

EFFECTS OF ELECTRIC CURRENT

Q1] Tell the odd one out. Give proper explanation.

a. Fuse wire, bad conductor, rubber gloves, generator.

Answer:

Generator. It converts mechanical energy into electric energy, the remaining three do not.

b. Voltmeter, Ammeter, galvanometer, thermometer.

Answer:

Thermometer. It measures temperature, the remaining three measure electrical quantities.

c. Loud speaker, microphone, electric motor, magnet.

Answer:

Magnet. It exerts a force on a magnetic material, the remaining three convert one form of energy into another.

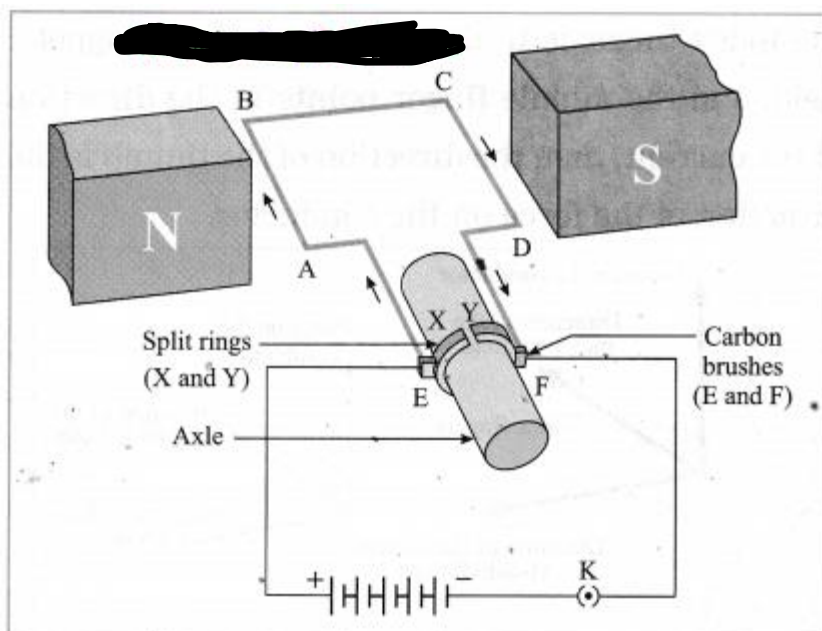
Explain the construction and working of the following. Draw a neat diagram and label it.

a. Electric motor

Answer:

Figure shows the construction of an electric motor. Here, a rectangular loop ABCD of copper wire with resistive coating is placed between the north pole and south pole or a strong magnet, such as a horseshoe magnet, such that the branches AB and CD are perpendicular to the direction of the magnetic field. The ends of the loop are connected to the two halves, X and Y, of split rings X and Y have resistive coating on their inner surfaces and are tightly fitted on the axle. The outer conducting surfaces of X and Y are in contact with two stationary carbon brushes, E and F, respectively.

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Working:

1. When the circuit is completed with a plug key or switch, the current flows in the direction $E \rightarrow A \rightarrow B \rightarrow C \rightarrow D \rightarrow F$. As the magnetic field is directed from the north pole to the south pole, the force on AB is downward and that on CD is upward by Fleming's left hand rule. Hence, AB moves downward and CD upward. These forces are equal in magnitude and opposite in direction. Therefore, as observed from the side AD, the loop ABCD and the axle start rotating in anticlockwise direction.

2. After half a rotation, X and Y come in contact with brushes F and E respectively and the current flows in the direction EDCBAF. Hence the force on CD is downward and that on AB is upward. Therefore, the loop and the axle continue to rotate in the anticlockwise direction.

