上海光華學院劍橋國際中心（光華劍橋）
Guanghua Cambridge International School

Cambridge IGCSE/G2 PHYSICS

Structured Questions

Volume IGCSE/G2

IV Electricity and Magnetism
V Nuclear Physics
VI Space Physics

Cambridge IGCSE/G2 PHYSICS

Structured Questions

Grading Table

Topic	HW #	Max	Earned	Penalties	Grade	Comment
	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
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	24					

Preface

This book covers the entire syllabus of CIE Physics for IGCSE level.The main task of this book is to help you to test your understanding and prepare for the examinations.

This book has been written specifically for a student of Cambridge's 0625 syllabus by an experienced team with examiners who are very familiar with the syllabus and examinations.

All of the questions are chosen from past papers. When tacking questions, it is a good idea to make a first attempt without referring to your textbook or to your notes. This will help to reveal any gap in your understanding. By sorting out any problems at early stage you will progress faster.

We hope that this book will help you to succeed in examinations and we also hope you will learn from the past to take physics to ever greater heights.

Changes for the 2023-2025 Syllabus

Note that many of the questions are taken from past syllabuses which, on occasion, might contain subject material removed from later incanations of the syllabus. These questions have not been removed from this book; rather, they have been mark with an open right bracket, as shown in the example below.

1 A thermocouple is used to measure the temperature of the inner wall of a pottery kiln.

(a) In the space below, draw a labelled diagram of a thermocouple that could be used for this purpose.

[2]

Questions marked as such can be ignored, insofar as the 2023-2025 examinations are concerned.

At the same time, some content has been added to the 2023-2025 syllabus. Attempts have been made to include questions coving this new material. Note that students can also consult the 2023-2025 texbook for further sample problems.

Several of these additional problems were taken from OpenStax, Rice University, 2020, under Creative Commons liscensing.

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Part IV
Electricity and magnetism

Chapter 16. Magnetism

4.1 Simple phenomena of magnetism

Core

1 Describe the forces between magnetic poles and between magnets and magnetic materials, including the use of the terms north pole (N pole), south pole (S pole), attraction and repulsion, magnetised and unmagnetised

2 Describe induced magnetism

3 State the differences between the properties of temporary magnets (made of soft iron) and the properties of permanent magnets (made of steel)

4 State the difference between magnetic and non-magnetic materials

5 Describe a magnetic field as a region in which a magnetic pole experiences a force

6 Draw the pattern and direction of magnetic field lines around a bar magnet

7 State that the direction of a magnetic field at a point is the direction of the force on the N pole of a magnet at that point

8 Describe the plotting of magnetic field lines with a compass or iron filings and the use of a compass to determine the direction of the magnetic field

9 Describe the uses of permanent magnets and electromagnets

Supplement

10 Explain that magnetic forces are due to interactions between magnetic fields

11 Know that the relative strength of a magnetic field is represented by the spacing of the magnetic field lines

1 **(a)** State two advantages that electromagnets have, compared with permanent magnets.

1. ....

2. .... [2]

(b) Tick one box in each of the columns below, to indicate what should be used to give the strongest electromagnet.

column 1 number of turns on coil	column 2 type of core	column 3 current
1000 turns ☐	air ☐	3.0 A ☐
500 turns ☐	plastic ☐	2.0 A ☐
250 turns ☐	iron ☐	1.0 A ☐

[2]

[Total: 4]

2 **(a)** Magnets A and B, shown in Fig. 9.1, attract each other.

Fig. 9.1

The S pole of magnet A has been marked.

On Fig. 9.1, mark the polarities of the other poles, using the letters N or S. [1]

(b) A soft-iron rod and a steel rod each have coils around them. Both rods are initially unmagnetised. The coils are attached to circuits, as shown in Fig. 9.2.

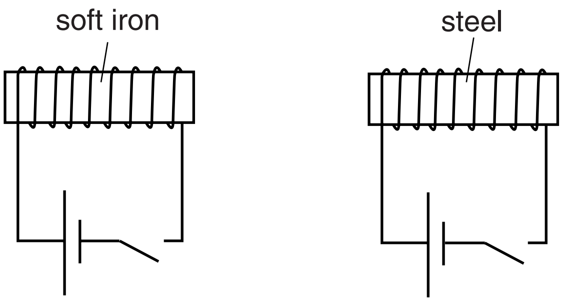


Fig. 9.2

(i) Use the following statements to complete the table referring to the soft-iron rod and the steel rod shown in Fig. 9.2.

magnetised **loses its magnetism** **keeps its magnetism**

	switch closed	switch open
soft iron		
steel		

[2]

(ii) Which words apply to the force between the rods when the switches are closed?

Tick one box.

no force ☐

attractive force ☐

repulsive force ☐ [1]

(iii) Which of the two arrangements in Fig. 9.2 would be used as the electromagnet on the crane in a scrap-metal yard?

....[1]

(iv) State one advantage that an electromagnet could have in comparison with a similar-sized permanent magnet.

....

....[1]

[Total: 6]

3 **(a)** State what is meant by magnetic field strength.

....

.... [2]

(b) State what is meant by magnetic field direction.

....

.... [2]

(c) Explain how iron filings could be used to map out magnetic field lines.

....

....

....

....

....

....

....

....

....

[4]

[Total: 6]

4 Describe how the interaction between magnetic poles could be studied experimentally. Include skethes and disgrams, where appropropriate.

....

....

....

....

....

....

....

....

....

[Total: 6]

Chapter 17. Static electricity

4.2.1 Electric charge

Core

1 State that there are positive and negative charges
2 State that positive charges repel other positive charges, negative charges repel other negative charges, but positive charges attract negative charges
3 Describe simple experiments to show the production of electrostatic charges by friction and to show the detection of electrostatic charges
4 Explain that charging of solids by friction involves only a transfer of negative charge (electrons)
5 Describe an experiment to distinguish between electrical conductors and insulators
6 Recall and use a simple electron model to explain the difference between electrical conductors and insulators and give typical examples

Supplement

7 State that charge is measured in coulombs
8 Describe an electric field as a region in which an electric charge experiences a force
9 State that the direction of an electric field at a point is the direction of the force on a positive charge at that point
10 Describe simple electric field patterns, including the direction of the field:
(a) around a point charge
(b) around a charged conducting sphere
(c) between two oppositely charged parallel conducting plates (end effects will **not** be examined)

17.1 Explaining static charge

1 **(a)** State the law of attraction and repulsion between electrostatic charge, including charge sign

....

....

.... [2]

(b) Sometimes, when people have been riding in a car, they get an electric shock from the door handle as they get out of the car.

Suggest why this happens.

....

....

.... [2]

(c) A plastic rod is rubbed with a cloth and becomes positively charged. After charging, the rod is held close to the suspended table-tennis ball shown in Fig. 8.1. The table-tennis ball is covered with metal paint and is initially uncharged.

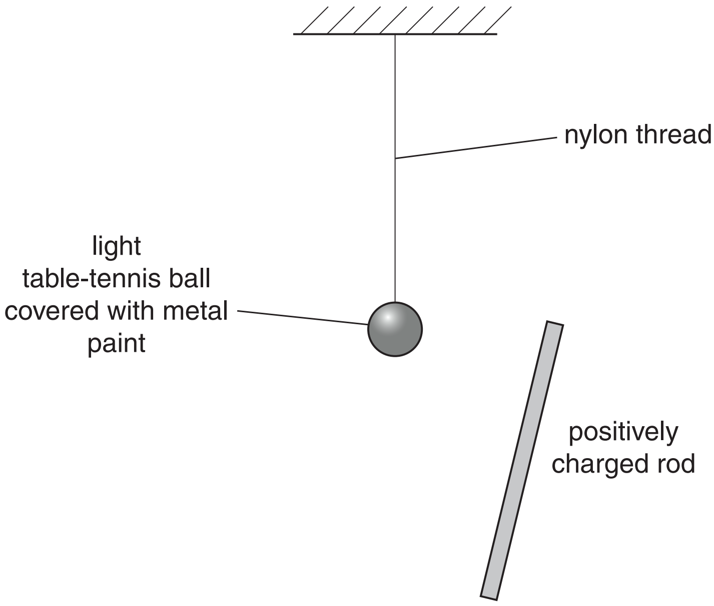


Fig. 8.1

(i) Describe what happens to the charges on the metal-painted table-tennis ball as the positively-charged rod is brought close to the ball.

....

....

.... [1]

(ii) The ball is attracted towards the charged rod.

Explain why this happens, whlst making refererence to charge conservation.

....

....

....

.... [3]

(iii) When it is a few centimetres away from the rod, the ball is briefly touched by a wire connected to earth.

In terms of the movement of charges, describe what happens to the charge on the ball.

....

.... [2]

[Total: 9]

2 In Fig. 9.1, A and B are two conductors on insulating stands. Both A and B were initially uncharged.

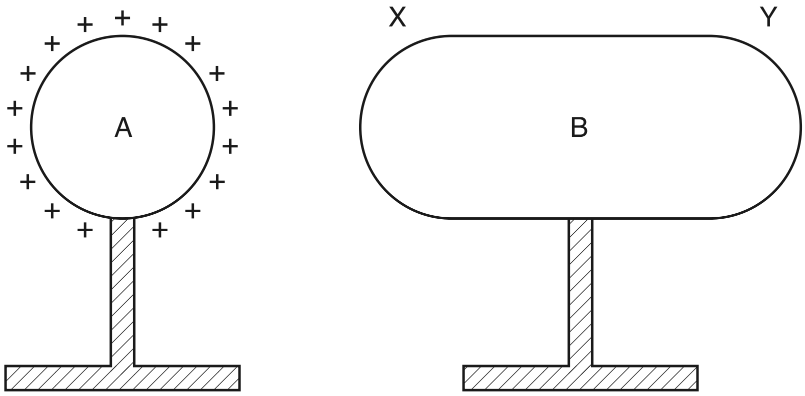


Fig. 9.1

(a) Conductor A is given the positive charge shown on Fig. 9.1.

(i) On Fig. 9.1, mark the signs of the charges induced at end X and at end Y of conductor B. [1]

(ii) Explain how these charges are induced.

....

....

.... [3]

(iii) Explain why the charges at X and at Y are equal in magnitude.

....

....

.... [1]

(b) B is now connected to earth by a length of wire.

Explain what happens, if anything, to

(i) the charge at X,

....

.... [1]

(ii) the charge at Y.

....

.... [2]

[Total: 8]

3 **(a)** In Fig. 8.1, S is a metal sphere standing on an insulating base. R is a negatively charged rod placed close to S.

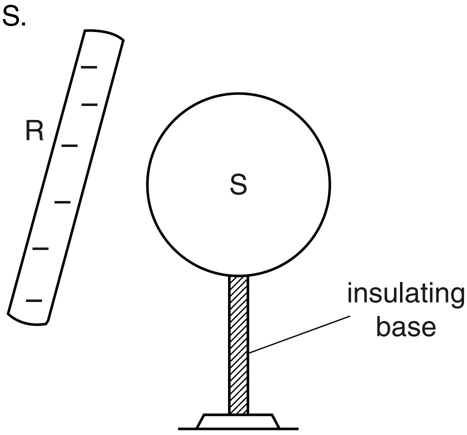


Fig. 8.1

(i) Name the particles in S that move when R is brought close to S.

.... [1]

(ii) On Fig. 8.1, add + signs and – signs to suggest the result of this movement. [1]

(iii) Describe the actions which now need to take place so that S becomes positively charged with the charge distributed evenly over its surface. A positively charged object is **not** available.

....

....

.... [3]

(b) During a thunderstorm, the potential difference between thunderclouds and the ground builds up to 1.5×10^6 V. In each stroke of lightning, 30 C of charge passes between the thunderclouds and the ground. Lightning strokes to the ground occur, on average, at 2 minute intervals.

Calculate

(i) the average current between the thunderclouds and the ground,

average current = ... [2]

(ii) the energy transferred in each stroke of lightning.

energy = ... [2]

4 **(a)** Fig. 7.1 shows a conducting sphere A, initially uncharged, mounted on an insulating base. The positively-charged, non-conducting sphere B is brought close to sphere A without touching the sphere.

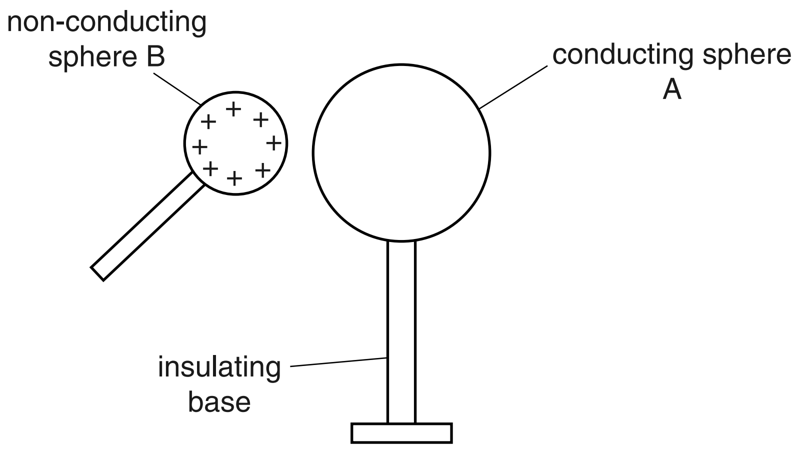


Fig. 7.1

(i) On Fig. 7.1, draw the resulting distribution of any positive and negative charges on sphere A. [2]

(ii) The sphere A is now earthed as shown in Fig. 7.2.

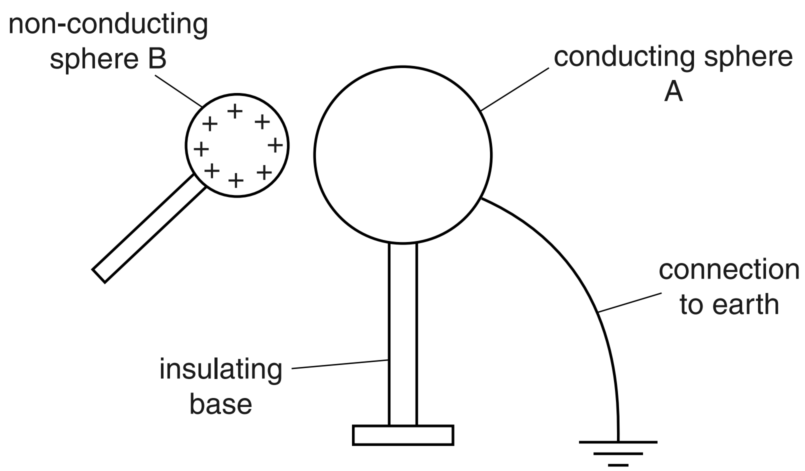


Fig. 7.2

On Fig. 7.2, draw the distribution of any positive and negative charges on sphere A after it is earthed. [1]

(b) (i) On Fig. 7.3, draw lines of force with direction arrows to represent the electric field pattern in the plane of the paper around a negative point charge at point X.

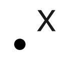


Fig. 7.3

(ii) State what is represented by the directions of the arrows on the lines.

....

....
[2]

[Total: 5]

5 **(a)** A student rubs one side of an inflated balloon on her hair. This side of the balloon becomes positively charged. Explain this.

....

....

.... [2]

(b) The charged side of the balloon is now brought close to a stream of water flowing from a pipe. The original position of the stream of water is shown in Fig. 8.1.

On Fig. 8.1, write in the boxes to indicate how each side of the stream of water is electrically charged.

Choose your answer in each case from: positive, negative or neutral.

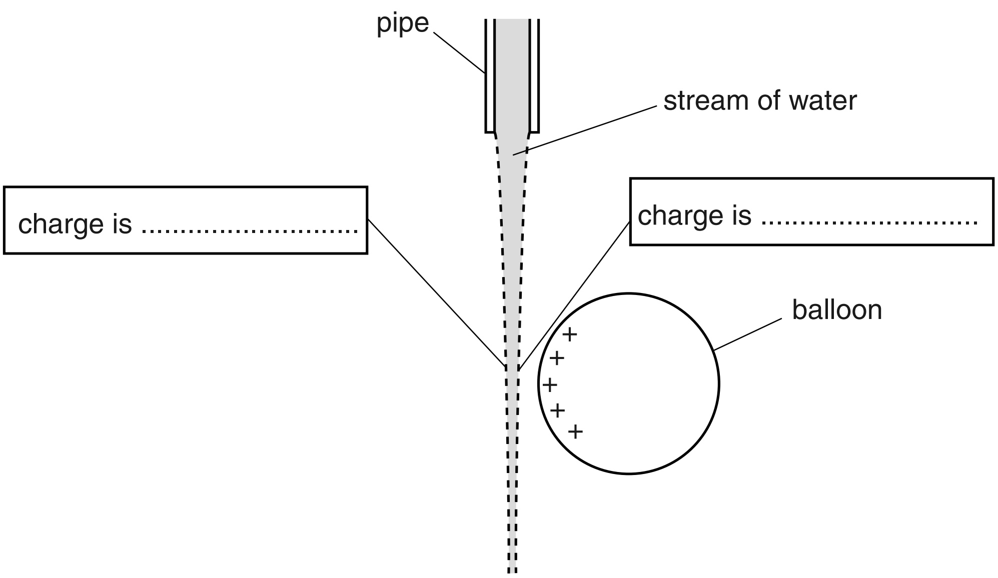


Fig. 8.1

[2]

(c) On Fig. 8.1, draw the new position of the stream of water. Explain this new position.

....

....

....

.... [2]

(d) Explain why rubbing one side of a metal sphere does not cause it to become charged.

....

.... [1]

[Total: 7]

17.2 Electrical force

1 Fig. 9.1 shows a beam of electrons, two charged plates and a screen. These components are inside an electron tube, the outline of which is not shown.

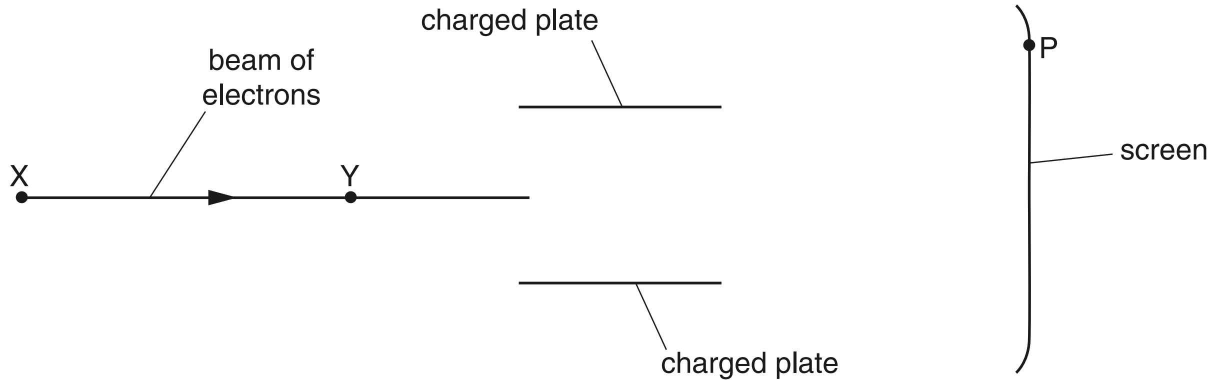


Fig. 9.1

The beam of electrons hits the screen at the point P.

(a) On Fig. 9.1,

(i) complete the path of the electron beam,

(ii) mark the charges on both plates,

(iii) mark with an arrow and the letter C the direction of the conventional current in the electron beam.

[4]

(b) In this electron tube, the electrons are produced at X and are accelerated towards Y.
In the space below, draw a labelled diagram of the components needed to produce and accelerate the electrons. [4]

2 **(a)** Fig. 9.1 shows how a beam of electrons would be deflected by an electric field produced between two metal plates.
The connections of the source of high potential difference are not shown.

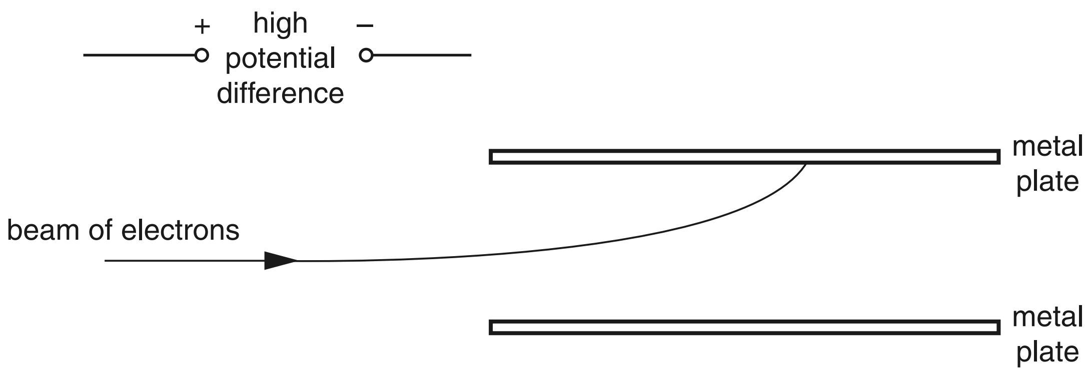


Fig. 9.1

(i) On Fig. 9.1, draw in the missing connections.

(ii) Explain why the beam of electrons is deflected in the direction shown. In your answer, consider all the charges involved and their effect on each other.

....

....

....

.... [5]

(b) The deflection of a beam of electrons by an electric field is used in cathode-ray oscilloscopes.

(i) What makes the electron beam move backwards and forwards across the screen?

....

....

(ii) What makes the electron beam move up and down the screen?

....

.... [2]

(c) An a.c. waveform is displayed so that two full waves appear on the screen of a cathode-ray oscilloscope.

Fig. 9.2 shows the face of the oscilloscope. On Fig. 9.2, draw in the waveform.

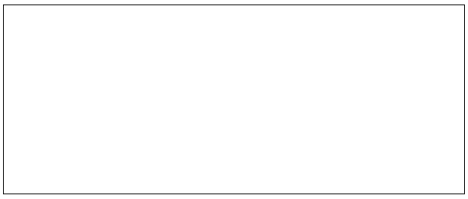


Fig. 9.2

[1]

Chapter 18. Electrical quantities

4.2.2 Electric current

Core

1 Know that electric current is related to the flow of charge

2 Describe the use of ammeters (analogue and digital) with different ranges

3 Describe electrical conduction in metals in terms of the movement of free electrons

4 Know the difference between direct current (d.c.) and alternating current (a.c.)

Supplement

5 Define electric current as the charge passing a point per unit time; recall and use the equation

$$I = \frac{Q}{t}$$

6 State that conventional current is from positive to negative and that the flow of free electrons is from negative to positive

4.2.3 Electromotive force and potential difference

Core

1 Define electromotive force (e.m.f.) as the electrical work done by a source in moving a unit charge around a complete circuit

2 Know that e.m.f. is measured in volts (V)

3 Define potential difference (p.d.) as the work done by a unit charge passing through a component

4 Know that the p.d. between two points is measured in volts (V)

5 Describe the use of voltmeters (analogue and digital) with different ranges

Supplement

6 Recall and use the equation for e.m.f.

$$E = \frac{W}{Q}$$

7 Recall and use the equation for p.d.

$$V = \frac{W}{Q}$$

4.2.4 Resistance

Core

1 Recall and use the equation for resistance

$$R = \frac{V}{I}$$

2 Describe an experiment to determine resistance using a voltmeter and an ammeter and do the appropriate calculations

3 State, qualitatively, the relationship of the resistance of a metallic wire to its length and to its cross-sectional area

Supplement

4 Sketch and explain the current–voltage graphs for a resistor of constant resistance, a filament lamp and a diode

5 Recall and use the following relationship for a metallic electrical conductor:

(a) resistance is directly proportional to length

(b) resistance is inversely proportional to cross-sectional area

4.2.5 Electrical energy and electrical power

Core

1. Understand that electric circuits transfer energy from a source of electrical energy, such as an electrical cell or mains supply, to the circuit components and then into the surroundings
2. Recall and use the equation for electrical power
   $P = IV$
3. Recall and use the equation for electrical energy
   $E = IVt$
4. Define the kilowatt-hour (kW h) and calculate the cost of using electrical appliances where the energy unit is the kW h

Supplement

1 **(a)** Two non-conducting spheres, made of different materials, are initially uncharged. They are rubbed together. This causes one of the spheres to become positively charged and one negatively charged.

Describe, in terms of electron movement, why the spheres become charged.

....

....

.... [2]

(b) Once charged, the two spheres are separated, as shown in Fig. 7.1.

Fig. 7.1

On Fig. 7.1, draw the electric field between the two spheres. Indicate by arrows the direction of the electric field lines. [2]

(c) A conducting wire attached to a negatively charged metal object is connected to earth. This allows 2.0×10^{10} electrons, each carrying a charge of 1.6×10^{-19} C, to flow to earth in 1.0×10^{-3} s.

Calculate

(i) the total charge that flows,

charge ....

(ii) the average current in the wire.

current ....

[3]

2 Fig. 7.1 shows an arrangement that could be used for making an electromagnet or a permanent magnet.

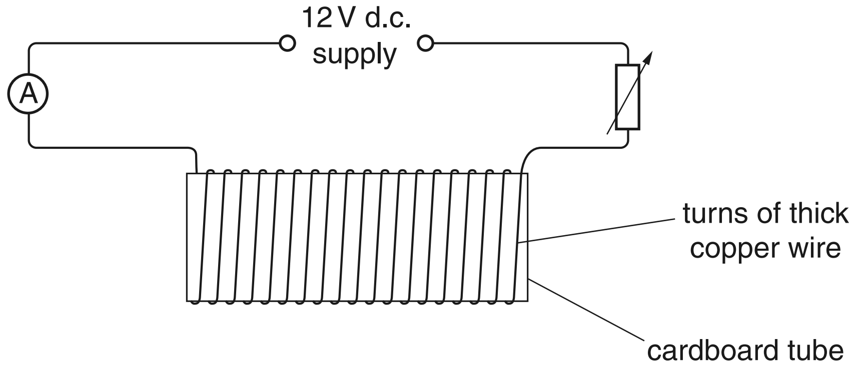


Fig. 7.1

Two bars of the same size are also available, one made of iron and the other of steel.

(a) **(i)** State which bar should be used to make a permanent magnet.

....

(ii) Describe how the apparatus would be used to make a permanent magnet.

....

....

....

(iii) Suggest one reason why the circuit contains an ammeter and a variable resistor.

....

....

[3]

(b) During the making of a permanent magnet, the ammeter reads a steady current of 4.0 A throughout the 5.0 s that the current is switched on. The voltage of the supply is 12 V.

Calculate

(i) the total circuit resistance,

resistance = ...

(ii) the power of the supply,

power = ...

(iii) the energy supplied during the 5.0 s.

energy = ...
[6]

(c) The potential difference across the variable resistor is 7.0 V and that across the ammeter is zero.

(i) Calculate the potential difference across the magnetising coil.

potential difference = ...

(ii) State the general principle used in making this calculation.

....

....
[3]

3 Fig. 8.1 shows a battery with a resistor connected across its terminals. The e.m.f. of the battery is 6.0 V.

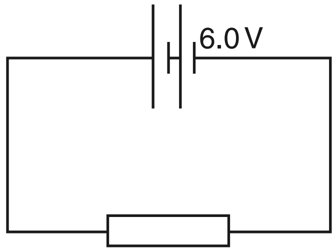


Fig. 8.1

The battery causes 90 C of charge to flow through the circuit in 45 s.

(a) Calculate

(i) the current in the circuit,

current = ...

(ii) the resistance of the circuit,

resistance = ...

(iii) the electrical energy transformed in the circuit in 45 s.

energy = ...
[6]

(b) Explain what is meant by the term *e.m.f. of the battery*.

....

....

....[2]

4 Fig. 10.1 shows a battery with an e.m.f of 12 V supplying power to two lamps.

The total power supplied is 150 W when both lamps are on.

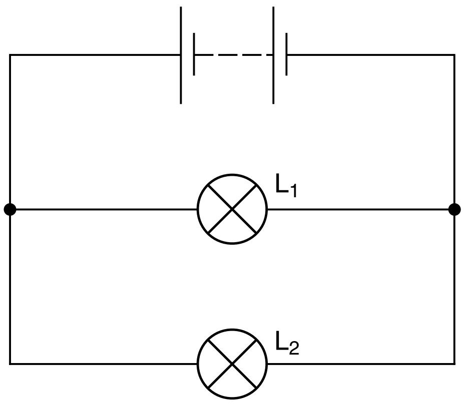


Fig. 10.1

(a) Calculate the current supplied by the battery when both lamps are on.

current = ... [2]

(b) The current in lamp L_2 is 5.0 A.

Calculate

(i) the current in lamp L_1,

current = ...

(ii) the power of lamp L_1,

power = ...

(iii) the resistance of lamp L_1.

resistance = ...
[6]

5 **(a)** Fig. 10.1 shows a positively charged plastic rod, a metal plate resting on an insulator, and a lead connected to earth.

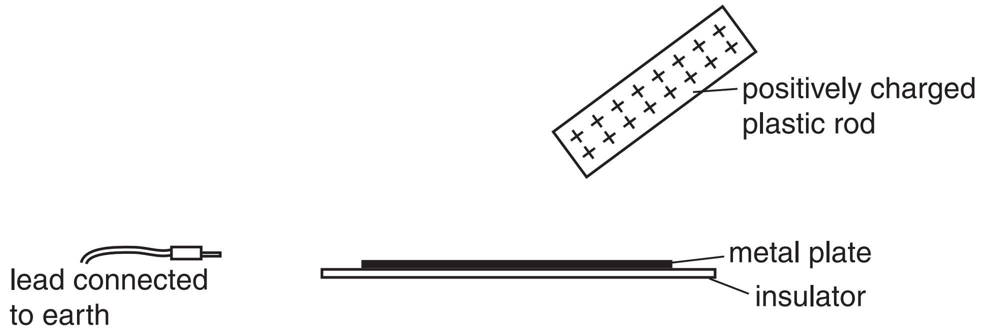


Fig. 10.1

Describe how the metal plate may be charged by induction.

....

....

....[3]

(b) An electrostatic generator sets up a current of 20 mA in a circuit.

Calculate

(i) the charge flowing through the circuit in 15 s,

charge = ...

(ii) the potential difference across a 10 kΩ resistor in the circuit.

potential difference = ...

[3]

6 **(a)** A coil of wire is connected into a circuit containing a variable resistor and a battery.

The variable resistor is adjusted until the potential difference across the coil is 1.8 V.

In this condition, the current in the circuit is 0.45 A.

Calculate

(i) the resistance of the coil,

resistance = ... [1]

(ii) the thermal energy released from this coil in 9 minutes.

energy released = ... [3]

(b) The coil in part **(a)** is replaced by one made of wire which has half the diameter of that in **(a)**.

When the potential difference across the coil is again adjusted to 1.8 V, the current is only 0.30 A.

Calculate how the length of wire in the second coil compares with the length of wire in the first coil.

length of wire in second coil is .... the length of wire in first coil [4]

[Total: 8]

7 When he leaves work at 6.30 p.m. (18:30) one evening, a caretaker forgets to switch off the 100 W lamp in his office. He doesn't discover this until he returns at 7.30 a.m. (07:30) the next morning.

