4. Electricity and magnetism

4.2 Electrical quantities

Paper 3 and 4

Question Paper

Paper 3

Questions are applicable for both core and extended candidates

1 A student tests various materials to determine whether they are electrical conductors or insulators. The student uses the circuit shown in Fig. 9.1.

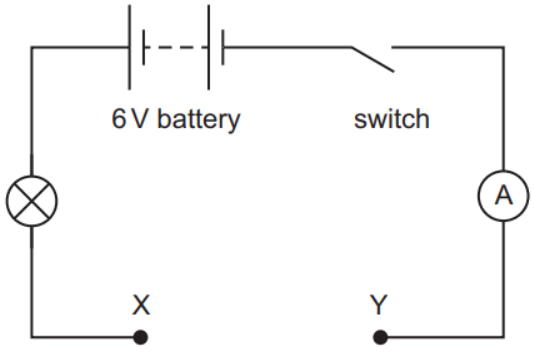


Fig. 9.1

(a) The student connects a piece of tin metal between X and Y.

Describe how the student can determine whether tin is an electrical conductor.

.....

.....

..... [2]

(b) Describe electrical conduction in a metal.

Use your ideas about electrons in your answer.

.....

.....

.....

..... [3]

[Total: 5]

2 In an experiment, a student uses an electrical heater connected to a power supply.

(a) The current in the electrical heater is 2.2 A. The voltage (p.d.) across the heater is 12 V.

Calculate the energy transferred to the heater in 90 s.

energy transferred = ... J [3]

(b) The power supply is connected to the electrical mains by a cable that consists of three wires.

State the name for each of the three wires in the cable.

1 ..... 2 ..... 3 .....

[2]

3 **(a)** Fig. 8.1 represents charges on an acetate strip and on a dry cloth.
Both the acetate strip and the dry cloth are electrically neutral.

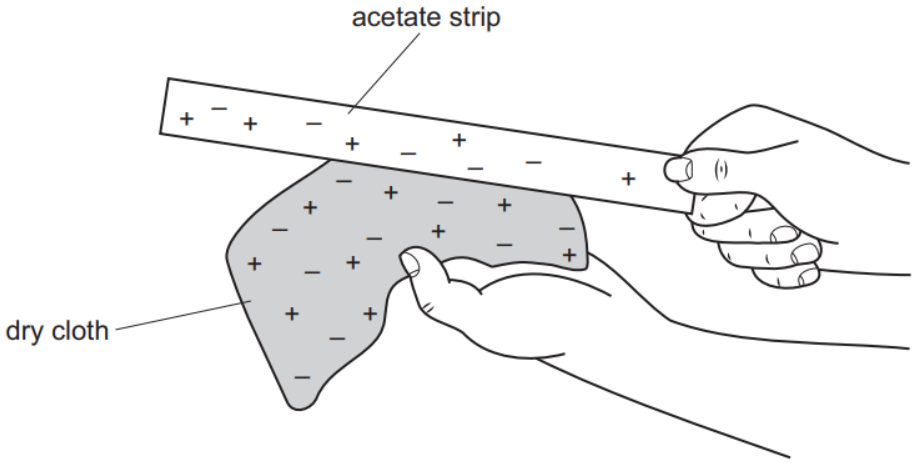


Fig. 8.1

The student charges the acetate strip by using the dry cloth. The acetate strip becomes positively charged.
Explain how the acetate strip becomes positively charged.

.....

.....

.....

.....

..... [3]

(b) The student brings the positively charged acetate strip close to another positively charged acetate strip. Fig. 8.2 shows this situation.

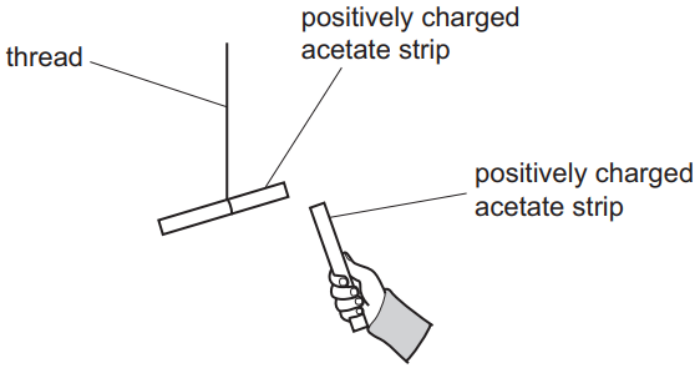


Fig. 8.2

Describe and explain what happens when the two positively charged acetate strips are close to each other.

.....

.....

..... [2]

[Total: 5]

4 Fig. 9.1 shows an electric circuit which includes uninsulated resistance wire XY. A teacher shows some students how to complete the circuit by placing the contact C at various positions on the wire XY.

