

CHAPTER - 13

MAGNETIC EFFECT OF ELECTRIC CURRENT

Exercises

Question 1:

Which of the following correctly describes the magnetic field near a long straight wire?

- (a) The field consists of straight lines perpendicular to the wire.
- (b) The field consists of straight lines parallel to the wire.
- (c) The field consists of radial lines originating from the wire.
- (d) The field consists of concentric circles centred on the wire.

Answer 1:

- (d) The field consists of concentric circles centred on the wire.

On applying right-hand thumb rule, we find the direction of magnetic field. The field is in the form of concentric circles centred on the wire carrying current.

Hence, the option (d) is correct.

Question 2:

The phenomenon of electromagnetic induction is

- (a) the process of charging a body.
- (b) the process of generating magnetic field due to a current passing through a coil.
- (c) producing induced current in a coil due to relative motion between a magnet and the coil.
- (d) the process of rotating a coil of an electric motor.

Answer 2:

- (c) producing induced current in a coil due to relative motion between a magnet and the coil.

In electromagnetic induction phenomenon an induced current begins to flow in a coil whenever there is change in magnetic field in and around a coil.

Hence, the option (c) is correct.

Question 3:

The device used for producing electric current is called a

- (a) generator.
- (b) galvanometer.
- (c) ammeter.
- (d) motor

Answer 3:

- (a) generator.

An A.C. generator is the device used for producing an electric current.

Hence, the option (a) is correct.

Question 4:

The essential difference between an AC generator and a DC generator is that

- (a) AC generator has an electromagnet while a DC generator has permanent magnet.
- (b) DC generator will generate a higher voltage.
- (c) AC generator will generate a higher voltage.
- (d) AC generator has slip rings while the DC generator has a commutator
(This question is out of syllabus now)

Answer 4:

- (d) AC generator has slip rings while the DC generator has a commutator

Question 5:

At the time of short circuit, the current in the circuit

- (a) reduces substantially.
- (b) does not change.
- (c) increases heavily.
- (d) vary continuously.

Answer 5:

- (c) increases heavily.

At the time of short circuiting the live wire and the neutral wire come into direct contact. As a result, the current in the circuit abruptly increases.

Hence, the option (c) is correct.

Question 6:

State whether the following statements are true or false.

- (a) An electric motor converts mechanical energy into electrical energy.
- (b) An electric generator works on the principle of electromagnetic induction.
- (c) The field at the centre of a long circular coil carrying current will be parallel straight lines.
- (d) A wire with a green insulation is usually the live wire of an electric supply.

Answer 6:

- (a) An electric motor converts mechanical energy into electrical energy. (**False**)
- (b) An electric generator works on the principle of electromagnetic induction. (**True**)
- (c) The field at the centre of a long circular coil carrying current will be parallel straight lines. (**True**)
- (d) A wire with a green insulation is usually the live wire of an electric supply. (**False**)

Question 7:

List three sources of magnetic fields.

Answer 7:

Three methods of producing magnetic field are as follows:

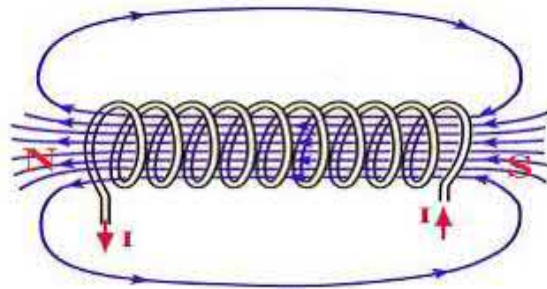
- Magnetic field can be produced by placing a permanent bar magnet or a horse-shoe magnet at the place, where magnetic field is required.
- Magnetic field is produced around a current-carrying straight conductor or a current carrying circular coil.
- A very good method to produce magnetic field is due to flow of current in a solenoid.

Question 8:

How does a solenoid behave like a magnet? Can you determine the north and south poles of a current-carrying solenoid with the help of a bar magnet? Explain.

Answer 8:

When current is passed through a solenoid coil, magnetic field produced due to each turn of solenoid coil is in the same direction. As a result, the resultant magnetic field become very strong and uniform. The field lines inside the solenoid are in the form of parallel straight lines along the axis of solenoid. Thus, the solenoid behaves like a bar magnet. One end of solenoid behaves as a magnetic North pole while the other end behaves as the South Pole.



We can determine the magnetic poles formed in a solenoid. The end of the current-carrying solenoid, which attracts North Pole but repels South Pole of a bar magnet, is behaving as south magnetic pole. The other end, which attracts South Pole of a bar magnet but repels the North Pole, is behaving as north magnetic pole. It is because like poles repel but unlike poles attract each other.

Question 9:

When is the force experienced by a current-carrying conductor placed in a magnetic field largest?

