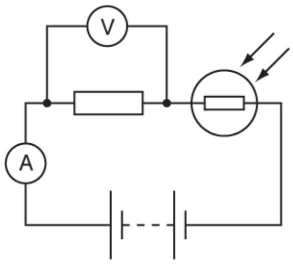
Resistance

1. A potential divider circuit with a light-dependent resistor (LDR) is shown below.



The intensity of the light incident on the LDR is reduced.

Which row correctly describes the observed change on the ammeter and voltmeter readings?

	Ammeter reading	Voltmeter reading
A	decreases	decreases
B	decreases	increases
C	increases	stays the same
D	stays the same	decreases

Your answer **[1]**

2. A student determines the resistance R of a filament lamp by measuring the potential difference V across it and the current I in it. The values recorded by the student are:

V = (5.00 ± 0.20) V and I = (40.0 ± 1.0) mA.

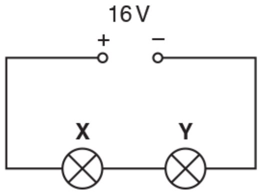
What is the percentage uncertainty in the value of R ?

A 1.5%
B 1.6%
C 6.5%
D 20%

Your answer

[1]

3. Two filament lamps **X** and **Y** are connected in series with a 16 V d.c. supply. The supply has negligible internal resistance.



Lamp **X** emits a power of 2.0 W and lamp **Y** emits a power of 6.0 W.

What is the potential difference across the lamp **X**?

A 1.0 V
B 4.0 V
C 12 V
D 16 V

Your answer **[1]**

4. A student is given two identical filament lamps. Each lamp is labelled as '12 V, 24 W'. The student connects the two lamps in series across a 12 V supply of negligible internal resistance.

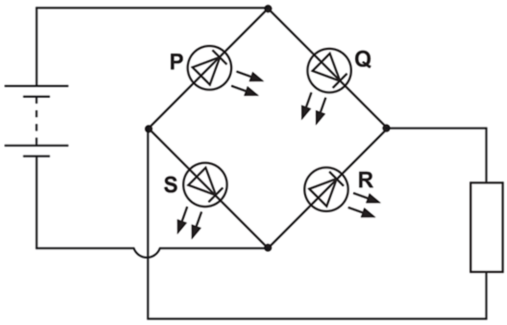
Which of the following statements is / are true when the lamps are in **series**?

1 The resistance of each lamp is 6.0 Ω
2 The current in the circuit is greater than 1.0 A.
3 The potential difference across each lamp is 6.0 V.

A 1, 2 and 3
B Only 2 and 3
C Only 1 and 2
D Only 2

Your answer **[1]**

5. A circuit with four light-emitting diodes (LEDs) **P**, **Q**, **R** and **S** is shown below.

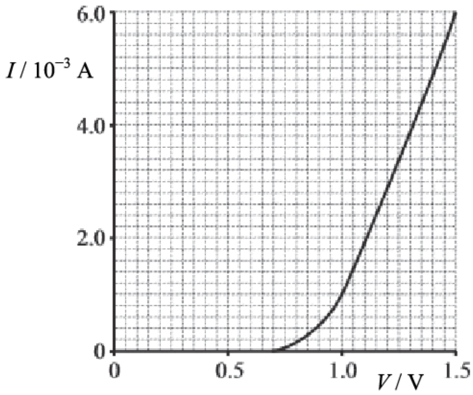


Two LEDs are lit in this circuit. Which **two** LEDs are lit?

A **P** and **Q**
B **P** and **R**
C **Q** and **R**
D **Q** and **S**

Your answer **[1]**

6. The graph shows the *I*-*V* characteristic of a semiconductor diode.



Which statement about the resistance of the diode can be deduced from the characteristic?

A. It is zero between 0 V and 0.70 V.
B. It is constant between 1.0 V and 1.5 V.
C. It is 0.4 Ω at 1.2 V.
D. It decreases between 0.70 V and 1.0 V.

Your answer

[1]

7. Fig. 6.1 shows the *I*−*V* characteristics for two electrical components **X** and **Y**.

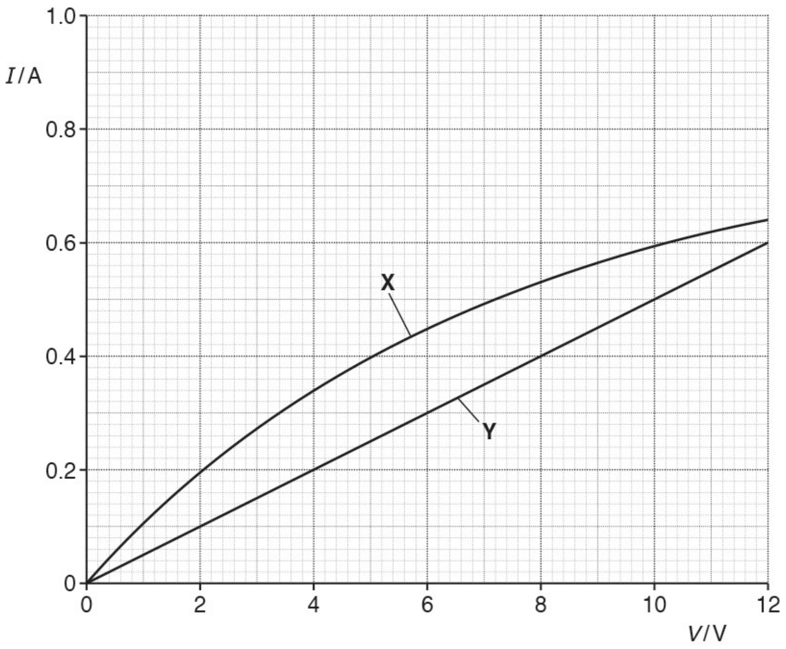


Fig. 6.1

Suggest the two components **X** and **Y** that were used.

Name of component **X**

Name of component **Y** **[1]**

8. 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.