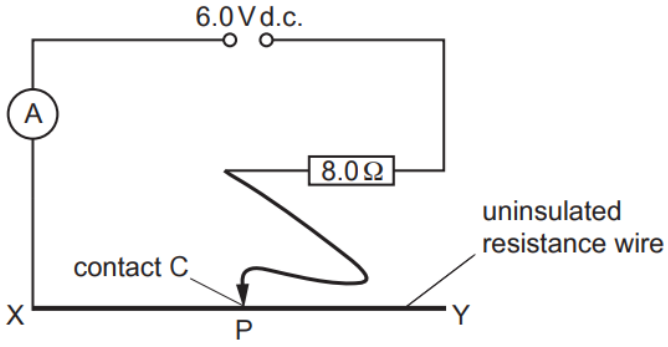


Fig. 9.1

(a) The students place contact C at Y. They measure the current on the ammeter. Then they move the contact C along the wire from Y to X.

State and explain the effect on the ammeter reading when they move the contact C from Y to X.

.....

..... [2]

(b) Calculate the reading on the ammeter when contact C is at X.

ammeter reading = ... A [3]

(c) The students move contact C to point P. The resistance of the wire between X and P is 20 Ω.

Calculate the total resistance of the resistance wire between X and P and the fixed resistor.

total resistance = ... Ω [2]

(d) The electric current in the circuit produces two effects.

Place a tick (✓) in the boxes next to these **two** effects.

gravitational	☐
magnetic	☐
heating	☐
sound	☐
X-ray emissions	☐

[2]

5 **(b)** **(i)** A plastic rod is rubbed with a cloth. The plastic rod becomes positively charged.

Explain how the friction between the cloth and the rod causes the rod to become positively charged.

Use your ideas about the movement of charge.

.....

..... [2]

(ii) Plastic is an electrical insulator. Iron is an electrical conductor.

State **two** other materials that are electrical conductors.

1 .....

2 .....

[1]

6 This question is about electric circuits.

(a) (i) State the name of the instrument used to measure potential difference (p.d.) in an electric circuit.

..... [1]

(ii) State the unit for the electromotive force (e.m.f.) of a battery.

..... [1]

(b) (i) A student connects a circuit to determine the resistance of a wire. The current in the wire is 0.20A when the potential difference across the wire is 6.4V.

Calculate the resistance of the wire.

resistance = ... Ω [3]

(ii) The student has some wires of the same material as those in **(b)(i)** but of various lengths and thicknesses. He wants a wire with higher resistance than the wire in **(b)(i)**.

State **two** ways of identifying a wire with a higher resistance by comparing its length and thickness with the wire in **(b)(i)**.

1 .....

2 .....

[2]

[Total: 7]

7 A student determines the resistance of a piece of metal wire XY.
Fig. 10.1 shows the wire connected in the circuit.

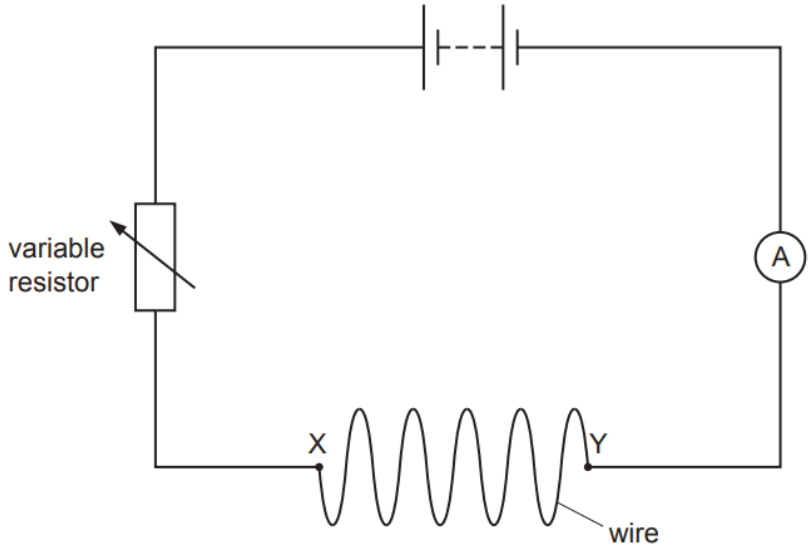


Fig. 10.1

(a) (i) The student measures the potential difference (p.d.) across the wire XY.
On Fig. 10.1, show the voltmeter correctly connected. Use the correct symbol. [1]

(ii) There is a current in the wire. State the name of the particles that flow through the wire.

..... [1]

(iii) The student removes wire XY and replaces it with another wire CD. Wire CD is the same length and is made of the same material as wire XY, but thinner.

State any difference between the current in wire CD and the current in wire XY. Explain your answer.

.....

.....

..... [2]

(iv) State the unit used for the electromotive force (e.m.f.) of the battery.

