 12 V. The power dissipated is 6.0 W.

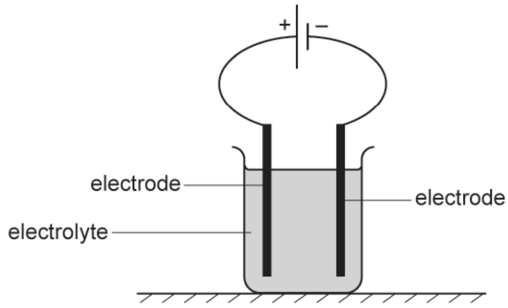
Which statement is correct?

A. The charge passing through the resistor in one second is 2.0 coulomb.
B. The resistor transfers 6.0 joule for each coulomb passing through the resistor.
C. The resistor transfers 12 joule in 2.0 second.
D. The resistor dissipates 6.0 joule when the current is 2.0 ampere.

Your answer ☐

[1]

17. Two electrodes are placed into a liquid (electrolyte).
The electrodes are connected to a cell.



Which row is correct?

	Direction of conventional current in the electrolyte	Particles responsible for the current in the electrolyte
A	To the left	Electrons
B	To the left	Ions
C	To the right	Electrons
D	To the right	Ions

Your answer ☐

[1]

18. A filament lamp is described as being 120 V, 60 W. The lamp is connected to a supply so that it lights normally.

Which statement is correct?

A. The charge passing through the filament in one second is 2.0 coulomb.
B. The lamp transfers 60 joule for each coulomb passing through the filament.
C. The lamp transfers 120 joule in 2.0 second.
D. The supply provides 60 joule to the lamp when the current is 2.0 ampere.

Your answer ☐

[1]

19. A resistor is connected across a power supply.

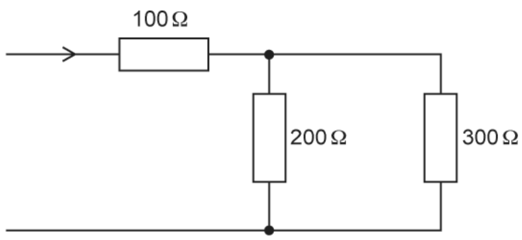
Which statement is correct about the conduction electrons in this resistor?

A. They travel at the speed of light between collisions with ions.
B. They make random collisions with vibrating electrons.
C. They travel at their mean drift velocity between collisions.
D. They drift towards the positive end of the power supply.

Your answer

[1]

20. The diagram below shows an electrical circuit.



The resistance of each resistor is shown.
All resistors are made from the same material and have the same diameter.
The mean drift velocity of the charge carriers in the 100 Ω resistor is *v*.

What is the mean drift velocity of the charge carriers in the 300 Ω resistor?

A 0.40*v*
B 0.50*v*
C 0.60*v*
D 1.00*v*

Your answer **[1]**

21. The electric charge on particles is quantised and a multiple of the elementary charge.

Which charge on a particle is possible?

A 1.0×10^{-19} C
B 4.0×10^{-19} C
C 8.0×10^{-19} C
D 8.8×10^{-19} C

Your answer **[1]**

22. One of Kirchhoff's laws is stated below.

The sum of the currents entering a point in a circuit is equal to the sum of the currents leaving the same point.

Which quantity is conserved according to this law?

A charge
B energy
C mass
D potential difference

Your answer [ ] **[1]**

23. The current at a point in a circuit is 10 mA.
Expressed to the nearest power of ten, how many electrons pass the point in 10 s?

A 10^2
B 10^{15}
C 10^{18}
D 10^{21}

Your answer [ ] **[1]**

24. A copper wire is connected across a cell. The electrons within the copper move.

Which statement is correct about these electrons?

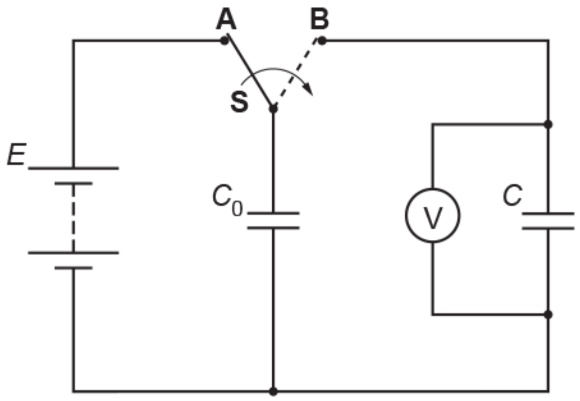
A. The electrons drift towards the negative end of the cell.
B. The electrons have random speeds because of collisions with many electrons.
C. The electrons travel through the copper at the speed of light.
D. The electrons collide with vibrating copper ions.