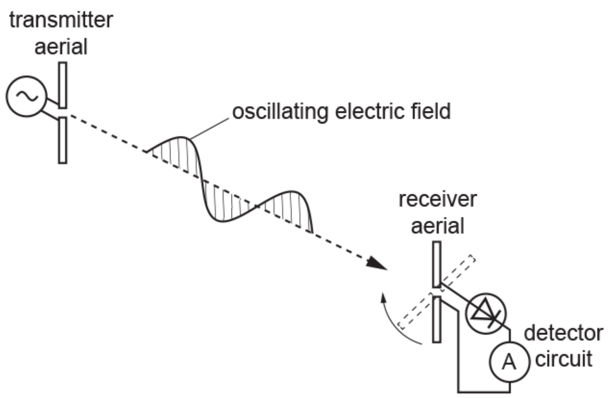


Fig. 5.1

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

--- **[1]**

9. 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	3*L*	2*d*	*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]**

10. A student uses the circuit shown in **Fig. 16.1** to determine the resistivity of a metal in the form of a wire.

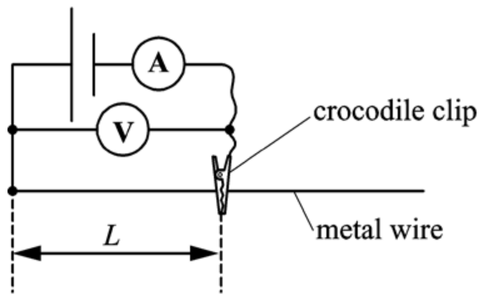


Fig. 16.1

The length *L* of the wire is changed with the help of a crocodile clip. The current in the wire is *I*, the p.d. across the wire is *V* and the wire has resistance *R*.

The table in **Fig. 16.2** shows the results recorded by the student from the experiment.

L / m	*V* / V	*I* / A	*R* / Ω
0.050	0.40	0.160	2.50
0.200	0.40	0.140	2.86
0.400	0.40	0.072	
0.800	0.40	0.036	11.1
1.000	0.40	0.029	13.8

Fig. 16.3 shows the graph of *R* against *L* for this wire.

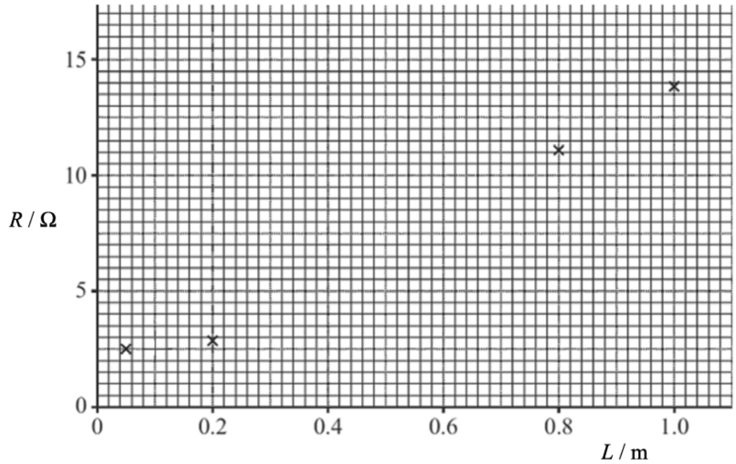


Fig. 16.3

Complete the table by calculating the resistance of the wire of length 0.400 m. On **Fig. 16.3** plot the data point corresponding to this length.

[1]

11. Which definition is correct and uses only quantities rather than units?

A Acceleration is the change in velocity per second.
B Resistance is potential difference per ampere.
C Intensity is energy per unit cross-sectional area.
D Electromotive force is energy transferred per unit charge.

Your answer ☐ **[1]**

12. A student connects a calibrated 10.0 Ω resistor across a chemical cell of electromotive force (e.m.f.) 1.50 V. The student expects the current in the resistor to be 0.150A.

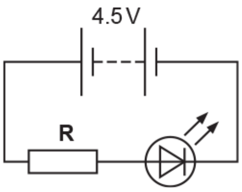
Explain why the actual current will not be 0.150A.

---

[2]

13. A light-emitting diode (LED) emits red light when it is positively biased and has a potential difference (p.d.) greater than about 1.8 V.

An LED is connected into a circuit, as shown below.



The battery has electromotive force (e.m.f.) 4.5 V and negligible internal resistance.
The resistor **R** has resistance 150 Ω.
Assume the p.d. across the LED is 1.8 V.

Calculate the ratio $\frac{\text{power dissipated by LED}}{\text{power dissipated by resistor}}$.

ratio = ... **[2]**

14.

Fig. 24 shows a circuit with a battery and two resistors.

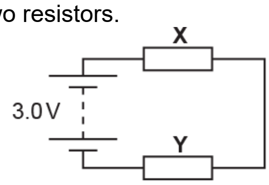


Fig. 24

The resistor **X** has length 8.0×10^{-3} m, cross–sectional area 1.2 mm^2 and is made of a material of resistivity 1.5×10^{-2} Ωm. The battery has e.m.f. 3.0 V and negligible internal resistance.
The resistor **Y** has resistance 68Ω.

Calculate the current *I* in the circuit.

I = A **[3]**

15 (a). Fig. 19.1 shows an electric circuit.

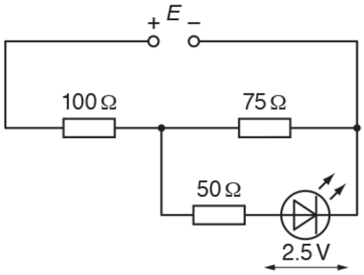


Fig. 19.1

The power supply has electromotive force (e.m.f.) *E* and negligible internal resistance.

The resistance values of the resistors are shown in Fig. 19.1. The *I*–V characteristic of the lightemitting diode (LED) is shown in Fig. 19.2.

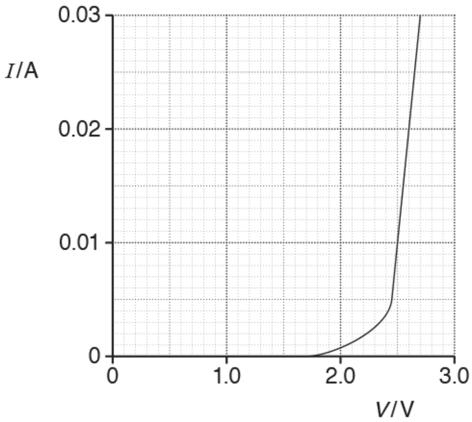


Fig. 19.2

The potential difference (p.d.) across the LED is 2.5 V.

Use Fig. 19.2 to show that the p.d. across the 50 Ω resistor is 0.50 V.

[2]

(b). Calculate the e.m.f. *E* of the power supply.