..... [1]

(b) (i) The resistance of wire CD is 8.7 Ω and the resistance of the variable resistor is 7.4 Ω.

Determine the combined resistance of the wire CD and the variable resistor.

resistance = ... Ω [1]

(ii) The current in the variable resistor is 0.40 A.

State the current in wire CD.

current = ... A [1]

[Total: 7]

8 **(a)** A student rubs a plastic rod with a dry cloth, as shown in Fig. 8.1. The rod becomes negatively charged.

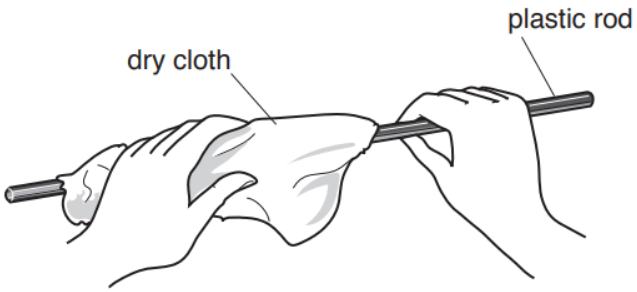


Fig. 8.1

(i) Use words from the box to complete the sentence.

air	cloth	electrons	hand	neutrons	protons

The rod becomes negatively charged because ..... move from the

..... to the rod.

[2]

(ii) The student moves the rod close to a suspended, charged rod. The two rods repel each other.

State the type of charge on the suspended rod.

..... [1]

(iii) Explain your answer to **(a)(ii)**.

.....

..... [1]

(b) A device has a metal case. Any charge on the case must be able to move to earth.

(i) Draw **one** ring around a material that is suitable for the connection to earth.

copper glass plastic rubber [1]

(ii) Explain your answer to **(b)(i)**.

.....

..... [1]

[Total: 6]

9 Fig. 9.1 shows a plastic ruler.

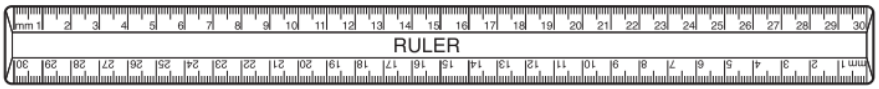


Fig. 9.1

(a) Suggest and explain how a student could give a positive charge to a plastic ruler.

.....

.....

..... [3]

(b) A plastic ruler is given a positive charge. A sphere hangs from an insulating thread.

A student holds the ruler near the sphere, as shown in Fig. 9.2. The ruler repels the sphere.

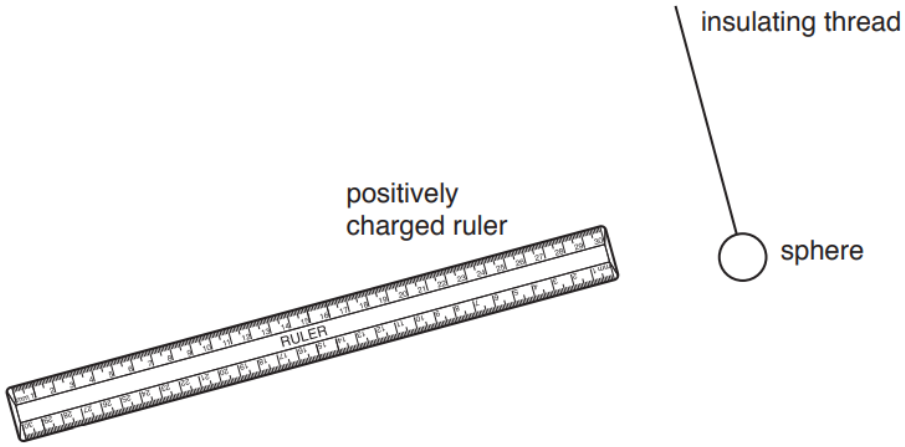


Fig. 9.2

(i) State what charge, if any, the sphere carries.

..... [1]

(ii) Explain your answer to **(b)(i)**.

..... [1]

[Total: 5]

10 A student experiments with electric charge.

(a) The student uses a dry cloth to rub a plastic rod. The rod becomes positively charged.

Explain how the friction between the rod and the cloth causes the rod to become positively charged.
Use your ideas about the movement of charge.

.....

.....

.....[2]

(b) The student suspends a balloon from an insulating thread, as shown in Fig. 9.1.

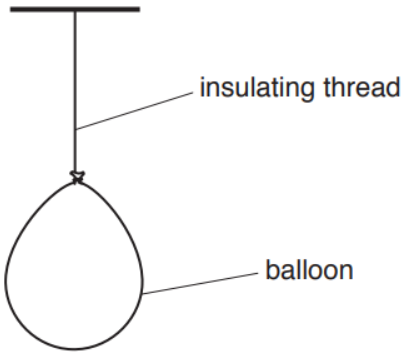


Fig. 9.1

The balloon has an electric charge.