Your answer [ ]

[1]

25(a). The diagram below shows a circuit containing two capacitors which are both initially uncharged. The battery has e.m.f. E and negligible internal resistance.

The switch **S** is first moved to position **A** until the capacitor of capacitance C_0 is fully charged.



The switch **S** is then moved to position **B**. The initial charge stored by the capacitor of capacitance C_0 is shared between the two capacitors.
The final reading on the voltmeter is V.

Show that $V = \frac{C_0}{C + C_0}E$.

[2]

(b). A student wants to determine the values of E and C_0 by repeating the experiment above and measuring the potential difference (p.d.) V for a selection of capacitors of capacitance C.

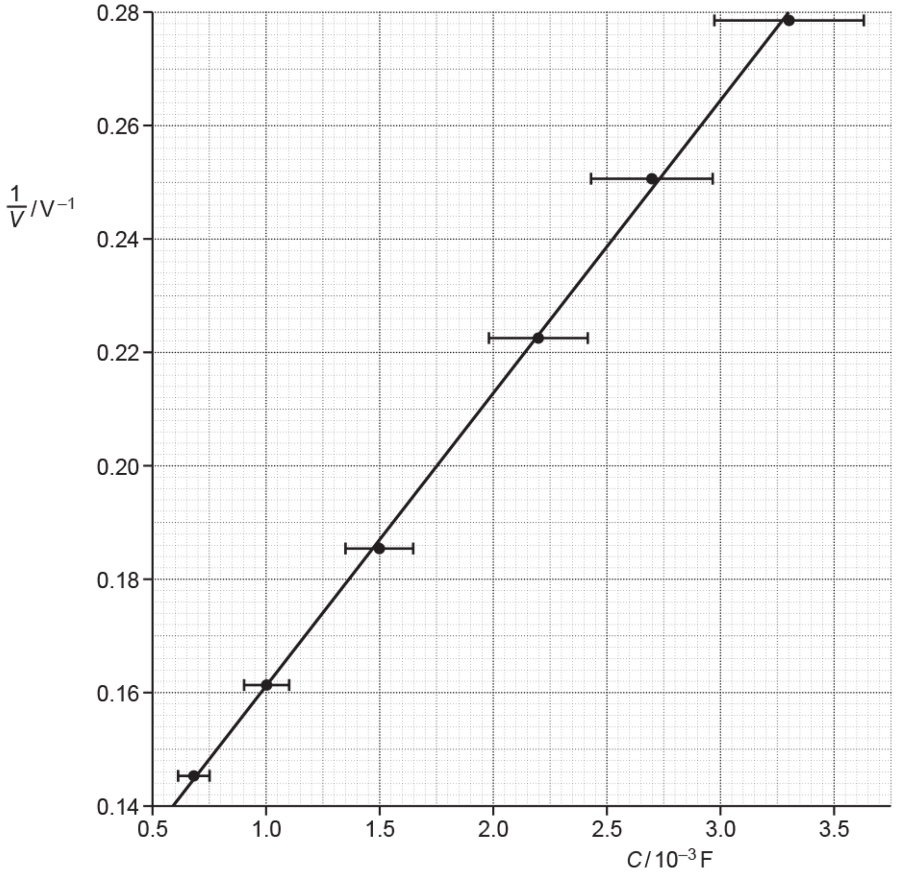
The student decides to plot a graph of $\frac{1}{V}$ against C.

i. Use the expression in **(a)** to show that the graph should be a straight line of gradient $\frac{1}{C_0E}$ and y-intercept $\frac{1}{E}$.

[1]

ii.

iii. The data points, error bars and the line of best fit drawn by the student are shown in the graph below.



The gradient of the line of best fit is 51 V^{-1} F^{-1}. The value of E is 9.1 V.