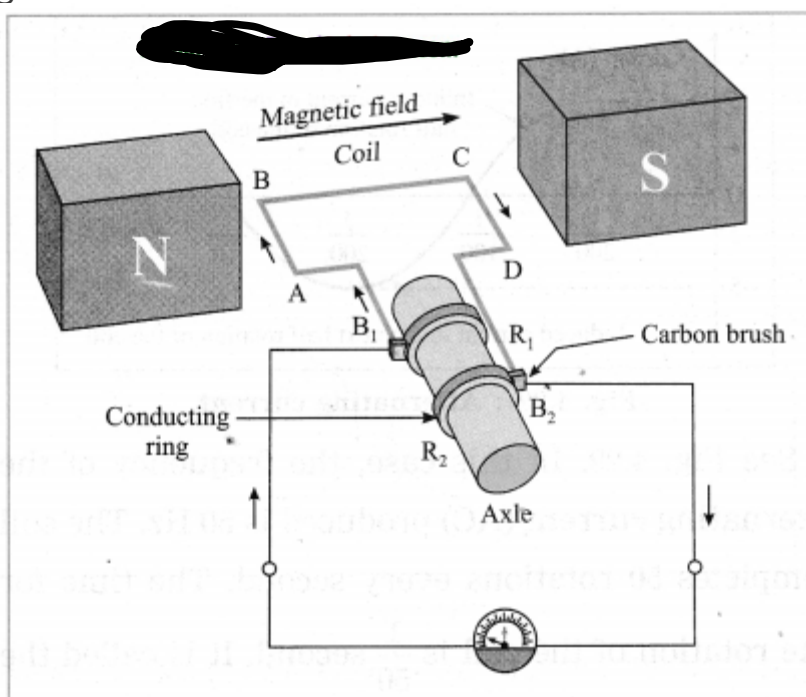
3. After every half rotation, the current in the loop is reversed and the loop and the axle continue to rotate in anti clockwise direction. When the current is switched off, the loop stops rotating after some time.

b. Electric Generator (AC)

Answer:

Figure shows the construction of an AC electric generator. Here, a coil ABCD of copper wire is kept between the pole pieces (N and S) of a strong magnet. The ends of the coil are connected to the conducting rings R_1 and R_2 via carbon brushes B_1 and B_2 . The rings are fixed to the axle and there is a resistive coating in between the rings and the axle. The stationary brushes are connected to a

galvanometer used to show the direction of the current in the circuit.



Working:

When the axle is rotated with a machine from outside, the coil ABCD starts rotating. Suppose the coil rotates in clockwise direction, as observed from the side AD. Then as the branch AB moves upward, the branch CD moves downward. By Fleming's right hand rule, the induced current flows in the direction $A \rightarrow B \rightarrow C \rightarrow D$ and in the external circuit, it flows from B₂ to B₁, through the galvanometer. The induced current is proportional to the number of turns of the copper wire in the coil.

After half a rotation, AB and CD interchange their places. Hence, the induced current flows in the direction $D \rightarrow C \rightarrow B \rightarrow A$. As AB is always in contact with B₁ and CD is in contact with B₂, the current in the external circuit flows from B₁ to B₂ through the galvanometer. Thus, the direction of the current in the external circuit is opposite to that in the previous half rotation. The process goes on repeating and alternating current is generated.

Q3] Electromagnetic induction means

Answer:

c. Generation of a current in a coil due to relative motion between the coil and the magnet.

4. Explain the difference: AC generator and DC generator.

Answer:

AC generator:

1. In an AC generator, the rings used are not split.
2. The direction of the current produced reverses after equal intervals of time.

DC generator:

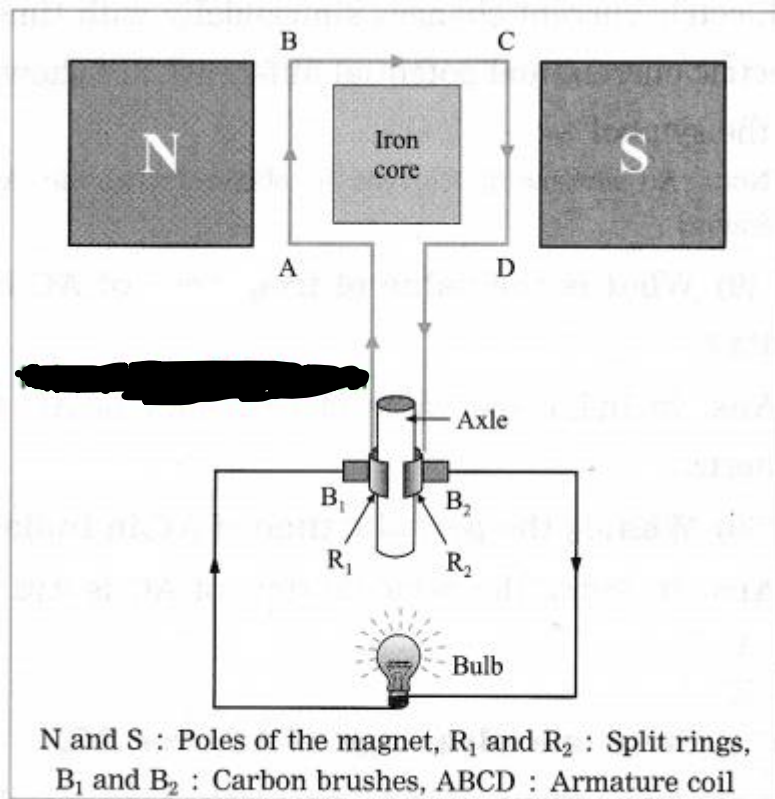
1. In a DC generator, split rings are used.
2. The current produced flows in the same direction all the time.