The mains electricity supply is 250 V.

(a) Calculate how much energy the caretaker has wasted.

energy wasted = ... [2]

(b) Calculate the charge that passed through the lamp during this time.

charge = ... [3]

(c) What happened to the energy wasted by the lamp?

....

.... [1]

[Total: 6]

8 Fig. 7.1 shows how the resistance of the filament of a lamp changes as the current through the lamp changes.

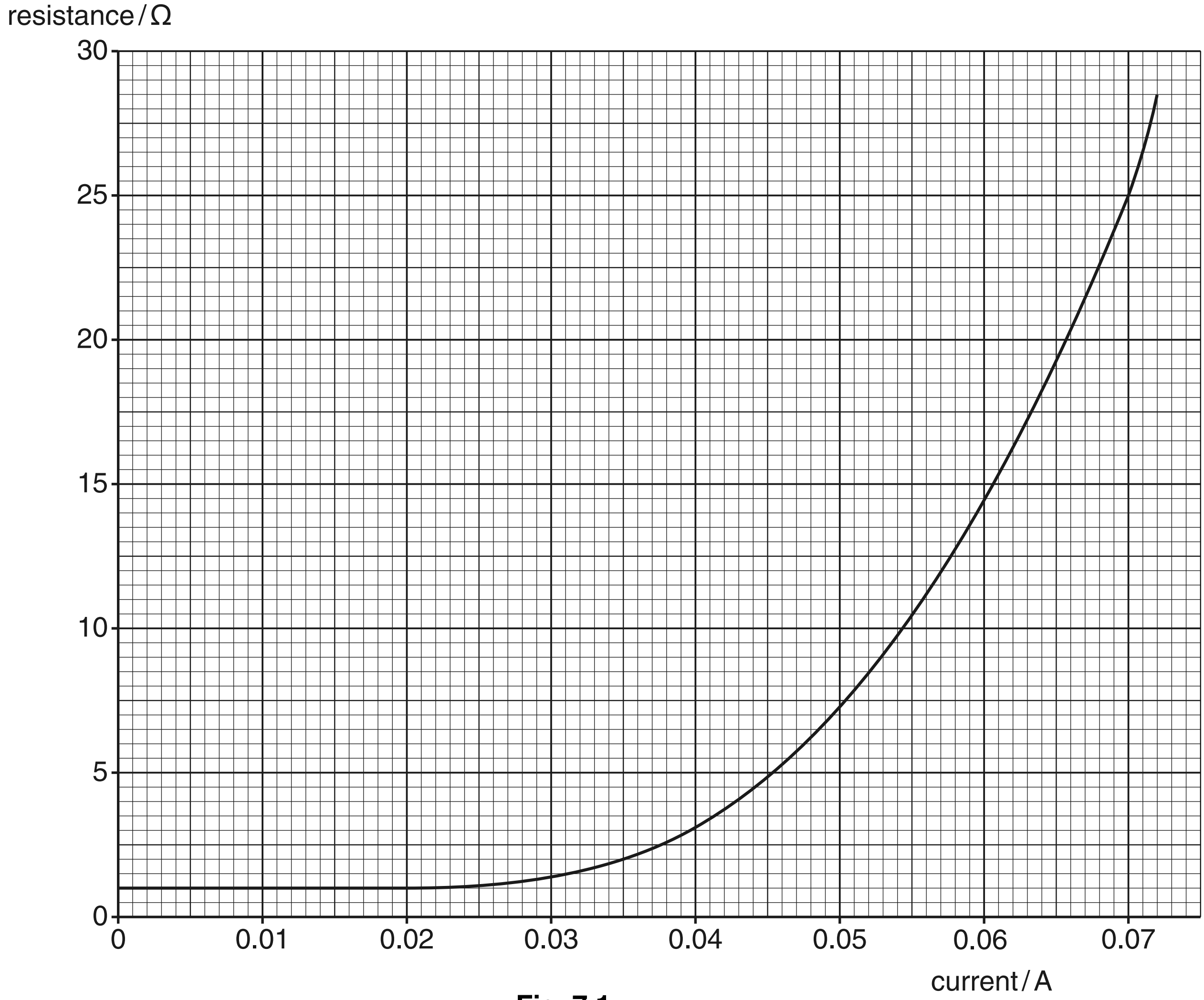


Fig. 7.1

(a) Describe how the resistance of the lamp changes.

....

....

.... [2]

(b) For a current of 0.070 A, find

(i) the resistance of the lamp,

resistance = ... [1]

(ii) the potential difference across the lamp,

potential difference = ... [2]

(iii) the power being dissipated by the lamp.

power = ... [2]

(c) Two of these lamps are connected in parallel to a cell. The current in each lamp is 0.070 A.

(i) State the value of the e.m.f. of the cell.

e.m.f. = ... [1]

(ii) Calculate the resistance of the circuit, assuming the cell has no resistance.

resistance = ... [2]

[Total: 10]

9 The graphs in Fig. 9.1 show the relation between the current I and the potential difference V for a resistor and a lamp.

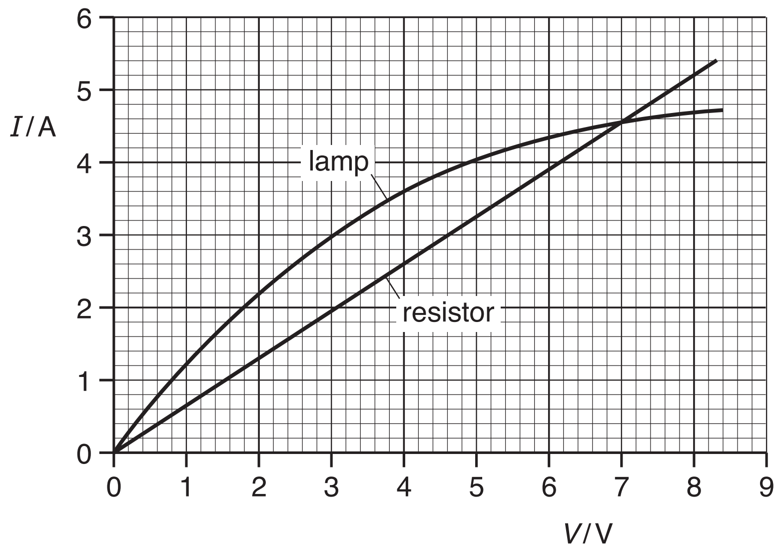


Fig. 9.1

(a) **(i)** Describe how, if at all, the resistance varies as the current increases in

1. the resistor, ...

2. the lamp. ....[2]

(ii) State the value of the potential difference when the resistor and the lamp have the same resistance.

potential difference = ...[1]

(b) The two components are connected **in parallel** to a supply of e.m.f. 4.0 V. Calculate the total resistance of the circuit.

total resistance = ...[4]

[Total: 7]

10 **(a)** Explain how d.c. and a.c. current sources differ, making reference to electron motion.

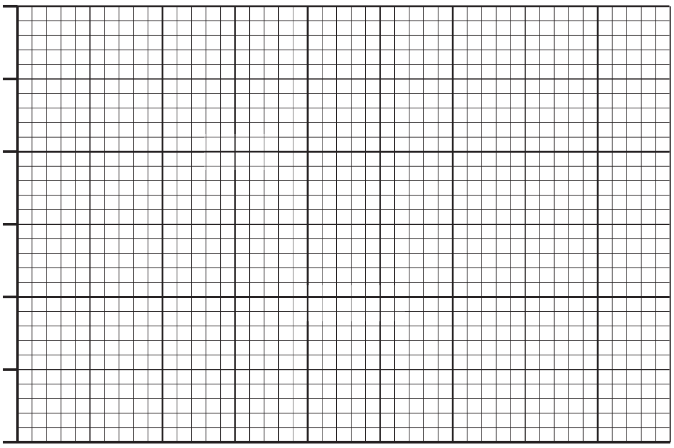
....

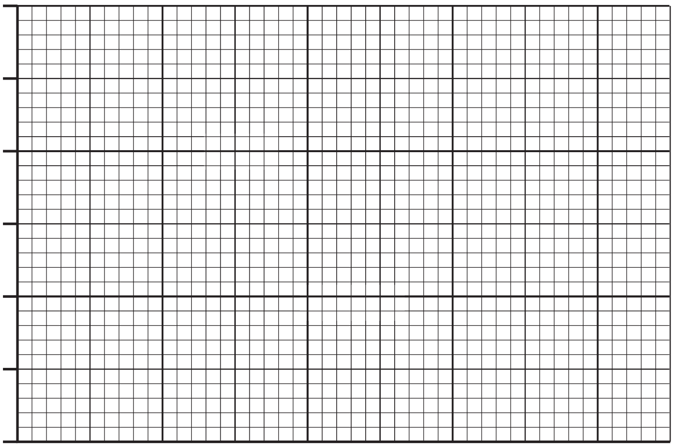
....

....

....[3]

(b) Sketch two properly labelled possible graphs of current versus time for both a.c. and d.c., where peak voltage is +5 V for each.





[5]

[Total: 8]

11 **(a)** State what is meant by potential difference, providing an equation, with all symbols named.

....

....

....

....[3]

(b) State what is meant by electromotive force, providing an equation, with all symbols named.

....

....

....

....[3]

[Total: 6]

Chapter 19. Electrical circuits

4.3.1 Circuit diagrams and circuit components

Core

1 Draw and interpret circuit diagrams containing cells, batteries, power supplies, generators, potential dividers, switches, resistors (fixed and variable), heaters, thermistors (NTC only), light-dependent resistors (LDRs), lamps, motors, ammeters, voltmeters, magnetising coils, transformers, fuses and relays, and know how these components behave in the circuit

Supplement

2 Draw and interpret circuit diagrams containing diodes and light-emitting diodes (LEDs), and know how these components behave in the circuit

4.3.2 Series and parallel circuits

Core

1 Know that the current at every point in a series circuit is the same

2 Know how to construct and use series and parallel circuits

3 Calculate the combined e.m.f. of several sources in series

4 Calculate the combined resistance of two or more resistors in series

5 State that, for a parallel circuit, the current from the source is larger than the current in each branch

6 State that the combined resistance of two resistors in parallel is less than that of either resistor by itself

7 State the advantages of connecting lamps in parallel in a lighting circuit

Supplement

8 Recall and use in calculations, the fact that:

(a) the sum of the currents entering a junction in a parallel circuit is equal to the sum of the currents that leave the junction

(b) the total p.d. across the components in a series circuit is equal to the sum of the individual p.d.s across each component

(c) the p.d. across an arrangement of parallel resistances is the same as the p.d. across one branch in the arrangement of the parallel resistances

9 Explain that the sum of the currents into a junction is the same as the sum of the currents out of the junction

10 Calculate the combined resistance of two resistors in parallel

4.3.3 Action and use of circuit components

Core

1 Know that the p.d. across an electrical conductor increases as its resistance increases for a constant current

Supplement

2 Describe the action of a variable potential divider

3 Recall and use the equation for two resistors used as a potential divider

$$\frac{R_1}{R_2} = \frac{V_1}{V_2}$$

4.4 Electrical safety

Core

1 State the hazards of:
   (a) damaged insulation
   (b) overheating cables
   (c) damp conditions
   (d) excess current from overloading of plugs, extension leads, single and multiple sockets

   when using a mains supply

2 Know that a mains circuit consists of a live wire (line wire), a neutral wire and an earth wire and explain why a switch must be connected to the live wire for the circuit to be switched off safely

3 Explain the use and operation of trip switches and fuses and choose appropriate fuse ratings and trip switch settings

4 Explain why the outer casing of an electrical appliance must be either non-conducting (double-insulated) or earthed

5 State that a fuse without an earth wire protects the circuit and the cabling for a double-insulated appliance

Supplement

19.1 Combination of circuits

1 Fig.1 shows three resistors connected across a low voltage d.c. supply, and a c.r.o.

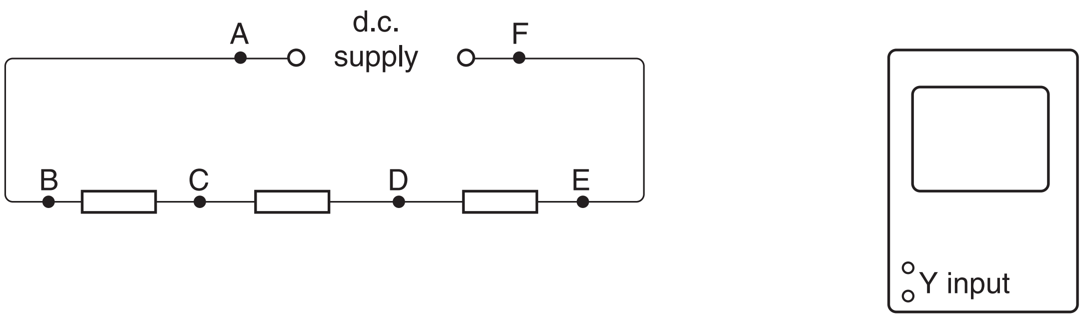


Fig.1

(a) Explain how you would use a 1 V d.c. supply to calibrate the c.r.o.

....

....

.... [2]

(b) On Fig.1, draw in the connections between the c.r.o. and the circuit so that the potential difference between points C and D may be measured. [2]

(c) The potential differences between A and F, B and C, C and D, and D and E are measured.

State the relationship between them.

....

....[2]

2 Fig. 8.1 shows a 240 V a.c. mains circuit to which a number of appliances are connected and switched on.

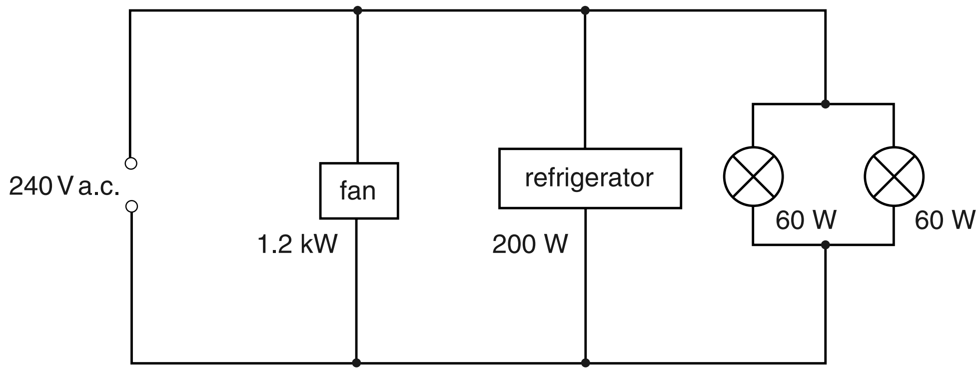


Fig. 8.1

(a) Calculate the power supplied to the circuit.

power = …………..[1]

(b) The appliances are connected in parallel.

(i) Explain what connected *in parallel* means.

....

....

(ii) State two advantages of connecting the appliances in parallel rather than in series.

advantage 1 ....

advantage 2 ....

[3]

(c) Calculate

(i) the current in the refrigerator,

current = …………..

(ii) the energy used by the fan in 3 hours,

energy = …………..

(iii) the resistance of the filament of one lamp.

resistance = …………..

[7]

3 Fig. 7.1 shows a 12 V battery connected to a number of resistors.

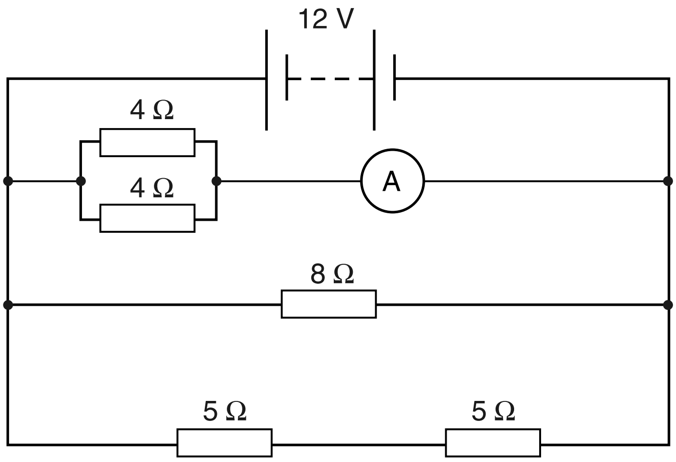


Fig. 7.1

(a) Calculate the current in the 8 Ω resistor.

current = ………………..[2]

(b) Calculate, for the resistors connected in the circuit, the combined resistance of

(i) the two 5 Ω resistors,

resistance = ………………..

(ii) the two 4 Ω resistors.

resistance = ………………..
[2]

(c) The total current in the two 4 Ω resistors is 6 A.
Calculate the total power dissipated in the two resistors.

power = ………………..[2]

(d) What will be the reading on a voltmeter connected across

(i) the two 4 Ω resistors,

reading = ………………..

(ii) one 5 Ω resistor?

reading = ………………..
[2]

(e) The 8 Ω resistor is made from a length of resistance wire of uniform cross-sectional area. State the effect on the resistance of the wire of using

(i) the same length of the same material with a greater cross-sectional area,

....

(ii) a smaller length of the same material with the same cross-sectional area.

....
[2]

(f) Redraw Fig. 7.1, replacing the battery with a cell.

[1]

[Total:11

4 A student has a power supply, a resistor, a voltmeter, an ammeter and a variable resistor.

(a) The student obtains five sets of readings from which he determines an average value for the resistance of the resistor.

In the space below, draw a labelled diagram of a circuit that he could use.

[3]

(b) Describe how the circuit should be used to obtain the five sets of readings.

....

....

.... [2]

(c) Fig. 8.1 shows another circuit.

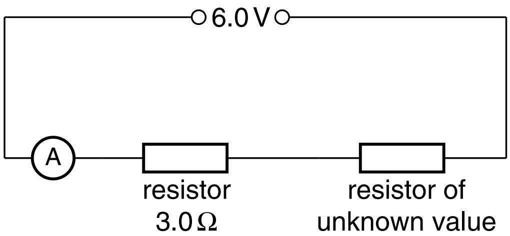


Fig. 8.1

When the circuit is switched on, the ammeter reads 0.50 A.

(i) Calculate the value of the unknown resistor.

resistance = ... [2]

(ii) Calculate the charge passing through the 3.0 Ω resistor in 120 s.

charge = ... [1]

(iii) Calculate the power dissipated in the 3.0 Ω resistor.

power = ... [2]

5 Fig. 8.1 shows a low-voltage lighting circuit.

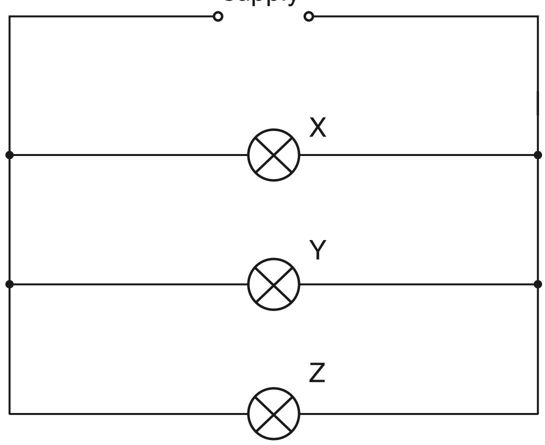


Fig. 8.1

(a) On Fig. 8.1, indicate with a dot and the letter S, a point in the circuit where a switch could be placed that would turn off lamps Y and Z at the same time but would leave lamp X still lit. [1]

(b) **(i)** In the space below, draw the circuit symbol for a component that would vary the brightness of lamp X.

(ii) On Fig. 8.1, mark with a dot and the letter R where this component should be placed.

[2]

(c) Calculate the current in lamp Y.

current = ...[2]

(d) The current in lamp Z is 3.0 A. Calculate the resistance of this lamp.

resistance = ...[2]

(e) The lamp Y is removed.

(i) Why do lamps X and Z still work normally?

....

....

(ii) The current in lamp X is 1.0 A. Calculate the current supplied by the battery with lamp Y removed.

current = ...

6 Fig. 8.1 shows part of a low-voltage lighting circuit containing five identical lamps.

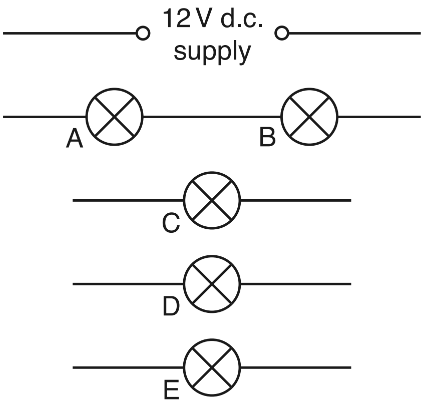


Fig. 8.1

(a) Complete the circuit, by the addition of components as necessary, so that

(i) the total current from the supply can be measured,

(ii) the brightness of lamp E only can be varied,

(iii) lamps C and D may be switched on and off together whilst lamps A, B and E remain on. [4]

(b) All five lamps are marked 12 V, 36 W. Assume that the resistance of each lamp is the same fixed value regardless of how it is connected in the circuit.

Calculate

(i) the current in one lamp when operating at normal brightness,

current = ... [1]

(ii) the resistance of one lamp when operating at normal brightness,

resistance = ... [1]

(iii) the combined resistance of two lamps connected in parallel with the 12 V supply,

resistance = ... [1]

(iv) the energy used by one lamp in 30 s when operating at normal brightness.

energy = ... [1]

(c) The whole circuit is switched on. Explain why the brightness of lamps A and B is much less than that of one lamp operating at normal brightness.

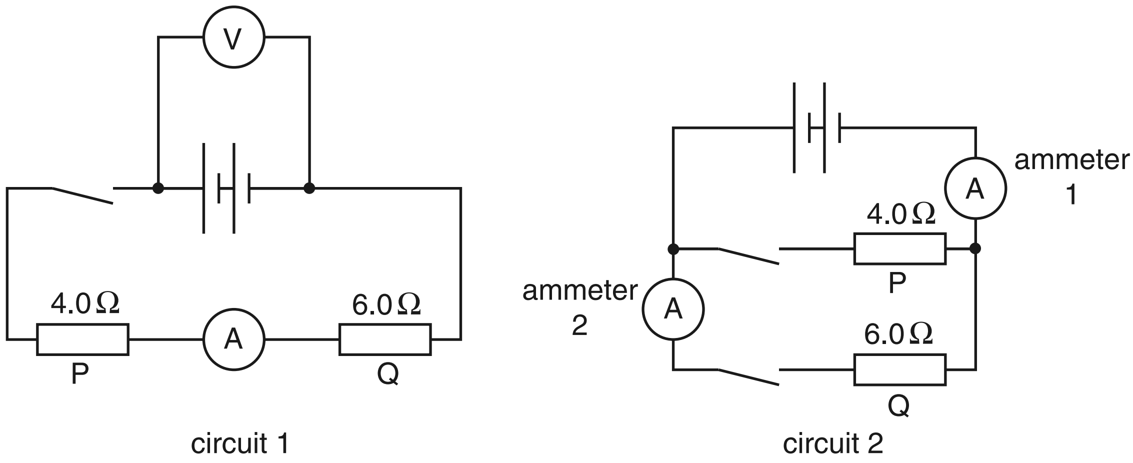
....

....

.... [2]

[Total: 10]

7 Fig. 8.1 shows two electrical circuits.



The batteries in circuit 1 and circuit 2 are identical.

Fig. 8.1

(a) Put ticks in the table below to describe the connections of the two resistors P and Q.

	series	parallel
circuit 1		
circuit 2		

[1]

(b) The resistors P and Q are used as small electrical heaters.

State two advantages of connecting them as shown in circuit 2.

advantage 1 ....

advantage 2 .... [2]

(c) In circuit 1, the ammeter reads 1.2 A when the switch is closed.

Calculate the reading of the voltmeter in this circuit.

voltmeter reading = ... [2]

(d) The two switches in circuit 2 are closed. Calculate the combined resistance of the two resistors in this circuit.

combined resistance = ... [2]

(e) When the switches are closed in circuit 2, ammeter 1 reads 5 A and ammeter 2 reads 2 A.

Calculate

(i) the current in resistor P,

current = ... [1]

(ii) the power supplied to resistor Q,

power = ... [1]

(iii) the energy transformed in resistor Q in 300 s.

energy = ... [1]

[Total: 10]

8 Fig. 8.1 is the plan of a small apartment that has four lamps as shown.

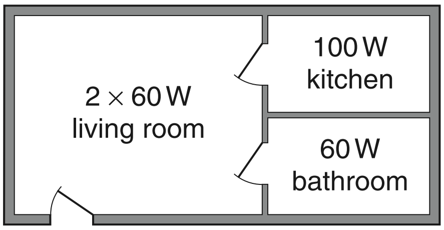


Fig. 8.1

Power for the lamps is supplied at 200 V a.c. and the lamps are all in parallel.

(a) In the space below, draw a lighting circuit diagram so that there is one switch for each room and one master switch that will turn off all the lamps. Label the lamps as 60 W or 100 W.

[3]

(b) The 100 W lamp is switched on. Calculate

(i) the current in the lamp,

current = ... [2]

(ii) the charge passing through the lamp in one minute.

charge = ... [2]

(c) The three 60 W lamps are replaced by three energy-saving ones, that give the same light output but are rated at only 15 W each.

Calculate

(i) the total reduction in power,

reduction in power = ... [1]

(ii) the energy saved when the lamps are lit for one hour.

energy saved = ... [2]

[Total: 10]

9 The circuit shown in Fig. 10.1 uses a 12 V battery.

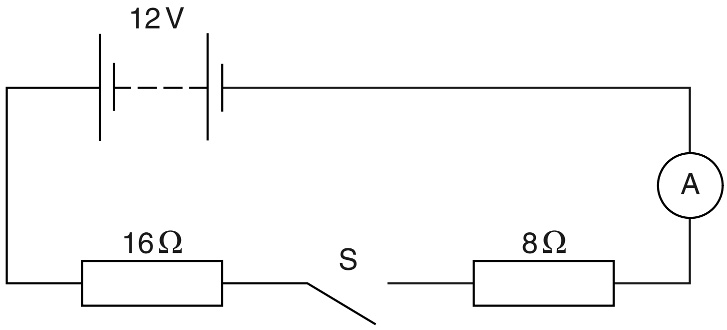


Fig. 10.1

(a) Switch S is open, as shown in Fig. 10.1.

State the value of

(i) the reading on the ammeter,

reading = ... [1]

(ii) the potential difference (p.d.) across S.

p.d. = ... [1]

(b) Switch S is now closed.

(i) Calculate the current in the ammeter.

current = ... [2]

(ii) Calculate the p.d. across the 8 Ω resistor.

p.d. = ... [2]

(c) The two resistors are now connected in parallel.

Calculate the new reading on the ammeter when S is closed, stating clearly any equations that you use.

reading = ... [4]

[Total: 10]

10 The circuit shown in Fig. 10.1 uses a 12 V battery. A and B are identical lamps, each designed to work from a 6 V supply.

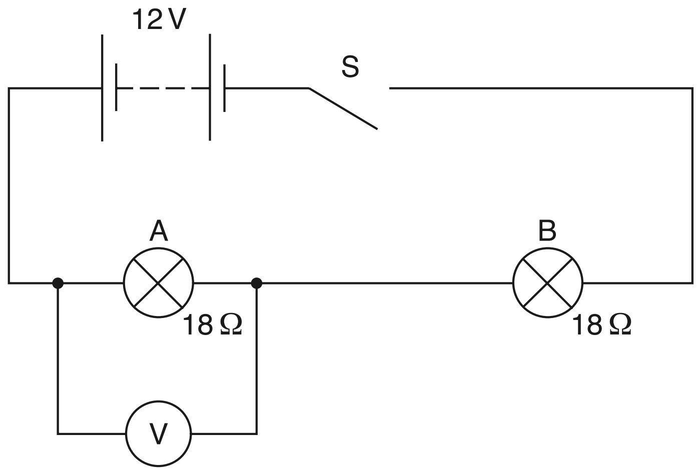


Fig. 10.1

(a) Switch S is open, as shown in Fig. 10.1.

(i) State the value of

1. the potential difference (p.d.) across S,

p.d. = ... [1]

2. the reading on the voltmeter.

reading = ... [1]

(ii) Comment on the brightness of the two lamps.

.... [1]

(b) Switch S is now closed.

(i) State the new reading on the voltmeter.

new reading = ... [1]

(ii) Comment on the brightness of the two lamps.

.... [1]

(iii) Under these conditions, each lamp has a resistance of 18 Ω.

Calculate the current in each lamp.

(c) With switch S open, lamp B is connected in parallel with lamp A. With no current, each lamp has a resistance of $1.8\,\Omega$.

(i) Calculate the value of the combined resistance of A and B.

combined resistance = ... [2]

(ii) State why it would not be wise to close S when A and B are connected in parallel.

....

.... [1]

[Total: 11]

11 Alternating current electricity is delivered at 22 000 V to a pair of transmission lines. The transmission lines carry the electricity to the customer at the receiving end, where the potential difference is *V*. This is shown in Fig. 10.1. Each transmission line has a resistance of 3 Ω.

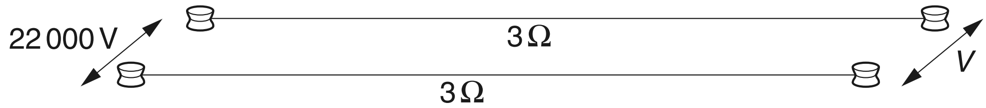


Fig. 10.1

(a) The a.c. generator actually generates at a much lower voltage than 22 000 V.

(i) Suggest how the voltage is increased to 22 000 V.

.... [1]

(ii) State one advantage of delivering electrical energy at high voltage.

.... [1]

(b) The power delivered by the generator is 55 kW. Calculate the current in the transmission lines.

current = ... [2]

(c) Calculate the rate of loss of energy from one of the 3 Ω transmission lines.

rate of energy loss = ... [2]

(d) Calculate the voltage drop across one of the transmission lines.

voltage drop = ... [2]

(e) Calculate the potential difference V at the receiving end of the transmission lines.

V = ... [2]

[Total: 10]

12 The manufacturer's label on an electric heater is as shown in Fig. 5.1.

C.I.E. Electrical Company
Suitable for use on 110 V, 60 Hz supply
1 kW/ 2 kW
This appliance must be earthed when in use

Fig. 5.1

(a) State what electrical quantity is represented by

(i) 110 V, ...

(ii) 60 Hz, ...

(iii) 1 kW. .... [1]

(b) (i) Which part of the electric heater must be earthed?

....[1]

(ii) Explain what the hazard might be if the heater is not earthed.

....

....

....[2]

(c) The heater has two 110 V heating elements, with two switches, so that either one or both elements may be switched on.

In the space below, draw a circuit diagram showing how the heating elements and switches are connected to the mains supply.
Use the symbol for each heating element.

[2]

[Total: 6]

13 **(a)** What is meant by the *electromotive force* (e.m.f.) of an electric power supply?

....

....[2]

(b) When connected to a 240 V supply, a desk lamp has a power rating of 60 W.

Calculate

(i) the current in the lamp,

current = ...[2]

(ii) the resistance of the lamp's filament.

resistance = ...[2]

(c) A torch lamp is normally connected to a 3.0 V battery and carries a current of 0.25 A. The resistance of its filament is 12 Ω.