Determine the value of C_0 in millifarads (mF). Write your answer to 2 significant figures.

C_0 = ... mF **[2]**

iv. Draw on the graph a straight line of worst fit.

Use this line to determine the absolute uncertainty in your value of C_0. Write your answer to an appropriate number of significant figures.

absolute uncertainty = ... mF **[4]**

(c). The experiment is repeated with a resistor of resistance 10 kΩ placed in series between **S** and the capacitor of capacitance C_0.

State with a reason what effect, if any, this would have on the experiment.

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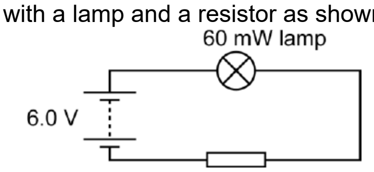
[1]

26. Derive the S.I. base units for resistance.

base units: ------------------------------ **[2]**

27(a). A battery is connected in series with a lamp and a resistor as shown.



The battery has e.m.f. 6.0 V and negligible internal resistance. The potential difference across the lamp is 2.4 V and it dissipates 60 mW. The resistor has cross-sectional area of 2.0 mm^2. The number density of charge carriers (free electrons) within the resistor is 1.4×10^{25} m^{-3}.

Calculate the resistance R of the resistor.

R = ... Ω **[3]**

(b). Calculate the mean drift velocity v of the free electrons within the resistor.

v = ... m s^{-1} **[3]**

(c). The number density of the free electrons in the connecting wires is greater than that of the resistor. The connecting wires have the same diameter as the resistor. State and explain whether the mean drift velocity of the free electrons would be smaller, the same, or larger than your value in **(b)**.

---

[2]

28. A copper rod of cross-sectional area $3.0 \times 10^{-4}\ m^2$ is used to transmit large currents.
A charge of 650 C passes along the rod every 5.0 s. Calculate
The copper rod is labelled **X** in **Fig. 4.1** and is connected to a longer thinner copper rod **Y**.

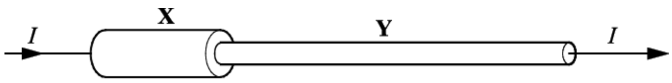


Fig. 4.1

i. State why the current in **Y** must also be *I*.

----
[1]

ii. Rod **Y** has half the cross-sectional area of rod **X**. Calculate the mean drift velocity of electrons in **Y**.

mean drift velocity = ... $m\ s^{-1}$ **[1]**

29. Nichrome is a metal. Silicon is a semiconductor.

State how the number density of charge carriers *n* and the resistivity *ρ* of silicon compare with that of nichrome.

n

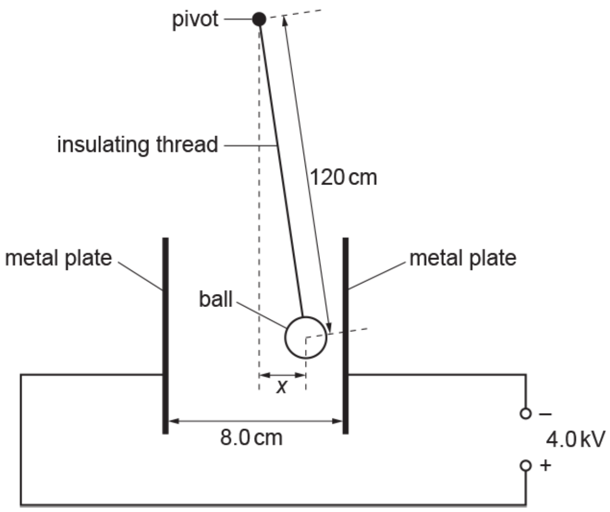
ρ

[2]

30 (a). A ball coated with conducting paint has weight 0.030 N and radius 1.0 cm. The ball is suspended from an insulating thread. The distance between the pivot and the centre of the ball is 120 cm.

The ball is placed between two vertical metal plates. The separation between the plates is 8.0 cm. The plates are connected to a 4.0 kV power supply.

The ball receives a positive charge of 9.0 nC when it is made to touch the positive plate. It then repels from the positive plate and hangs in equilibrium at a displacement *x* from the vertical, as shown below. The diagram is **not** drawn to scale.



i. Show that the electric force acting on the charged ball is 4.5×10^{-4} N.