Question 5.

Which device is used to produce electricity? Describe with a neat diagram.

Answer:

Electric generator (DC).



Electric DC generator

Figure shows the construction of a DC generator.

Working: The axle is rotated with a machine from outside. When the armature coil of the generator rotates in the magnetic field, electric potential difference is produced in the coil due to electromagnetic induction. This produces a

current as shown by the glowing of the bulb or by a galvanometer. The direction of the current depends on the sense of rotation of the coil.

In a DC generator, one brush is always in contact with the arm of the coil moving up while the other brush is in contact with the arm of the coil moving down in the magnetic field. Hence, the flow of the current in the circuit is always in the same direction and the current flows so long as the coil continues to rotate in the magnetic field.

Q6]How does the short circuit form? What is its effect?

Answer:

If a bare live wire (phase wire) and a bare neutral wire touch each other (come in direct contact) or come very close to each other, the resistance of the circuit becomes very small and hence huge (very high) electric current flows through it. This condition is called a short circuit or short circuiting.

In this case, a large amount of heat is produced and the temperature of the components involved becomes very high. Hence, the circuit catches fire.

Q7]a. Tungsten is used to make a solenoid type coil in an electric bulb.

Answer:

1. The intensity of light emitted by the filament of a bulb depends on the temperature of the filament. It increases with the temperature.

2. The melting point of the material used to make the filament of a bulb should be very high so that the filament can be heated to a high temperature by passing a current through it, without melting it. This enables us to obtain more light. The melting point of tungsten is very high.

Hence, tungsten is used to make a solenoid type coil (filament) in an electric bulb.

b. In the electric equipment producing heat e.g. iron, electric heater, boiler, toaster, etc. an alloy such as Nichrome is used, not pure metals.

Answer:

1. The working of heating devices such as a toaster and an electric iron is based on the heating effect of electric current, i.e., conversion of electric energy into heat by passage of electric current through a metallic conductor.

2. An alloy, such as Nichrome, has high resistivity and it can be heated to a high temperature without oxidation, in contrast to pure metals. Therefore, the coils in heating devices such as a toaster and an electric iron are made of an alloy, such as Nichrome, rather than a pure metal.

c. For electric power transmission, copper or aluminium wire is used.

Answer:

1. Copper and aluminium are good conductors of electricity.

2. Copper, and aluminium have very low resistivity. Hence, when an electric current flows through a wire of copper or aluminium, heat produced is comparatively low. Therefore, for electric power transmission, copper or aluminium wire is used.

d. In practice the unit kWh is used for the measurement of electric energy, rather than the joule.

Answer:

(1) If an electric device rated 230 V, 5 A is operated for one hour, electric energy used

$$= VIt = 230 \text{ V} \times 5 \text{ A} \times 3600 \text{ s} = 4140000 \text{ joules.}$$

(2) If this energy is expressed in kW.h, it will be $4140000/3.6 \times 10^6 \text{ kW}\cdot\text{h} = 1.15 \text{ kW}\cdot\text{h}$ (more convenient). 3.6×10^6

Hence, in practice the unit kW·h is used for the measurement of electric energy, rather than the joule.