The desk lamp in **(b)** and the torch lamp are connected in series.

Students X and Y plan to connect the lamp combination to a 240 V supply.

Student X says that the filament of the torch lamp will melt and the circuit will no longer work. Student Y says that both lamps will light up and stay on.

Show, with a suitable calculation, whether student X or student Y is correct.

....

....[2]

[Total: 8]

14 Fig. 9.1 shows a circuit containing a battery, three resistors and an ammeter.

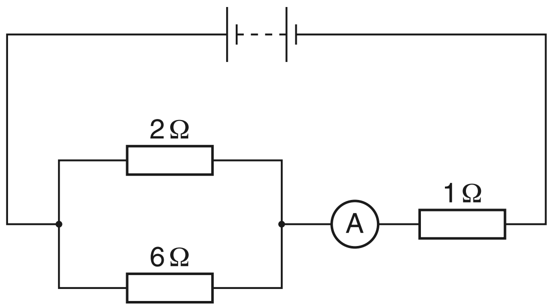


Fig. 9.1

(a) **(i)** Write down the equation for the effective resistance R_p of two resistors of resistances R_1 and R_2 connected in parallel.

(ii) Use this equation to calculate the effective resistance of the two resistors in parallel in Fig. 9.1.

effective resistance = ... [2]

(b) A voltmeter is to be used to measure the potential difference across the resistors in parallel.

(i) On Fig. 9.1, draw the voltmeter in position in the circuit, using the correct circuit symbol.

(ii) The ammeter reads 1.6 A. Calculate the reading on the voltmeter.

voltmeter reading = ... [3]

(c) State what happens to the ammeter reading if the 1 Ω resistor is replaced by a 3 Ω resistor.

....

.... [1]

[Total: 6]

15 Fig. 7.1 shows a circuit containing a 12V power supply, some resistors and an ammeter whose resistance is so small that it may be ignored.

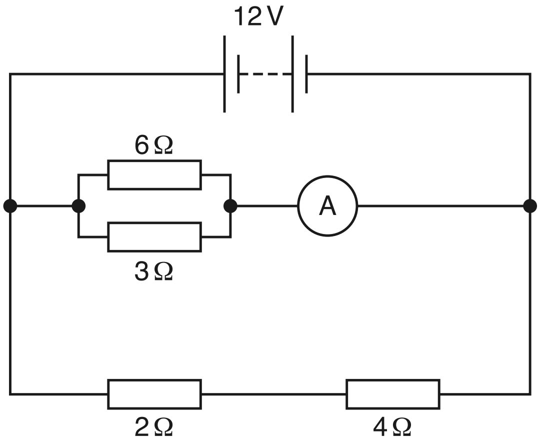


Fig. 7.1

(a) **(i)** Determine the potential difference across the 2Ω resistor.

potential difference = ...[1]

(ii) State the potential difference across the 3Ω resistor. .... [1]

(b) Calculate the effective resistance of

(i) the 2Ω and 4Ω resistors connected in series,

resistance = ...[1]

(ii) the 3Ω and 6Ω resistors connected in parallel.

resistance = ...[2]

(c) Calculate the reading on the ammeter.

ammeter reading = ...[2]

(d) Without further calculation, state what happens, if anything, to the ammeter reading if

(i) the 2 Ω resistor is shorted out with a thick piece of wire,

....

(ii) the thick piece of wire from **(d)(i)** and the 3 Ω resistor are both removed.

....
[2]

[Total: 9]

16 This question refers to quantities and data shown on the circuit diagram of Fig. 9.1.

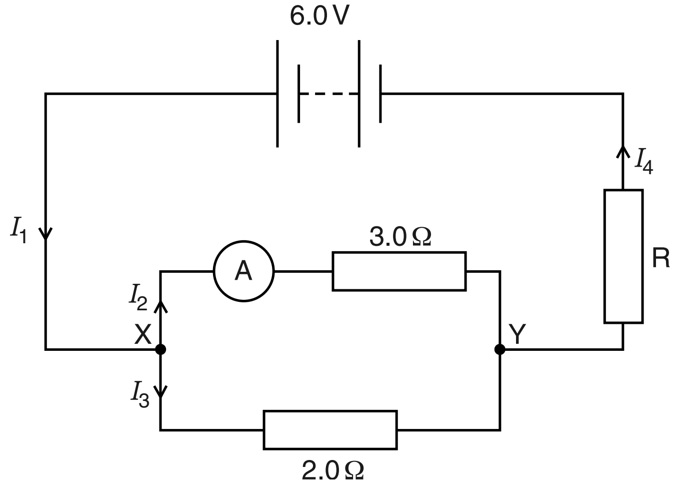


Fig. 9.1

(a) State the relationship between

(i) the currents I_1, I_2 and I_3, ...[1]

(ii) the currents I_1 and I_4. .... [1]

(b) The ammeter reads 0.80 A. Assume it has zero resistance.

Calculate

(i) the potential difference between X and Y,

p.d. = ... [1]

(ii) the current I_3,

current = ... [2]

(iii) the resistance of R.

resistance = ... [4]

[Total: 9]

17 40 lamps, each of resistance 8.0 Ω, are connected in series to a 240 V supply in order to decorate a tree.

(a) Calculate

(i) the current in each lamp,

current = ... [2]

(ii) the power dissipated in each lamp.

power = ... [2]

(b) The lamps are designed to "fail-short". If a filament fails, the lamp shorts so that it has no resistance. The other lamps continue to light and the current increases.

The lamps are connected through a fuse that blows when the current rises above 0.9 A. At this current, the resistance of each lamp is 5% greater than its normal working resistance.

Calculate the maximum number of lamps that can fail before the fuse blows.

number of lamps = ... [4]

[Total: 8]

18 **(a)** Determine which **one** of the following resistors, connected in parallel with a 24.0 Ω resistor, would give a total resistance of 8.0 Ω. Show your working.

Available resistors: 2.0 Ω, 4.0 Ω, 6.0 Ω, 8.0 Ω, 12.0 Ω, 16.0 Ω, 18.0 Ω, 32.0 Ω

value of resistor = ... [3]

(b) **(i)** In the space below, draw the parallel combination of resistors from **(a)** connected in a circuit with a 6.0 V battery. The circuit should also include an ammeter to measure the current in the 24.0 Ω resistor.

[2]

(ii) Calculate the current in each of the resistors when connected as in **(b)(i)**. Show your working.

current in 24.0 Ω resistor = ...

current in the other resistor = ...
[3]

[Total: 8]

19 An electric heater is connected to a 230V mains supply. The heater circuit includes two resistors R_1 and R_2, and two switches S_1 and S_2. Fig. 8.1 is the circuit diagram.

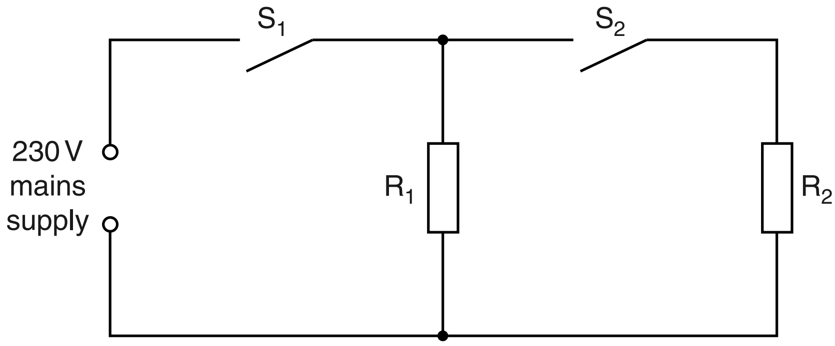


Fig. 8.1

The resistance of R_1 is 46 Ω and the resistance of R_2 is also 46 Ω.

Switch S_1 is closed and switch S_2 remains open.

(a) Calculate

(i) the current from the mains supply,

current = ... [2]

(ii) the power dissipated in the heater.

power = ... [2]

(b) Switch S_2 is now closed.

State the current in R_2.

current = ... [1]

[Total: 5]

20 Figure 8 shows a circuit figure.

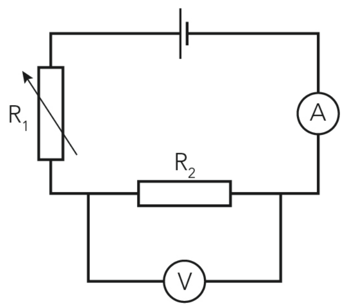


Figure 8

a Name component R_1. **[1]**

____

b State what is measured by the component labelled V. **[1]**

____

c State what happens to the readings on components A and V when the value of R_1 is increased.

i The reading on component A _______________. **[1]**

ii The reading on component V _______________. **[1]**

[Total: 4]

19.2 Sensors

1 Fig. 8.1 shows a high-voltage supply connected across two metal plates.

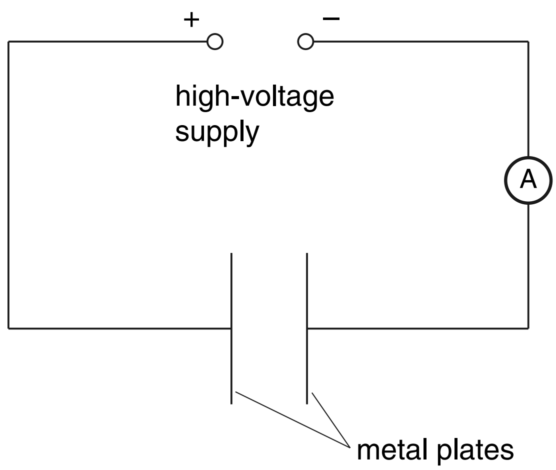


Fig. 8.1

When the supply is switched on, an electric field is present between the plates.

(a) Explain what is meant by an *electric field*.

.... [2]

(b) On Fig. 8.1, draw the electric field lines between the plates and indicate their direction by arrows. [2]

(c) The metal plates are now joined by a high-resistance wire. A charge of 0.060 C passes along the wire in 30 s.
Calculate the reading on the ammeter.

ammeter reading = ……………………… [2]

(d) The potential difference of the supply is re-set to 1500 V and the ammeter reading changes to 0.0080 A. Calculate the energy supplied in 10 s. Show your working.

energy = ………………. [3]

2 Fig. 8.1 shows an electrical circuit.

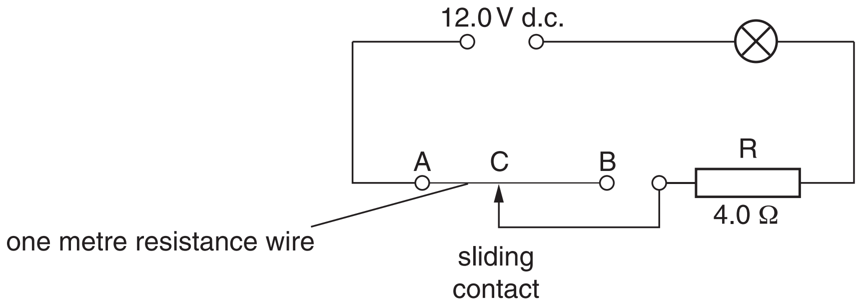


Fig. 8.1

The resistance of the lamp is 4.0 Ω when it is at its normal brightness.

(a) The lamp is rated at 6.0 V, 9.0 W.
Calculate the current in the lamp when it is at its normal brightness.

current = ...[2]

(b) The sliding contact C is moved to A. The lamp lights at its normal brightness.
Calculate

(i) the total circuit resistance,

resistance = ...[1]

(ii) the potential difference across the 4.0 Ω resistor R.

potential difference = ...[1]

(c) The sliding contact C is moved from A to B.

(i) Describe any change that occurs in the brightness of the lamp.

....[1]

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

....

....[2]

(d) The 1 m wire between A and B, as shown in Fig. 8.1, has a resistance of 2.0 Ω.
Calculate the resistance between A and B when

(i) the 1 m length is replaced by a 2 m length of the same wire,

resistance = ...[1]

(ii) the 1 m length is replaced by a 1 m length of a wire of the same material but of only half the cross-sectional area.

resistance = ...[1]

3 Fig. 10.1 shows a circuit that is used to switch on a lamp automatically when it starts to go dark.

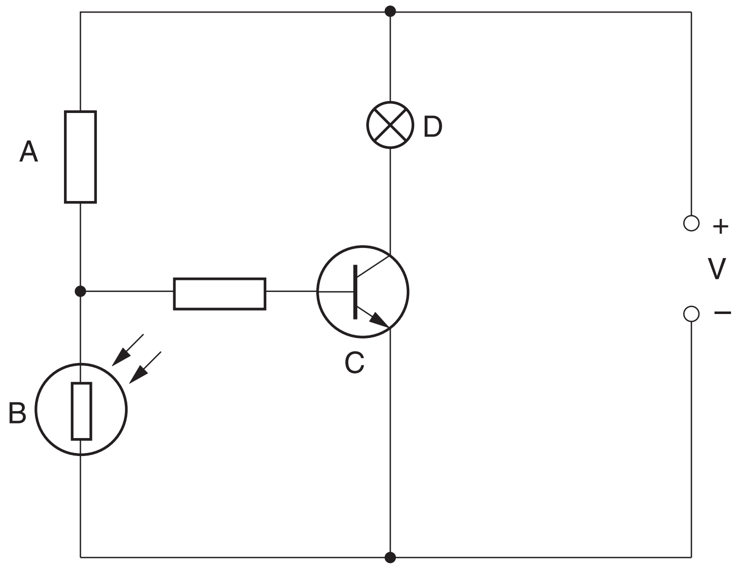


Fig. 10.1

(a) Write down the names of the components labelled A, B, C and D.

A .... B ....

C .... D .... [2]

(b) Which of the four components A, B, C or D acts as a switch?

.... [1]

(c) Explain why the lamp comes on as it goes dark.

....

....

....

.... [3]

4 Fig. 10.1 shows a circuit based on a transistor and a thermistor.

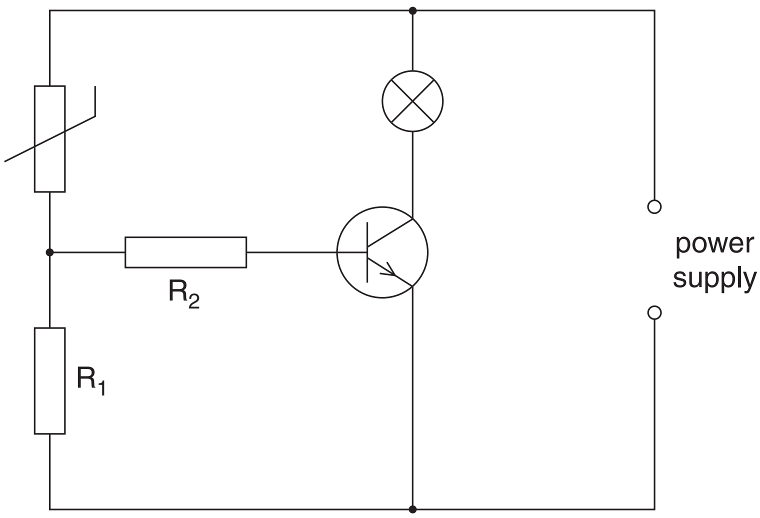


Fig. 10.1

(a) Describe the action of the thermistor in this circuit.

....

....

....

.... [3]

(b) State and explain how the circuit may be modified so that the lamp switches on at a different temperature.

....

....

.... [2]

(c) State one practical use of this circuit.

.... [1]

5 Fig. 8.1 shows a car battery being charged from a 200 V a.c. mains supply.

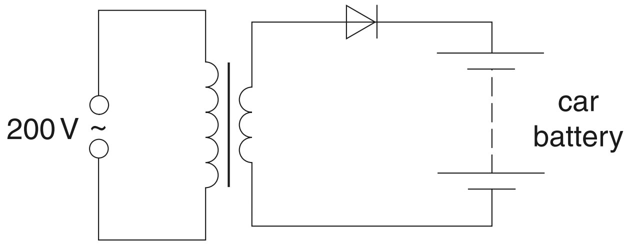


Fig. 8.1

(a) State the function of the diode.

....

.... [1]

(b) The average charging current is 2.0 A and the battery takes 12 hours to charge fully.

Calculate the charge that the battery stores when fully charged.

charge stored .... [2]

(c) The battery has an electromotive force (e.m.f.) of 12 V and, when connected to a circuit, supplies energy to the circuit components.

State what is meant by an *electromotive force of 12 V*.

....

....

.... [2]

(d) (i) In the space below, draw a circuit diagram to show how two 6.0V lamps should be connected to a 12V battery so that both lamps glow with normal brightness. [1]

(ii) The power of each lamp is 8.0W. Calculate the current in the circuit.

current = ... [2]

(iii) Calculate the energy used by the two lamps when both are lit for one hour.

energy = ... [2]

[Total: 10]

6 Fig. 10.1 shows a circuit for a warning lamp that comes on when the external light intensity falls below a pre-set level.

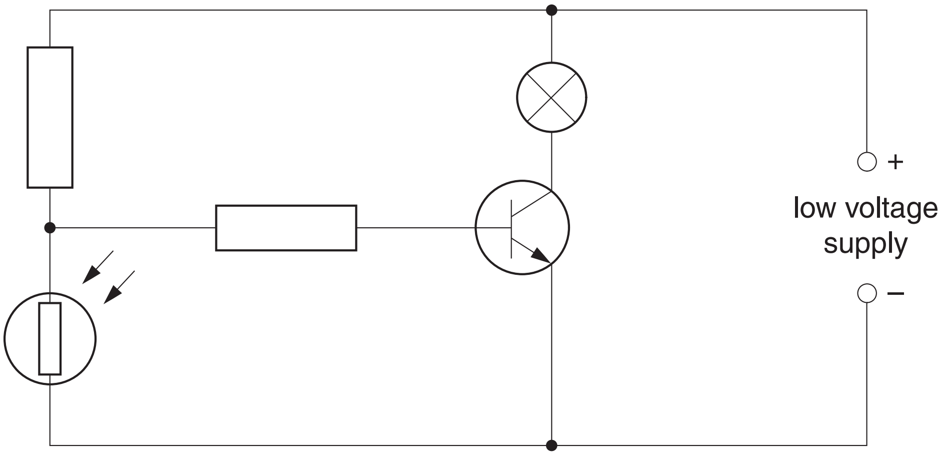


Fig. 10.1

(a) On Fig. 10.1, label

(i) with the letter X the component that detects the change in external light intensity,

(ii) with the letter Y the lamp,

(iii) with the letter Z the component that switches the lamp on and off.

[3]

(b) Describe how the circuit works as the external light intensity decreases and the lamp comes on.

....

....

....

....

....

....

.... [3]

[Total: 6]

7 **(a)** Fig. 9.1 shows an a.c. supply connected in series to a diode and a resistor.

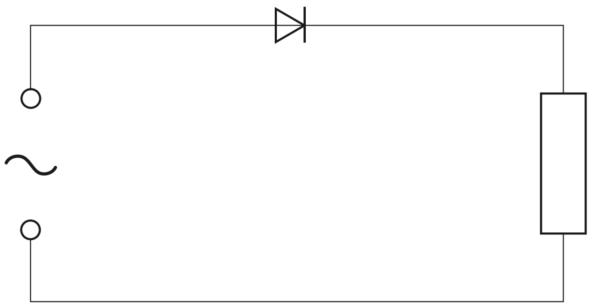


Fig. 9.1

On the axes of Fig. 9.2, draw a graph showing the variation of the current in the resistor. [1]

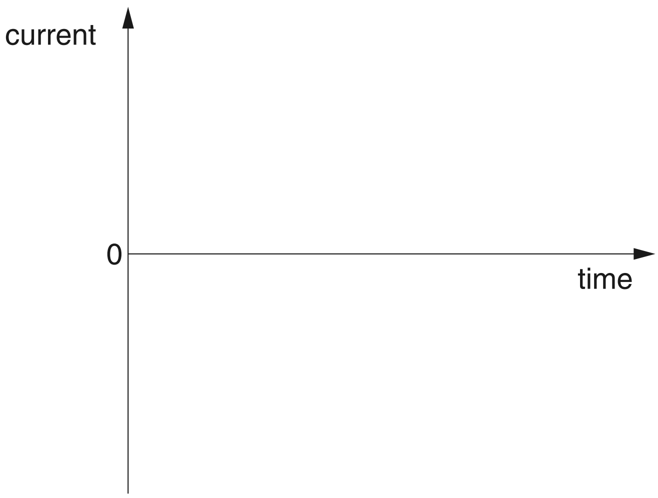


Fig. 9.2

(b) Fig. 9.3 shows four attempts, **A**, **B**, **C** and **D**, to connect a circuit known as a bridge rectifier.

The circuit is connected to a 12V a.c. supply.

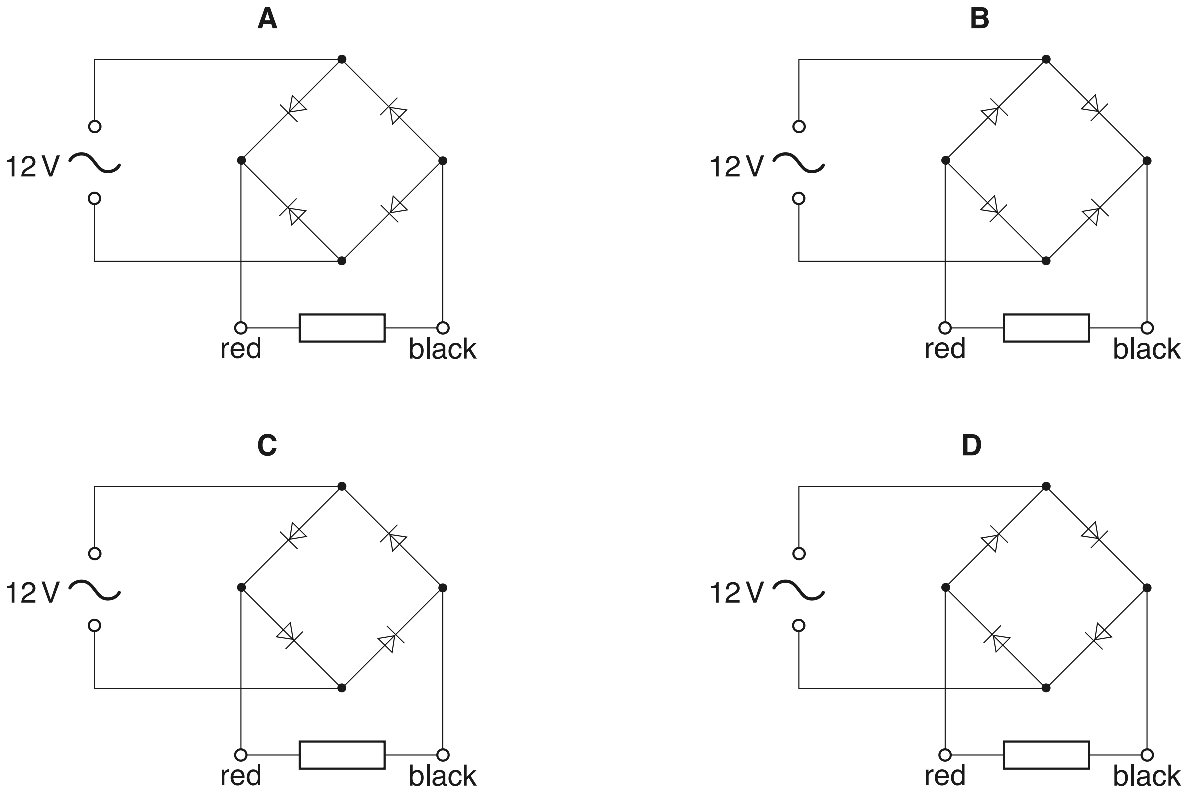


Fig. 9.3

(i) In which circuit will the direction of the conventional current in the resistor always be from red to black?

.... [1]

(ii) On the circuit you chose in **(b)(i)**, clearly indicate with arrows the path of the conventional current in the circuit when the upper terminal of the a.c. supply is positive with respect to the lower terminal. [2]

[Total: 4]

8 Fig. 11.1 is an electronic circuit controlling an electric heater.

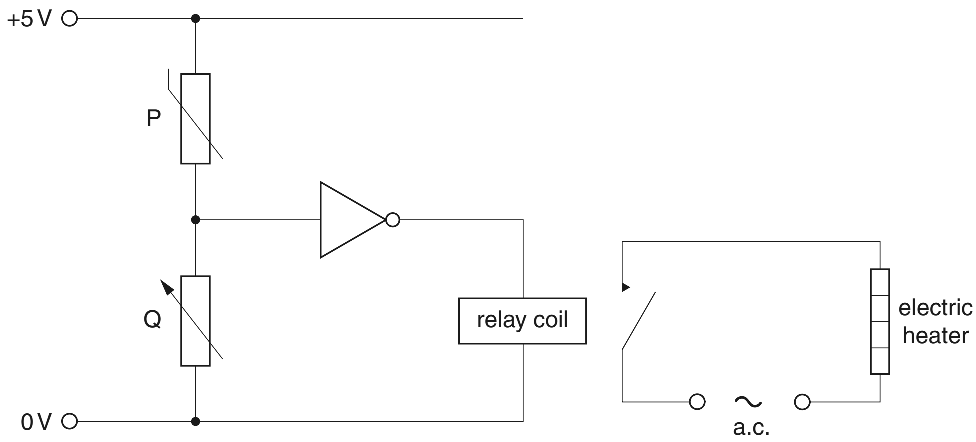


Fig. 11.1

The relay contacts close when there is a current in the relay coil.

(a) State the name of the logic gate in the circuit.

.... [1]

(b) **(i)** State the name of component P.

.... [1]

(ii) State what happens to P when its temperature falls.

.... [1]

(c) For the relay to operate, the output of the gate must be high (logic 1).

(i) What must be the input of the gate for the relay to operate?

.... [1]

(ii) State what the resistance of P must be, compared with the resistance of Q, in order to give this input to the gate.

.... [1]

(iii) Under what conditions will P have this resistance?

.... [1]

(d) Suggest why component Q is a variable resistor, rather than one with a fixed value.

.... [1]

(e) Suggest a practical use for this circuit.

.... [1]

9 The circuit in Fig. 8.1 contains a 2.0 V cell, whose resistance you should ignore.
There are also three resistors, a 3-position switch, an ammeter and another component, P.

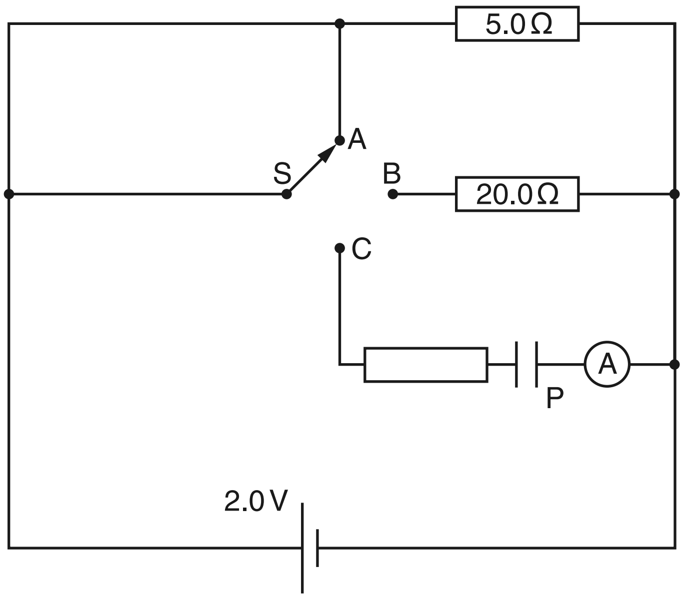


Fig. 8.1

(a) State the name of component P. .... [1]

(b) Deduce the resistance of the circuit when switch S is

(i) in position A,

resistance = ... [1]

(ii) in position B.

resistance = ... [3]

(c) Describe and explain what is seen on the ammeter when S is moved to position C.

....

....

....

.... [2]

(d) With S in position A, calculate how long it takes for the circuit to transfer 320 J of electrical energy to other forms.

time taken = ... [3]

[Total: 10]

10 The circuit of Fig. 4.1 is set up to run a small immersion heater from a 6.0 V battery.

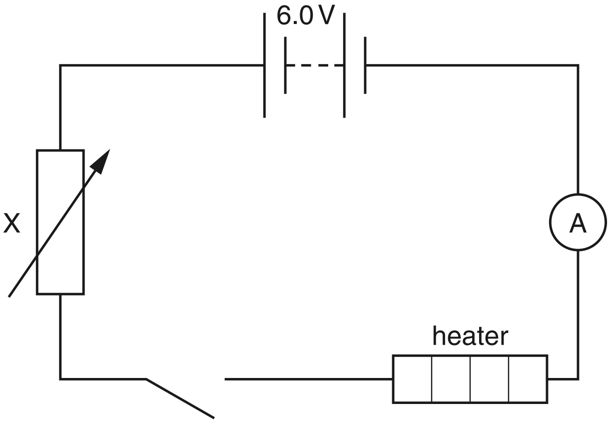


Fig. 4.1

(a) State the name and purpose of component X.

name ....

purpose ....[1]

(b) The heater is designed to work from a 3.6 V supply. It has a power rating of 4.5 W at this voltage.

(i) Calculate the current in the heater when it has the correct potential difference across it.

current = ...[2]

(ii) Calculate the resistance of component X if there is to be the correct potential difference across the heater. The battery and the ammeter both have zero resistance.

resistance = ...[3]

(c) Some time after the heater is switched on, the ammeter reading is seen to have decreased.

Suggest why this happens.

....

....

(d) As an alternative to running the heater from a battery, it is decided to construct a circuit to enable it to be operated from the a.c. mains supply.

Name the electrical component needed to

(i) reduce the potential difference from that of the mains supply down to a potential difference suitable for the heater,

....[1]

(ii) change the current from a.c. to a current which has only one direction.

....[1]

[Total: 9]

11 **(a)** In Fig. 10.1, A is a 1000 Ω resistor, C is a transistor, and D is a lamp. S is a 9 V supply.

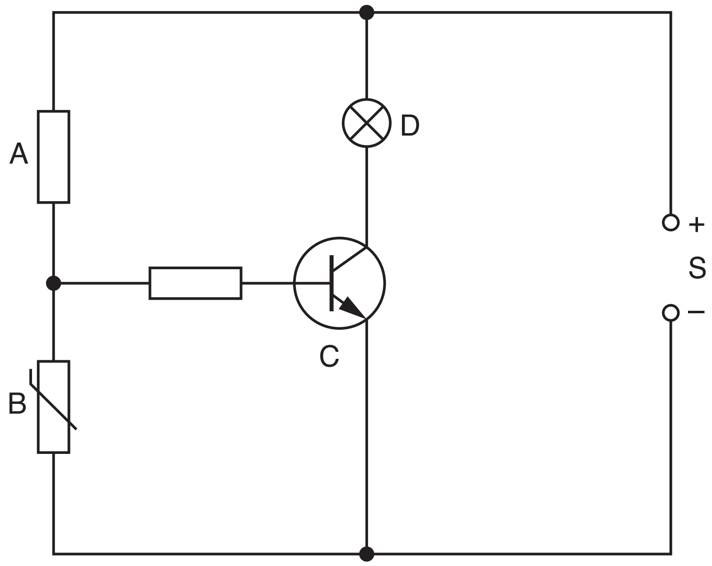


Fig. 10.1

(i) Name the component labelled B.