E = ... V **[3]**

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

base units: **[2]**

17 (a). A student uses the circuit shown in **Fig. 16.1** to determine the resistivity of a metal in the form of a wire.

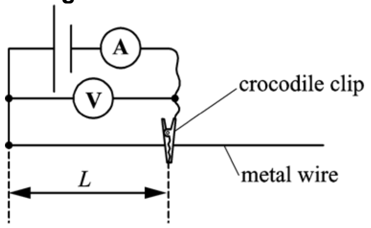


Fig. 16.1

The length *L* of the wire is changed with the help of a crocodile clip. The current in the wire is *I*, the p.d. across the wire is *V* and the wire has resistance *R*.
The table in **Fig. 16.2** shows the results recorded by the student from the experiment.

L / m	*V* / V	*I* / A	*R* / Ω
0.050	0.40	0.160	2.50
0.200	0.40	0.140	2.86
0.400	0.40	0.072	
0.800	0.40	0.036	11.1
1.000	0.40	0.029	13.8

Fig. 16.3 shows the graph of *R* against *L* for this wire.

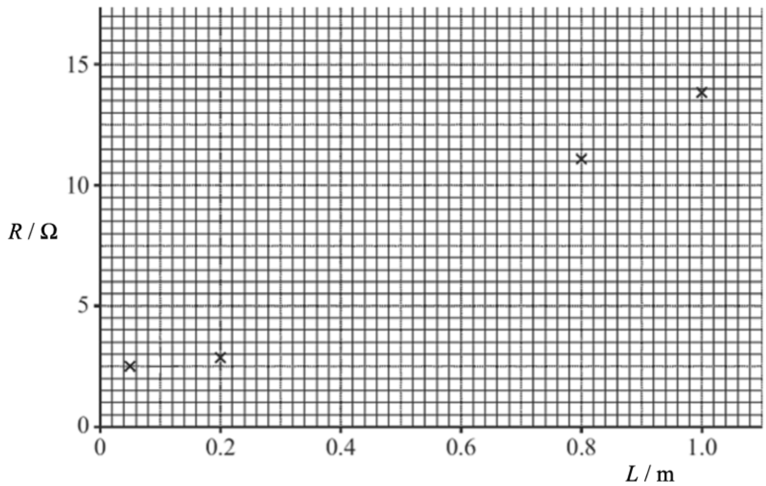


Fig. 16.3

The student observed that the wire was significantly hotter when the shortest length *L* = 0.050 m was used.

The cross-sectional area of the wire is 8.0×10^{-8} m^2.

Use **Fig.16.3** to determine the resistivity of the metal.

resistivity = ... Ωm **[3]**

(b). The voltmeter used in the experiment had a zero error. The potential difference recorded in the experiment was smaller than it should have been.

Discuss how the actual value of the resistivity of the metal would differ from the value calculated in **(b)**.

[3]

18. A student is investigating a potential divider circuit containing a light-dependent resistor (LDR). The student sets up the circuit shown in Fig. 4.

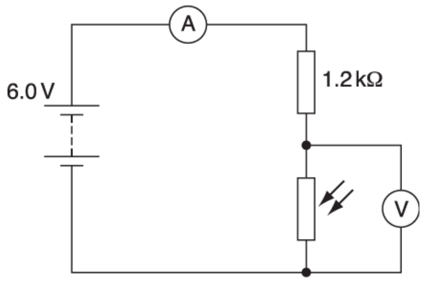


Fig. 4

The battery has an e.m.f. of 6.0 V and negligible internal resistance. The resistor has a resistance of 1.2 kΩ. In a dark room the voltmeter reading is 5.1 V.

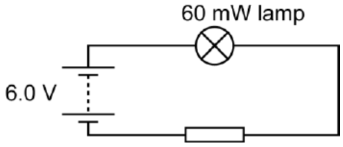
i. Show that the resistance R_{LDR} of the LDR is 6800 Ω.

[2]

ii. Calculate the current I delivered by the battery.

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

19 (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]

20. A battery of negligible internal resistance is connected across two resistors of resistance values *R* and *2R* as shown in **Fig. 24.1.**

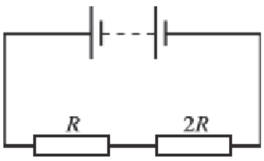


Fig. 24.1

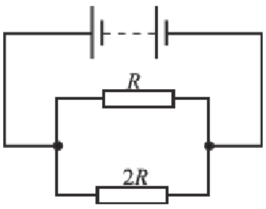


Fig. 24.2

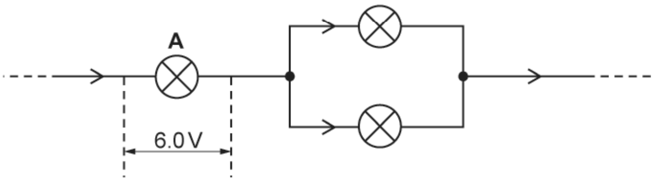
The same battery is now connected to the same resistors as shown in **Fig. 24.2.**

Calculate the ratio

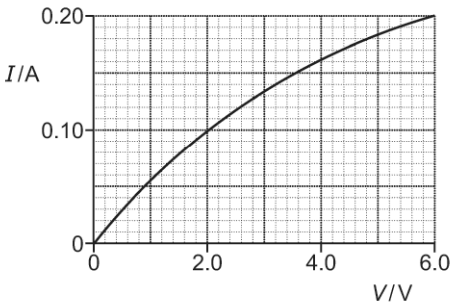
$$\frac{\text{current from battery in circuit of Fig. 24.1}}{\text{current from battery in circuit of Fig. 24.2}}.$$

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

21. The diagram below shows part of an electrical circuit connected by a student.



The lamps are identical.
The graph below shows the *I* -*V* characteristic of one of the lamps.



The potential difference (p.d.) across lamp **A** is 6.0 V.

Use the graph to determine the total resistance of the lamps.

resistance =... Ω **[3]**

22. Two resistors of resistances R_1 and R_2 are connected in **parallel**.
Show that the total resistance R of this combination is given by the equation

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}.$$

[3]

23. A student conducts an experiment using two identical filament lamps and a variable power supply of negligible internal resistance. The lamps are connected in series to the supply. The current in the circuit is 0.030 A and the lamps are dimly lit.

The e.m.f. of the power supply is then doubled and the experiment repeated.
The student expected the current to double, but the current only increased to 0.040 A. The lamps are brightly lit.