Answer 9:

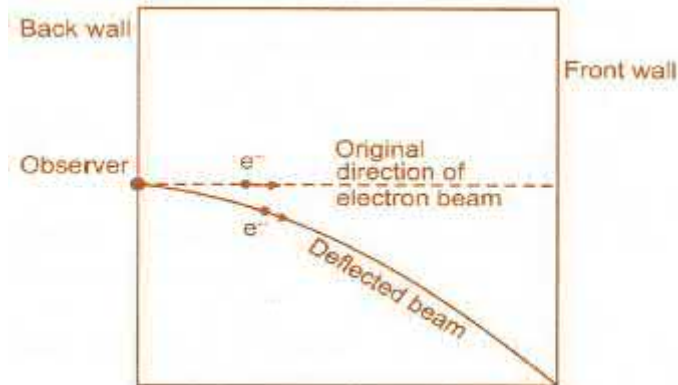
The force experienced by a current-carrying conductor placed in a magnetic field is largest when the current-carrying conductor is placed in a direction perpendicular to that of magnetic field.

Question 10:

Imagine that you are sitting in a chamber with your back to one wall. An electron beam, moving horizontally from back wall towards the front wall, is deflected by a strong magnetic field to your right side. What is the direction of magnetic field?

Answer 10:

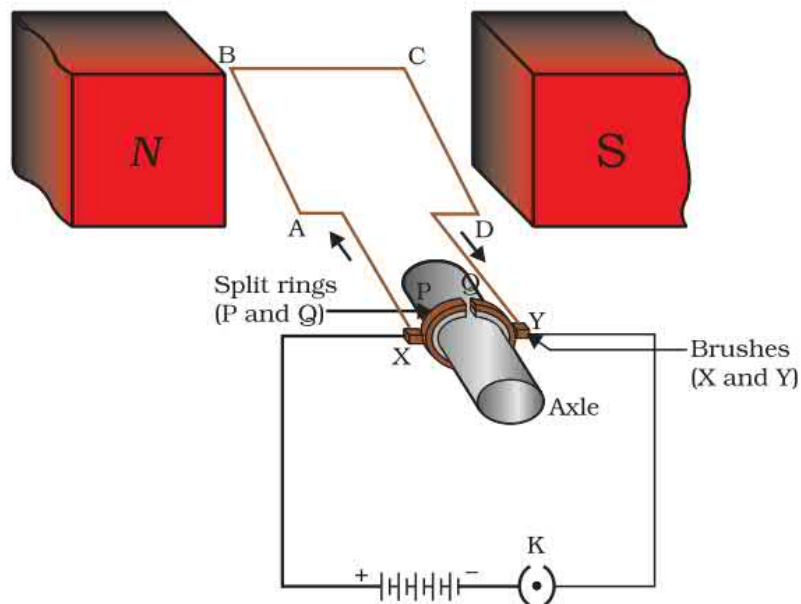
An electron beam moving horizontally from back wall towards the front wall is equivalent to a current flowing in the opposite direction (i.e., from front wall towards the back wall). The deflection of electron beam as seen by observer is to his right side and is shown in Figure. On applying Fleming's left-hand rule we find that the magnetic field is acting in vertically downward direction.



Question 11:

Draw a labelled diagram of an electric motor. Explain its principle and working. What is the function of a split ring in an electric motor?

Answer 11:



A simple electric motor

Principle

A current-carrying conductor, when placed in a magnetic field, experiences a force. If the direction of the field and that of the current are mutually perpendicular then force acting on the conductor will be perpendicular to both and will be given by Fleming's left-hand rule. Due to this force the conductor begins to move.

Working

Current in the coil ABCD enters from the source battery through conducting brush X and flows back to the battery through brush Y. The current in arm AB of the coil flows from A to B. In arm CD it flows from C to D, that is, opposite to the direction of current through arm AB. We find that the force acting on arm AB pushes it downwards while the force acting on arm CD pushes it upwards. Thus the coil and the axle O, mounted free to turn about an axis, rotate anti-clockwise. At half rotation, Q makes contact with the brush X and P with brush Y. Therefore the current in the coil gets reversed and flows along the path DCBA. The reversal of current also reverses the direction of force acting on the two arms AB and CD. Thus the arm AB of the coil that was earlier pushed down is now pushed up and the arm CD previously pushed up is now pushed down. Therefore the coil and the axle rotate half a turn more in the same direction. The reversing of the current is repeated at each half rotation, giving rise to a continuous rotation of the coil and to the axle. (*Working is out of syllabus now*)

Question 12:

Name some devices in which electric motors are used.

Answer 12:

Electric motors are used in all such devices where we want to convert electrical energy into mechanical energy so as to drive that machine. In our houses, electric motors are being fitted in electric fans, coolers, air conditioners, mixer grinders, washing machines, refrigerators, juicers, computers etc. In factories, motors are used in almost all machines.

Question 13:

A coil of insulated copper wire is connected to a galvanometer. What will happen if a bar magnet is (i) pushed into the coil, (ii) withdrawn from inside the coil, (iii) held stationary inside the coil?

Answer 13:

A current induces in a solenoid if a bar magnet is moved relative to it. This is the principle of electromagnetic induction.

(i) When a bar magnet is pushed into a coil of insulated copper wire, a current is induced momentarily in the coil. As a result, the needle of the galvanometer deflects momentarily in a particular direction.