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[2]

ii. Draw, on the diagram above, arrows which represent the **three** forces acting on the ball. Label each arrow with the name of the force it represents.

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[2]

iii. By taking moments about the pivot, or otherwise, show that x = 1.8 cm.

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[2]

(b). The ball is still positively charged.

The plates are now moved slowly towards each other whilst still connected to the 4.0 kV power supply. The plates are stopped when the separation is 5.0 cm.

Explain the effect that this has on the deflection of the ball and explain why the ball eventually starts to oscillate between the plates.

----

[4]

(c). When the ball oscillates between the plates, the current in the external circuit is 3.2×10^{-8} A.

A charge of 9.0 nC moves across the gap between the plates each time the ball makes one complete oscillation.

Calculate the frequency *f* of the oscillations of the ball.

f = ... Hz **[2]**

31. This question is about a photoelectric cell, which is an electronic device that detects photons.
Fig. 6 shows a cross-section through a simple photocell.

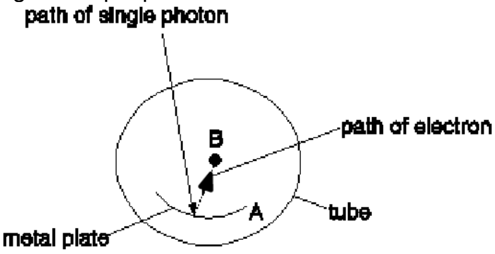

Fig. 6

A metal plate **A** is coated with potassium in an evacuated transparent tube. A photon of high enough energy, incident on the plate, can cause an electron to be released from the surface towards the collector rod **B**.

The photocell is connected to a 12 V supply and a sensitive ammeter which can detect a current of 1.0×10^{-9} A. Only 5.0% of the photons of average energy 4.0×10^{-19} J incident on the plate **A** cause electrons to be released.

Calculate the minimum light energy that plate **A** must absorb per second for the photocell circuit to detect a current.

[3]

32. Fig. 19 shows a photocell.

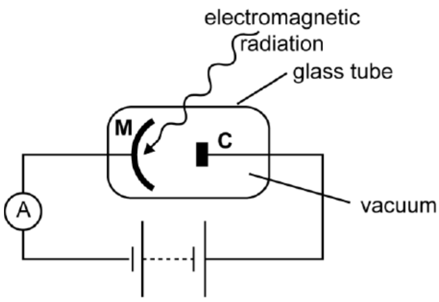

Fig. 19

When the metal **M** is exposed to electromagnetic radiation, photoelectrons are ejected from the surface of the metal. These photoelectrons are collected at the electrode **C** and the sensitive ammeter indicates the presence of a tiny current.
The work function of the metal **M** is 2.3 eV.
The incident electromagnetic radiation has wavelength 5.1×10^{-7} m.
The ammeter reading is 0.24 μA.

Calculate the number of photoelectrons reaching **C** in a time of 5.0 s.

number = ... **[3]**

33 (a). Fig. 4 shows a circuit with five identical 60 Ω resistors. The battery has electromotive force (e.m.f.) 9.0 V and negligible internal resistance.

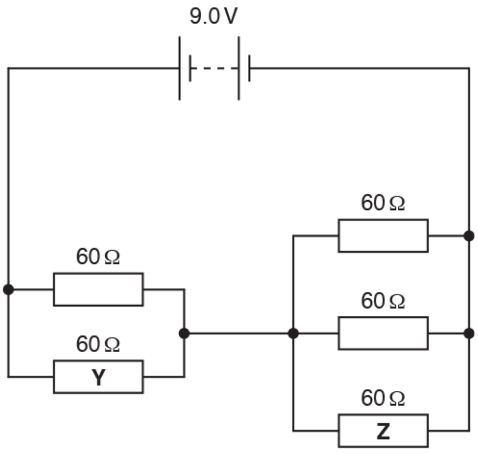

Fig. 4

i. Show that the total resistance in the circuit is 50 Ω.
Make your reasoning clear.

[2]

ii. Calculate the potential difference *V* across resistor **Y**.

V = ... V **[2]**

iii. Calculate the charge *Q* passing through resistor **Y** in two minutes (include an appropriate unit).