....[1]

(ii) At 20 °C the resistance of B is 800 Ω.
At 100 °C the resistance of B is 25 Ω.

In terms of the p.d. across B, explain what happens in the circuit as the temperature varies from 20 °C to 100 °C.

....

....

....

....

....

....[4]

(b) Suggest a practical use for this circuit.

....

....[1]

[Total: 6]

12 Fig. 11.1 shows part of a circuit designed to switch on a security lamp when it gets dark.

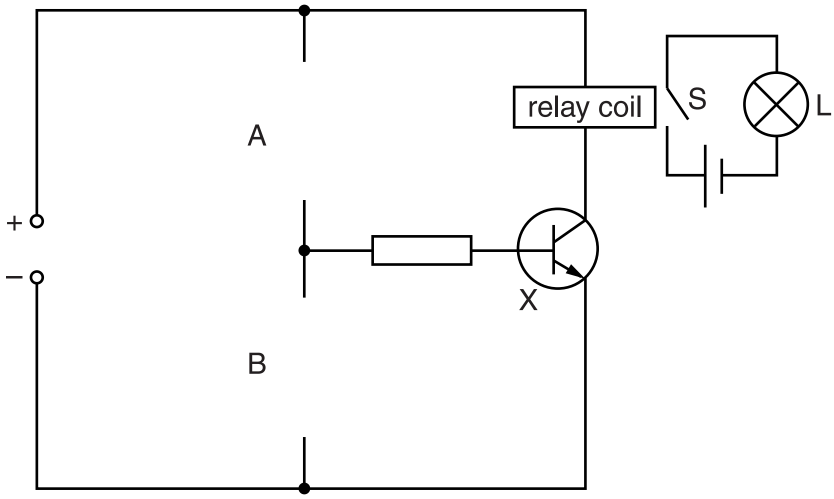


Fig. 11.1

When there is a current in the relay coil, switch S closes and the lamp L comes on.

(a) Write down the name of the component X. .... [1]

(b) The circuit has gaps at A and at B.

State the components that need to be connected into these gaps for the circuit to perform its required function.

gap A ....

gap B ....
[3]

(c) The circuit in Fig. 11.1 is modified. The function of lamp L is now to give a warning when the temperature becomes too high.

State any necessary changes of components in the circuit.

....

....

.... [2]

[Total: 6]

13 **(a)** State the electrical quantity that has the same value for each of two resistors connected to a battery

(i) when they are in series, ...

(ii) when they are in parallel. ....
[1]

(b) Fig. 10.1 shows a circuit with a 1.2 kΩ resistor and a thermistor in series. There is no current in the voltmeter.

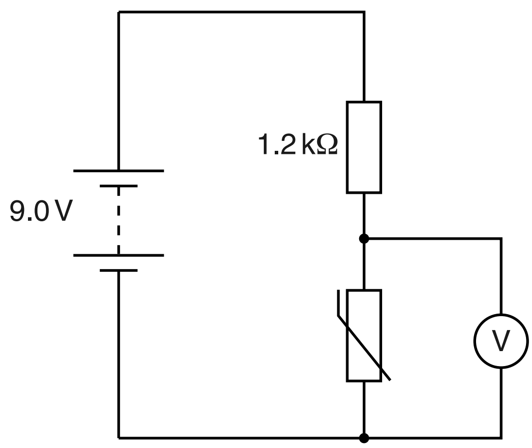


Fig. 10.1

Calculate the voltmeter reading when the resistance of the thermistor is 3.6 kΩ.

voltmeter reading = ... [3]

(c) Fig. 10.2 shows a fire-alarm circuit. The circuit is designed to close switch S and ring bell B if there is a fire.

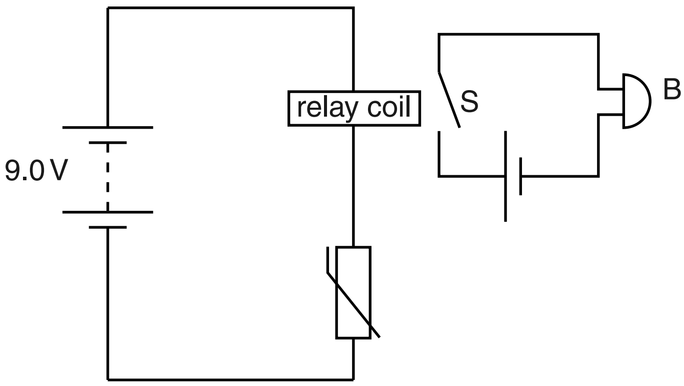


Fig. 10.2

Explain the operation of the circuit.

....

....

....

....

....

....

.... [3]

[Total: 7]

14 A student carries out an experiment with the circuit shown in Fig. 11.1. The component in the dashed box labelled X is a diode.

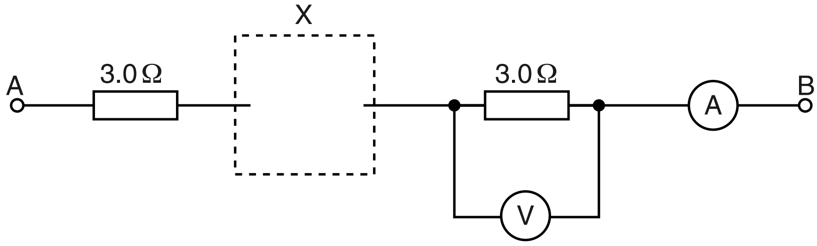


Fig. 11.1

(a) On Fig. 11.1, draw the correct symbol for a diode, connected either way round, in the dashed box labelled X. [1]

(b) (i) +6.0 V is applied to point A, 0 V to point B.

State what the student observes on the ammeter.

....

(ii) −6.0 V is applied to point A, 0 V to point B.

State what the student observes on the ammeter.

....

[2]

(c) The voltage shown in Fig. 11.2 is applied to the point A of the circuit in Fig. 11.1. Point B is kept at 0 V.

On Fig. 11.2, draw a graph of the readings indicated by the voltmeter.

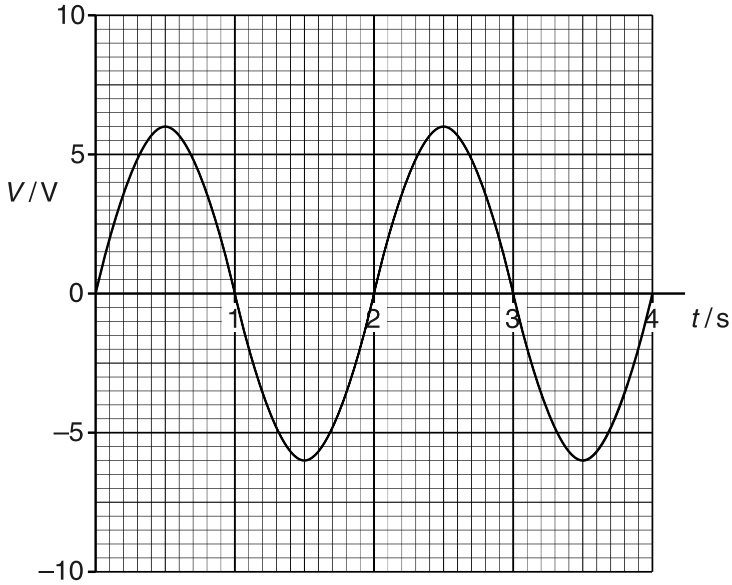


Fig. 11.2

[2]

(d) The circuit shown in Fig. 11.3 contains two switches S_1 and S_2 and two indicator lamps L_1 and L_2.

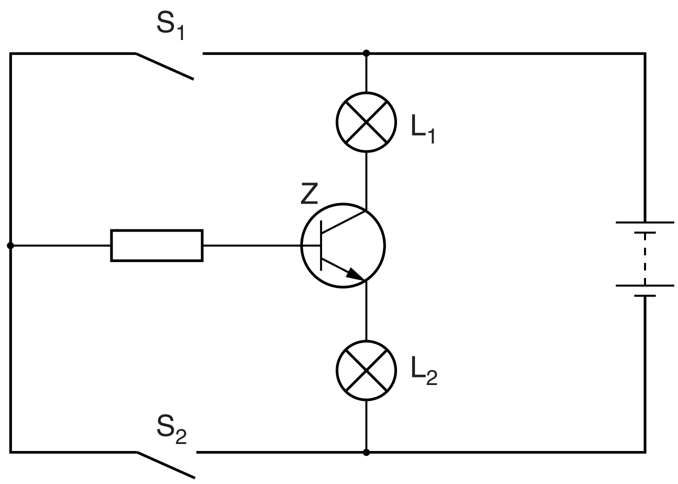


Fig. 11.3

(i) Name component Z. .... [1]

(ii) Complete the table to state whether the lamps are on or off with the switches in the positions stated.

switch S_1	switch S_2	lamp L_1	lamp L_2
open	closed		
closed	open		

[2]

[Total: 8]

15 A warning bell is fitted in a photographic dark room. In the dark, the bell is silent but in bright light, it rings. Two circuits linked by a relay R control the bell B. Fig. 10.1 is the circuit diagram for the arrangement.

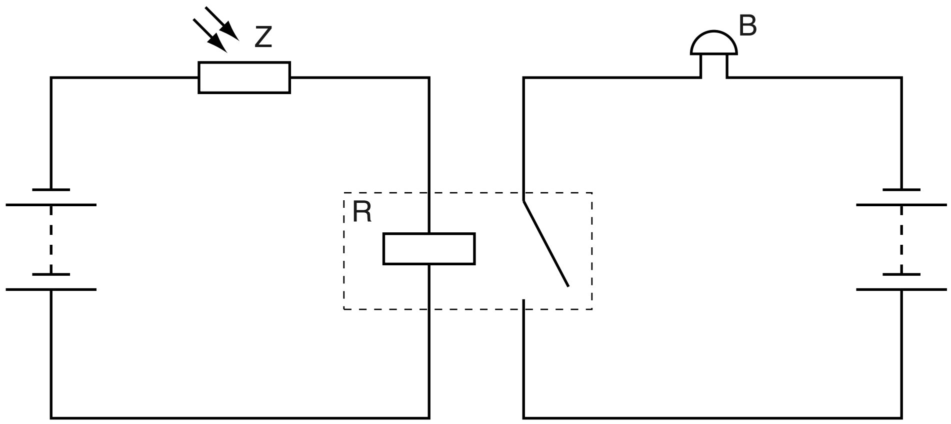


Fig. 10.1

(a) **(i)** State the name of component Z.

.... [1]

(ii) Explain why B rings in bright light.

....

....

....

....

....

....

.... [4]

(b) A change is made to one of the circuits so that B starts to ring when the temperature in the room rises.

State the change made.

....

.... [1]

[Total: 6]

19.3 Electronic circuits

1 **(a)** Fig. 10.1 shows the faces of two ammeters. One has an analogue display and the other a digital display.

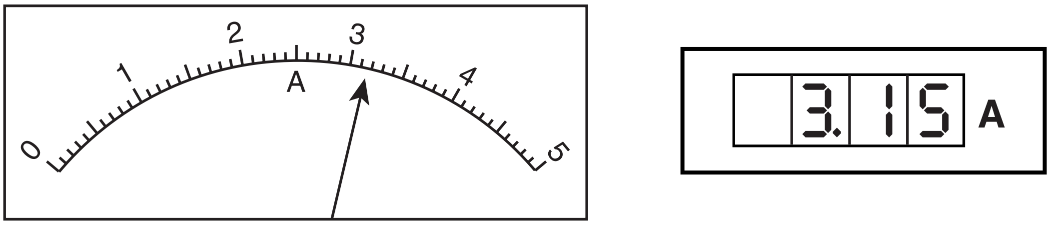


Fig. 10.1

State what is meant by the terms *analogue* and *digital*.

....

....

....[2]

(b) **(i)** Name the components from which logic gates are made.

....[1]

(ii) In the space below, draw the symbol for an AND gate.
Label the inputs and the output. [1]

(iii) Describe the action of an AND gate with two inputs. [2]

2 **(a)** **(i)** What is the function of a transistor when placed in an electrical circuit?

....

(ii) Describe the action of a transistor.

....

....

....
[3]

(b) **(i)** In the space below, draw the symbol for an OR gate. Label the inputs and the output.
[1]

(ii) Describe the action of an OR gate that has two inputs.

....

....

....[2]

3 **(a)** Fig. 9.1 shows an a.c. supply connected to a resistor and a diode.

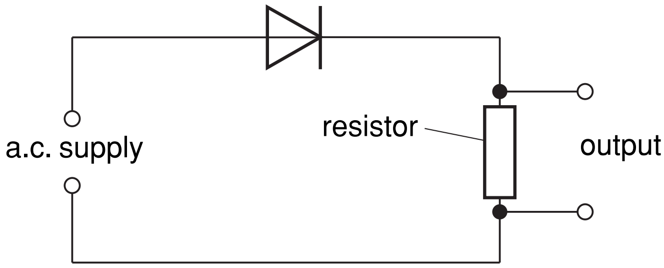


Fig. 9.1

(i) State the effect of fitting the diode in the circuit.

....

.... [1]

(ii) On Fig. 9.2, sketch graphs to show the variation of the a.c. supply voltage and the output voltage with time.

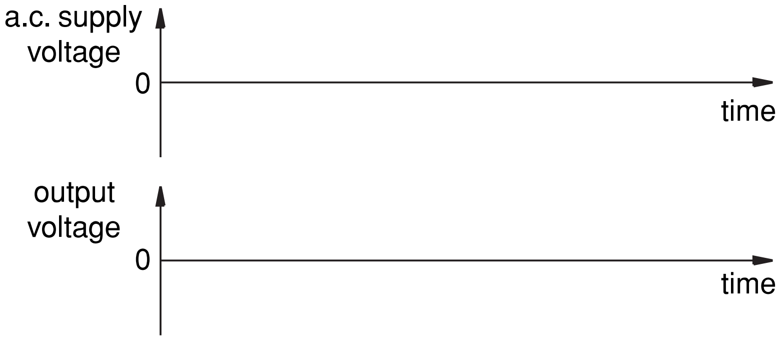


Fig. 9.2

[2]

(b) **(i)** In the space below, draw the symbol for a NOT gate.

[1]

(ii) State the action of a NOT gate.

....

....

.... [2]

4 **(a)** In the space provided, draw the symbol for a NOR gate. Label the inputs and the output.

[2]

(b) State whether the output of a NOR gate will be high (ON) or low (OFF) when

(i) one input is high and one input is low,

....

(ii) both inputs are high.

....
[1]

(c) Fig. 9.1 shows a digital circuit made from three NOT gates and one NAND gate.

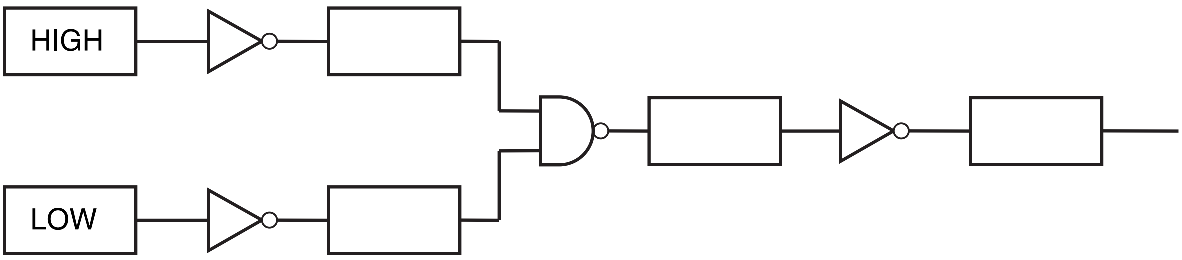


Fig. 9.1

(i) Write HIGH or LOW in each of the boxes on Fig. 9.1. [2]

(ii) State the effect on the output of changing both of the inputs.

....

.... [1]

5 **(a)** Fig. 10.1 shows an AND gate with two inputs A and B and one output.

Fig. 10.1

State the output when

(i) A is high and B is low,

.... [1]

(ii) both A and B are low.

.... [1]

(b) An electrical thermometer in a greenhouse gives a low output if the temperature is too low.

A humidity sensor in the same greenhouse gives a high output if the humidity in the greenhouse is too high.

An alarm sounds when both the temperature is too low and the humidity is too high.

(i) Complete the diagram below to show how a NOT gate and an AND gate may be used to provide the required output to the alarm. [2]

(ii) On your diagram, use either 'high' or 'low' to indicate the level of the inputs and outputs of both gates when the alarm sounds. [2]

[Total: 6]

6 **(a)** In the space below, draw the symbol for a NOR gate.

[1]

(b) Describe the action of a NOR gate in terms of its inputs and output.

....

....

....

....

.... [2]

(c) A chemical process requires heating at low pressure to work correctly.

When the heater is working, the output of a temperature sensor is high.

When the pressure is low enough, a pressure sensor has a low output.

Both outputs are fed into a NOR gate. A high output from the gate switches on an indicator lamp.

(i) Explain why the indicator lamp is off when the process is working correctly.

....

....

.... [1]

(ii) State whether the lamp is on or off in the following situations.

1. The pressure is low enough, but the heater stops working. ....

2. The heater is working, but the pressure rises too high. .... [2]

[Total: 6]

7 Fig. 11.1 is a schematic diagram of an electronic circuit controlling a lamp.

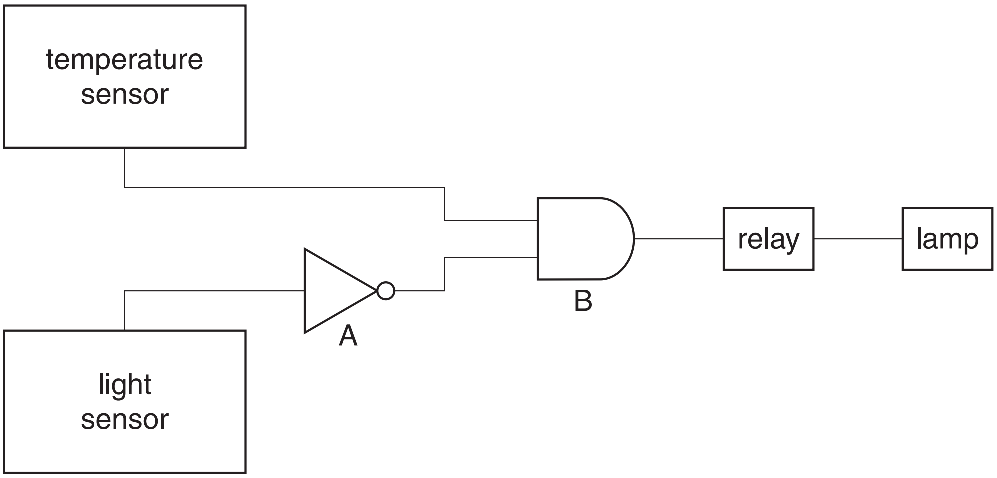


Fig. 11.1

(a) State the names of the logic gates A and B.

A .... B .... [2]

(b) The output of the temperature sensor is high (logic 1) when it detects raised temperature. The output of the light sensor is high (logic 1) when it detects raised light levels.

State the outputs of A and B when the surroundings are

(i) dark and cold, output of A = ...

output of B = ... [1]

(ii) dark and warm, output of A = ...

output of B = ... [1]

(iii) bright and warm. output of A = ...

output of B = ... [1]

(c) **(i)** Suggest why B is connected to a relay, rather than directly to the lamp.

.... [1]

(ii) The relay switches on when its input is high. In which of the three combinations in **(b)** will the lamp light up?

.... [1]

(iii) Suggest a practical use for this circuit.

.... [1]

[Total: 8]

8 **(a)** Explain what is meant by the terms *analogue* and *digital*, as applied to electronic circuits.

analogue ....

....

digital ....

.... [2]

(b) Describe, if necessary using a diagram, the function of an AND gate in digital electronics.

....

....

....

.... [2]

[Total: 4]

9 **(a)** In the space below, draw the symbol for an OR gate.

[1]

(b) Describe the action of an OR gate in terms of its inputs and outputs.

....

....

....

....

....[2]

(c) A car manufacturer wishes to install an alarm system in a 2-door car to inform the driver if either door is not properly closed. An OR gate is to be used in the construction of this system. Describe suitable input and output arrangements for the gate.

....

....

....

....

....

....[3]

[Total: 6]

10 The circuit shown in Fig. 10.1 was designed by an electronics student to provide a warning, by sounding the buzzer, that there is light in a photographic darkroom at times when it is in use.

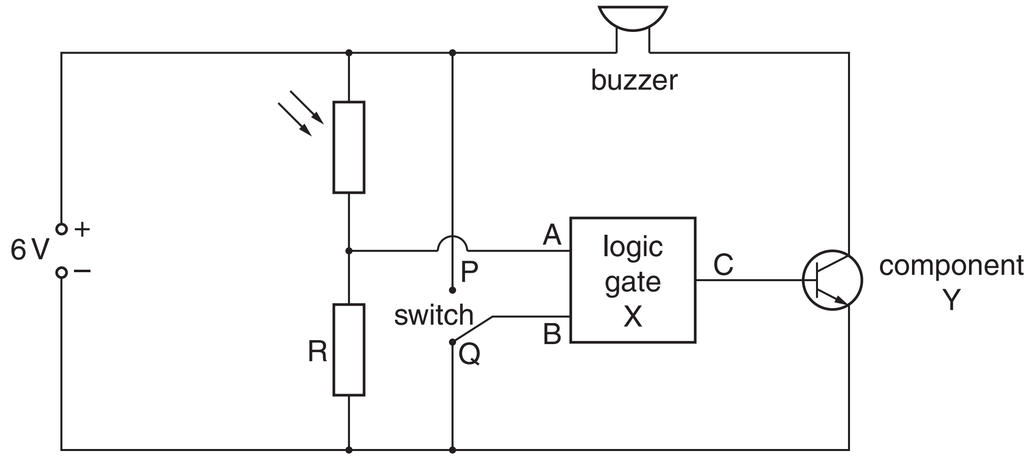


Fig. 10.1

When the darkroom is in use the switch is moved to position P. When it is not in use, the switch is in position Q.
Depending upon the light level, the resistance of the light dependent resistor varies between much higher and much lower than the resistance of resistor R.

(a) State what happens to the resistance of the light dependent resistor when the light level changes from dark to light.

....

.... [1]

(b) Write down whether the voltage level is high (logic 1) or low (logic 0) at the various points in the circuit in the following situations:

(i) at A light in the darkroom, ...

dark in the darkroom, ...

(ii) at B switch in position P, ...

switch in position Q. .... [2]

(c) The output C of logic gate X is only high (logic 1) when both inputs A and B are high (logic 1). State which type of gate is logic gate X.

.... [1]

(d) State the name of component Y.

.... [1]

(e) Explain whether or not the student's circuit achieves the aim of providing a warning that there is light in the darkroom when it is in use.

....

....

....

.... [2]

[Total: 7]

11 Fig. 10.1 shows schematically a digital electronic circuit.

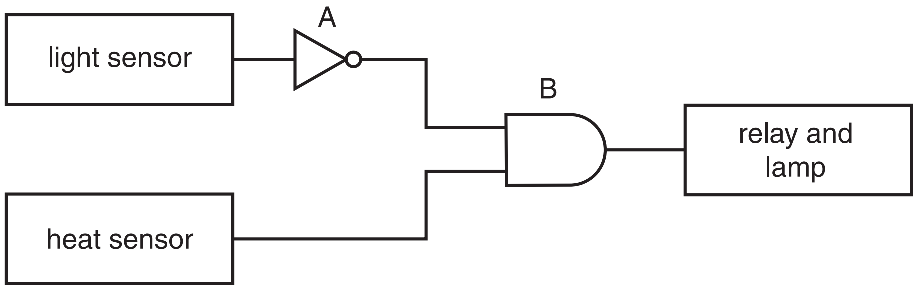


Fig. 10.1

(a) State the name of the logic gate

(i) at A, ...

(ii) at B. ....
[2]

(b) The light sensor has a "high" (logic 1) output in bright light and a "low" (logic 0) output when it is dark.

The heat sensor has a "high" (logic 1) output when it is hot and a "low" (logic 0) output when it is cold.

State the outputs of A and B when

(i) it is bright and cold,

output of A = ...

output of B = ...

(ii) it is dark and hot.

output of A = ...

output of B = ...
[4]

(c) Suggest why B is connected to a relay in order to light the lamp.

....

....[1]

(d) Suggest a practical use for this circuit.

....

....

....[1]
[Total: 8]

12 A student is designing a digital electronics circuit and needs to use the logic gate X shown in Fig. 10.1.

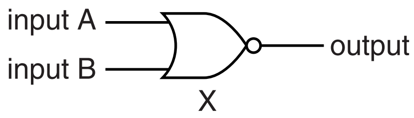


Fig. 10.1

(a) Name the logic gate X. .... [1]

(b) Write down the values of the output when the inputs are

(i) input A low (logic 0), input B low (logic 0), output ....

(ii) input A low (logic 0), input B high (logic 1), output ....

(iii) input A high (logic 1), input B low (logic 0), output ....

(iv) input A high (logic 1), input B high (logic 1). output ....

[2]

(c) When the student starts to build the circuit, he finds that the store room has run out of this type of logic gate. There is a supply of AND, OR and NOT gates. The student's teacher explains that a combination of two of these gates may be used instead of logic gate X.

(i) State the two gates he should use to replace logic gate X.

.... and ....

(ii) Draw clearly in the space below these two logic gates, correctly connected, using standard symbols.

[3]

(d) Fig. 10.2 shows a block diagram, not using standard symbols, of a combination of gates.

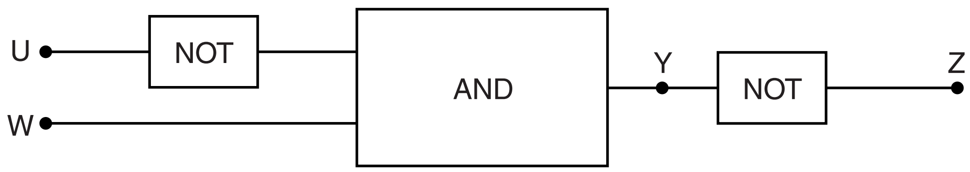


Fig. 10.2

State the logic levels of points Y and Z when the logic levels of points U and W are both 1.

logic level at point Y ....

logic level at point Z ....

[2]

[Total: 8]

19.4 Electrical Safety

1 Figure 19.5 shows an extension socket with seven different pieces of electrical equipment connected.

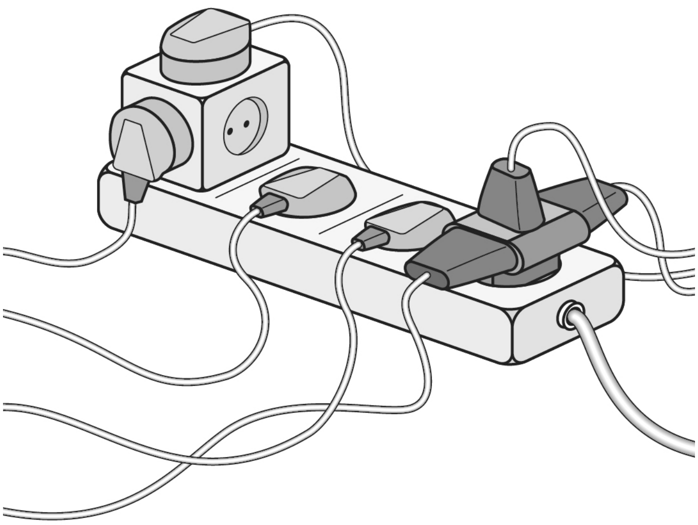


Figure 19.5

a Explain the electrical hazard caused by using an extension socket this way. **[2]**

____

____

____

____

b List two things that could be used in the mains circuit to protect against possible overloading of sockets. **[2]**

1 ____

2 ____

[Total: 4 marks]

2 Fig. 10.1 shows a simplified circuit diagram for an electric oven. The oven contains a fan driven by a motor.

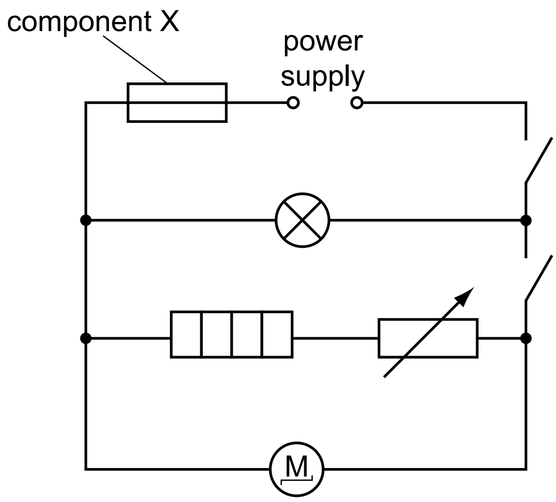


Fig. 10.1

(a) On Fig. 10.1, circle the symbol representing the heater. [1]

(b) Fig. 10.1 includes a variable resistor.

Explain the function of the variable resistor in this circuit.

....

.... [2]

(c) The potential difference across the motor is 250 V. The current in the motor is 2.0 A.

Calculate the resistance of the motor.

resistance = ... Ω [3]

(d) State the name of component X and explain how it contributes to the safety of the user.

name of component X ....

explanation ....

....

[2]

[Total: 8]

Chapter 20. Electromagnetic force

4.5.3 Magnetic effect of a current

Core

1 Describe the pattern and direction of the magnetic field due to currents in straight wires and in solenoids

2 Describe an experiment to identify the pattern of the magnetic field (including direction) due to currents in straight wires and in solenoids

3 Describe how the magnetic effect of a current is used in relays and loudspeakers and give examples of their application

Supplement

4 State the qualitative variation of the strength of the magnetic field around straight wires and solenoids

5 Describe the effect on the magnetic field around straight wires and solenoids of changing the magnitude and direction of the current

4.5.4 Force on a current-carrying conductor

Core

1 Describe an experiment to show that a force acts on a current-carrying conductor in a magnetic field, including the effect of reversing:

(a) the current

(b) the direction of the field

Supplement

2 Recall and use the relative directions of force, magnetic field and current

3 Determine the direction of the force on beams of charged particles in a magnetic field

4.5.5 The d.c. motor

Core

1 Know that a current-carrying coil in a magnetic field may experience a turning effect and that the turning effect is increased by increasing:

(a) the number of turns on the coil

(b) the current

(c) the strength of the magnetic field

Supplement

2 Describe the operation of an electric motor, including the action of a split-ring commutator and brushes

1 Fig. 8.1 shows a long straight wire between the poles of a permanent magnet.
It is connected through a switch to a battery so that, when the switch is closed, there is a steady current in the wire.