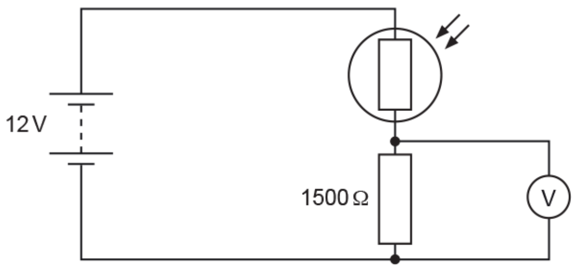
Use your knowledge of physics to explain these observations.

----

[3]

24. This question is about a light-dependent resistor (LDR).

A student connects a potential divider circuit as shown below. It contains an LDR.



The fixed resistor has resistance 1500 Ω.
The battery has electromotive force (e.m.f.) 12 V and negligible internal resistance.
The voltmeter has extremely high resistance.

i. When the LDR is covered, its resistance is 3000 Ω.

Calculate the voltmeter reading.

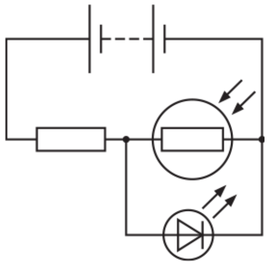
= .... V**[2]**

ii. When fully illuminated, the resistance of the LDR is 100 Ω.
Show that the voltmeter reading **changes**by more than 7 V.

[1]

25. A light-emitting diode (LED) emits red light when it is positively biased and has a potential difference (p.d.) greater than about 1.8 V.

The diagram below shows a circuit designed by a student.



The LED is very close to, and facing the light dependent resistor (LDR).
The circuit is taken into a dark room.

i. The student thought that the LED would switch on.
Instead, the LED was found to repeatedly switch on and off.

Explain this behaviour of the LED in this potential divider circuit.

---

[2]

ii. Suggest a possible refinement so that the LED switches on permanently when taken into the dark room.

---

[1]

26. Fig. 17 shows a potential divider circuit consisting of a fixed resistor of resistance *R* and a negative temperature coefficient (NTC) thermistor.

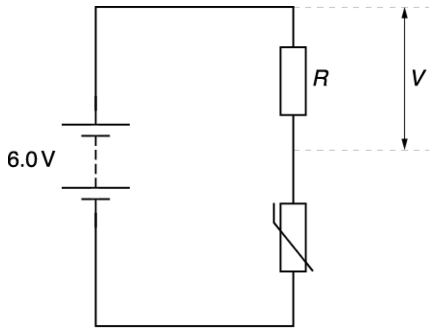


Fig. 17

The battery has electromotive force (e.m.f.) of 6.0 V and negligible internal resistance.
The thermistor is at room temperature. The resistance of the thermistor is 0.25 *R*.

The circuit shown in Fig. 17 is now placed in a cold fridge. The temperature of the thermistor slowly decreases to a constant value.

Describe and explain, in terms of current in the circuit, the variation of the potential difference *V* across the fixed resistor with time.

---

[4]

27. Fig. 27.1 shows the *I-V* characteristic of an LED designed to emit blue light.

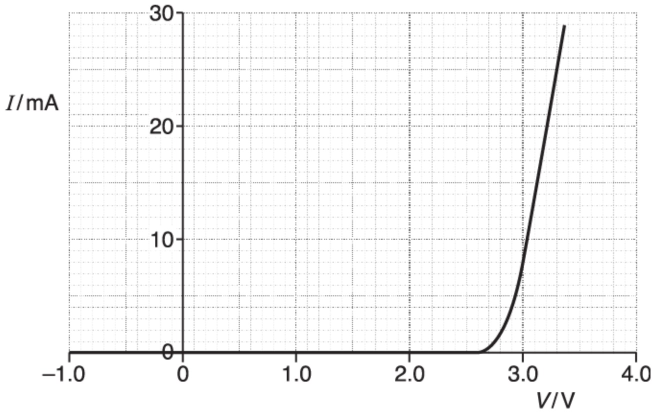


Fig. 27.1

Describe and justify the variation of resistance *R* of the LED as the potential difference *V* across the LED is increased from

- −1.0 V to 2.6 V

- 2.6 V to 3.0 V

- 3.0 V to 3.4 V

---

[4]

28. A researcher connects the circuit as shown in **Fig. 24.3** to determine the resistivity of a new metal designed from waste metals.

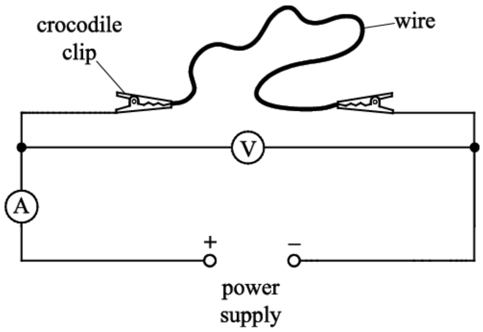


Fig. 24.3

The wire has length 0.75 m and cross-sectional area 1.3×10^{-7} m^2. The ammeter reading is 0.026 A and the voltmeter reading is 1.80 V.

i. Calculate the resistivity of the metal.

resistivity = ... Ω m **[2]**

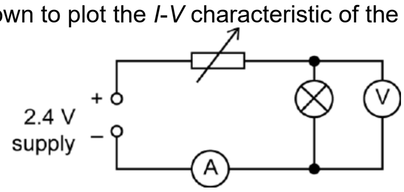
ii. The resistivity of the metal in **(c)(i)** is larger than the value predicted by the researcher.

Explain **one** possible limitation of the experiment.

---

[2]

29. A student connects the circuit shown to plot the *I*-*V* characteristic of the filament lamp.



The current in the lamp is *I* and the potential difference across it is *V*. The supply has e.m.f. 2.4 V and negligible internal resistance. The maximum resistance of the variable resistor is about 60 Ω.

i. Explain why this circuit will provide data for large *V* values but not for small *V* values.

---

[2]

ii. Complete Fig. 16 to design a circuit so that data may be obtained for *V* from zero to 2.4 V for the lamp.