Q = ... unit: .... **[3]**

iv. Calculate the energy *W* dissipated in resistor **Y** in two minutes.

W = ... J **[1]**

(b). Explain how the mean drift velocity of electrons in resistor **Y** compares with the mean drift velocity of electrons in resistor **Z**.

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[3]

(c). Copper is a metal, carbon is a semiconductor and ceramic is an insulator.

Describe the difference between these three materials in terms of the number density *n* of free electrons. Include an explanation of the term **number density**.

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[3]

34. A small thin rectangular slice of semiconducting material has width a and thickness b and carries a current I. The current is due to the movement of electrons. Each electron has charge $-e$ and mean drift velocity v.
A uniform magnetic field of flux density B is perpendicular to the direction of the current and the top face of the slice as shown in Fig. 2.1.

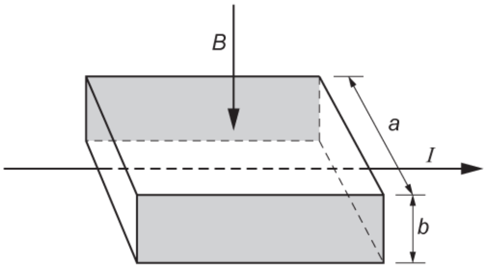


Fig. 2.1

Here are some data for the slice in a particular experiment.
number of conducting electrons per cubic metre, $n = 1.2 \times 10^{23}\ \text{m}^{-3}$
$a = 5.0$ mm
$b = 0.20$ mm
$I = 60$ mA
$B = 0.080$ T

Use this data to calculate

i. the mean drift velocity v of electrons within the semiconductor

v = ... m s^{-1} **[3]**

ii. the potential difference V between the shaded faces of the slice.

V = ... V **[1]**

35. Fig. 6.1 shows a single photomultiplier tube and its internal components. The tube can detect gamma photons in high-energy physics experiments.
A single gamma photon incident on the scintillator crystal generates many photons of blue light. These visible light photons travel to the photocathode where they are converted into photoelectrons. The number of electrons is then multiplied in the photomultiplier tube with the help of electrodes called dynodes. A short pulse of electric current is produced at the output end of the photomultiplier tube.

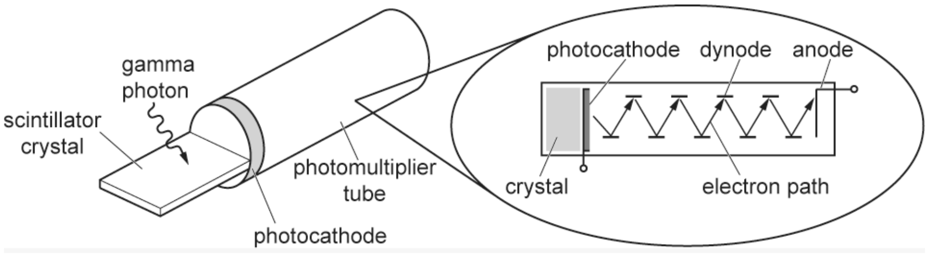


Fig. 6.1

The photocathode is coated with potassium which has a work function of 2.3 eV. Each emitted photoelectron is accelerated by a potential difference of 100 V between the photocathode and a metal plate, called the first dynode.

i. Show that the maximum kinetic energy of an emitted electron at the photocathode is very small compared to its kinetic energy of 100 eV at the first dynode.

[1]

ii. 2000 photoelectrons are released from the photocathode. Each photoelectron has enough energy to release four electrons from the first dynode at the collision. These four electrons are then accelerated to the next dynode where the process is repeated. There are 9 dynodes in the photomultiplier tube. The total number of electrons collected at the anode for each photoelectron is 4^9.

The pulse of electrons at the anode lasts for a time of 2.5×10^{-9} s.

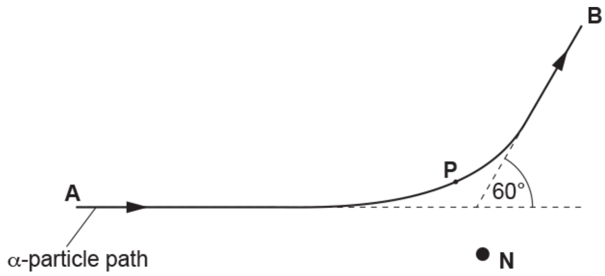
Calculate the average current due to this pulse.

average current = ________________________________ A **[3]**

36. A beam of α-particles is incident on a thin gold foil. Most α-particles pass straight through the foil. A few are deflected by gold nuclei.