Q8] Which of the statements given below correctly describes the magnetic field near a long, straight current-carrying conductor?

Answer:

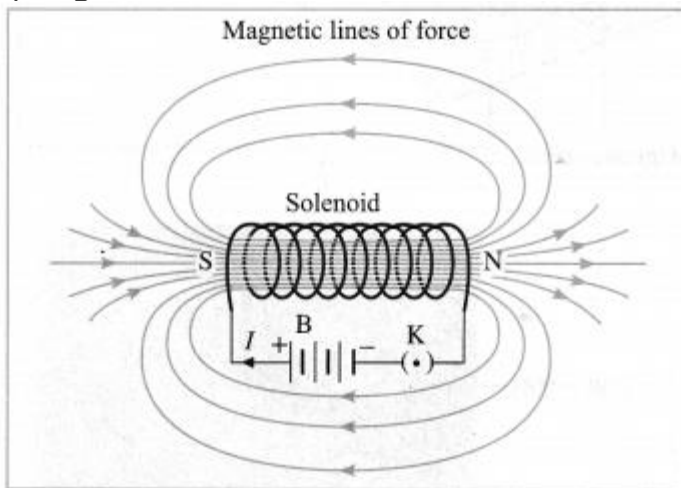
The magnetic lines of force are in concentric circles with the wire as the centre, in a plane perpendicular to the conductor.

Question 9.

What is a solenoid? Compare the magnetic field produced by a solenoid with the magnetic field of a bar magnet. Draw neat figures and name various components.

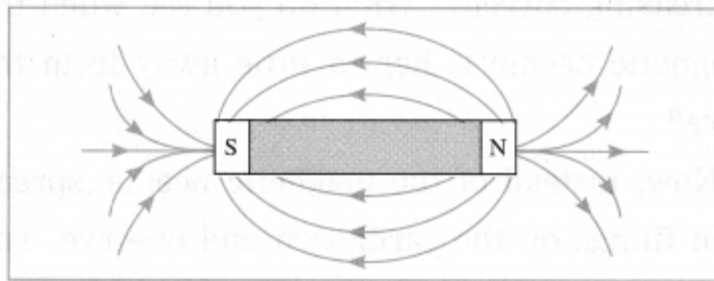
Answer:

When a copper wire with a resistive coating is wound in a chain of loops (like a spring), it is called a solenoid.



Magnetic lines of force (magnetic field lines) due to a current carrying solenoid.

B: Battery, K: Plug key, I: Current, N: North pole, S: South pole



Magnetic lines of force around a bar magnet

The magnetic field lines (magnetic lines of force) due to a current-carrying solenoid are similar to those of a bar magnet. One face of the coil acts as the south pole and the other face as the north pole.

[Note: A current-carrying coil, like a magnet, can be used to magnetise the rod of a given material such as carbon steel or chromium steel. With a strong magnetic field, permanent magnetism can be produced in these materials.]

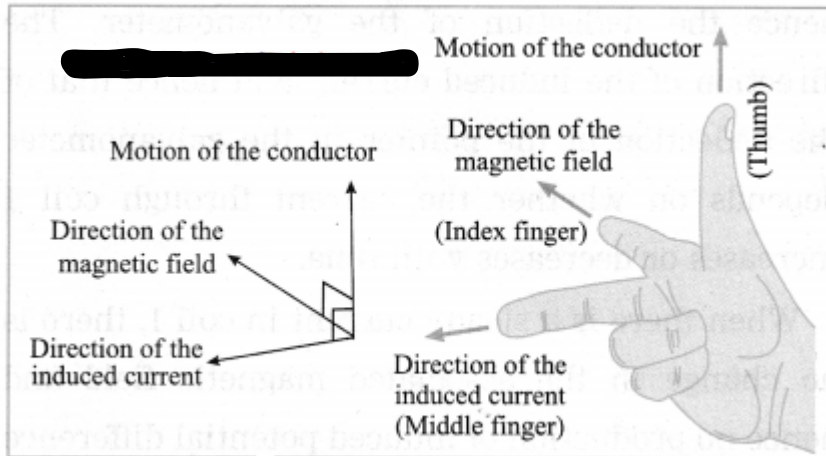
Q10] Name the following diagrams and explain the concept behind them.