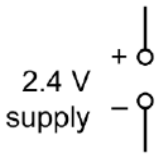


Fig. 16

[2]

30. This question is about two identical filament lamps. Fig. 23.2 shows the *I*-*V* characteristic of each lamp.

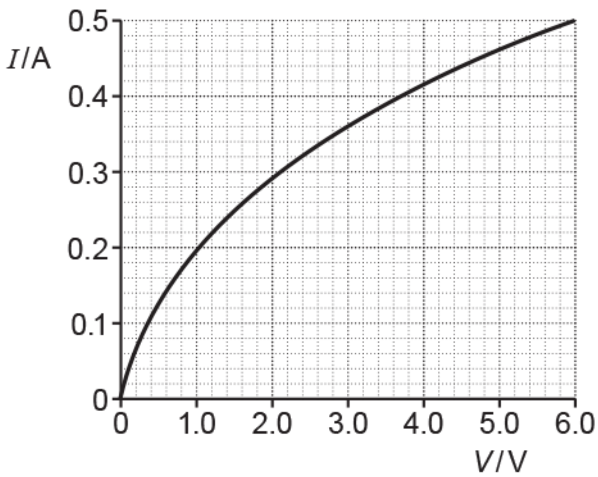


Fig. 23.2

The lamps are connected to a 6.0 V supply of negligible internal resistance in **series**, as shown in Fig. 23.3, and then in **parallel**, as shown in Fig. 23.4.

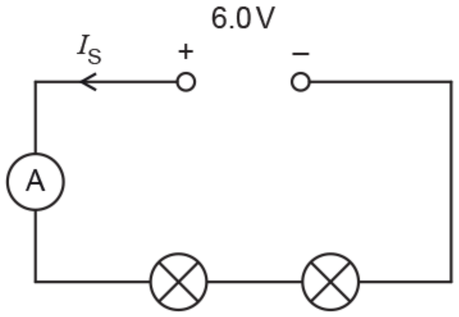


Fig. 23.3

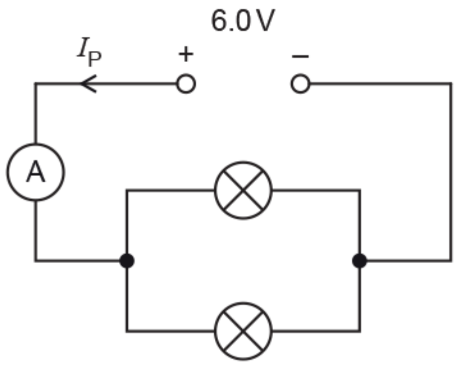


Fig. 23.4

The current from the supply in the series circuit is I_S and the current from the supply in the parallel circuit is I_P. I_P is found to be almost 3 times greater than I_S.

Use Fig. 23.2 to explain why I_P is almost 3 times greater than I_S.
Show any calculations and your reasoning below.

Fig. 23.3	Fig. 23.4

[4]

31. A student is investigating an unidentified component found in the laboratory.
The table shows the results from the lab book of the student.

V / V	I / mA
− 5.0	− 5.0
+ 5.0	+ 5.0
+ 10.0	+ 30.0

The potential difference across the component is *V* and the current through it is *I*.

i. Calculate the power dissipated by the component when *V* is +10.0 V.

power = W **[1]**

ii. Analyse the data in the table and hence identify the component.

---

[3]

32. A student is investigating a potential divider circuit containing a light-dependent resistor (LDR). The student sets up the circuit shown in Fig. 4.

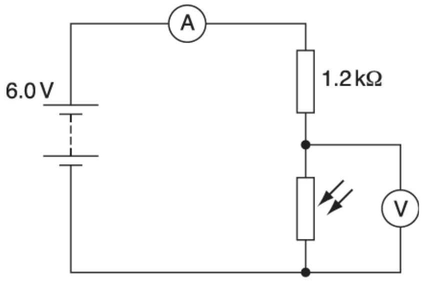


Fig. 4

The circuit is moved so that the LDR is now in sunlight.

Without reference to the potential divider equation, describe and explain how the readings on the ammeter and voltmeter will change.

---

[4]

33. Fig. 4.1 shows part of the *I* – *V* characteristic of a silicon diode.

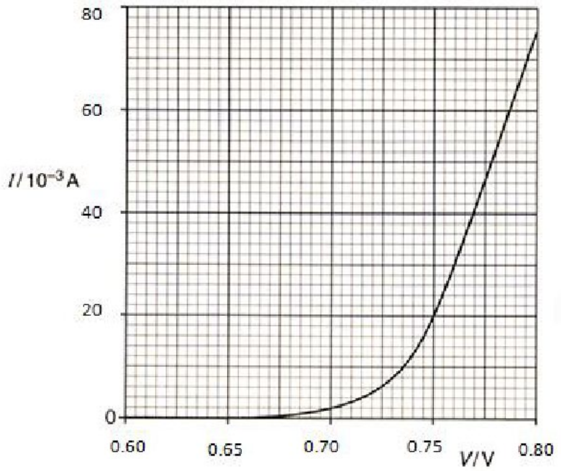


Fig. 4.1

The graph has three distinct regions, from 0.60 V to 0.65 V, 0.65 V to 0.75 V and above 0.75 V.

State and justify how the resistance of the diode increases, remains the same or decreases in each of these regions.

[5]

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

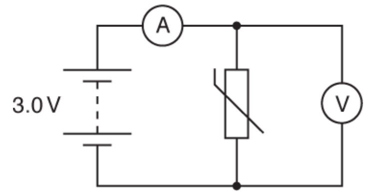


Fig. 24.1

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.

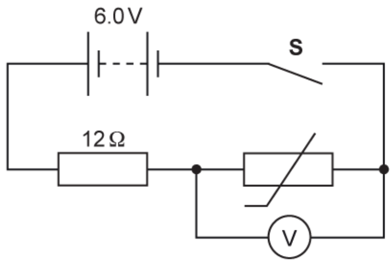
v = ... m s^{-1} **[2]**

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

---

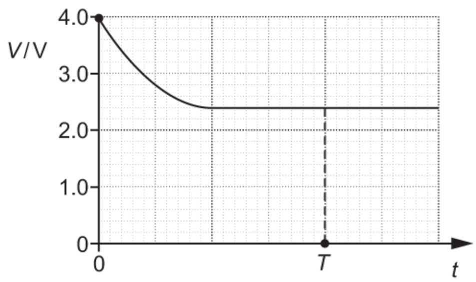
[3]

35. A student connects a resistor and a thermistor in a circuit, as shown in the circuit diagram below.



The battery has electromotive force (e.m.f.) 6.0 V and negligible internal resistance.
The resistor has resistance 12 Ω.
The thermistor is at room temperature. The student closes the switch **S** at time *t* = 0.