The diagram shows the path of one α-particle which passes close to a gold nucleus **N** in the foil. The α-particle is deflected through an angle of 60° as it travels from **A** to **B**.

P marks its position of closest approach to the gold nucleus.



The distance between **P** and **N** is 6.8×10^{-14} m.

Calculate the magnitude of the electrostatic force *F* between the α-particle ($^{4}_{2}He$) and the gold nucleus ($^{197}_{79}Au$) when the α-particle is at **P**.

F = ... N **[4]**

37. A copper rod of cross-sectional area 3.0×10^{-4} m^2 is used to transmit large currents. A charge of 650 C passes along the rod every 5.0 s. Calculate

i. the current *I* in the rod

I = ... A **[1]**

ii. the total number of electrons passing any point in the rod per second

number per second = ... **[1]**

iii. the mean drift velocity of the electrons in the rod given that the number density of free electrons is 1.0×10^{29} m^{-3}.

mean drift velocity = ... m s^{-1} **[2]**

38. Fig. 24.1 shows a battery connected across a negative temperature coefficient (NTC) thermistor.

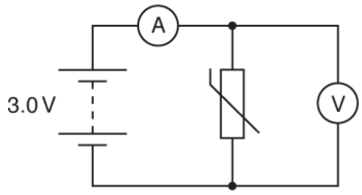


Fig. 24.1

The battery has electromotive force (e.m.f.) 3.0 V and negligible internal resistance. The ammeter has negligible resistance and the voltmeter has a very large resistance.
The thermistor has resistance 100 Ω at room temperature and a cross-sectional area of 3.8×10^{-6} m^2.
The number density of the free electrons within the thermistor is 5.0×10^{25} m^{-3}.

i. Calculate the mean drift velocity *v* of the free electrons in the thermistor.

v = ... m s^{-1} **[2]**

ii. The thermistor is now heated using a naked flame.
Describe and explain the effect on the ammeter and voltmeter readings.

----

[3]

39. A chemical cell is connected across a resistor.

i. The terms electromotive force (e.m.f.) and potential difference (p.d.) are terms associated with the circuit.

State **one** similarity and **one** difference between e.m.f. and p.d.

similarity:

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ii. difference:

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[2]

iii. The resistor is cylindrical in shape. It has cross-sectional area 1.2×10^{-6} m^2 and length 6.0×10^{-3} m. In this resistor there are 9.6×10^{16} free electrons.
Calculate the mean drift velocity v of the electrons when the current in the resistor is 3.0 mA.

v = ... m s^{-1} **[3]**

40. The current in a filament lamp is 0.045A.
The filament wire of the lamp has diameter 0.24mm. The number density n of charge carriers (electrons) within the material of the filament is 6.3×10^{28}m^{-3}.

i. Calculate the number of electrons passing through the filament in one second.

number of electrons = ... **[2]**

ii. Calculate the mean drift velocity *v* of the electrons within the filament.

v = ... ms^{-1} **[3]**

41 (a). The circuit diagram shows a battery of e.m.f. *E* and internal resistance *r* connected to a variable resistor *R*.

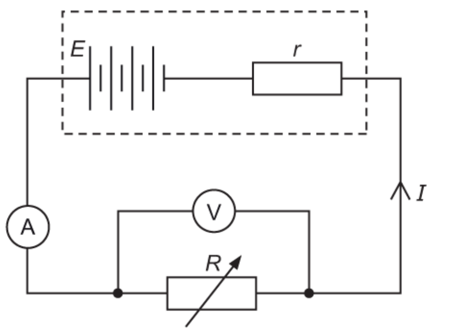

Fig. 5.1

The current *I* in the variable resistor is measured using an ammeter and the potential difference *V* across the variable resistor is measured using a voltmeter.

The resistance *R* of the variable resistor is varied. *I* and *V* are recorded for each value of *R*.
A graph of *V* (*y*-axis) against *I* (*x*-axis) is plotted.