Explain how the student can use a positively charged rod to determine the charge on the balloon.

.....

.....

.....[3]

[Total: 5]

11 Fig. 10.1 shows a circuit used by a student to test a metal wire made of nichrome.

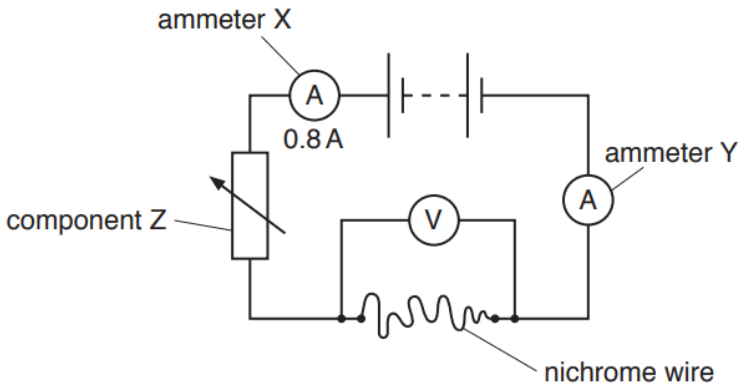


Fig. 10.1

(a) State the name of component Z.

..... [1]

(b) The current reading on ammeter X is 0.8 A. State the reading on ammeter Y.

..... [1]

(c) The current in the nichrome wire is 0.8 A. The potential difference (p.d.) across the nichrome wire is 4.5 V.

Calculate the resistance of the nichrome wire.

resistance = ... Ω [3]

(d) The student tests a different nichrome wire, which is thicker than the wire in **(c)**, but of the same length. When testing this wire, the current in the wire is different from the value given in **(c)**.

State and explain the difference in current.

.....

.....

..... [2]

[Total: 7]

12 Fig. 10.1 shows a circuit for determining the resistance of a component.

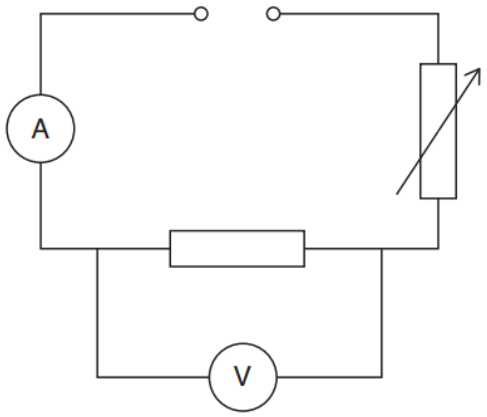


Fig. 10.1

(a) On Fig. 10.1, label the fixed resistor, by writing the letter R. [1]

(b) Two components in Fig. 10.1 measure electrical quantities.

Identify the quantity that each component measures.

Write each quantity and the unit of each quantity in the correct place in Table 10.1.

component	quantity	unit
A		
V		

Table 10.1

[4]

(c) A student uses the circuit in Fig. 10.1 to determine the resistance of wires made from the same material.

State how the resistance of a wire is related to its length and its diameter.

length .....

.....

diameter .....

.....

[2]

[Total: 7]

13 **(a)** Fig. 10.1 shows a balloon hanging from an insulating thread.

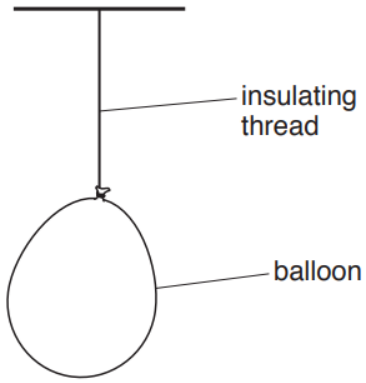


Fig. 10.1

(i) A student gives the balloon a positive charge.

Which statement explains why the balloon becomes positively charged? Tick **one** box.

- ☐ The balloon gains electrons
- ☐ The balloon loses electrons
- ☐ The balloon gains protons
- ☐ The balloon loses protons [1]

(ii) The student brings a charged rod close to the balloon as shown in Fig. 10.2.

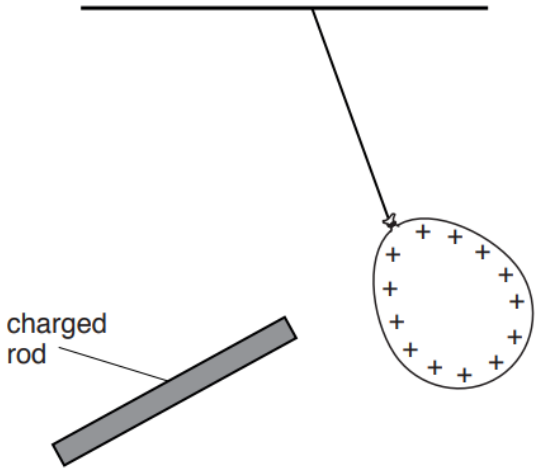


Fig. 10.2

State the type of charge on the rod.