The student draws the following graph which shows potential difference (p.d.) *V* across the thermistor against time *t*.



i. Explain why *V* decreases at the start.

---

[2]

ii. Use the graph to calculate the resistance of the thermistor at *t* = *T*.

resistance = ... Ω **[3]**

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

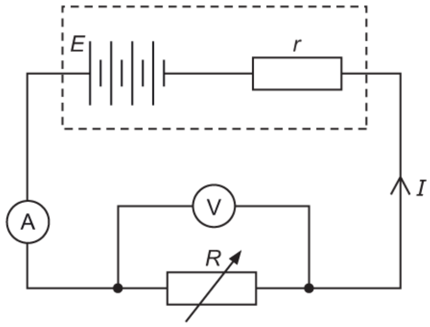


Fig. 5.1

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.

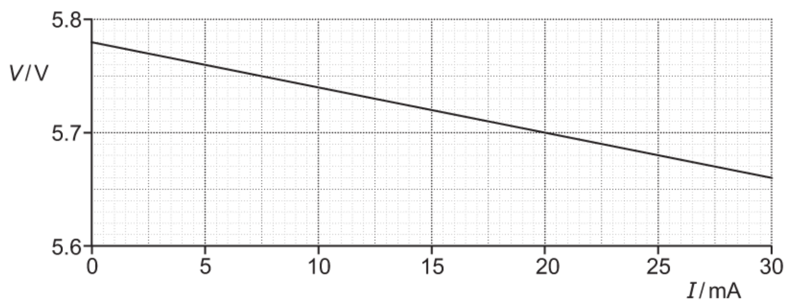


Fig. 5.2

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

--- **[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]**

37 (a). A light-dependent resistor (LDR) is connected between points **X** and **Y** in the circuit of Fig. 4.2. The circuit is used to switch on a lamp during the hours of darkness.

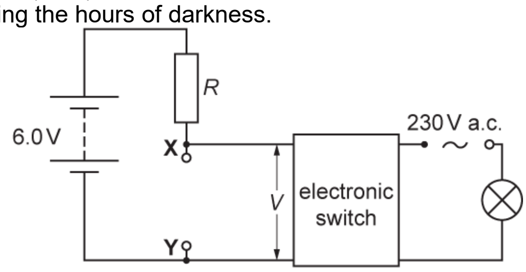


Fig. 4.2

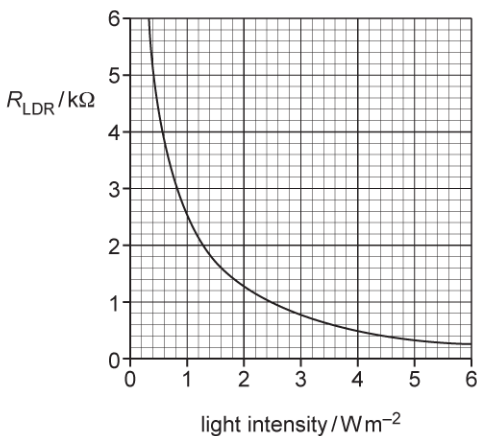


Fig. 4.3

i. Draw the symbol for an LDR on Fig. 4.2 between **X** and **Y**.

[1]

ii. Fig. 4.3 shows how the resistance of the LDR varies with light intensity. The electronic switch closes when
V across **XY** is 4.0 V and opens when *V* across **XY** is 2.4 V. The electronic switch draws a negligible current.

Calculate

1 the resistance *R* of the resistor for the lamp to switch on at a light intensity of 0.80 W m^{-2}

R = ... Ω **[3]**

2 the light intensity of the surroundings at which the lamp switches off.

light intensity = ... W m^{-2} **[2]**

(b). You are given an unmarked sealed square box which has four identical terminals at each corner.

Fig 4.1 shows the circuit diagram for the contents of the box with the four terminals labeled **A**, **B**, **C** and **D**.

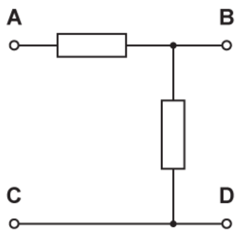


Fig. 4.1

One of the resistors in the box has resistance 220 Ω. The other resistor has resistance 470 Ω. Two of the terminals are connected by a wire.

The four terminals on your unmarked sealed box are **not** labelled.

You are given a 6.0 V d.c. supply, a 100 Ω resistor (labelled R) and a digital ammeter.

Plan an experiment to determine the arrangement of the components and identify which terminal of your unmarked sealed box is **A**, **B**, **C** and **D**.

A space has been left for you to draw circuit diagrams to illustrate your answer.

[6]

38 (a). Some houses are heated by "night storage heaters" which use cheap electricity between the hours of midnight and 7.00 am.

Fig. 4.1 shows a circuit diagram of three identical 230 V, 3.5 kW storage heaters connected to a 230 V mains power supply of negligible internal resistance.

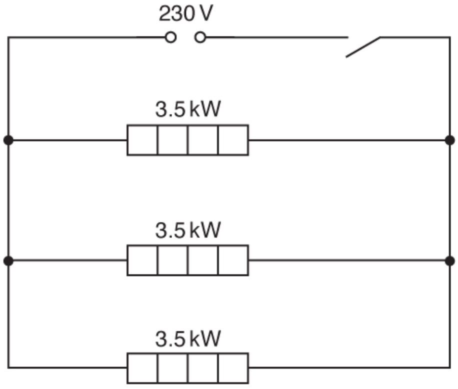


Fig. 4.1

i. Show that the resistance of each heating element is about 15 Ω when the heater is operating at 230 V.

[1]

ii. The heating element is constructed from a metallic wire of resistivity 1.6×10^{-6} Ω m.
The radius of the wire is 0.55 mm.
Determine the length *L* of the metallic wire in one heating element.

L = ... m **[3]**

iii. State and explain whether the heater obeys Ohm's law.