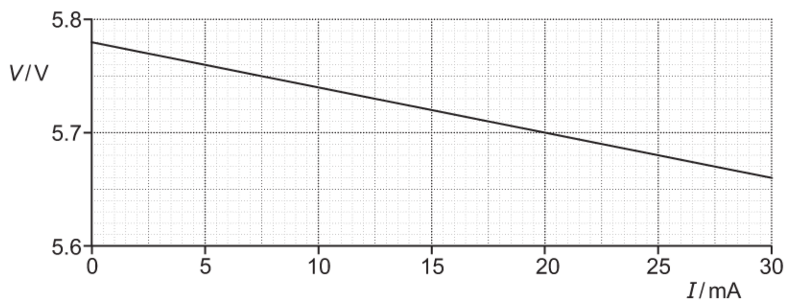

Fig. 5.2

Explain how values for *E* and *r* may be determined from the graph.
No calculations are required.

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[2]

(b). The resistance of the variable resistor is now fixed. The current is 25 mA.

i. Use the graph to determine the resistance *R* of the variable resistor.

R = ... Ω **[1]**

ii. Calculate the energy *W* dissipated in the variable resistor in 5.0 minutes.

W = ... J **[2]**

iii. Calculate the charge *Q* passing through the variable resistor in 5.0 minutes. Include an appropriate unit.

Q = ... unit .... **[2]**

42. A 150 W heater constructed from nichrome wire is switched on for 5.0 hours.

The wire has a cross-sectional area of 4.1×10^{-9} m^2.
The current in the wire is 1.5 A.
The number density of charge carriers in nichrome is 7.9×10^{28} m^{-3}.

Calculate

i. the resistance *R* of the heater

R = ... Ω **[2]**

ii. the number *N* of electrons passing through the heater in 5.0 hours

N = ... **[2]**

iii. the mean drift velocity *v* of the electrons (charge carriers) in the heater.

v = ... ms^{-1} **[2]**

43. This question is about the Sun and its radiation.

* A student attends a lecture about the Sun and makes the following notes.

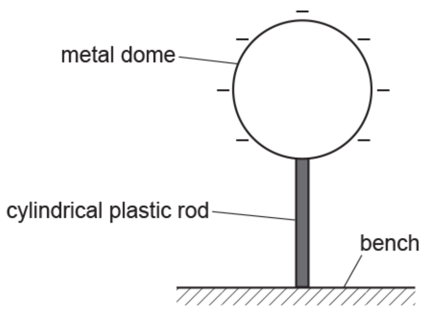
1. The Sun loses more than 4×10^9 kg of its mass every second to maintain its luminosity.
2. Treating hydrogen nuclei (protons) as an ideal gas, a temperature of 10^{10} K provides a kinetic energy of about 1 MeV, which is necessary for fusion.
3. However, the Sun's core temperature is only 10^7 K, so the chance of protons fusing on collision is very small. This explains why the Sun has such a long lifetime.

Explain the principles of physics which are involved in each of the three points.
You should include relevant formulae, but no numbers or calculations are required.

----

[6]

44. A spherical metal dome shown below is charged to a potential of −12 kV.



The dome is supported by a cylindrical plastic rod. The radius of the dome is 0.19 m.

i. Show that the magnitude of the total charge *Q* on the dome is 2.5×10^{-7} C.

[2]

ii. The dome discharges slowly through the plastic rod.
It takes 78 hours for the dome to completely discharge.

1 Show that the mean current *I* in the plastic rod is about 9×10^{-13} A.

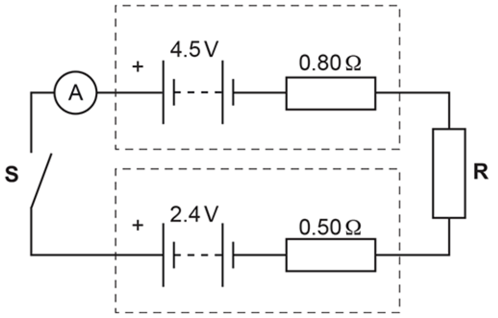
[2]

The average potential difference across the plastic rod during discharge is 6000 V.
The rod has cross-sectional area 1.1×10^{-4} m^2 and length 0.38 m.