.....

Explain your answer.

.....

.....

[2]

(b) Electrical charges can move easily through some materials.

Draw a circle around each material that charges can move through easily.

copper plastic rubber silver wood [1]

[Total: 4]

Paper 4

Questions are applicable for both core and extended candidates unless indicated in the question

14 A washing machine has an electric motor and an electric heater. Fig. 7.1 shows a simplified circuit diagram for the washing machine.

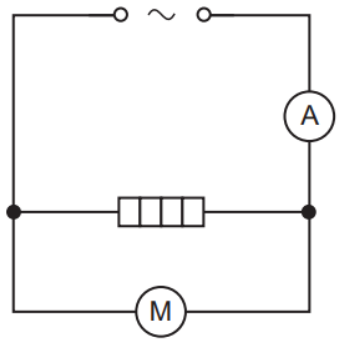


Fig. 7.1

The heater has a resistance of 25 Ω and the power supply has an electromotive force (e.m.f.) of 230 V.

(a) State the meaning of electromotive force.

.....

..... [2]

(b) State the potential difference (p.d.) across the heater.

p.d. = ... [1]

(c) Calculate the current in the heater.

Current = ... [2]

(d) The current in the motor is 1.6 A.
Determine the reading on the ammeter in Fig. 7.1. Explain your answer. **(extended only)**

Ammeter reading .....

Explanation .....

.....

[2]

[Total: 7]

15 Fig. 6.1 shows an isolated metal sphere suspended by an insulating thread from the ceiling.

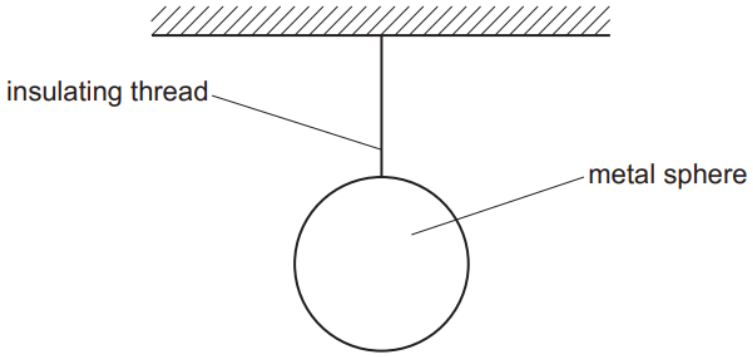


Fig. 6.1

The sphere is negatively charged.

(a) The charge on the sphere produces an electric field in the surroundings.

(i) State what is meant by 'electric field'. **(extended only)**

.....

..... [1]

(ii) Draw on Fig. 6.1 to show the pattern and direction of the electric field produced by the charge on the sphere. Draw at least **four** lines. [3]

(b) The magnitude of the charge on the sphere is 3.5×10^{-10} C.

An earthed metal wire is touched against the surface of the sphere and the sphere is discharged.

(i) State what happens in the wire as the sphere is discharged. **(extended only)**

.....

.....

..... [2]

(ii) It takes a time of 0.14 ns for the sphere to discharge completely. **(extended only)**

Calculate the average current in the earthed wire as the sphere discharges.

average current = ... [3]

[Total: 9]

16 **(a)** A plastic rod is uncharged.

When the rod is rubbed with a woollen cloth, the rod becomes negatively charged.

Explain, in terms of particles, why the rod becomes negatively charged.

.....

.....

..... [2]

(b) Fig. 7.1 shows a negatively charged metal sphere S.

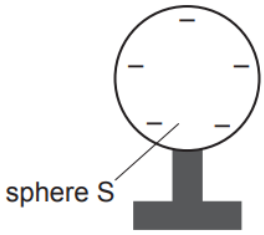


Fig. 7.1

There is an electric field surrounding S.

(i) State what is meant by an electric field. **(extended only)**

.....

..... [1]

(ii) On Fig. 7.1, draw the pattern of the electric field surrounding sphere S and indicate its direction. **(extended only)** [2]

(c) Fig. 7.2 shows a small negative charge Z placed near to sphere S. **(extended only)**

Fig. 7.2

Charge Z experiences a force due to the electric field surrounding S.

On Fig. 7.2, draw an arrow to show the direction of this force on Z. [1]

[Total: 6]

17 A cylinder is made of modelling clay. The modelling clay is an electrical conductor.

Fig. 8.1 shows the cylinder.