---

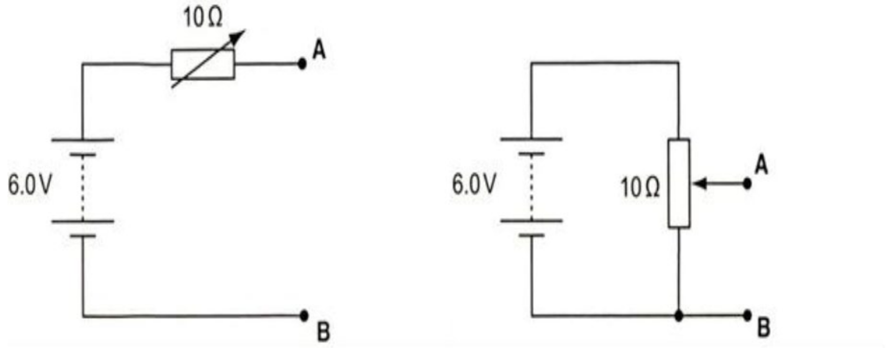
[2]

(b). The cost of 1 kW h of energy is 7.6 pence.

Calculate the cost of using the three storage heaters between midnight and 7.00 am every night for one week.

cost = £ .... **[2]**

39. *In order to determine the *I-V* characteristic for an LED, one student connects to the incomplete circuit **X** shown in **Fig. 4.2(a)** and a second student connects to the incomplete circuit **Y** shown in **Fig. 4.2(b).** Each adds an LED with a resistor in series and suitable meters to take the measurements between terminals **A** and **B**.



Incomplete circuit X **Incomplete circuit Y**

Fig. 4.2(a) **Fig. 4.2(b)**

Only one of these circuits is suitable to carry out the task.
Draw an LED with a 100 Ω resistor in series and suitable meters to complete the correct circuit on **Fig. 4.2(a)** or **4.2(b)**.

Explain why only one of the circuits is suitable to carry out the task and why the 100 Ω resistor has been included.

----

[6]

40. A cell of electromotive force (e.m.f.) 1.4 V and internal resistance 0.62 Ω is connected to resistor **A** and wire **B** as shown in Fig. 23.1.

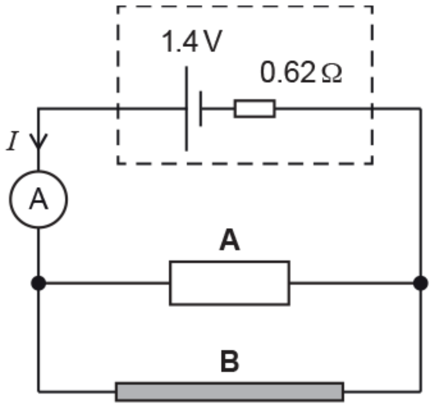


Fig. 23.1

The resistance of resistor **A** is 1.8 **Ω** and resistance per unit length of wire **B** is 9.5 Ωm^{-1}. The length of wire **B** is 40 cm.

i. Calculate the current *I* in the circuit. Write your value to an appropriate number of significant figures.

I = ... A **[4]**

ii.

Calculate the ratio $\frac{\text{power dissipated in the internal resistance}}{\text{total power supplied by cell}}$

ratio = ... **[2]**

41. A metal circular plate is rotated at a constant frequency by an electric motor.
The plate has a small hole close to its rim.
Fig. 17.1 shows an arrangement used by a student to determine the frequency of the rotating plate.

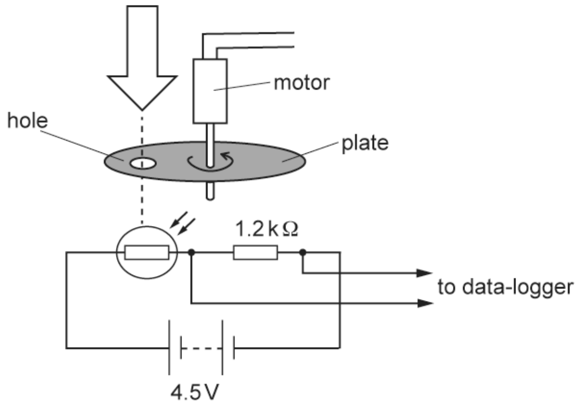


Fig. 17.1

A light-dependent resistor (LDR) and a fixed resistor of resistance 1.2 kΩ are connected in series to a battery. The battery has e.m.f. 4.5 V and has negligible internal resistance. The potential difference *V* across the resistor is monitored using a data-logger.

Fig. 17.2 shows the variation of *V* with time *t*.

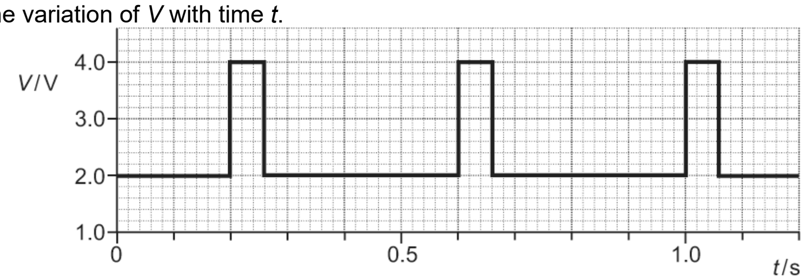


Fig. 17.2

Use your knowledge and understanding of potential divider circuits to explain the shape of the graph shown in Fig. 17.2. Include in your answer the maximum and minimum values of the resistance of the LDR.
Describe how the student can determine the frequency of the rotating plate.

---

[6]

42. This question is about a resistance wire made of nichrome.

It is suggested that the resistance R of a length of nichrome wire varies with temperature θ in °C according to the equation

$$R = R_0 (1 + k\theta)$$

where R_0 is the resistance of the wire at 0 °C and k is a constant for the wire.

Fig. 1.1 shows a diagram of the arrangement of apparatus in an experiment to test the relationship between R and θ and to determine the value of k.

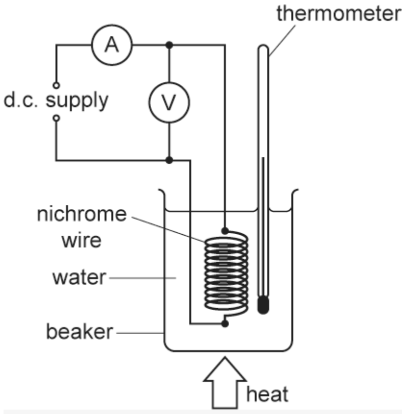


Fig. 1.1

The resistance wire is coiled and placed in a water bath.

Describe how you would carry out the experiment, analyse the data to verify the relationship between R and θ and determine a value for k.
In your description, state any precautions that you would take to improve the accuracy and precision of the measurements.