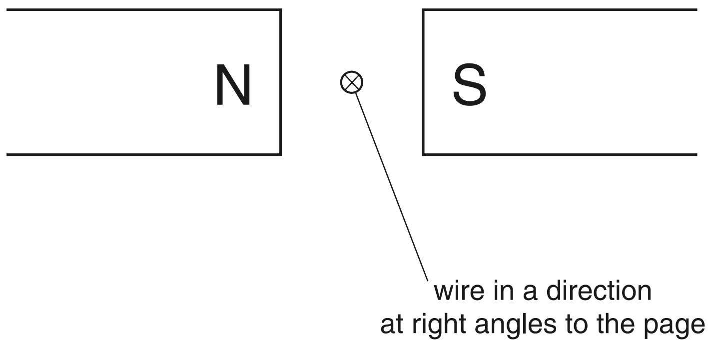


Fig. 8.1

(a) State the direction of the magnetic field between the poles of the magnet.

....[1]

(b) The wire is free to move. The current is switched on so that its direction is into the page.

(i) State the direction of movement of the wire.

....

....

(ii) Explain how you reached your answer to **(b)(i)**.

....

....

....
[4]

(c) This experiment is the basis of an electric motor.
Describe two changes to the arrangement shown in Fig. 8.1 that would enable continuous rotation to take place.

change 1 ....

....

change 2 ....

....[2]

2 Fig. 10.1 and Fig. 10.2 show two views of a vertical wire carrying a current up through a horizontal card. Points P and Q are marked on the card.

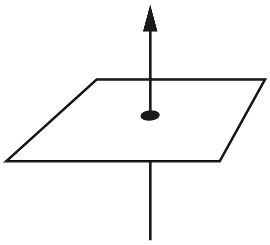
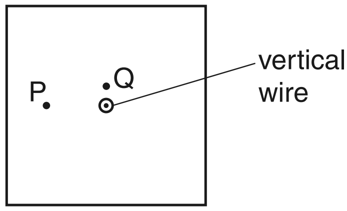


Fig. 10.1



view from above the card
Fig. 10.2

(a) On Fig. 10.2,

(i) draw a complete magnetic field line (line of force) through P and indicate its direction with an arrow,

(ii) draw an arrow through Q to indicate the direction in which a compass placed at Q would point.

[3]

(b) State the effect on the direction in which compass Q points of

(i) increasing the current in the wire,

....

(ii) reversing the direction of the current in the wire.

....

[2]

(c) Fig. 10.3 shows the view from above of another vertical wire carrying a current up through a horizontal card. A cm grid is marked on the card. Point W is 1 cm vertically above the top surface of the card.

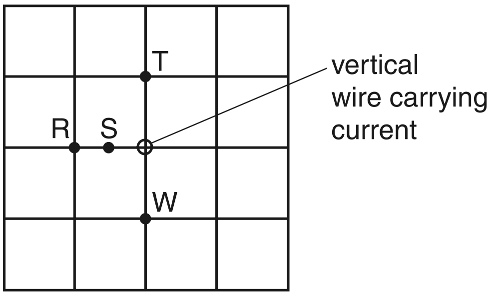


Fig. 10.3

State the magnetic field strength at S, T and W in terms of the magnetic field strength at R. Use one of the alternatives, **weaker**, **same strength** or **stronger** for each answer.

at S ....

at T ....

at W.. [3]

3 Fig. 11.1 shows a flexible wire hanging between two magnetic poles. The flexible wire is connected to a 12 V d.c. supply that is switched off.

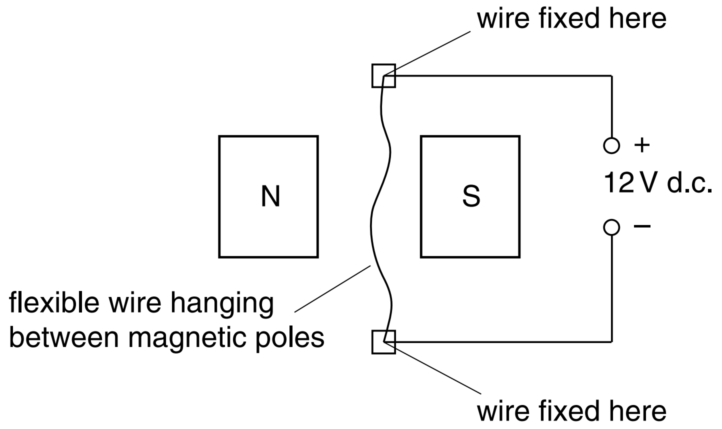


Fig. 11.1

(a) Explain why the wire moves when the supply is switched on.

....

....

.... [2]

(b) State the direction of the deflection of the wire.

....

.... [2]

(c) When the wire first moves, energy is changed from one form to another. State these two forms of energy.

from .... to ....

(d) Fig. 11.2 shows the flexible wire made into a rigid rectangular coil and mounted on an axle.

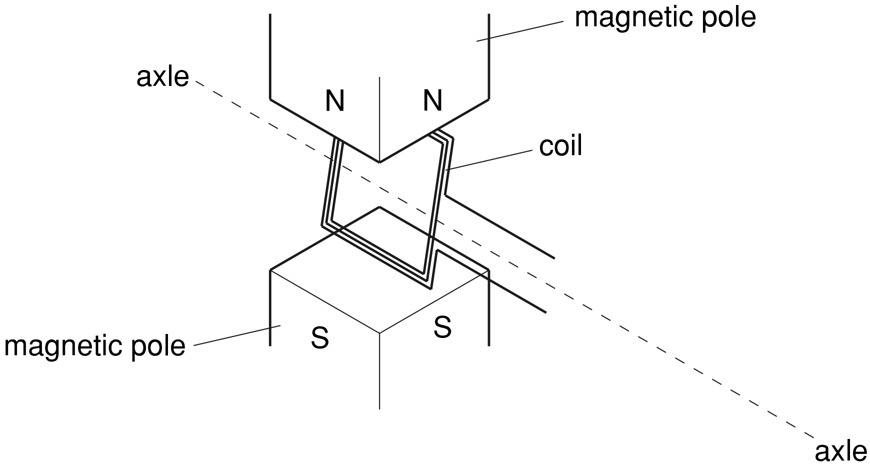


Fig. 11.2

(i) Add to the diagram an arrangement that will allow current to be fed into the coil whilst allowing the coil to turn continuously. Label the parts you have added. [1]

(ii) Briefly explain how your arrangement works.

....

.... [2]

4 Fig. 9.1 is a sketch of some apparatus, found in a Science museum, which was once used to show how electrical energy can be converted into kinetic energy.

When the switch is closed the wheel starts to turn.

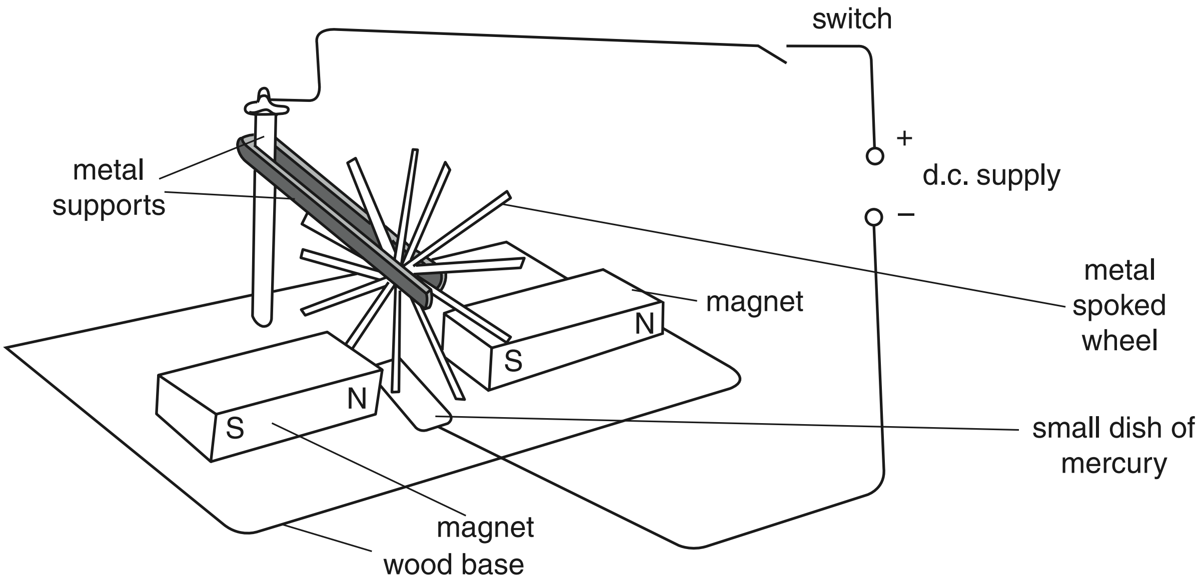


Fig. 9.1

(a) Explain why the wheel turns when the switch is closed.

....

....

....

.... [2]

(b) On Fig. 9.1, draw an arrow to show the direction of rotation of the wheel. [1]

(c) The d.c. motor is another way to convert electrical energy into kinetic energy.

In the space below, draw a labelled diagram of a d.c. motor.

[3]

(d) Describe how the split-ring commutator on an electric motor works.

....

....

....

.... [2]

[Total: 8]

5 Fig. 9.1 shows apparatus used to investigate electromagnetic effects around straight wires.

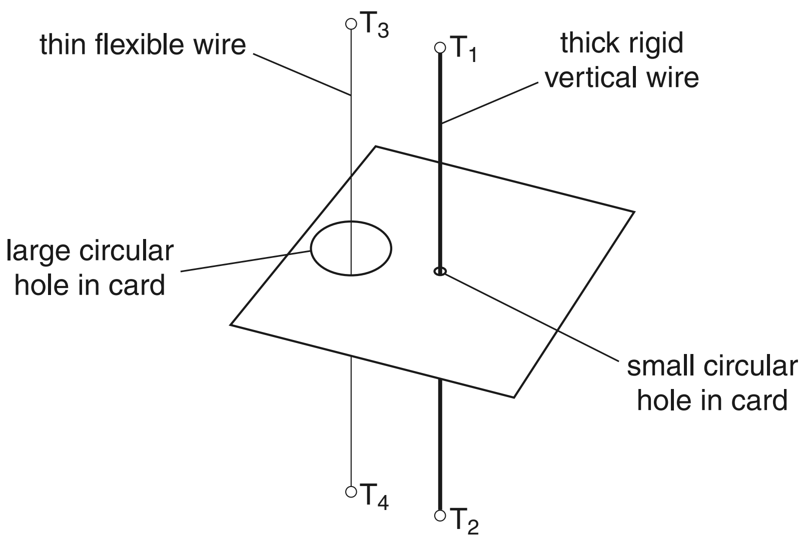


Fig. 9.1

Fig. 9.2 is a view looking down on the apparatus shown in Fig. 9.1.

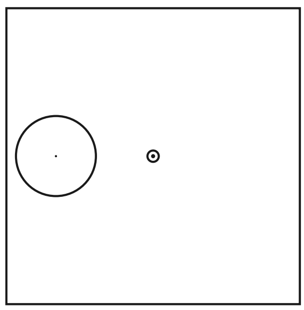


Fig. 9.2

(a) A battery is connected to T_1 and T_2 so that there is a current vertically down the thick wire.

On Fig. 9.2, draw three magnetic field lines and indicate, with arrows, the direction of all three. [2]

(b) Using a variable resistor, the p.d. between terminals T_1 and T_2 is gradually reduced.

State the effect, if any, that this will have on

(i) the strength of the magnetic field, ... [1]

(ii) the direction of the magnetic field. .... [1]

(c) The battery is now connected to terminals T_3 and T_4, as well as to terminals T_1 and T_2, so that there is a current down both wires. This causes the flexible wire to move.

(i) Explain why the flexible wire moves.

....

....

....

.... [2]

(ii) State the direction of the movement of the flexible wire.

.... [1]

(iii) The battery is replaced by one that delivers a smaller current.

State the effect that this will have on the force acting on the flexible wire.

....

.... [1]

[Total: 8]

6 **(a)** Fig. 9.1 illustrates the left hand rule, which helps when describing the force on a current-carrying conductor in a magnetic field.

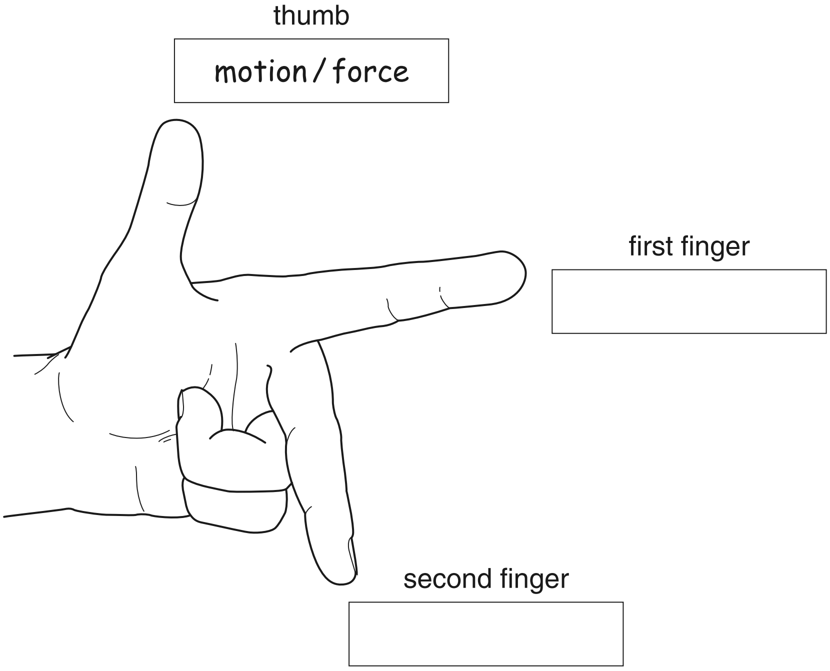


Fig. 9.1

One direction has been labelled for you.

In each of the other two boxes, write the name of the quantity that direction represents. [1]

(b) Fig. 9.2 shows a simple d.c. motor connected to a battery and a switch.

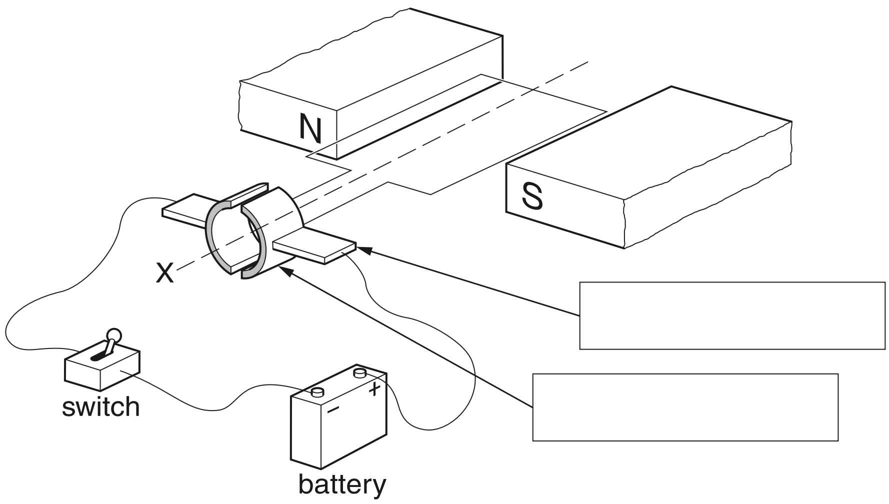


Fig. 9.2

(i) On Fig. 9.2, write in each of the boxes the name of the part of the motor to which the arrow is pointing. [2]

(ii) State which way the coil of the motor will rotate when the switch is closed, when viewed from the position X.

.... [1]

(iii) State two things which could be done to increase the speed of rotation of the coil.

1. ....

2. .... [2]

[Total: 6]

7 A simple motor is made in a school laboratory. A coil of wire is mounted on an axle between the poles of a horseshoe magnet, as illustrated in Fig. 9.1.

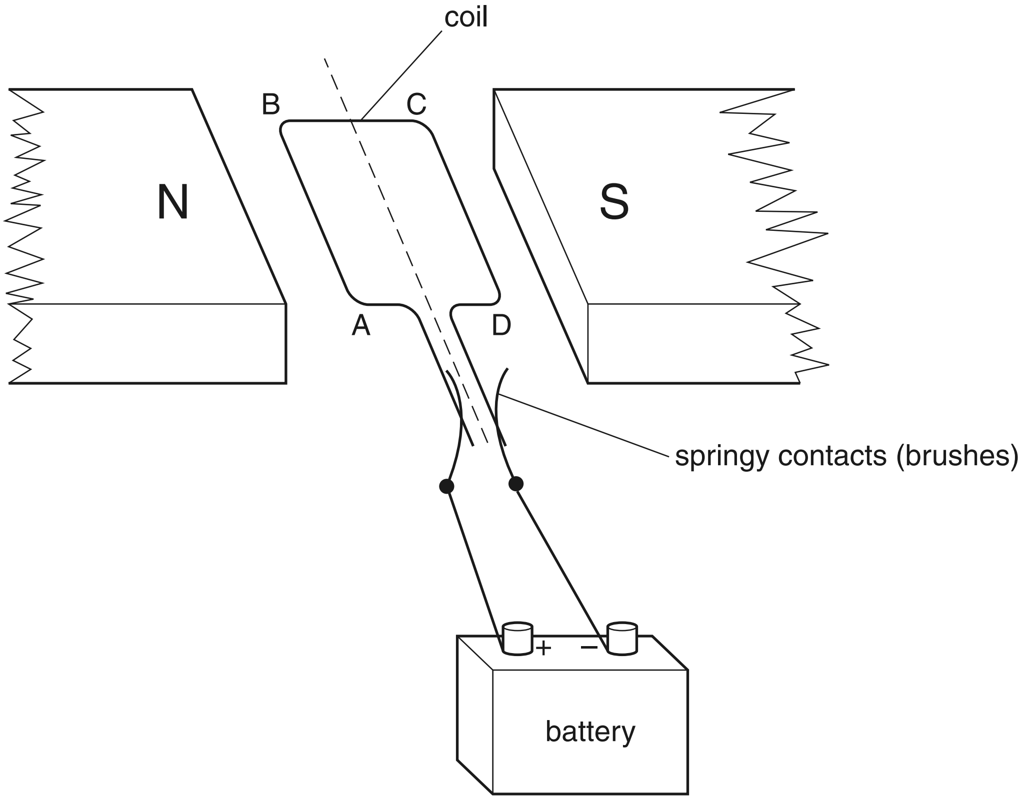


Fig. 9.1

(a) At the instant illustrated in Fig. 9.1, the coil ABCD is horizontal and the battery is connected as shown.

(i) For this position, state the direction of the force on AB and the direction of the motion of AB.

force on AB ....

direction of motion of AB ....[1]

(ii) Explain why BC does not contribute to the turning force on the coil.

....

....[1]

(b) At the instant when the coil is vertical, the springy contacts do not, in fact, make contact with the ends of the coil.

Describe and explain what happens to the coil.

....

....

....

....[2]

(c) The motor in Fig. 9.1 does not rotate very quickly. The designer of a commercial motor is required to produce a faster-rotating motor.

Suggest **one** change that could be made to increase the speed of the motor.

....

....[1]

[Total: 5]

8 **(a)** Fig. 9.1 shows a wire, held between the poles of a magnet, carrying a current in the direction of the arrow.

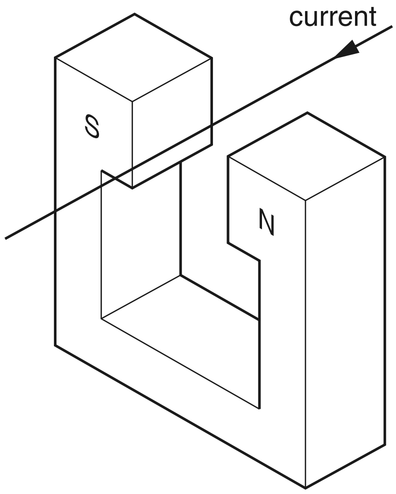


Fig. 9.1

(i) On Fig. 9.1, draw an arrow, labelled *F*, to show the direction of the force acting on the wire. [1]

(ii) Explain why the force *F* acts on the wire.

....

....[1]

(iii) The directions of the current and the magnetic field are both reversed. State the effect on the force *F*.

.... [1]

(b) Fig. 9.2 shows a negatively charged particle travelling, in a vacuum, into a region where a magnetic field acts. The magnetic field, shown by the crosses, is acting **into** the paper.

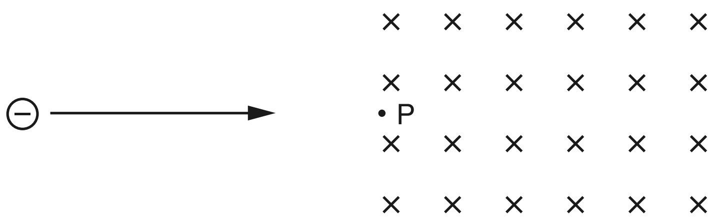


Fig. 9.2

(i) Draw an arrow, labelled *F*, to show the direction of the force on the particle at point P where it enters the field.

(ii) Describe the path of the particle as it continues to move through the magnetic field.

....[2]

[Total: 5]

9 Fig. 8.1 shows a simple motor with a rectangular coil that is free to rotate about an axis A_1A_2. The coil is connected to a battery by brushes B_1 and B_2.

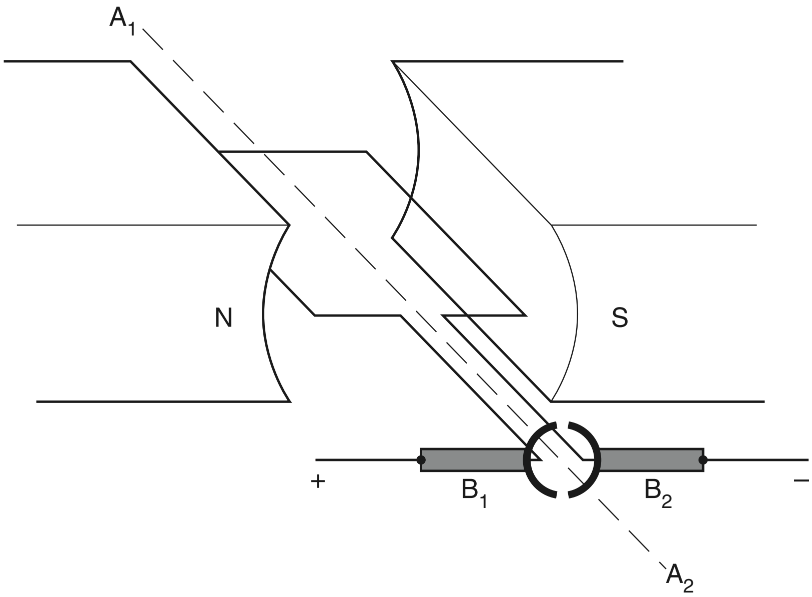


Fig. 8.1

(a) Brush B_1 is connected to the positive terminal of the battery and brush B_2 is connected to the negative terminal of the battery.

(i) On Fig. 8.1, use an arrow to show the direction of the conventional current in the coil. [1]

(ii) State the direction in which the coil rotates, when viewed from the end closest to the brushes.

....[1]

(b) State what difference, if any, each of the following changes makes to the rotation of the coil:

(i) using a battery with a larger potential difference,

....

(ii) using a coil with several turns of wire carrying the same current as in **(a)**,

....

(iii) using a stronger magnetic field.

....

[3]

(c) The structure of the motor is very similar to that of an a.c. generator. Use ideas about induction to suggest why the current from the battery falls as the motor speeds up.

....

....

....[1]

[Total: 6]

10 **(a)** Fig. 10.1 shows a wire PQ placed between the poles of a magnet. There is a current in wire PQ.

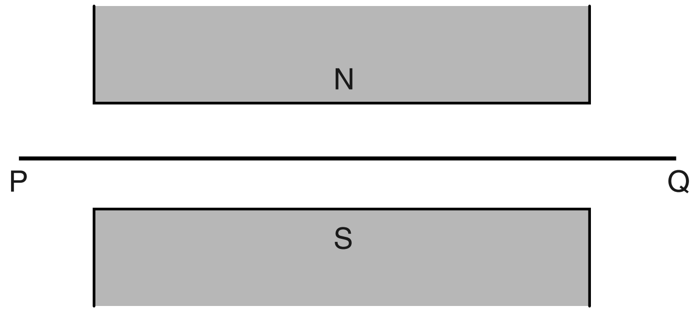


Fig. 10.1

(i) On Fig. 10.1, sketch lines with arrows to show the direction of the magnetic field between the poles of the magnet. [1]

(ii) The force on PQ is into the paper.

Draw an arrow on PQ to show the direction of the current. [1]

(b) The wire PQ in Fig. 10.1 is replaced by a narrow beam of β-particles travelling from left to right.

(i) Suggest a suitable detector for the β-particles.

.... [1]

(ii) State the direction of the force on the β-particles.

.... [1]

(iii) Describe the path of the β-particles in the space between the poles of the magnet.

....

.... [1]

(iv) State what happens to the air molecules along the path of the β-particles.

.... [1]

[Total: 6]

11 Explain the operation of a moving coil loudspeaker. In addition to a providing a description, make use of a propely labelled diagram.

....

....

....

....

....

....

....

....

....

....

....

[Total: 6]

Chapter 21. Electromagnetic induction

4.5.1 Electromagnetic induction

Core

1 Know that a conductor moving across a magnetic field or a changing magnetic field linking with a conductor can induce an e.m.f. in the conductor

2 Describe an experiment to demonstrate electromagnetic induction

3 State the factors affecting the magnitude of an induced e.m.f.

Supplement

4 Know that the direction of an induced e.m.f. opposes the change causing it

5 State and use the relative directions of force, field and induced current

4.5.2 The a.c. generator

Core

Supplement

1 Describe a simple form of a.c. generator (rotating coil or rotating magnet) and the use of slip rings and brushes where needed

2 Sketch and interpret graphs of e.m.f. against time for simple a.c. generators and relate the position of the generator coil to the peaks, troughs and zeros of the e.m.f.

4.5.6 The transformer

Core

1 Describe the construction of a simple transformer with a soft iron core, as used for voltage transformations

2 Use the terms primary, secondary, step-up and step-down

3 Recall and use the equation

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

where p and s refer to primary and secondary

4 Describe the use of transformers in high-voltage transmission of electricity

5 State the advantages of high-voltage transmission

Supplement

6 Explain the principle of operation of a simple iron-cored transformer

7 Recall and use the equation for 100% efficiency in a transformer

$$I_p V_p = I_s V_s$$

where p and s refer to primary and secondary

8 Recall and use the equation

$$P = I^2 R$$

to explain why power losses in cables are smaller when the voltage is greater

21.1 Electrical generator

1 Fig. 8.1 shows the outline of an a.c. generator. The peak output voltage of the generator is 6.0 V and the output has a frequency of 10 Hz.

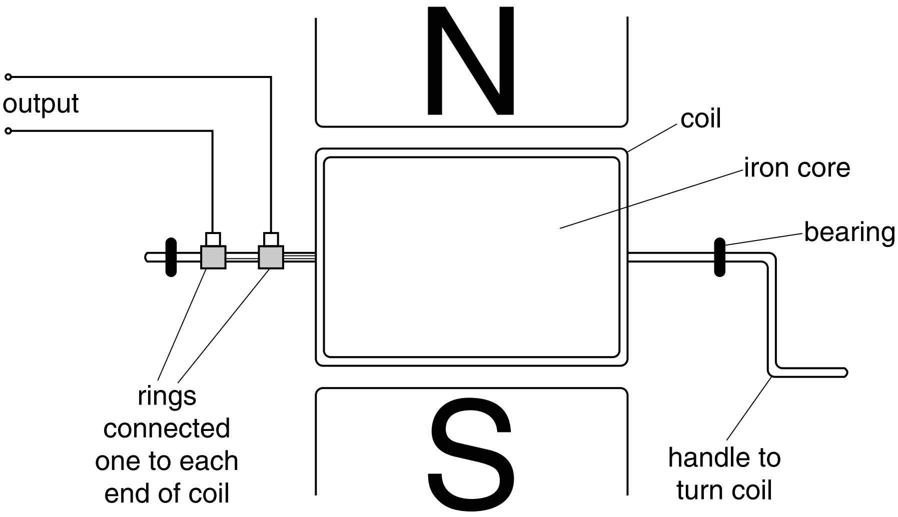


Fig. 8.1

(a) Fig. 8.2 shows the axes of a voltage-time graph for the generator output.

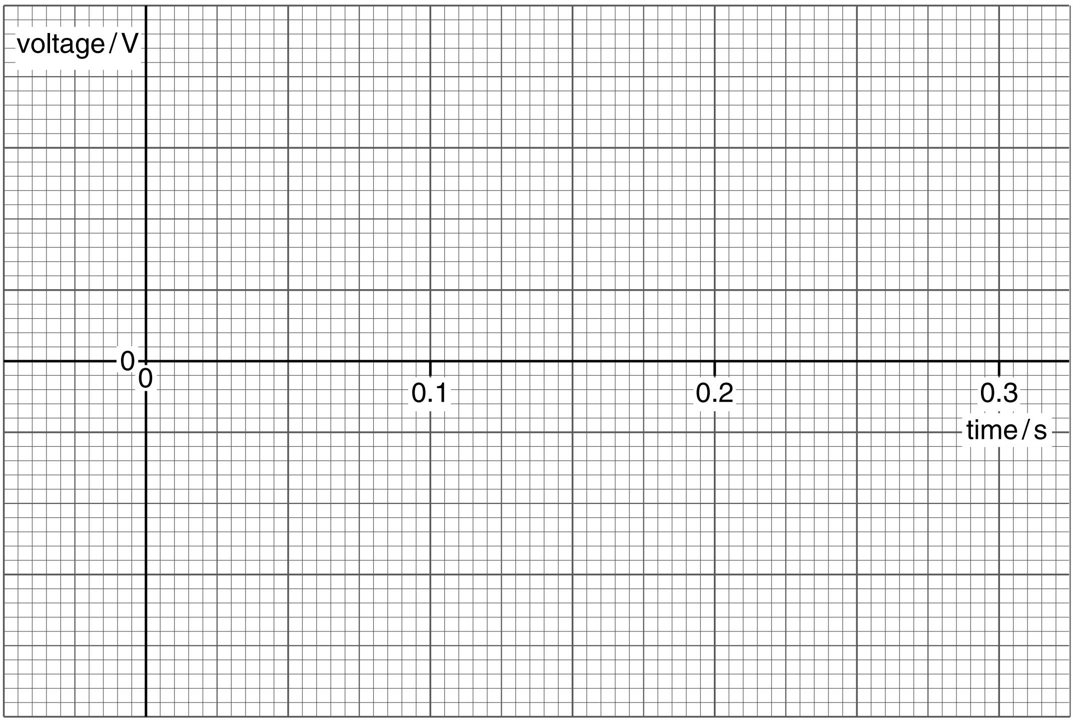


Fig. 8.2

On Fig. 8.2,

(i) mark suitable voltage values on the voltage axis,

(ii) draw a graph of the generator output.

[3]

(b) The generator shown in Fig. 8.1 works by electromagnetic induction.

Explain how this effect produces the output voltage.

....

....

....

.... [3]

(c) State the energy changes that occur in the generator when it is producing output.