2 Calculate the resistivity *ρ* of the plastic.

ρ = ... Ωm **[3]**

45. The circuit diagram of an electrical circuit is shown below.



The positive terminals of the batteries are connected together.
One battery has electromotive force (e.m.f.) 4.5 V and internal resistance 0.80 Ω.
The other battery has e.m.f. 2.4 V and internal resistance 0.50 Ω.
R is a coil of insulated wire of resistance 1.2 Ω at room temperature.

The switch **S** is closed.

i. On the diagram, draw an arrow to show the direction of the conventional current.

[1]

ii. Calculate the current *I* shown by the ammeter.

I = ... A **[3]**

iii. The insulated wire has diameter 4.6×10^{-4}m.
The number density of charge carriers in **R** is 4.2×10^{28} m^{-3}

Calculate the mean drift velocity v of the charge carriers in **R**.

v = ... m s^{-1} **[2]**

iv. The current measured by the ammeter is smaller than that calculated in **(ii)**. This is because the temperature of **R** increased due to heating by the current.

Without any changes to the circuit itself, state and explain what practically can be done to make the measured current the same as the calculated current.

---

[2]

46. A filament lamp **X** is part of an electrical circuit. The circuit has a battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance. The potential difference across the lamp can be increased **continuously** from 0 to 6.0 V. This potential difference is measured using a voltmeter.
The lamp glows brightly at 6.0 V.

i. Draw a circuit diagram for this electrical arrangement.

[2]

ii. Describe and explain the variation of the resistance of this lamp as the potential difference across it is changed from 0 to 6.0 V.

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[4]

iii. The filament lamp **X** is now connected in a different circuit as shown in Fig. 16.

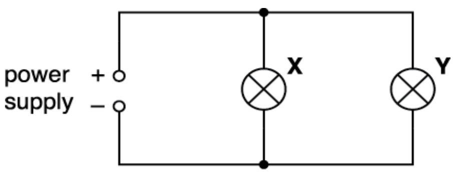

Fig. 16

The power dissipated in **X** is three times more than the power dissipated in the filamentlamp **Y**. The filament wire of lamp **X** has a diameter half that of lamp **Y**.
The filament wires of **X** and **Y** are made of the same material and are at the same temperature.

Calculate the ratio

$$\frac{\text{mean drift velocity of charge carriers in lamp } \mathbf{X}}{\text{mean drift velocity of charge carriers in lamp } \mathbf{Y}}.$$

ratio = ... **[3]**

47. Fig. 16.1 shows the *I-V* characteristics of two electrical components **L** and **R**.

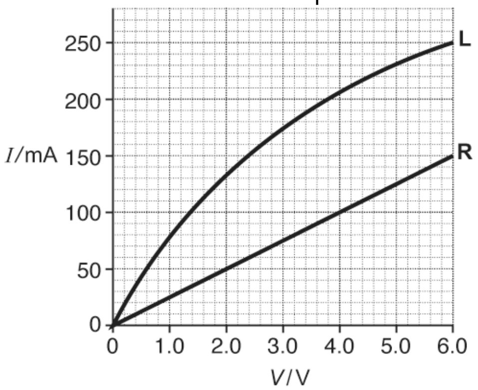

Fig. 16.1

The component **L** is a filament lamp and the component **R** is a resistor.

i. Show that the resistance of **R** is 40 Ω.

ii. Fig. 16.2 shows the components **L** and **R** connected in series to a battery of e.m.f. 6.0 V.

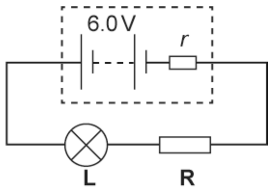

Fig. 16.2

The resistor **R** is a cylindrical rod of length 8.0 mm and cross-sectional area 2.4×10^{-6} m^2. The current in the circuit is 100 mA.

1 Use Fig. 16.1 to determine the internal resistance *r* of the battery.

r = ... Ω **[3]**

2 Calculate the resistivity ρ of the material of the resistor **R**.

ρ = ______________________________ Ω m **[2]**

3 There are 6.5×10^{17} charge carriers within the volume of **R**.

Calculate the mean drift velocity v of the charge carriers within the resistor **R**.

v = ______________________________ m s^{-1} **[3]**

END OF QUESTION PAPER