Answer:

(a) Fleming's right hand rule:

Answer:

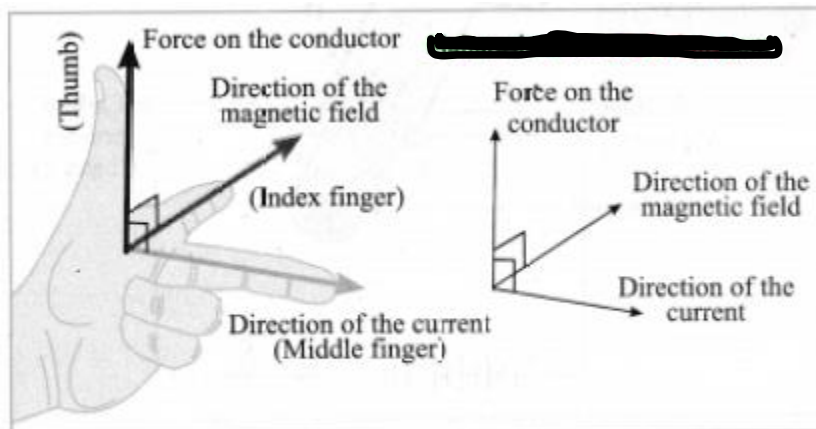
Stretch the thumb, the index finger and the middle finger of the right hand in such a way that they are perpendicular to each other. In this position, the thumb indicates the direction of the motion of the conductor, the index finger the direction of the magnetic field, and the middle finger shows the direction of the induced current.



Fleming's right hand rule

[Note The induced current is maximum when the direction of motion of the conductor is at right angles to the magnetic field.]

(b) Fleming's left hand rule: The left hand thumb, index finger, and the middle finger are stretched so as to be perpendicular to each other. If the index finger is in the direction of the magnetic field, and the middle finger points in the direction of the current, then the direction of the thumb in the direction of the force on the conductor.



Q11] Identify the figures and explain their use.

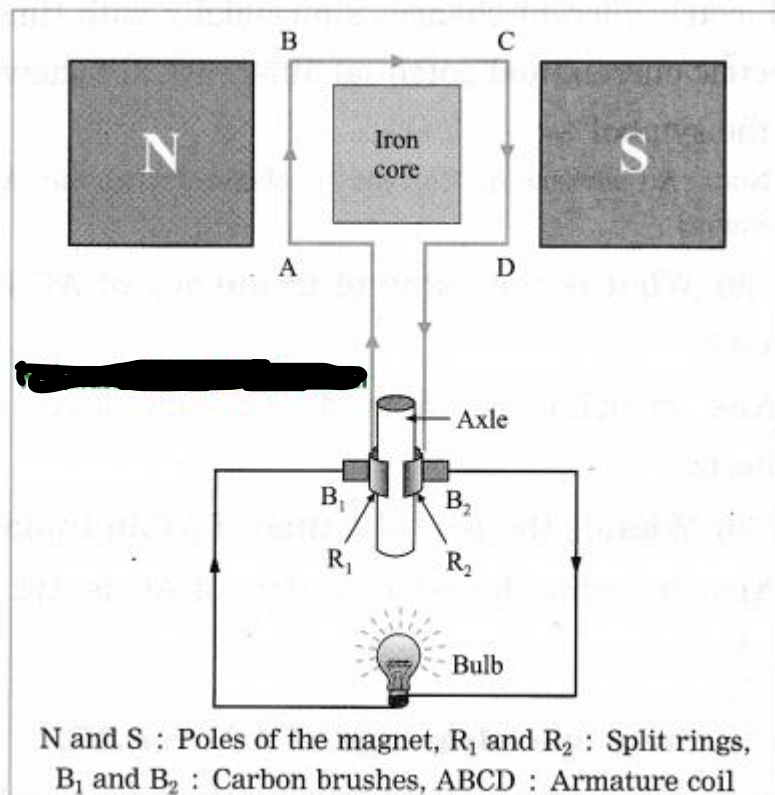
(a) Fuse:

A fuse protects electrical circuits and appliances by stopping the flow of electric current when it exceeds a specified value. For this, it is connected in series with the appliance (or circuit) to be protected. A fuse is a piece of wire made of an alloy of low melting point (e.g. an alloy of lead and tin). If a current larger than the specified value flows through the fuse, its temperature increases enough to melt it. Hence, the circuit breaks and the appliance is protected from damage.