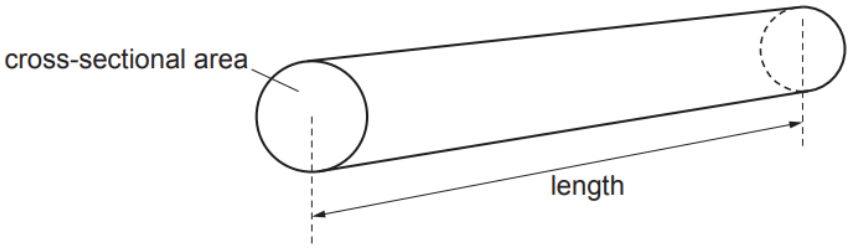


Fig. 8.1

The cylinder is connected into a circuit.

Fig. 8.2 shows that the circuit also includes a battery of electromotive force (e.m.f.) 9.0 V and a resistor P.

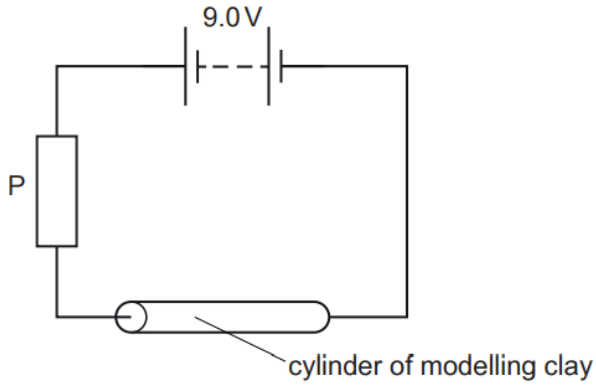


Fig. 8.2

The resistance of P is 4.0 Ω. The current in P is 1.5 A.

(a) Calculate:

(i) the magnitude *X* of the charge that flows through P in 600 s **(extended only)**

X = ... [2]

(ii) the resistance of the cylinder of modelling clay.

resistance = ... [3]

(b) The cylinder is removed from the circuit and replaced with a new cylinder made of the same modelling clay. **(extended only)**

The new cylinder is twice the length and has half the cross-sectional area of the first cylinder.

Calculate the time that it now takes for a charge of magnitude *X* to flow through resistor P.

time = ... [4]

[Total: 9]

18 Fig. 6.1 shows the circuit diagram for a flashlight (torch).

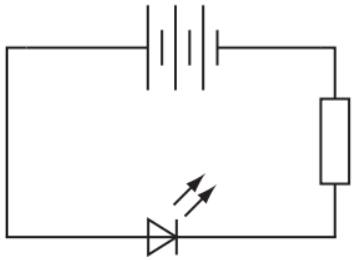


Fig. 6.1

The electromotive force (e.m.f.) of the battery is 4.5 V. The circuit contains a 60 Ω fixed resistor. The current in the light-emitting diode (LED) is 0.020 A.

(a) Calculate the potential difference (p.d.) across the LED. **(extended only)**

p.d. = ... [2]

(b) Explain why the LED does **not** light up if the battery is reversed. **(extended only)**

.....

..... [1]

(c) The chemical energy stored in the battery is 1050 J. **(extended only)**

Show that the flashlight operates for approximately 3 h.

[2]

(d) Calculate the total charge that flows through the LED in 3600 s. **(extended only)**

charge = ... [2]

[Total: 7]

19 **(a)** **(i)** State what is meant by a magnetic field.

.....

..... [1]

(ii) Define the direction of a magnetic field.

.....

..... [1]

(b) Fig. 8.1 shows a negatively charged metal sphere. **(extended only)**

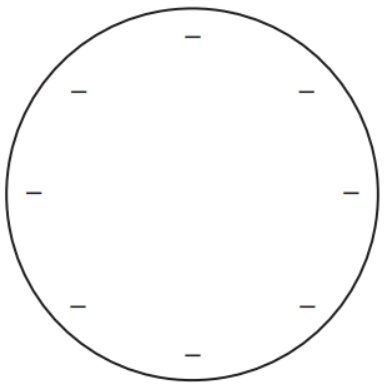


Fig. 8.1

On Fig. 8.1, draw **four** lines to show the electric field and its direction. [2]

20 Fig. 8.1 shows an electrical circuit.

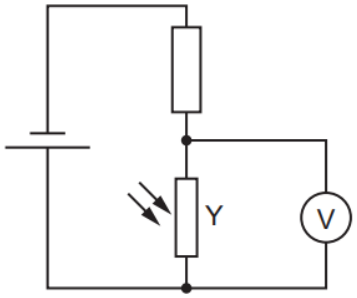


Fig. 8.1

(a) The light intensity at the circuit increases from dark to bright.

State any effect on the resistance of component Y.

.....

State and explain any effect on the reading of the voltmeter.

.....

.....

[3]

(b) The circuit shown in Fig. 8.2 is switched on for 2.0 min.

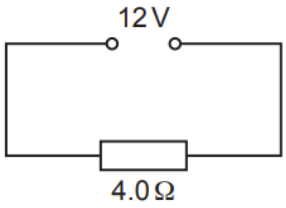


Fig. 8.2

The current in the 4.0 Ω resistor is 3.0 A and the magnitude of the charge on an electron is 1.6×10^{-19} C.