----

[6]

43. This question is about an electric cooker, which consists of an oven and an electromagnetic induction hob.

The electromagnetic induction hob is shown in **Fig. 4.1.**

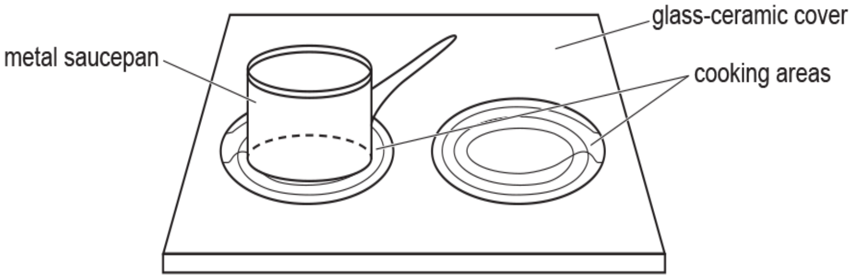


Fig. 4.1

Each cooking area has a coil below the glass-ceramic cover. When switched on, the coils carry a high-frequency **alternating** current.

A metal saucepan is placed above one of the coils. A large alternating current is induced in the saucepan base, and this causes the saucepan to heat up.

i. **Fig. 4.2**shows one of the coils at a time when the current is in the direction indicated by the arrows.

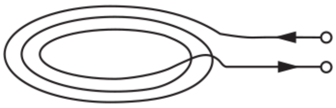


Fig. 4.2

On **Fig. 4.2**, sketch the magnetic field pattern for the current-carrying coil.

[2]

ii. Fig. 4.3 shows the path of the large alternating current induced in the metal base of the saucepan

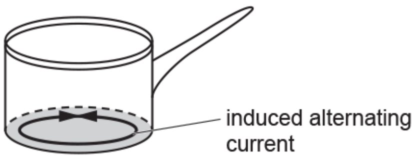


Fig. 4.3

Explain the origin of this large current.

---

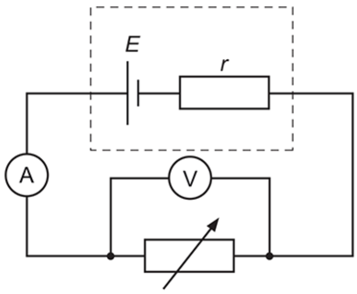
[2]

iii. Explain why it would be safe for a person to place a hand on the cooking area before the saucepan is put onto it.

---

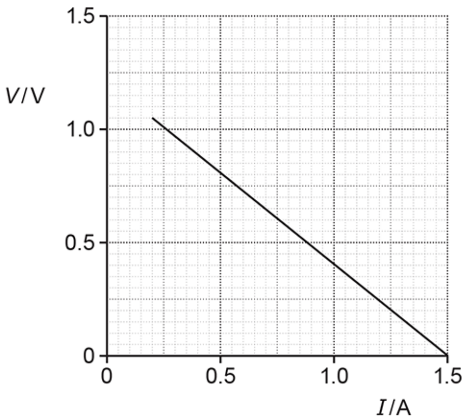
[2]

44. A student is doing an experiment to determine the e.m.f. *E* of a cell and its internal resistance *r*.
The circuit diagram of the arrangement is shown below.



The student changes the resistance of the variable resistor. The potential difference *V* across the variable resistor and the current *I* in the circuit are measured.

The *V* against *I* graph plotted by the student is shown below.



V / V	I / A	R / Ω	P / W
0.20	1.25		
0.40	1.00		
0.60	0.75		
0.80	0.50		
1.00	0.25		

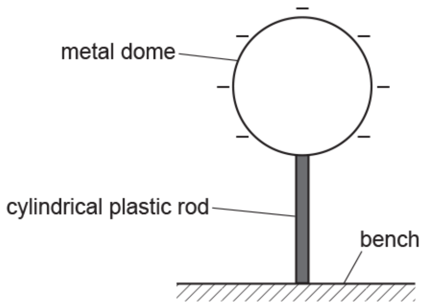
There is an incomplete table next to the graph.
R is the resistance of the variable resistor and *P* is the power dissipated by the variable resistor.

- Use the graph to determine E and r. Explain your reasoning.
- Calculate *R* and *P* to complete the table. Describe how P depends on R.

---

[6]

46. 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.

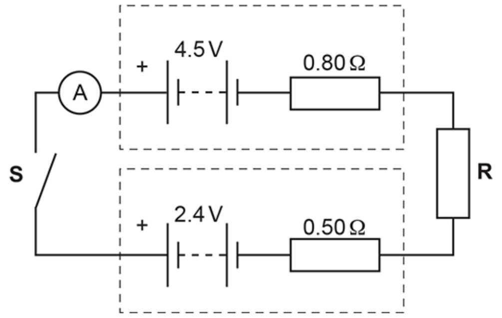
[2]

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.

Calculate the resistivity ρ of the plastic.

ρ = ... Ωm **[3]**

47. 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]

48. 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.

----

[4]

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

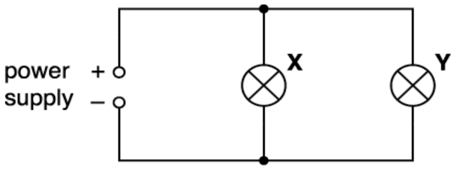


Fig. 16

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]**

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

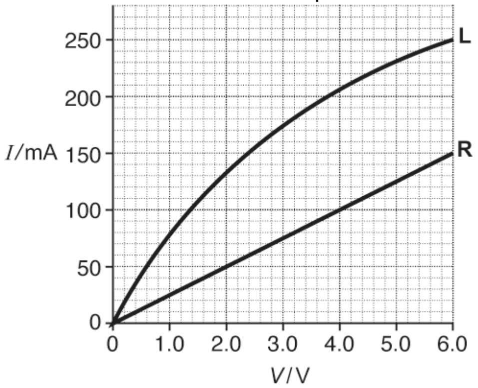


Fig. 16.1

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.

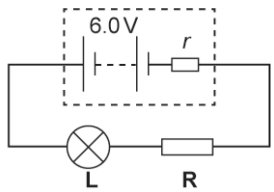


Fig. 16.2

The resistor **R** is a cylindrical rod of length 8.0 mm and cross-sectional area 2.4×10^{-6} m². 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]**

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

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

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

END OF QUESTION PAPER