(b) Miniature circuit breaker:

These days miniature circuit breaker (MCB) switches are used in homes. When the current in the circuit suddenly increases this switch opens and current stops. Different types of MCBs are in use. For the entire house, however the usual fuse wire is used.

c) Figure shows the construction of a DC generator.



Electric DC generator

Here, an ammeter is shown instead of a bulb.

Working: The axle is rotated with a machine from outside. When the armature coil of the generator rotates in the magnetic field, electric potential difference is produced in the coil due to electromagnetic induction. This produces a

current as shown by the glowing of the bulb or by a galvanometer. The direction of the current depends on the sense of rotation of the coil.

In a DC generator, one brush is always in contact with the arm of the coil moving up while the other brush is in contact with the arm of the coil moving down in the magnetic field. Hence, the flow of the current in the circuit is always in the same direction and the current flows so long as the coil continues to rotate in the magnetic field.

Q12] Solve the following examples.

a. Heat energy is being produced in a resistance in a circuit at the rate of 100 W. The current of 3 A is flowing in the circuit. What must be the value of the resistance?

Solution:

Data: $P = 100 \text{ W}$, $I = 3 \text{ A}$, $R = ?$, $P = I^2 R$

$$\therefore \text{Resistance, } R = \frac{P}{I^2} = \frac{100}{3^2} = \frac{100}{9} \Omega = 11.11 \Omega$$

b. Two tungsten bulbs of wattage 100 W and 60 W power work on 220 V potential difference. If they are connected in parallel, how much current will flow in the main conductor?

Solution:

Data : $P_1 = 100 \text{ W}$, $P_2 = 60 \text{ W}$, $V = 220 \text{ V}$,

$I = ?$, $\therefore I = PV$

$P = VI$

$$\begin{aligned} \therefore I_1 \frac{P_1}{V} \text{ and } I_2 &= \frac{P_2}{V} \text{ Current in the main conductor, } I = I_1 + I_2 \text{ (parallel connection)} \\ &= \frac{P_1}{V} + \frac{P_2}{V} = \frac{P_1 + P_2}{V} = \frac{100 \text{ W} + 60 \text{ W}}{220 \text{ V}} = \frac{160}{220} \text{ A} \\ &= 0.727 \text{ A} = \text{nearby } 0.73 \text{ A.} \end{aligned}$$

c. Who will spend more electrical energy? 500 W TV set in 30 mins, or 600 W heater in 20 mins?

Solution:

Data : $P_1 = 500 \text{ W}$, $t_1 = 30 \text{ min} = \frac{30}{60} \text{ h} = \frac{1}{2} \text{ h}$,

$P_2 = 600 \text{ W}$, $t_2 = 20 \text{ min} = \frac{20}{60} \text{ h} = \frac{1}{3} \text{ h}$

Electrical energy used = Pt

TV set : $P_1 t_1 = 500 \text{ W} \times \frac{1}{2} \text{ h} = 250 \text{ W} \cdot \text{h}$

Heater : $P_2 t_2 = 600 \text{ W} \times \frac{1}{3} \text{ h} = 200 \text{ W} \cdot \text{h}$

Thus, the TV set will spend more electrical energy than the heater.

d. An electric iron of 1100 W is operated for 2 hours daily. What will be the electrical consumption expenses for that in the month of April? (The electric company charges ₹ 5 per unit of energy.)

Solution:

Data: $P = 1100 \text{ W}$, $t = 2 \times 30 = 60 \text{ h}$,

₹ 5 per unit of energy, expenses = ?

$$N = \frac{Pt}{1000 \text{ W} \cdot \text{h/unit}} = \frac{1100 \text{ W} \times 60 \text{ h}}{1000 \text{ W} \cdot \text{h/unit}} = 66 \text{ units.}$$

∴ Electrical consumption expenses = 66 units × ₹ 5 per unit = ₹ 330.

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