(i) Calculate the number of electrons that pass through the resistor each second. **(extended only)**

number = ... [3]

(ii) Calculate the power dissipated by the resistor.

power = ... [2]

[Total: 8]

21 Fig. 8.1 shows how the electromotive force (e.m.f.) of a 60 Hz alternating current (a.c.) power supply varies with time.

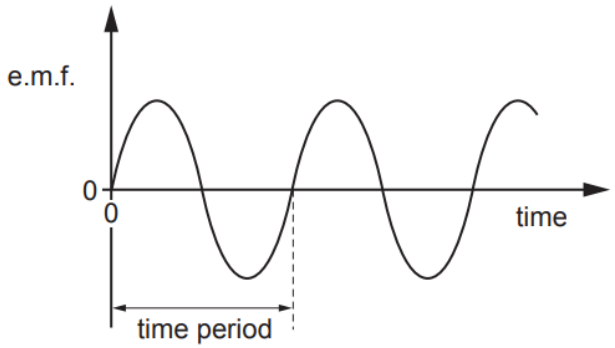
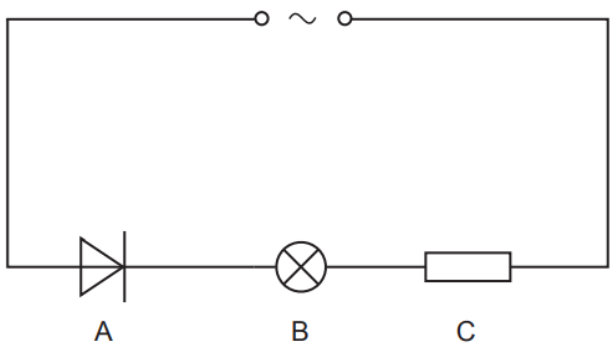


Fig. 8.1

(a) Calculate the time period of the a.c.

time period = ... [1]

(b) Fig. 8.2 shows this power supply connected in a circuit.



(i) State the name of component A.
(extended only)

..... [1]

(ii) In each time period of the a.c., 1.5×10^{17} electrons pass through component A. The charge on an electron is 1.6×10^{-19} C. **(extended only)**

Calculate the average current in the circuit during one time period.

current = ... [3]

(c) On Fig. 8.3: **(extended only)**

1. mark, with an arrow labelled E, the direction of the electron flow through component B

2. mark, with an arrow labelled I, the direction of the conventional current in component C.

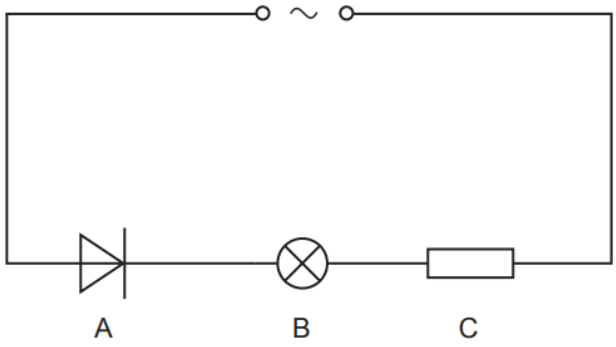


Fig. 8.3

[2]

(d) Fig. 8.4 shows a circuit with components B and C connected to a direct current (d.c.) power supply of e.m.f. 12 V.

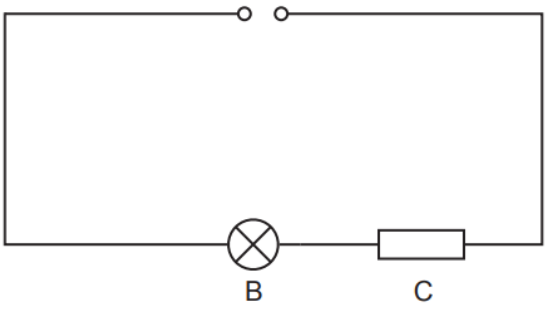


Fig. 8.4

The current in the circuit is 0.35 A.

Calculate the power delivered by the power supply to the circuit.

power = ... [2]

[Total: 9]

22 A plastic rod becomes negatively charged when it is rubbed with a woollen cloth.

(a) Describe, in terms of particles, how the rod becomes negatively charged when rubbed with the cloth.

.....

.....

..... [2]

(b) A light, conducting ball is at rest on a metal table. When the rod is brought close to the ball, as shown in Fig. 7.1, the ball jumps up towards the rod.