.... [2]

2 Electromagnetic induction can be demonstrated using a solenoid, a magnet, a sensitive ammeter and connecting wire.

(a) In the space below, draw a labelled diagram of the apparatus set up to demonstrate electromagnetic induction. [2]

(b) State one way of using the apparatus to produce an induced current.

....

....[1]

(c) Explain why your method produces an induced current.

....

....

....[2]

(d) Without changing the apparatus, state what must be done to produce

(i) an induced current in the opposite direction to the original current,

....

....

(ii) a larger induced current.

....

....

[2]

3 Electromagnetic induction may be demonstrated using a magnet, a solenoid and other necessary apparatus.

(a) Explain what is meant by *electromagnetic induction*.

....

....

....

.... [2]

(b) In the space below, draw a labelled diagram of the apparatus set up so that electromagnetic induction may be demonstrated. [2]

(c) Describe how you would use the apparatus to demonstrate electromagnetic induction.

....

....

....

.... [2]

(d) State two ways of increasing the magnitude of the induced e.m.f. in this experiment.

1. ....

....

2. ....

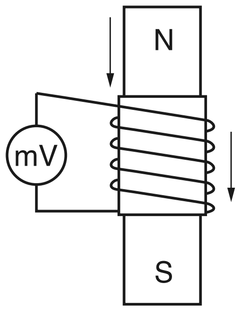
.... [2]

[Total: 8]

4 A coil is wound on a cylindrical cardboard tube and connected to a sensitive centre-zero millivoltmeter.

Figs. 8.1, 8.2 and 8.3 show three situations involving the coil and a magnet.

(a) On the lines alongside each situation, describe what, if anything, is seen happening on the millivoltmeter.



magnet inside coil, both moving at same speed

....

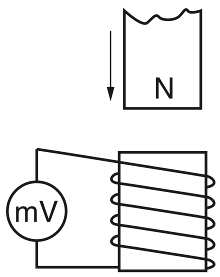
....

....

....

.... [1]

Fig. 8.1



magnet moving towards coil

coil stationary

....

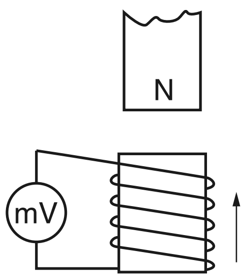
....

....

....

.... [1]

Fig. 8.2



magnet stationary

coil moving towards magnet

....

....

....

....

.... [2]

Fig. 8.3

(b) Choose one of the situations in **(a)** where something is seen happening to the millivoltmeter. For this situation, state three changes which could be made to increase the magnitude of what is seen.

1. ....

2. ....

3. .... [3]

[Total: 7]

5 In the laboratory demonstration shown in Fig. 11.1, a copper rod rolls at a steady speed down the sloping parallel copper rails. The rails are in the region of a strong magnetic field that acts vertically downwards.

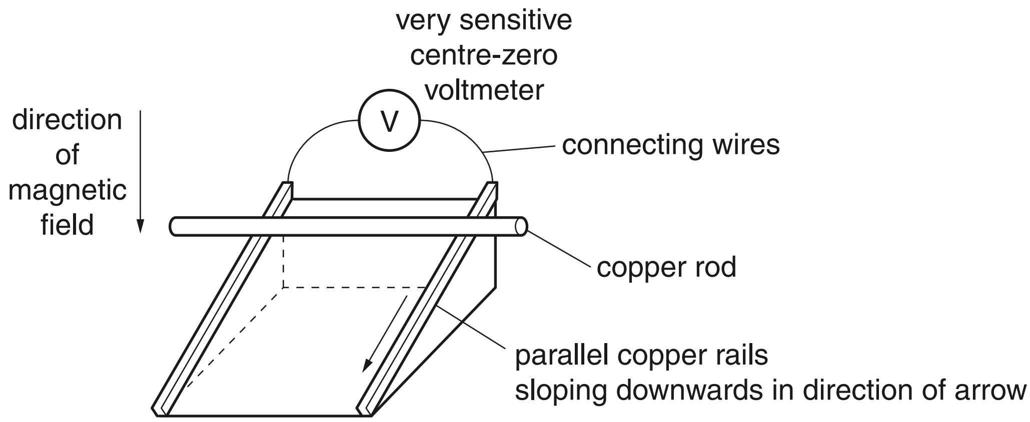


Fig. 11.1

(a) Explain why the voltmeter shows a deflection.

....

....

....

.... [2]

(b) State, with reasons, the effect on the voltmeter deflection of the following changes:

(i) increasing the strength of the magnetic field,

deflection ....

reason ....

....

....

(ii) slightly increasing the slope of the copper rails,

deflection ....

reason ....

....

....

(iii) changing the direction of the magnetic field so it is parallel to the copper rails and directed down the slope.

deflection ....

reason ....

....

....
[4]

[Total: 6]

6 A student holds a magnet above a solenoid, which is connected to a centre-zero milli-ammeter as shown Fig. 8.1.

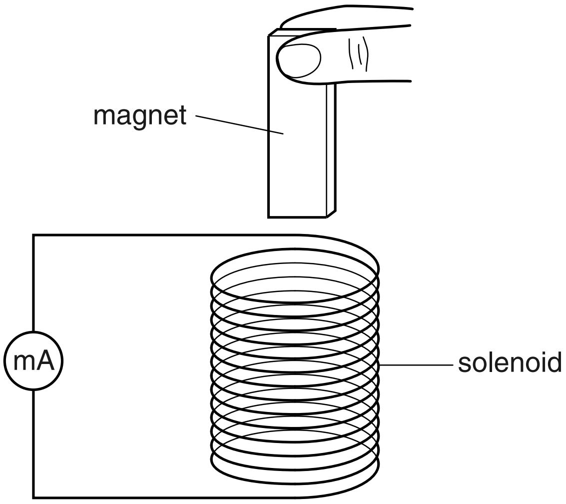


Fig. 8.1

(a) The student drops the magnet so that it falls through the solenoid.

State and explain what would be observed on the milliammeter

(i) as the magnet enters the solenoid,

....

....

.... [2]

(ii) as the magnet speeds up inside the solenoid.

....

....

.... [2]

(b) As the magnet passes into the coil in part **(a)**, the coil exerts a force on the magnet even though there is no contact between them.

(i) State the direction of this force.

....

(ii) Explain how this force is caused.

....

....

....

[3]

[Total: 7]

7 Fig. 9.1 shows a thin, straight rod XY placed in the magnetic field between the poles of a magnet. The wires from the ends of XY are connected to a centre-zero voltmeter.

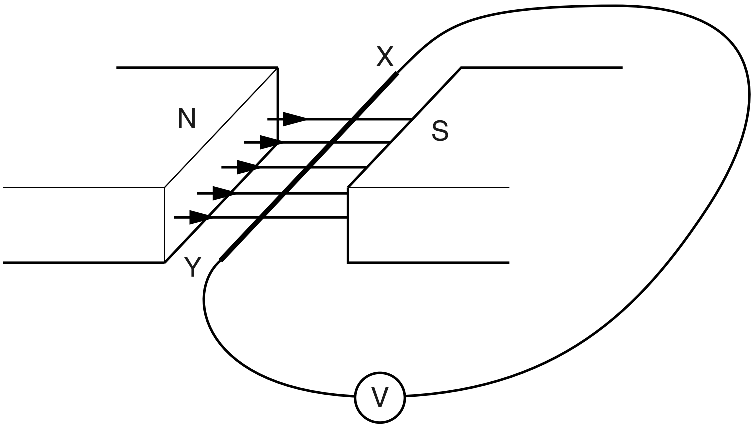


Fig. 9.1

(a) When XY is moved slowly upwards the needle of the voltmeter shows a small deflection.

(i) State how XY must be moved to produce a larger deflection in the opposite direction.

....

.... [2]

(ii) XY is now rotated about its central point by raising X and lowering Y. Explain why no deflection is observed.

....

....

.... [2]

(b) The effect of moving XY can be seen if the wires are connected to the terminals of a cathode-ray oscilloscope instead of the voltmeter.

(i) State the parts inside the oscilloscope tube to which these terminals are connected.

.... [1]

(ii) The spot on the oscilloscope screen moves up and down repeatedly. State how XY is being moved.

.... [1]

(iii) State the setting of the time-base of the oscilloscope during the process described in **(ii)**.

.... [1]

[Total: 7]

8 **(a)** A very sensitive, centre-zero voltmeter is connected to the two terminals of a solenoid (long coil). Fig. 9.1 shows the S pole of a cylindrical magnet being inserted into the solenoid.

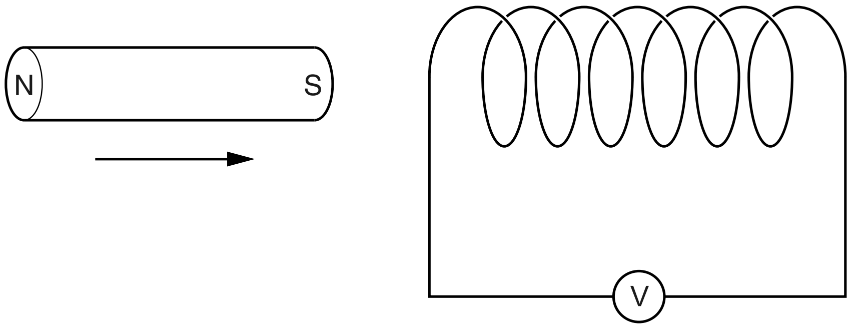


Fig. 9.1

As the magnet is inserted into the left-hand end of the solenoid, the needle of the voltmeter deflects.

(i) Explain why the needle deflects as the magnet is inserted.

....

.... [2]

(ii) State and explain the effect of inserting the magnet more slowly.

....

.... [2]

(iii) State what is observed when the magnet is withdrawn from the left-hand end of the solenoid.

.... [1]

(b) A transformer consists of a primary coil and a secondary coil on an iron core. An alternating voltage is connected to the primary coil.

Describe and explain the operation of the transformer.

....

....

....

....

....

.... [4]

[Total: 9]

21.2 Transformer

1 Fig.1 shows a transformer and a rectifier used in a battery charging circuit for a 12 V battery.

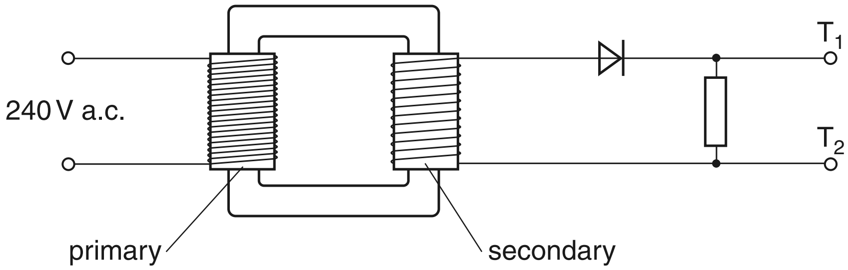


Fig.1

(a) The transformer produces an output of 15 V across the secondary coil.

Calculate a suitable turns ratio for the transformer.

turns ratio = ... [2]

(b) Fig.2 shows the 15 V output across the secondary coil.

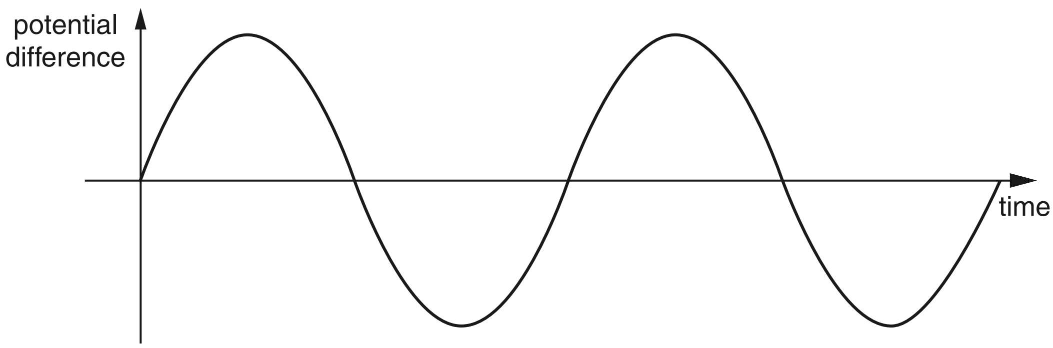


Fig.2

On the same axes, sketch the graph of the potential difference across the terminals T_1 and T_2 before the battery is connected. [2]

(c) Explain how the circuit converts an a.c. supply into a d.c. output.

....

....

.... [2]

(d) On Fig.1, draw in a battery connected so that it may be charged. [1]

(e) When fully charged, the 12V battery can supply a current of 2.0 A for 30 hours (1.08×10^5 s).

Calculate

(i) the battery power when supplying a current of 2.0 A,

power = ...

(ii) the total energy that the battery will supply during the 30 hours.

energy = ...
[4]

2 A transformer has an output of 24 V when supplying a current of 2.0 A. The current in the primary coil is 0.40 A and the transformer is 100% efficient.

(a) Calculate

(i) the power output of the transformer,

power = ...

(ii) the voltage applied across the primary coil.

voltage = ...
[4]

(b) Explain

(i) what is meant by the statement that the transformer is 100% efficient,

....

....

....

(ii) how the transformer changes an input voltage into a different output voltage.

....

....

....

....
[4]

3 **(a)** An engine on a model railway needs a 6 V a.c. supply. A mains supply of 240 V a.c. is available.

(i) In the space below, draw a labelled diagram of a transformer suitable for producing the required supply voltage.

(ii) Suggest suitable numbers of turns for the coils.

....

....
[4]

(b) The power needed for this model engine is 12 W. Calculate the current taken from the mains when just this engine is in use, assuming that the transformer is 100% efficient.

current = ………………..[2]

(c) Explain why transformers will only work when connected to an a.c. supply.

....

....

....[2]

4 Fig. 10.1 shows the basic parts of a transformer.

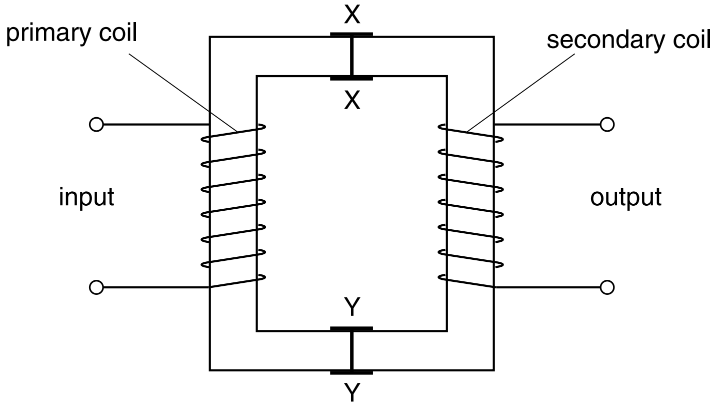


Fig. 10.1

(a) Use ideas of electromagnetic induction to explain how the input voltage is transformed into an output voltage. Use the three questions below to help you with your answer.

What happens in the primary coil?

....

....

....

What happens in the core?

....

....

What happens in the secondary coil?

....

....

.... [5]

(b) State what is needed to make the output voltage higher than the input voltage.

.... [1]

(c) The core of this transformer splits along XX and YY. Explain why the transformer would not work if the two halves of the core were separated by about 30 cm.

....

.... [1]

(d) A 100% efficient transformer is used to step up the voltage of a supply from 100 V to 200 V. A resistor is connected to the output. The current in the primary coil is 0.4 A.

Calculate the current in the secondary coil.

current = ... [2]

5 A transformer is needed to step down a 240 V a.c. supply to a 12 V a.c. output.

(a) In the space below, draw a labelled diagram of a suitable transformer. [3]

(b) Explain

(i) why the transformer only works on a.c.,

....

....[1]

(ii) how the input voltage is changed to an output voltage.

....

....

....[2]

(c) The output current is 1.5 A.

Calculate

(i) the power output,

power = ...[1]

(ii) the energy output in 30 s.

energy = ...[1]

6 Fig. 9.1 is a block diagram of an electrical energy supply system, using the output of a coal-fired power station.

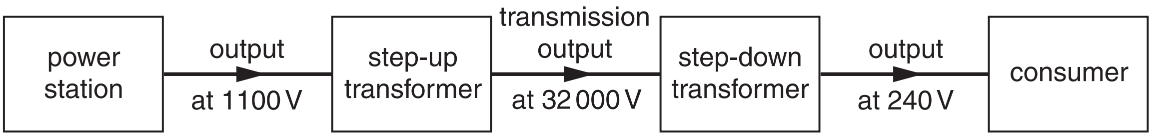


Fig. 9.1

(a) Suggest **one** possible way of storing surplus energy when the demand from the consumers falls below the output of the power station.

....

.... [1]

(b) State why electrical energy is transmitted at high voltage.

.... [1]

(c) A transmission cable of resistance R carries a current I. Write down a formula that gives the power loss in the cable in terms of R and I.

.... [1]

(d) The step-up transformer has 1200 turns on the primary coil. Using the values in Fig. 9.1, calculate the number of turns on its secondary coil. Assume that the transformer has no energy losses.

number of turns = ... [2]

(e) The input to the step-up transformer is 800 kW.

Using the values in Fig. 9.1, calculate the current in the transmission cables, assuming that the transformer is 100% efficient.

current = ... [3]

(f) The long distance transmission cables have a bulit in resistance of 2 kΩ.

Calculate the power loss due to cable internal resistance.

loss = ... [2]

[Total: 10]

7 **(a)** The transformer in Fig. 8.1 is used to convert 240V a.c. to 6V a.c.

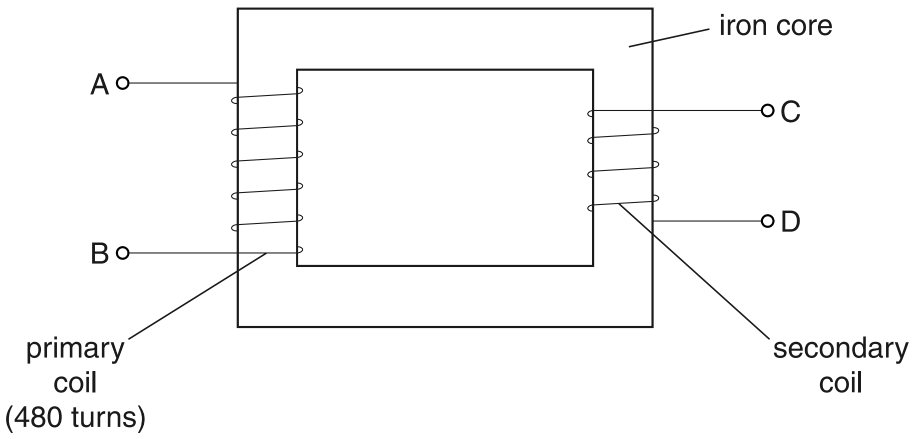


Fig. 8.1

(i) Using the information above, calculate the number of turns on the secondary coil.

number of turns = ... [2]

(ii) Describe how the transformer works.

....

....

....

....

.... [3]

(iii) State one way in which energy is lost from the transformer, and from which part it is lost.

.... [1]

(b) Fig. 8.2 shows a device labelled "IGCSE Transformer".

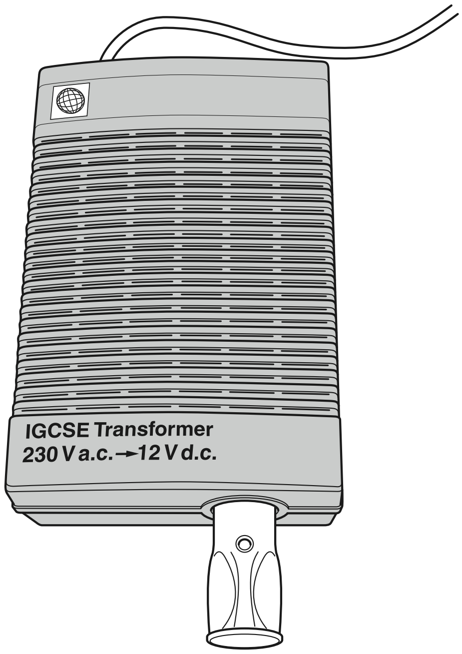


Fig. 8.2

Study the label on the case of the IGCSE Transformer.

(i) What is the output of the device? .... [1]

(ii) From the information on the case, deduce what other electrical component must be included within the case of the IGCSE Transformer, apart from a transformer.

.... [1]

(c) A transformer supplying electrical energy to a factory changes the 11 000 V a.c. supply to 440 V a.c. for use in the factory. The current in the secondary coil is 200 A.

Calculate the current in the primary coil, assuming no losses from the transformer.

current = ... [2]

[Total: 10]

8 Fig. 8.1 shows a simple transformer.

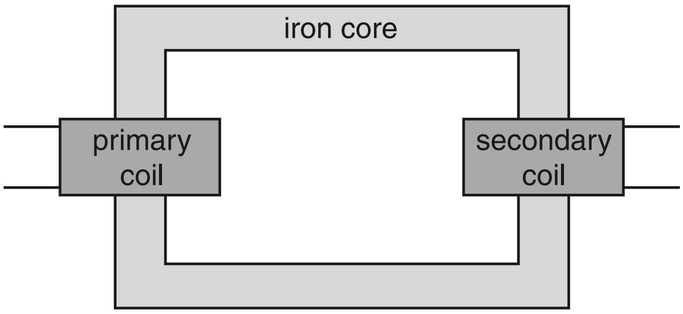


Fig. 8.1

(a) Describe how a voltage across the primary coil causes a voltage across the secondary coil.

....

....

....

....

....

.... [3]

(b) State what design feature would cause the voltage across the secondary coil to be larger than the voltage across the primary coil.

....

.... [1]

(c) The output of a power station is connected to a transformer, which you are to assume is 100% efficient.

The input to the primary coil is 24 000 V, 12 000 A.

The output from the secondary coil is 400 000 V. This is the voltage at which the electrical energy is transmitted through the transmission lines.

Calculate the current in the secondary coil.

current = ... [2]

(d) State two reasons why it is cheaper to transmit electrical energy at high voltage.

1. ....

....

2. ....

.... [2]

[Total: 8]

9 **(a)** In Fig. 8.1, a magnet is moving towards one end of a solenoid connected to a sensitive centre-zero meter. During this movement a current is induced in the solenoid.

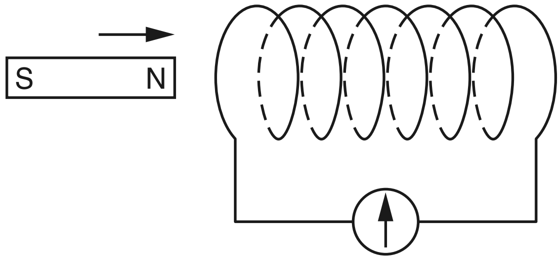


Fig. 8.1

Suggest **three** possible changes to the system in Fig. 8.1 that would increase the induced current.

1. ....

2. ....

3. ....[3]

(b) Fig. 8.2 shows a transformer. P is the primary coil. S is the secondary coil. The coils are wound on an iron core.

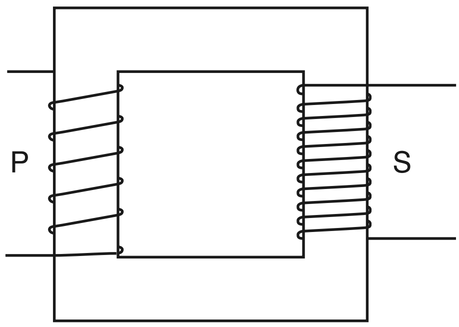


Fig. 8.2

P has 200 turns and S has 800 turns. The e.m.f. induced across S is 24 V. The current in S is 0.50 A. The transformer operates with 100% efficiency.

Calculate

(i) the voltage of the supply to P,

voltage = ...[2]

(ii) the current in P.

current = ...[2]

[Total: 7]

Part V
Atomic physics

Chapter 22. The nuclear atom

5.1.1 The atom

Core

1 Describe the structure of an atom in terms of a positively charged nucleus and negatively charged electrons in orbit around the nucleus

2 Know how atoms may form positive ions by losing electrons or form negative ions by gaining electrons

Supplement

3 Describe how the scattering of alpha (α) particles by a sheet of thin metal supports the nuclear model of the atom, by providing evidence for:
(a) a very small nucleus surrounded by mostly empty space
(b) a nucleus containing most of the mass of the atom
(c) a nucleus that is positively charged

5.1.2 The nucleus

Core

1 Describe the composition of the nucleus in terms of protons and neutrons

2 State the relative charges of protons, neutrons and electrons as +1, 0 and –1 respectively

3 Define the terms proton number (atomic number) *Z* and nucleon number (mass number) *A* and be able to calculate the number of neutrons in a nucleus

4 Use the nuclide notation $^{A}_{Z}X$

5 Explain what is meant by an isotope and state that an element may have more than one isotope

Supplement

6 Describe the processes of nuclear fission and nuclear fusion as the splitting or joining of nuclei, to include the nuclide equation and qualitative description of mass and energy changes without values

7 Know the relationship between the proton number and the relative charge on a nucleus

8 Know the relationship between the nucleon number and the relative mass of a nucleus

22.1 c.r.o.

1 Fig. 11.1 shows the basic design of the tube of a cathode ray oscilloscope (CRO).

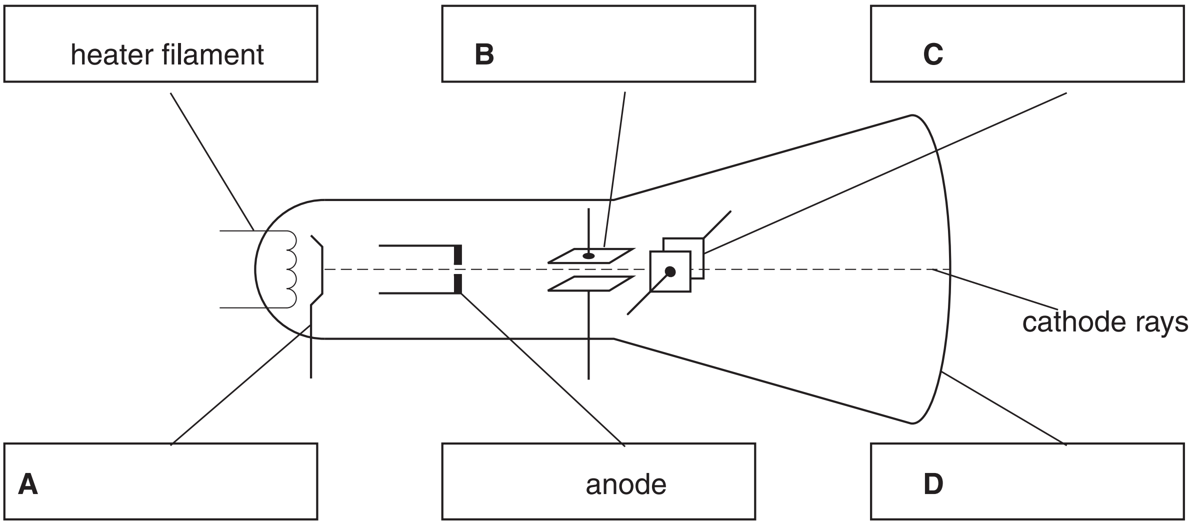


Fig. 11.1

(a) On Fig. 11.1, write the names of parts **A**, **B**, **C** and **D** in the boxes provided. [2]

(b) State the function of:

part **A**, ...

....

part **B**. ....

.... [2]

(c) A varying p.d. from a 12V supply is connected to a CRO, so that the waveform of the supply is shown on the screen.

To which of the components in Fig. 11.1

(i) is the 12V supply connected,

.... [1]

(ii) is the time-base connected?

.... [1]

[Total: 6]

2 A student is using a cathode-ray oscilloscope to display the waveform of an alternating current supply. The arrangement is shown in Fig. 10.1.

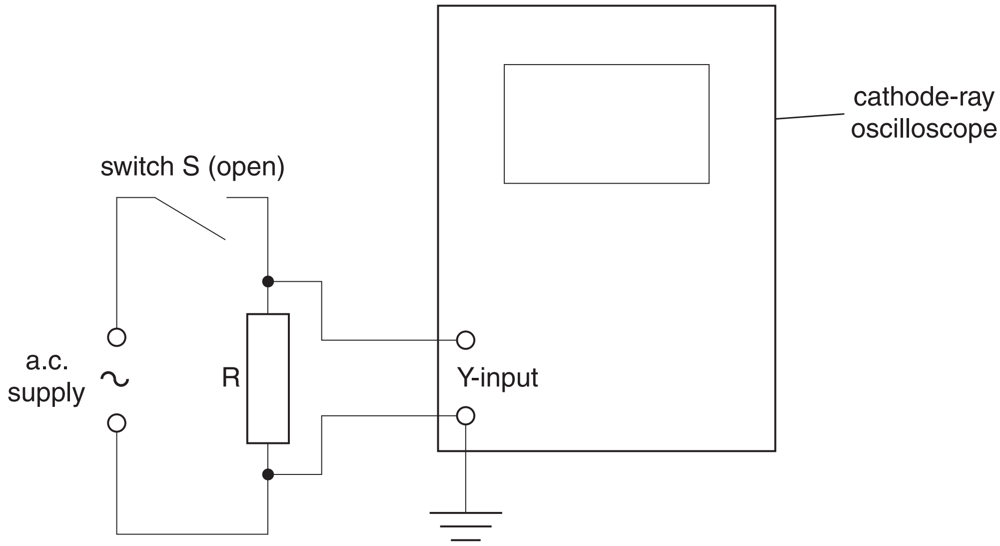


Fig. 10.1

When switch S is closed, the trace seen on the screen is as shown in Fig. 10.2. To get this trace, the settings of the oscilloscope controls are

volts / cm: 5 V / cm

time-base: 10 ms / cm

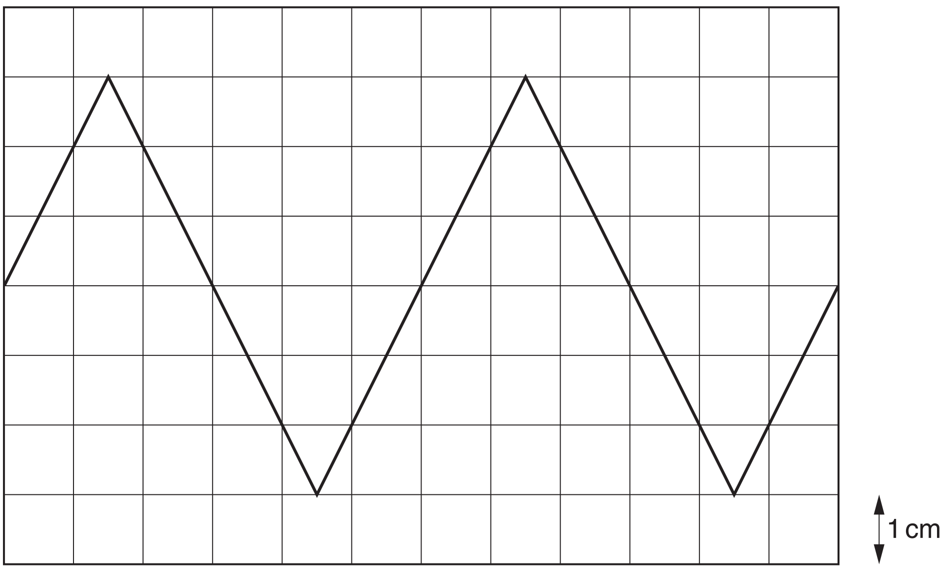


Fig. 10.2

(a) On Fig. 10.2, carefully draw what is seen on the screen when the frequency of the supply is increased to 1.5 times its previous value. [3]

(b) What change, if any, must be made to the oscilloscope volts / cm and time-base controls in order to reduce the peak-to-peak height of the trace to half that shown in Fig. 10.2?

volts / cm setting .... [2]

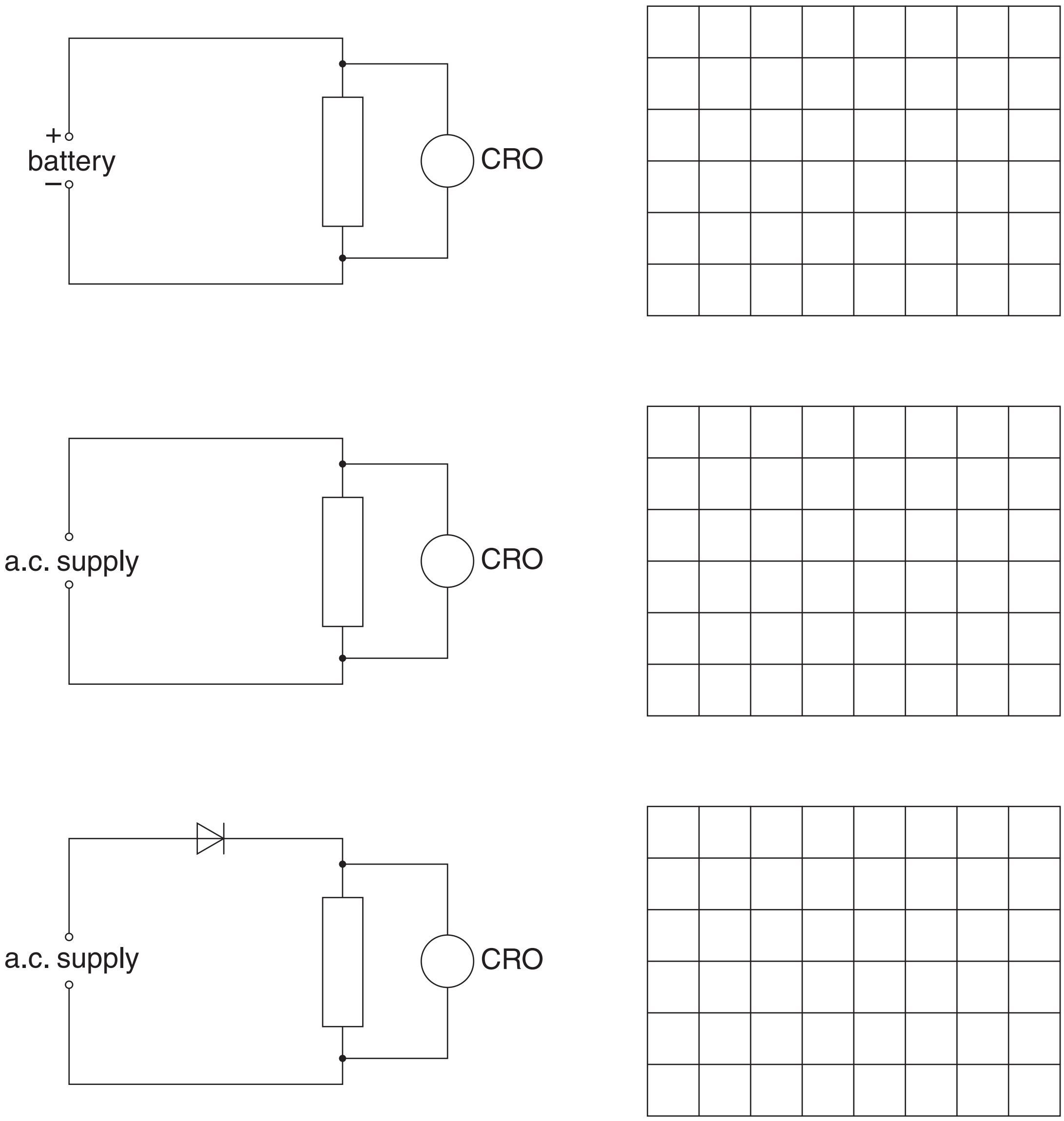
time-base setting .... [1]

[Total: 6]

3 When no circuit is connected to the input of a cathode-ray oscilloscope (CRO), there is a horizontal trace across the middle of the screen.

Fig. 11.1 shows three circuits, each connected to a CRO.

On the grid alongside each circuit, draw the trace that might be seen on the screen of the CRO.



[6]

Fig. 11.1

[Total: 6]

4 **(a)** A cathode-ray oscilloscope makes use of the process known as thermionic emission.

Describe what happens during this process.

....

....

....[1]

(b) In the space below, draw a **labelled** diagram of a cathode-ray oscilloscope.

Include in your diagram the tube, the cathode, the accelerating anode, the focusing anode and both X- and Y-plates. Do not attempt to show any external circuits.

[3]

(c) A cathode ray is a beam of electrons.

Suggest one way of controlling the number of electrons in the beam.

....

....[1]

(d) One cathode-ray tube has 5000 V between the accelerating anode and the cathode.

The beam of electrons carries a total charge of 0.0095 C in 5.0 s.

Calculate

(i) the current caused by the beam,

current = ...[2]

(ii) the energy transferred by the beam in 20 s.

energy = ...[2]

[Total: 9]

5 Fig. 11.1 shows the main components of a cathode-ray oscilloscope.

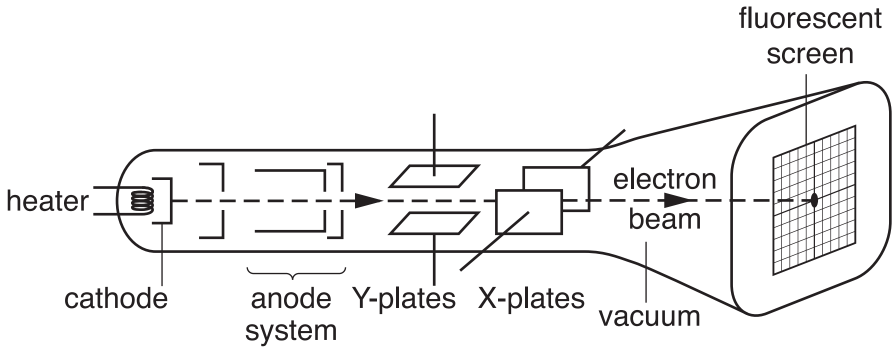


Fig. 11.1

(a) State the purpose of

(i) the heater,

....

....

(ii) the cathode,

....

....

(iii) the anode system.

....

....

....

[4]

(b) Without deflection, the electron beam produces a spot at the centre of the fluorescent screen. A deflection of the spot towards the top of the screen is required.

(i) Describe how the Y-plates can be used to bring about this deflection.

....

....

(ii) Fig. 11.2 shows the Y-plates.

Fig. 11.2

On Fig. 11.2, sketch the pattern of the electric field produced between the plates.

[4]

[Total: 8]

22.2 Rutherford α particle scattering experiment

1 **(a)** α-particles can be scattered by thin gold foils.

Fig. 11.1 shows part of the paths of three α-particles.
Complete the paths of the three α-particles. [3]

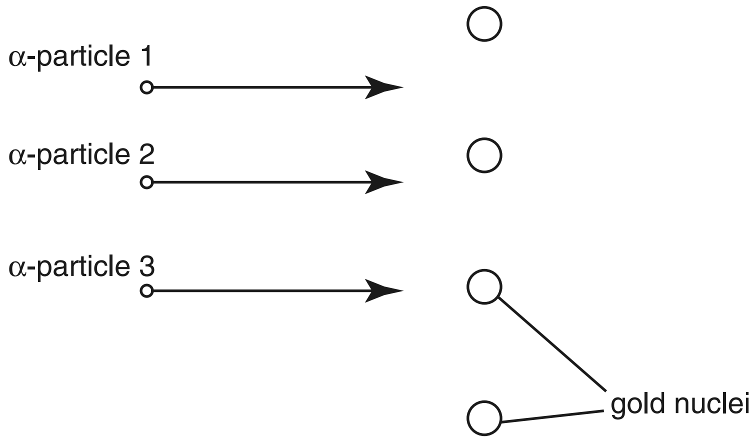


Fig. 11.1

(b) What does the scattering of α-particles show about atomic structure?

....

....

....[2]

(c) State the nucleon number (mass number) of an α-particle.

nucleon number = ...[1]

2 Fig. 11.1 shows the paths of three α-particles moving towards a thin gold foil.

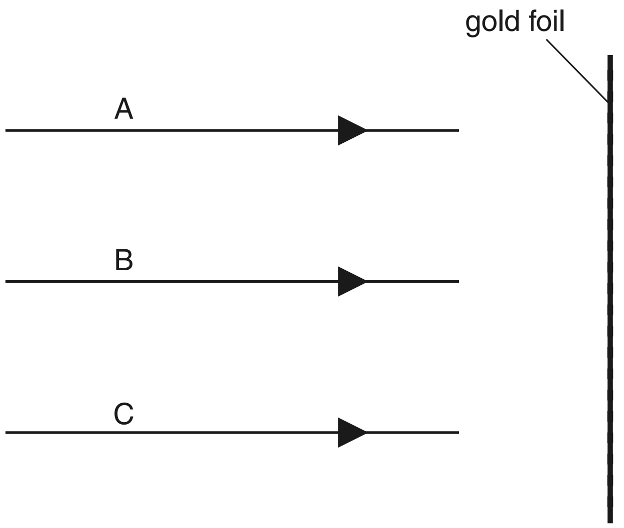


Fig. 11.1

Particle A is moving directly towards a gold nucleus.
Particle B is moving along a line which passes close to a gold nucleus.
Particle C is moving along a line which does not pass close to a gold nucleus.

(a) On Fig. 11.1, complete the paths of the α-particles A, B and C. [3]

(b) State how the results of such an experiment, using large numbers of α-particles, provides evidence for the existence of nuclei in gold atoms.

....

....

....

.... [3]

[Total: 12]

3 In Geiger and Marsden's α-particle scattering experiment, α-particles were directed at a very thin gold foil.

Fig. 10.1 shows five of the nuclei of the atoms in one layer in the gold foil. Also shown are the paths of three α-particles directed at the foil.

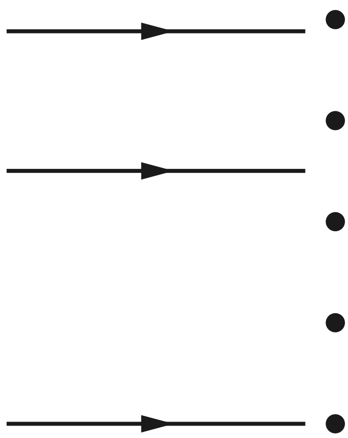


Fig. 10.1

(a) On Fig.10.1, complete the paths of the three α-particles. [3]

(b) **(i)** What result of the experiment confirmed that an atom consisted of a very tiny charged core, containing almost all the mass of the atom?

....

.... [1]

(ii) What is the sign of the charge on this core? .... [1]

(iii) What occupies the space between these charged cores?

.... [1]

[Total: 6]

22.3 Protons,neutrons and electrons

1 **(a)** Chlorine has two isotopes, one of nucleon number 35 and one of nucleon number 37. The proton number of chlorine is 17.

Table 11.1 refers to neutral atoms of chlorine.

Complete Table 11.1.

	nucleon number 35	**nucleon number 37**
number of protons		
number of neutrons		
number of electrons		

[3]

Table 11.1

(b) Some isotopes are radioactive.

State the three types of radiation that may be emitted from radioactive isotopes.

1. ....

2. ....

3. .... [1]

(c) **(i)** State one practical use of a radioactive isotope.

....

.... [1]

(ii) Outline how it is used.

....

....

....

....

.... [1]

[Total: 6]

2 An atom of one of the isotopes of sodium contains

11 protons, 11 electrons and 13 neutrons.

(a) Underline which of these three will be the same in neutral atoms of all isotopes of sodium. [2]

(b) State the nucleon number of this isotope. .... [1]

(c) What can you say about the chemical properties of the different isotopes of sodium?

.... [1]

(d) One isotope of sodium is ^{25}Na.

How many neutrons are there in one atom of this isotope? .... [1]

[Total: 5]

3 The most abundant stable isotope of strontium is strontium-88. Its nucleon number is 88 and its proton number is 38. In nuclide notation it is written $^{x}_{y}\mathrm{Sr}$.

(a) Write down

(i) the values of x and y for strontium-88, x = ...

y = ...

(ii) the number of neutrons in a nucleus of strontium-88, ...

(iii) the number of electrons in a neutral atom of strontium-88. ....

[3]

(b) Strontium-90 is a radioactive isotope produced by nuclear reactions. State how the structure of this isotope differs from that of strontium-88.

....

....

....

....

.... [2]

[Total: 5]

4 **(a)** Explain what is meant by relative charge.

....

....[1]

(b) For uranium-235, state the relative charges of each of the following:

(i) one proton ....

(ii) one electron ....

(iii) the nucleus ....

(vi) the atom ....

(v) an isotope .... [5]

[Total: 6]

5 **(a)** Briefly state the difference between nuclear fission and nuclear fusion.

....

....[2]

(b) Write a propery balanced equation describing a nuclear fission process.

[3]

(c) Write a propery balanced equation describing a nuclear fusion process.

[3]

[Total: 8]

Chapter 23. Radioactivity

5.2.1 Detection of radioactivity

Core

1 Know what is meant by background radiation

2 Know the sources that make a significant contribution to background radiation including:
   - (a) radon gas (in the air)
   - (b) rocks and buildings
   - (c) food and drink
   - (d) cosmic rays

3 Know that ionising nuclear radiation can be measured using a detector connected to a counter

4 Use count rate measured in counts / s or counts / minute

Supplement

5 Use measurements of background radiation to determine a corrected count rate

5.2.2 The three types of nuclear emission

Core

1 Describe the emission of radiation from a nucleus as spontaneous and random in direction

2 Identify alpha (α), beta (β) and gamma (γ) emissions from the nucleus by recalling:
   - (a) their nature
   - (b) their relative ionising effects
   - (c) their relative penetrating abilities (β^+ are not included, β-particles will be taken to refer to β^-)

Supplement

3 Describe the deflection of α-particles, β-particles and γ-radiation in electric fields and magnetic fields

4 Explain their relative ionising effects with reference to:
   - (a) kinetic energy
   - (b) electric charge

5.2.3 Radioactive decay

Core

1 Know that radioactive decay is a change in an unstable nucleus that can result in the emission of α-particles or β-particles and/or γ-radiation and know that these changes are spontaneous and random

2 State that during α-decay or β-decay, the nucleus changes to that of a different element

Supplement

3 Know that isotopes of an element may be radioactive due to an excess of neutrons in the nucleus and/or the nucleus being too heavy

4 Describe the effect of α-decay, β-decay and γ-emissions on the nucleus, including an increase in stability and a reduction in the number of excess neutrons; the following change in the nucleus occurs during β-emission

neutron $\rightarrow$ proton + electron

5 Use decay equations, using nuclide notation, to show the emission of α-particles, β-particles and γ-radiation

5.2.4 Half-life

Core

1 Define the half-life of a particular isotope as the time taken for half the nuclei of that isotope in any sample to decay; recall and use this definition in simple calculations, which might involve information in tables or decay curves (calculations will not include background radiation)

Supplement

2 Calculate half-life from data or decay curves from which background radiation has not been subtracted

3 Explain how the type of radiation emitted and the half-life of an isotope determine which isotope is used for applications including:

(a) household fire (smoke) alarms

(b) irradiating food to kill bacteria

(c) sterilisation of equipment using gamma rays

(d) measuring and controlling thicknesses of materials with the choice of radiations used linked to penetration and absorption

(e) diagnosis and treatment of cancer using gamma rays

5.2.5 Safety precautions

Core

1 State the effects of ionising nuclear radiations on living things, including cell death, mutations and cancer

2 Describe how radioactive materials are moved, used and stored in a safe way

Supplement

3 Explain safety precautions for all ionising radiation in terms of reducing exposure time, increasing distance between source and living tissue and using shielding to absorb radiation

23.1 Radiation

1 Some liquid from an atomic power station is known to be radioactive. A sample of this liquid is tested in a laboratory.

(a) In the space below, draw a labelled diagram of the test apparatus used to verify that α-particles are emitted from the liquid. [2]

(b) Explain how the apparatus may be used to estimate the quantity of α-radiation being emitted from the sample.

....

....

....

....

.... [2]

(c) State any two safety precautions that the technician might take whilst making the test.

precaution 1 ....

....

precaution 2 ....

.... [2]

2 **(a)** A radioactive isotope emits only α-particles.

(i) In the space below, draw a labelled diagram of the apparatus you would use to prove that no β-particles or γ-radiation are emitted from the isotope.

(ii) Describe the test you would carry out.

....

....

....

....

(iii) Explain how your results would show that only α-particles are emitted.

....

....

....
[6]

(b) Fig. 11.1 shows a stream of α-particles about to enter the space between the poles of a very strong magnet.

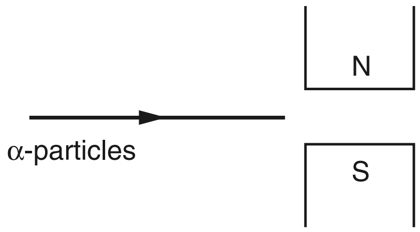


Fig. 11.1

Describe the path of the α-particles in the space between the magnetic poles.

....

....

....[3]

3 **(a)** A sodium nucleus decays by the emission of a β-particle to form magnesium.

(i) Complete the decay equation below.

$$^{24}_{11}\text{Na} \longrightarrow \quad \text{Mg} \; +$$

(ii) Fig. 11.1 shows β-particles from sodium nuclei moving into the space between the poles of a magnet.

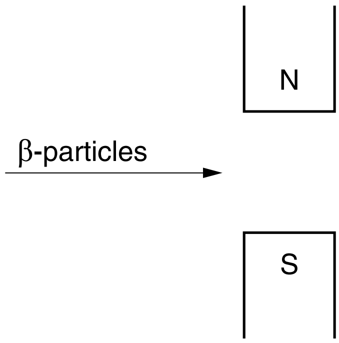


Fig. 11.1

Describe the path of the β-particles between the magnetic poles.

....

....

....
[5]

(b) Very small quantities of a radioactive isotope are used to check the circulation of blood by injecting the isotope into the bloodstream.

(i) Describe how the results are obtained.

....

....

....

....

(ii) Explain why a γ-emitting isotope is used for this purpose rather than one that emits either α-particles or β-particles.

....

....

....
[4]

4 A radioactive source emits only β-particles.

(a) A scientist wishes to investigate the deflection of β-particles by an electric field. Draw a labelled diagram to suggest a suitable experimental arrangement.

[3]

(b) State how the apparatus would be used to show the deflection of the β-particles by the electric field.

....

....

.... [2]

(c) State how the results would show the deflection of the β-particles.

....

.... [1]

(d) Explain the direction of the deflection obtained.

....

.... [1]

5 Fig. 11.1 shows a beam of radiation that contains α-particles, β-particles and γ-rays. The beam enters a very strong magnetic field shown in symbol form by N and S poles.

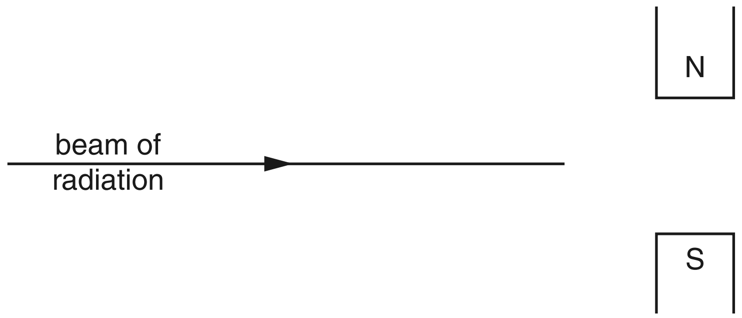


Fig. 11.1

Complete the table below.

radiation	direction of deflection, if any	charge carried by radiation, if any
α-particles		
β-particles		
γ-rays		

[6]

6 **(a)** α-particles, β-particles and γ-rays are known as ionising radiations.

(i) Describe what happens when gases are ionised by ionising radiations.

....

....

....

(ii) Suggest why α-particles are considered better ionisers of gas than β-particles.

....

....
[3]

(b) **(i)** Suggest two practical applications of radioactive isotopes.

1. ....

2. ....

(ii) For one of the applications that you have suggested, describe how it works, or draw a labelled diagram to illustrate it in use.

....

....

....

7 Fig. 11.1 shows an experiment to test the absorption of β-particles by thin sheets of aluminium. Ten sheets are available, each 0.5 mm thick.

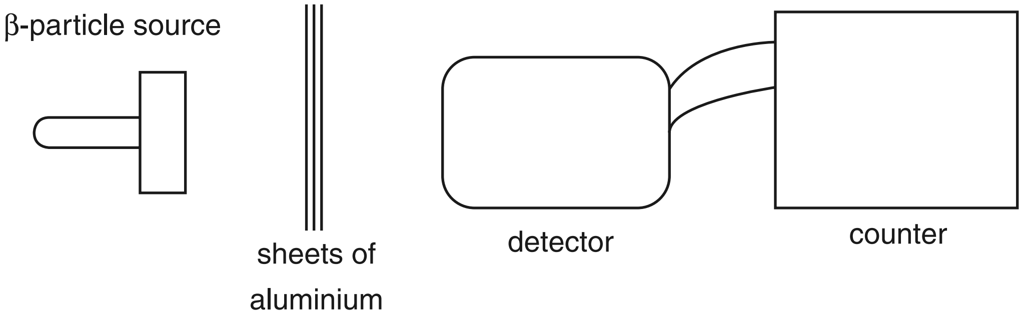


Fig. 11.1

(a) Describe how the experiment is carried out, stating the readings that should be taken.

....

....

....

....

.... [4]

(b) State the results that you would expect to obtain.

....

....

....

.... [2]

[Total: 6]

8 A beam of ionising radiation, containing α-particles, β-particles and γ-rays, is travelling left to right across the page. A magnetic field acts perpendicularly into the page.

(a) In the table below, tick the boxes that describe the deflection of each of the types of radiation as it passes through the magnetic field. One line has been completed, to help you.

	not deflected	**deflected towards top of page**	**deflected towards bottom of page**	**large deflection**	**small deflection**
α-particles		✓			✓
β-particles					
γ-rays					

[3]

(b) An electric field is now applied, in the same region as the magnetic field and at the same time as the magnetic field.

What is the direction of the electric field in order to cancel out the deflection of the α-particles?

.... [2]

[Total: 5]

9 A radium source emits α, β and γ radiations. Fig. 11.1 illustrates what happens to these radiations when they pass through a magnetic field. The left hand beam is actually deviated a great deal less than shown on Fig. 11.1.

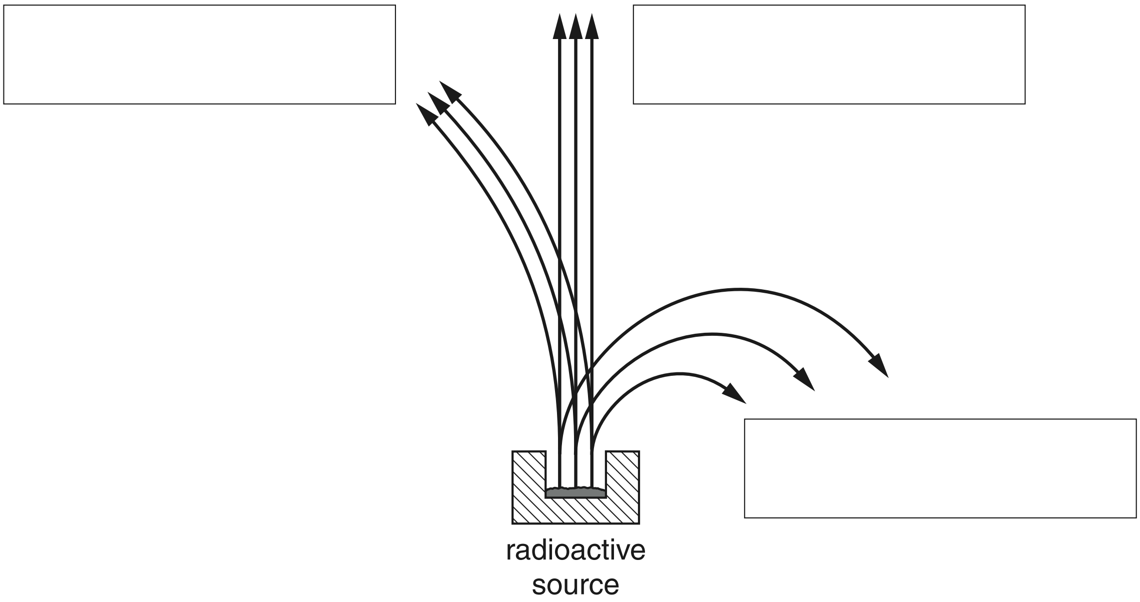


Fig. 11.1

(a) On Fig. 11.1, label the three radiations by writing in the boxes provided. [2]

(b) State the direction of the magnetic field that gives the deflections shown in Fig. 11.1.

.... [2]

[Total: 4]

10 **(a)** A radioactive source emits α-, β- and γ-radiation.

Which of these radiations

(i) has the shortest range in air, ...

(ii) has a negative charge, ...

(iii) is not deflected in a magnetic field? ....

[2]

(b) In a famous experiment, carried out in a vacuum, a very thin sheet of gold was placed in the path of alpha particles.

It was found that a large number of the alpha particles passed through the sheet with little or no deflection from their original path. A very small number of the alpha particles were reflected back towards the source.

(i) Explain, in terms of the force acting, why the direction of motion of an alpha particle changes when it comes close to the nucleus of a gold atom.

....

....

.... [2]

(ii) State **two** conclusions, about the nuclei of atoms, that were made from the results of this experiment.

1. ....

....

2. ....

....

[2]

[Total: 6]

11 Fig. 9.1 shows an experiment carried out **in a vacuum** to investigate the deflection of α-particles and γ-rays in a magnetic field.

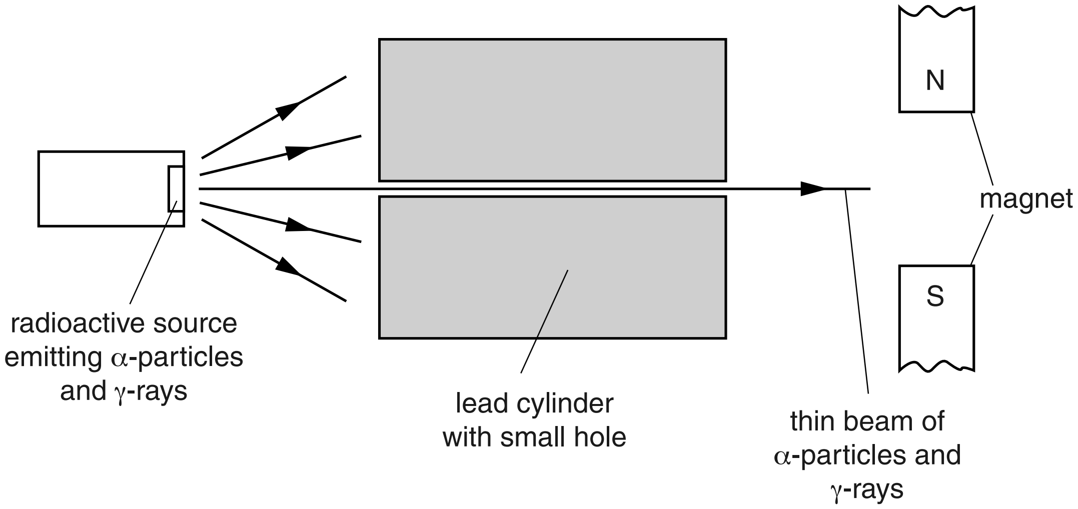


Fig. 9.1

(a) Complete the table to describe the deflection, if any, of the α-particles and the γ-rays in the magnetic field shown. Place **one** tick in **each** column.

possible deflection	α-particles	γ-rays
no deflection		
towards N pole of magnet		
towards S pole of magnet		
out of paper		
into paper		

[3]

(b) The experiment of Fig. 9.1 was carried out in a vacuum.

State the effect of carrying out the experiment in air.

....

....

.... [2]

(c) State and explain the purpose of the lead cylinder.

....

....

.... [2]

[Total: 7]

12 The isotope thorium-234 is radioactive. It emits β-particles as it decays.

(a) The incomplete nuclide equation represents the decay of thorium-234 to an isotope of protactinium (Pa).

Complete the equation.

$$ {}^{234}_{90}\mathrm{Th} \longrightarrow {}^{\cdots\cdots}_{\cdots\cdots}\mathrm{Pa} + {}^{\cdots\cdots}_{\cdots\cdots}\beta $$

[3]

(b) Fig. 11.1 shows a beam of β-particles from a sample of thorium-234 passing into the electric field between two charged plates in a vacuum.

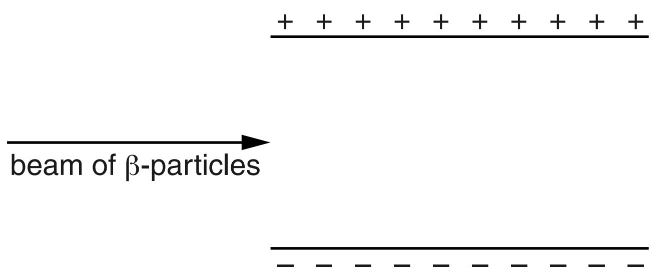


Fig. 11.1

(i) By drawing on Fig. 11.1, show how the β-particles move as they pass between the plates. [1]

(ii) Explain why the β-particles move in this way.

....

.... [1]

[Total: 5]

23.2 Radioactive decay

1 Fig. 10.1 is part of the decay curve for a sample of a β-emitting isotope.

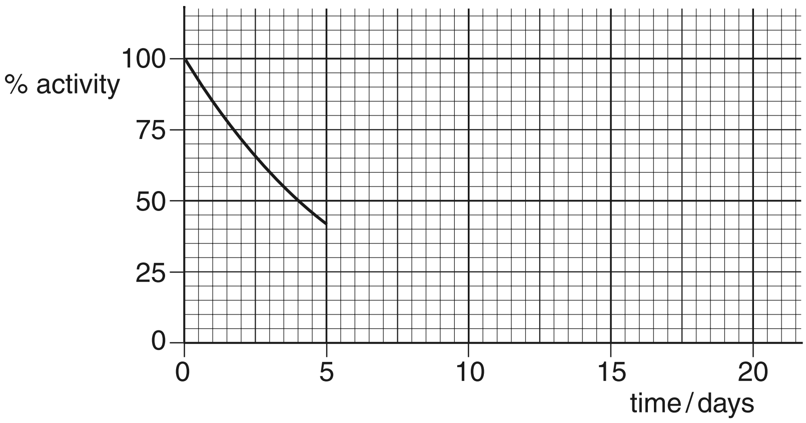


Fig. 10.1

(a) Use Fig. 10.1 to find the half-life of the isotope.

half-life = ... [1]

(b) Complete Fig. 10.1 as far as time = 20 days, by working out the values of a number of points and plotting them. Show your working. [2]

(c) The decay product of the β-emitting isotope is not radioactive.
Explain why the sample of the radioactive isotope will be safer after 20 days than after 1 day. Support your answer by reference to the graph.