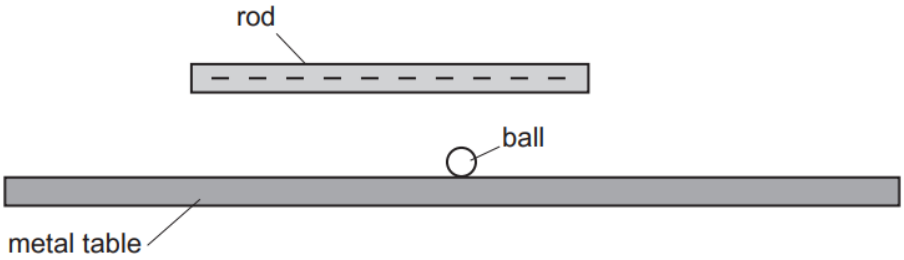


Fig. 7.1

(i) Explain why the ball jumps up.

.....

.....

.....

..... [3]

(ii) The ball touches the rod and falls back down to the table.

Explain why this happens.

.....

.....

..... [2]

[Total: 7]

23 **(a)** Fig. 8.1 shows a conducting object A, initially uncharged, held on an insulating stand. The positively charged rod B is brought close to object A.

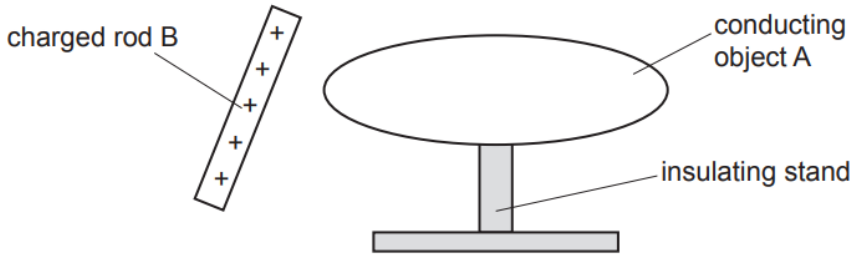


Fig. 8.1

(i) On Fig. 8.1, draw the distribution of charges on object A. [2]

(ii) A wire is connected from object A to earth.

State and explain any movement of charge.

statement .....

explanation .....

.....

.....

[2]

(b) There is a current in a wire of 0.65 mA for 2.2 minutes. **(extended only)**

Calculate the charge that flows.

charge = ... [3]

[Total: 7]

24 **(a)** Fig. 9.1 shows a circuit. **(extended only)**

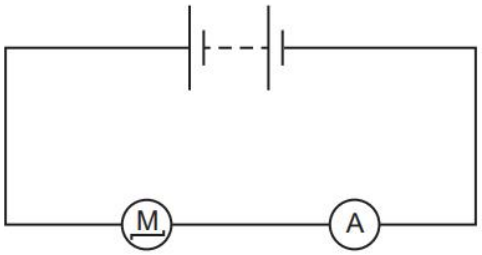


Fig. 9.1

On Fig. 9.1, draw **two** clearly labelled arrows to show the direction of the electron flow and the direction of the conventional current in the circuit. [2]

(b) The current in the motor is 13A. The charge on an electron is 1.6×10^{-19}C. **(extended only)**

Calculate the number of electrons that pass through the motor every second.

number of electrons = ... [3]

[Total: 5]

25 Fig. 7.1 shows three identical lamps and an ammeter connected to a power supply.

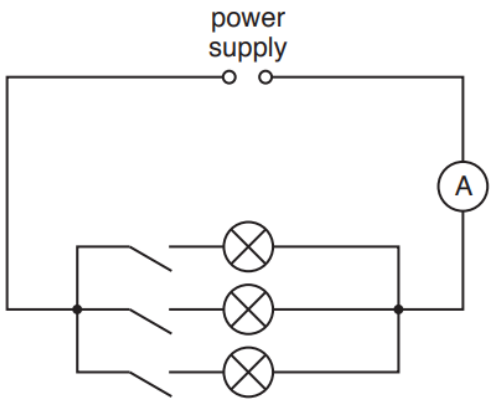


Fig. 7.1

The switches are closed. Each lamp is rated at 60 W and operates at its normal working voltage of 110 V.

(a) Calculate:

(i) the current in each lamp

current = ...[2]

(ii) the current in the ammeter **(extended only)**

current = ...[1]

(iii) the voltage of the power supply. **(extended only)**

voltage = ...[1]

(b) (i) Calculate the resistance of the filament of one of the lamps when working normally.

resistance = ...[2]

(ii) Another lamp X has a filament with twice the resistance of each lamp in the circuit of Fig. 7.1. The material and the temperature of the filament in lamp X is the same as the filaments in the lamps in Fig. 7.1. **(extended only)**

In Table 7.1, tick any box in the right-hand column that shows a possible difference between the filament of lamp X and a filament of one of the lamps in the circuit.

Table 7.1

X has half the length	
X has twice the length	
X has one quarter the area of cross-section	
X has half the area of cross-section	
X has two times the area of cross-section	
X has four times the area of cross-section	

[2]

[Total: 8]