....

....[1]

(d) The isotope used for this decay curve may be represented by the symbol ${}^{A}_{Z}X$.
Write down an equation, by filling in the gaps below, to show the β-decay of this isotope to a decay product that has the symbol Y.

${}^{A}_{Z}X \rightarrow \qquad + \qquad Y$ [2]

2 **(a)** The decay of a nucleus of radium $^{226}_{88}Ra$ leads to the emission of an α-particle and leaves behind a nucleus of radon (Rn).
In the space below, write an equation to show this decay. [2]

(b) In an experiment to find the range of α-particles in air, the apparatus in Fig. 11.1 was used.

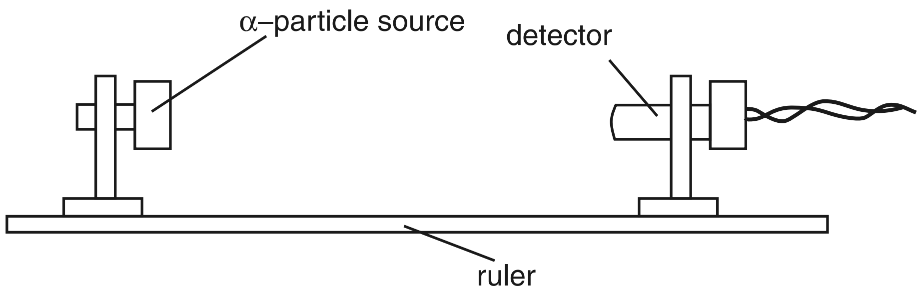


Fig. 11.1

The results of this experiment are shown below.

count rate / (counts/minute)	681	562	441	382	317	20	19	21	19
distance from source to detector/cm	1	2	3	4	5	6	7	8	9

(i) State what causes the count rate 9 cm from the source.

....

(ii) Estimate the count rate that is due to the source at a distance of 2 cm.

....

(iii) Suggest a value for the maximum distance that α-particles can travel from the source.

....

(iv) Justify your answer to **(iii)**.

....

....
[4]

(c) **(i)** State where radon gas is likey to be found in a home, and explain what can be done to reduce its presence.

....

....

.... [3]

(i) State three additional sources of background radiation.

....

....

.... [3]

[Total:12

3 **(a)** Fig. 10.1 is the decay curve for a radioactive isotope that emits only β-particles.

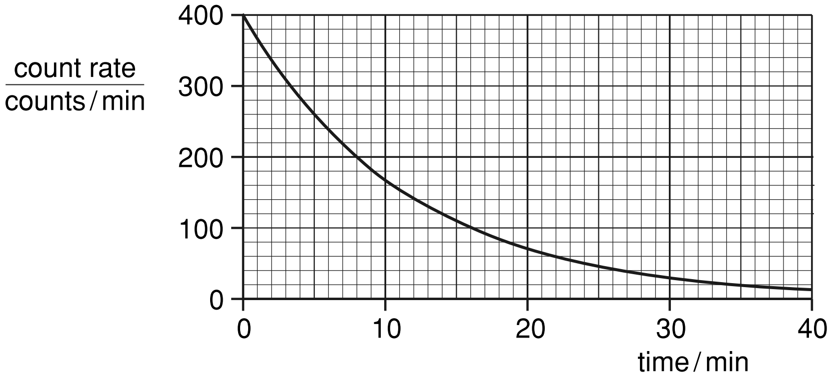


Fig. 10.1

Use the graph to find the value of the half-life of the isotope.

Indicate, on the graph, how you arrived at your value.

half-life .... [2]

(b) A student determines the percentage of β-particles absorbed by a thick aluminium sheet. He uses a source that is emitting only β-particles and that has a long half-life.

(i) In the space below, draw a labelled diagram of the apparatus required, set up to make the determination.

[2]

(ii) List the readings that the student needs to take.

....

....

....

.... [3]

4 A certain element is known to exist as two different isotopes.

(a) State one thing that is the same for atoms of both isotopes.

.... [1]

(b) State one thing that is different between atoms of these two isotopes.

.... [1]

(c) An atom of one of these isotopes is unstable and decays into a different element by emitting a β-particle.

(i) State one thing about the atom that remains the same during this decay.

.... [1]

(ii) State one thing about the atom that changes as a result of this decay.

.... [1]

[Total: 4]

5 Emissions from a radioactive source pass through a hole in a lead screen and into a magnetic field, as shown in Fig. 10.1.

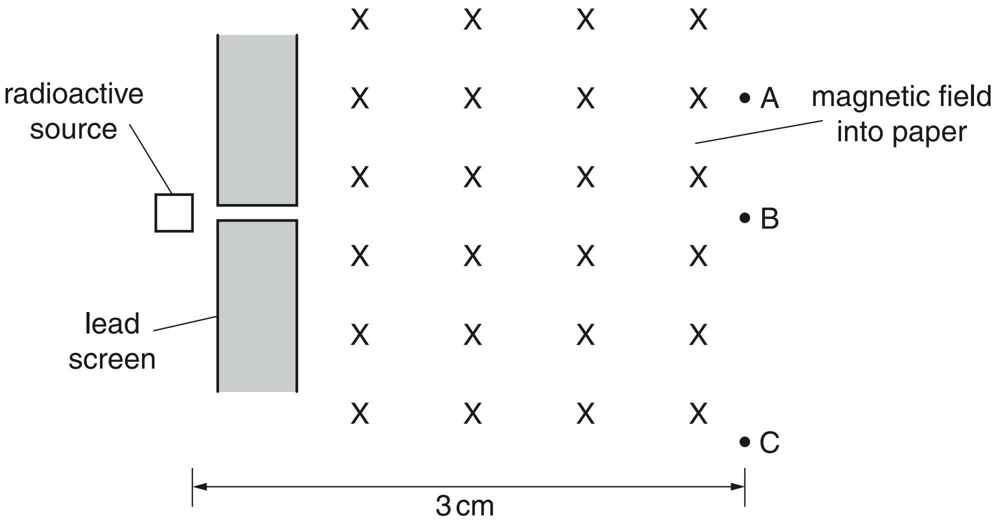


Fig. 10.1

Radiation detectors are placed at A, B and C. They give the following readings:

A	B	C
32 counts/min	543 counts/min	396 counts/min

The radioactive source is then completely removed, and the readings become:

A	B	C
33 counts/min	30 counts/min	31 counts/min

(a) Explain why there are still counts being recorded at A, B and C, even when the radioactive source has been removed, and give the reason for them being slightly different.

....

....

....

.... [2]

(b) From the data given, deduce the type of emission being detected, if any, at A, at B and at C when the radiation source is present.

State the reasons for your answers.

detector at A ....

....

.... [2]

detector at B ....

....

.... [3]

detector at C ....

....

.... [3]

[Total: 10]

6 A radioactive source is placed near a radiation detector connected to a counter, as shown in Fig. 11.1.

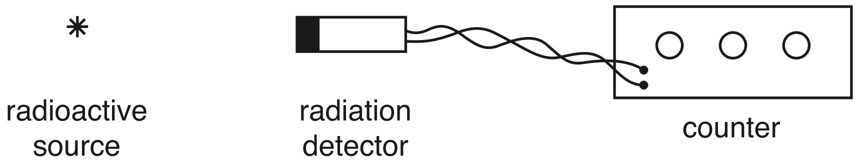


Fig. 11.1

(a) The count rate, measured over three successive minutes, gives values of

720 counts / minute

691 counts / minute

739 counts / minute.

Explain why a variation like this is to be expected in such an experiment.

....

.... [1]

(b) The radiation detector and counter are left untouched. The radioactive source is put in its lead container and returned to the metal security cupboard.

Once this has been done, a further measurement is taken over one minute.

This gives a reading of 33 counts / minute.

(i) State the name used for the radioactivity being detected during this minute.

....

(ii) Suggest two possible sources for this radioactivity.

1. ....

2. .... [3]

[Total: 4]

7 **(a)** Six different nuclides have nucleon and proton numbers as follows:

nuclide	nucleon number	proton number
A	214	84
B	214	85
C	211	84
D	211	86
E	210	82
F	210	83

State which two nuclides are isotopes of the same element. .... and .... [1]

(b) Thorium-232 has a half-life of 1.4×10^{10} years.

At a particular instant, the activity of a sample of thorium-232 is 120 Bq.

(i) Calculate the time taken for the activity of this sample to fall to 15 Bq.

time taken ....[1]

(ii) Explain why, when the activity has become 15 Bq, much of the sample will no longer be thorium-232.

....

....

....[1]

(iii) The sample of thorium-232 is used in an experiment in a laboratory.

Explain why its activity may be regarded as constant.

....

....

....[1]

[Total: 4]

8 **(a)** An atom consists of a nucleus made up of protons and neutrons, surrounded by orbiting electrons.

(i) Which of these particles has a positive charge? ....[1]

(ii) Which two of these particles have almost equal mass?

.... and .... [1]

(b) A silver nucleus is denoted by $^{107}_{47}Ag$. State the number of protons and the number of neutrons in this nucleus.

number of protons = ... number of neutrons = ... [2]

(c) The graph in Fig. 11.1 shows part of the decay curve of a radioactive nuclide. The count rate is plotted against time.

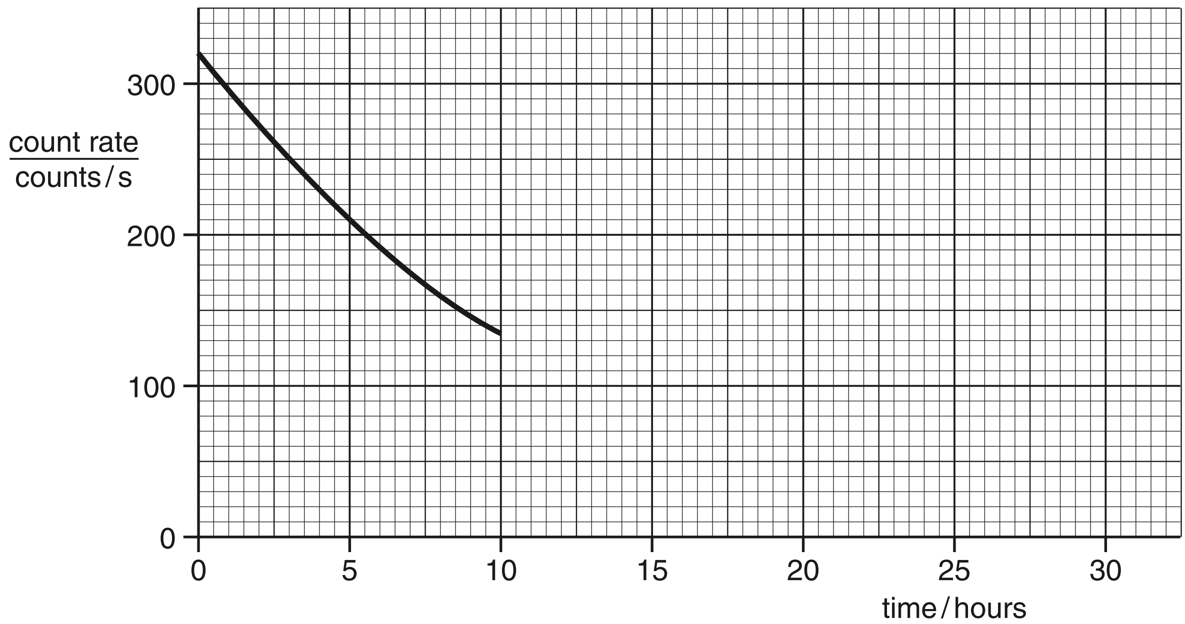


Fig. 11.1

(i) Use the graph to find the half-life of this nuclide.

half-life = ...[1]

(ii) Plot two more points on Fig. 11.1 at times greater than 10 hours. Use a dot in a circle to indicate each point. [2]

[Total: 7]

9 **(a)** In a laboratory's secure radioactivity cupboard are two unlabelled radioactive sources. A scientist knows that one is an alpha-emitter and the other is a beta-emitter, but is not sure which is which.

A radiation detector, a magnet and some paper are available.

Briefly describe two different experimental tests, using this equipment, which would allow the scientist to identify which is the alpha-emitter and which is the beta-emitter.

test	outcome for alpha	outcome for beta

[4]

(b) Radioactive carbon-14 ($^{14}_{6}C$) decays by emitting β-particles.

(i) What are the values of the proton and nucleon numbers of carbon-14?

proton number ....

nucleon number ....[2]

(ii) Carbon-14 is absorbed by living organisms. When the organism dies, no more carbon-14 is absorbed. The carbon-14 already absorbed decays with a half-life of 5730 years.

Recent human skeletons have an activity of 64 units, but a human skeleton dug up by an archaeologist has an activity of 8 units.

Determine the age of this ancient skeleton.

age = ...[2]

[Total: 8]

10 In a research laboratory, a radioactive sample is placed close to a radiation detector. The graph in Fig. 11.1 shows the decay of the sample.

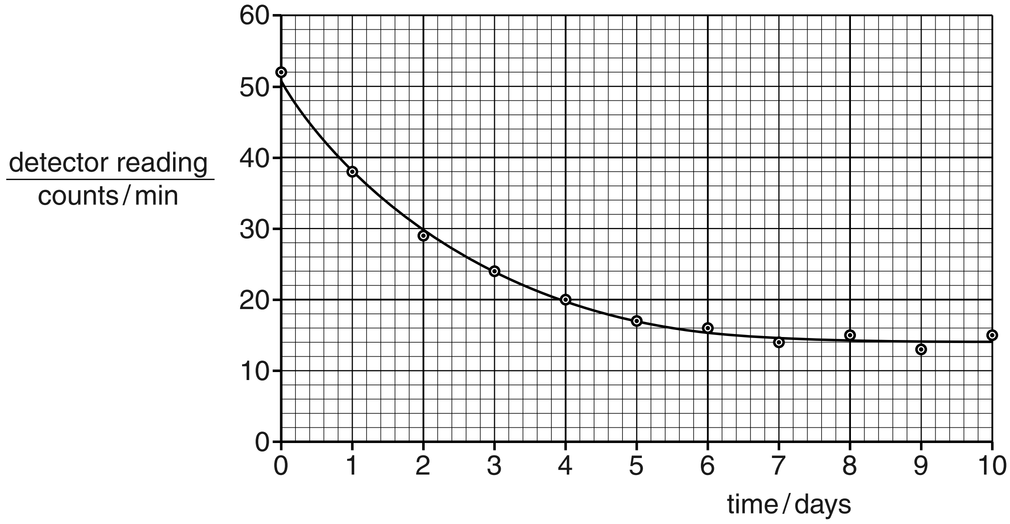


Fig. 11.1

(a) After 6 days the count rate hardly decreases and, in fact, increases a little at times. Explain these observations.

....

....

....

.... [2]

(b) Use the graph to determine the half-life of the sample. Explain your working carefully.

half-life = ... [4]

(c) Another radioactive sample is a strong emitter of α-particles and γ-rays. A junior researcher suggests that a sufficient safety precaution, when working with this sample, would be to hold the sample with long forceps. Explain why this suggestion, although helpful, may be insufficient.

....

....

....

.... [2]

[Total: 8]

11 **(a)** State what is meant by spontaneous nuclear decay.

....

....

.... [2]

(b) Explain how the neutron number of a nucleus is related to spontaneous nuclear decay.

....

....

.... [3]

[Total: 5]

12 List five applications utilising nuclear radioactivity and the corresponding types of radiation typically used for each.

....

....

....

....

....

....

....

....

[Total:1C

Part VI
Space Physics

Chapter 22. Earth and the Solar System

22.1 The Earth

6.1.1 The Earth

Core

1 Know that the Earth is a planet that rotates on its axis, which is tilted, once in approximately 24 hours, and use this to explain observations of the apparent daily motion of the Sun and the periodic cycle of day and night

2 Know that the Earth orbits the Sun once in approximately 365 days and use this to explain the periodic nature of the seasons

3 Know that it takes approximately one month for the Moon to orbit the Earth and use this to explain the periodic nature of the Moon's cycle of phases

Supplement

4 Define average orbital speed from the equation

$$v = \frac{2\pi r}{T}$$

where r is the average radius of the orbit and T is the orbital period; recall and use this equation

22.1 The Earth

1 Complete these sentences using words from the list.

Each word or words can be used once, more than once or not at all.

the seasons **day and night** **tilted** **orbital**
24 hours **365 days** **one month**

The Earth takes _______________ to spin once on its axis.

The Earth spinning on its axis causes _______________.

The Earth's axis is _______________.

This causes _______________.

2 Figure 24.2 shows the Sun and the Earth.

The figure is **not** to scale.

Figure 24.2

i State the season at position A on Figure 24.2.

____

ii Positions A and B in the figure have different daytime temperatures. Explain why.

____

____

____

____

22.2 The Solar System

6.1.2 The Solar System

Core

1 Describe the Solar System as containing:

(a) one star, the Sun

(b) the eight named planets and know their order from the Sun

(c) minor planets that orbit the Sun, including dwarf planets such as Pluto and asteroids in the asteroid belt

(d) moons, that orbit the planets

(e) smaller Solar System bodies, including comets and natural satellites

2 Know that, in comparison to each other, the four planets nearest the Sun are rocky and small and the four planets furthest from the Sun are gaseous and large, and explain this difference by referring to an accretion model for Solar System formation, to include:

(a) the model's dependence on gravity

(b) the presence of many elements in interstellar clouds of gas and dust

(c) the rotation of material in the cloud and the formation of an accretion disc

Supplement

7 Know that planets, minor planets and comets have elliptical orbits, and recall that the Sun is not at the centre of the elliptical orbit, except when the orbit is approximately circular

8 Analyse and interpret planetary data about orbital distance, orbital duration, density, surface temperature and uniform gravitational field strength at the planet's surface

6.1.2 The Solar System continued

Core

3 Know that the strength of the gravitational field

(a) at the surface of a planet depends on the mass of the planet

(b) around a planet decreases as the distance from the planet increases

4 Calculate the time it takes light to travel a significant distance such as between objects in the Solar System

5 Know that the Sun contains most of the mass of the Solar System and this explains why the planets orbit the Sun

6 Know that the force that keeps an object in orbit around the Sun is the gravitational attraction of the Sun

Supplement

9 Know that the strength of the Sun's gravitational field decreases and that the orbital speeds of the planets decrease as the distance from the Sun increases

10 Know that an object in an elliptical orbit travels faster when closer to the Sun and explain this using the conservation of energy

22.2 The Solar System

1 Describe the difference in structure between the four planets closest to the Sun and the four planets furthest from the Sun. **[3]**

[Total: 3]

2 Saturn has many Moons. The largest Moon of Saturn is called Titan.

The orbit of Titan is approximately circular.

a Name the object at the centre of Titan's orbit. **[1]**

b The radius of Titan's orbit is 1.2×10^9 m.

The time taken for Titan to complete one orbit is 1.4×10^6 s.

Calculate the orbital speed of Titan. Show your working.

[3]

[Total: 4]

3 Planets orbit the Sun.

a Name two **other** types of objects in the Solar System that also orbit the Sun.

1 ______________________________

2 ______________________________

b Name two of the planets that are classed as gas giants.

______________________________ and ______________________________

c The Earth takes 365 days to orbit the Sun.

i Calculate the number of seconds in 365 days.

Give your answer in standard form to 3 significant figures.

Show your working.

________________ s

ii The radius of the Earth's orbit is 1.5×10^{11} m.

Use this value and your answer to part **c i** to calculate the Earth's orbital speed.

Show your working.

________________ m/s

d Explain why planets closer to the Sun have higher orbital speeds than those planets that are further away from the Sun.

____

____

____

____

4 Figure 24.1 shows part of the orbit of a planet, P around the Sun, S.

The figure is **not** to scale.

Figure 24.1

a Draw on the figure the direction of the force that keeps P in orbit. **[1]**

b State what causes this force. **[2]**

____

____

c Each planet has a different orbital radius.

Explain what happens to the force keeping each planet in orbit as the orbital radius increases. **[2]**

____

____

[Total: 5]

5 Light travels at a speed of 3.0×10^8 m/s.

The average distance from the Sun to Earth is 1.5×10^{11} m.

a Calculate the time taken for light to travel from the Sun to Earth.

b The average distance from the Sun to Neptune is 4.5×10^{12} m.

Calculate how many times longer it takes for light to travel from the Sun to Neptune than from the Sun to Earth. Show your working.

6 The table shows some information about the planets.

Planet	**Average distance from the Sun / millions of km**	**Average surface temperature / °C**
Mercury	58	167
Venus	108	457
Earth	150	14
Mars	228	−55
Jupiter	778	−153
Saturn	1427	−185
Uranus	2869	−214
Neptune	4496	−225

a Calculate how many times further away Neptune is from the Sun than Mercury is from the Sun. **[1]**

____

b A learner says 'The average surface temperature of the planets decreases as the average distance from the Sun increases.'

Discuss whether this statement is true. **[2]**

____

____

____

c Light travels at a speed of 0.3 million km per second.

Calculate the time taken for light to travel from the Sun to Jupiter. **[2]**

[Total: 5]

7 Figure 24.1 shows three objects in the Solar System, A, B and C. The figure is **not** to scale.

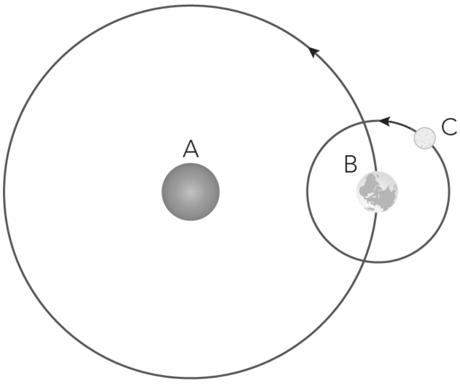


Figure 24.1

a Write the letter of the object that represents:

i the Earth ________________

ii the Moon ________________

iii the Sun. ________________

b Draw an arrow on the figure to show the direction of the force that keeps object B in its orbit.

Chapter 23. Stars and the Universe

23.1 The Sun as a Star

6.2.1 The Sun as a star

Core

1 Know that the Sun is a star of medium size, consisting mostly of hydrogen and helium, and that it radiates most of its energy in the infrared, visible and ultraviolet regions of the electromagnetic spectrum

Supplement

2 Know that stars are powered by nuclear reactions that release energy and that in stable stars the nuclear reactions involve the fusion of hydrogen into helium

23.1 The Sun as a Star

1 Each of these sentences has a choice of words. Underline the correct word in each case.

The Sun is a **planet / star / galaxy**.

The Sun is classed as having a **small / medium / large** size.

The Sun’s energy comes from nuclear **fission / fusion** reactions that produce **hydrogen / helium**.

23.2 Stars

6.2.2 Stars

Core

1 State that:

(a) galaxies are each made up of many billions of stars

(b) the Sun is a star in the galaxy known as the Milky Way

(c) other stars that make up the Milky Way are much further away from the Earth than the Sun is from the Earth

(d) astronomical distances can be measured in light-years, where one light-year is the distance travelled in (the vacuum of) space by light in one year

Supplement

2 Know that one light-year is equal to 9.5×10^{15} m

3 Describe the life cycle of a star:

(a) a star is formed from interstellar clouds of gas and dust that contain hydrogen

(b) a protostar is an interstellar cloud collapsing and increasing in temperature as a result of its internal gravitational attraction

(c) a protostar becomes a stable star when the inward force of gravitational attraction is balanced by an outward force due to the high temperature in the centre of the star

(d) all stars eventually run out of hydrogen as fuel for the nuclear reaction

(e) most stars expand to form red giants and more massive stars expand to form red supergiants when most of the hydrogen in the centre of the star has been converted to helium

(f) a red giant from a less massive star forms a planetary nebula with a white dwarf star at its centre

(g) a red supergiant explodes as a supernova, forming a nebula containing hydrogen and new heavier elements, leaving behind a neutron star or a black hole at its centre

(h) the nebula from a supernova may form new stars with orbiting planets

23.2 Stars

1 **(a)** Describe and explain how a stable star is formed.

....

....

....

....

....

.... [3]

(b) Describe and explain what can be deduced from cosmic microwave background radiation (CMBR).

....

....

....

....

....

.... [3]

[Total: 6]

2 The Tucana Dwarf galaxy is 2.87 million light years away from Earth.

a Describe what is meant by the word *galaxy*. **[1]**

---

b Calculate the distance of the Tucana Dwarf galaxy from Earth in metres. **[2]**

3 The speed of light in a vacuum is 3.0×10^8 m/s. Use this speed to show by calculation that a light year is approximately 9.5×10^{15} m.

4 **a** In the early stages of the life cycle of a star, a protostar becomes stable.

Explain what causes a protostar to become stable. **[2]**

b Describe the stages in the life cycle of a star when a small or medium sized star runs out of fuel. **[3]**

5 Name:

a the star that is closest to Earth

b the galaxy that contains the Solar System.

b State the approximate distance of the next closest galaxy to Earth.

6 Describe what is meant by the term 'light year'.

7 **a** Outline the how a protostar is formed.

____

____

____

b Describe the next stage in a star's life cycle after a star the size of the Sun runs out of hydrogen fuel.

____

____

23.3 The Universe

6.2.3 The Universe

Core

1 Know that the Milky Way is one of many billions of galaxies making up the Universe and that the diameter of the Milky Way is approximately 100 000 light-years
2 Describe redshift as an increase in the observed wavelength of electromagnetic radiation emitted from receding stars and galaxies
3 Know that the light emitted from distant galaxies appears redshifted in comparison with light emitted on the Earth
4 Know that redshift in the light from distant galaxies is evidence that the Universe is expanding and supports the Big Bang Theory

Supplement

5 Know that microwave radiation of a specific frequency is observed at all points in space around us and is known as cosmic microwave background radiation (CMBR)
6 Explain that the CMBR was produced shortly after the Universe was formed and that this radiation has been expanded into the microwave region of the electromagnetic spectrum as the Universe expanded
7 Know that the speed v at which a galaxy is moving away from the Earth can be found from the change in wavelength of the galaxy's starlight due to redshift
8 Know that the distance of a far galaxy d can be determined using the brightness of a supernova in that galaxy
9 Define the Hubble constant H_0 as the ratio of the speed at which the galaxy is moving away from the Earth to its distance from the Earth; recall and use the equation

$$H_0 = \frac{v}{d}$$

10 Know that the current estimate for H_0 is 2.2×10^{-18} per second
11 Know that the equation

$$\frac{d}{v} = \frac{1}{H_0}$$

represents an estimate for the age of the Universe and that this is evidence for the idea that all the matter in the Universe was present at a single point

23.3 The Universe

1 **(a)** The Sun is our nearest star.

(i) State the **three** main forms of electromagnetic radiation emitted by the Sun.

1 ....

2 ....

3 ....
[2]

(ii) State the **two** main elements that are found in the Sun.

1 ....

2 ....
[1]

(b) State and explain what can be deduced from the 'redshift' observed by astronomers in the light from all distant galaxies.

....

....

....

....

.... [3]

[Total: 6]

2 Explain what is meant by the word Universe.

3 Light from distance galaxies shows redshift.

a Describe what is meant by *redshift*. **[1]**

____

____

b Figure 25.1 shows the relationship between two quantities, v and d for different galaxies.
Each dot on the graph represents one galaxy.

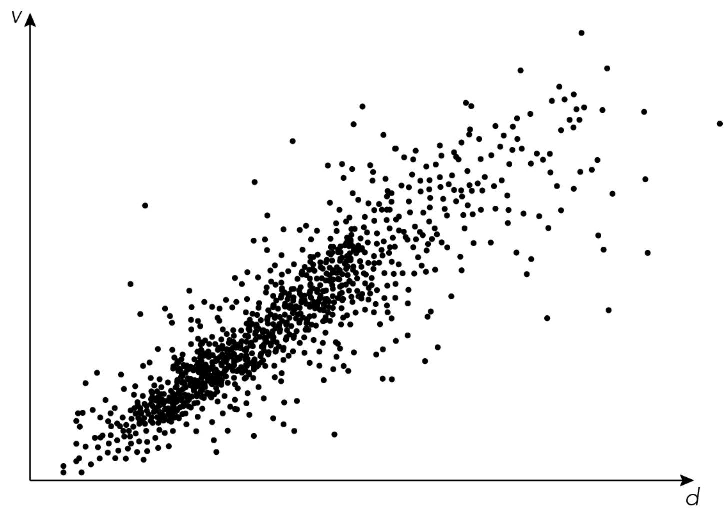


Figure 25.1

i State what the quantities v and d represent. **[2]**

v ____

d ____

ii A learner looks at the graph and says: *'As d increases, v also increases.'*

Discuss whether the learner is correct. **[2]**

____

____

____

iii The equation $H_0 = \dfrac{v}{d}$ was derived from the observations shown in Figure 25.1.

Use the equation to calculate the value of d when $v = 1.9 \times 10^8$ m/s. **[3]**

$d =$ ______________

4 Describe the possible origin of cosmic microwave background radiation (CMBR). **[2]**

5 Complete these sentences using words or phrases from the list.

approaching **expanding** **receding** **contracting**
not moving **staying the same size**

Light from distant galaxies shows redshift. This is evidence that these galaxies are ________________.

This, in turn is evidence that the Universe is ________________.

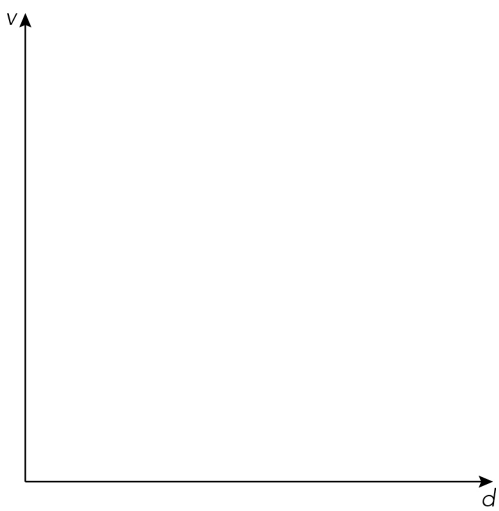
6 **a** Complete these sentences using the best choice of words.

Light from distant galaxies shows redshift. This is evidence that these galaxies are

________________.

This, in turn is evidence that the Universe is ________________.

b Sketch a graph of the speed, *v* that galaxies are moving relative to Earth against their distance, *d* away from Earth.



7 There is microwave radiation in space that comes from all directions.

a State the name given to this radiation.

8 There is microwave radiation in space that comes from all directions.

a State the name given to this radiation.

b State where this radiation is thought to have come from.