(ii) When the bar magnet is withdrawn from inside the coil of the insulated copper wire, a current is again induced momentarily in the coil in the opposite direction. As a result, the needle of the galvanometer deflects momentarily in the opposite direction.

(iii) When a bar magnet is held stationary inside the coil, no current will be induced in the coil. Hence, galvanometer will show no deflection.

Question 14:

Two circular coils A and B are placed closed to each other. If the current in the coil A is changed, will some current be induced in the coil B? Give reason.

Answer 14:

Yes, a current is induced in the coil B.

When the current in the coil A is changed, the magnetic field associated with it also changes. As coil B is placed close to A, hence magnetic field lines around this coil also change. Due to change in magnetic field lines associated with coil B, an induced current is also induced in it.

Question 15:

State the rule to determine the direction of a (i) magnetic field produced around a straight conductor-carrying current, (ii) force experienced by a current-carrying straight conductor placed in a magnetic field which is perpendicular to it, and (iii) current induced in a coil due to its rotation in a magnetic field.

Answer 15:

- (i) Maxwell's right hand thumb rule
- (ii) Fleming's left hand rule
- (iii) Fleming's right hand rule

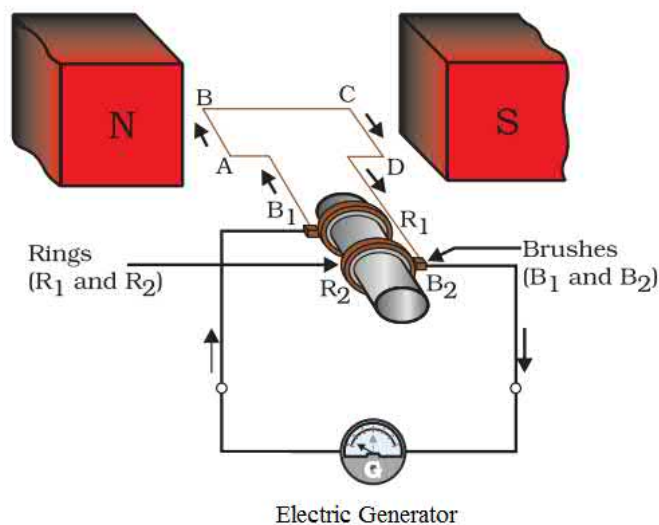
Question 16:

Explain the underlying principle and working of an electric generator by drawing a labelled diagram. What is the function of brushes?

Answer 16:

Principle

An electric generator works on the principle of electromagnetic induction phenomenon. According to it, whenever a coil is rotated between the poles of a magnet, an induced current is set up in the coil, whose direction is given by Fleming's right-hand rule.



Working

When the axle attached to the two rings is rotated such that the arm AB moves up (and the arm CD moves down) in the magnetic field produced by the permanent magnet. The coil ABCD is rotated clockwise in the arrangement. By applying Fleming's right-hand rule, the induced currents are set up in these arms along the directions AB and CD. Thus an induced current flows in the direction ABCD. If there are larger numbers of turns in the coil, the current generated in each turn adds up to give a large current through the coil. This means that the current in the

external circuit flows from B_2 to B_1 . After half a rotation, arm CD starts moving up and AB moving down. As a result, the directions of the induced currents in both the arms change, giving rise to the net induced current in the direction DCBA. The current in the external circuit now flows from B_1 to B_2 . Thus after every half rotation the polarity of the current in the respective arms changes. Such a current, which changes direction after equal intervals of time, is called an alternating current (abbreviated as AC). This device is called an AC generator.
(Working of AC generator is out of syllabus)

Question 17:

When does an electric short circuit occur?

Answer 17:

If either the insulation of wires used in an electrical circuit is damaged or there is a fault in the appliance, live wire and neutral wire may come in direct contact. As a result, the current in the circuit abruptly rises and short-circuiting occurs.

Question 18:

What is the function of an earth wire? Why is it necessary to earth metallic appliances?

Answer 18:

The metallic body of electric appliances is connected to the earth by means of earth wire so that any leakage of electric current is transferred to the ground. This prevents any electric shock to the user. That is why earthing of the electrical appliances is necessary.

Question 1:

Why does a compass needle get deflected when brought near a bar magnet?

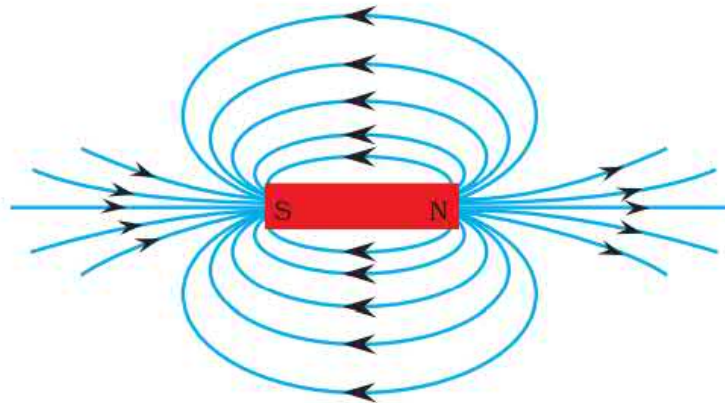
Answer 1:

Magnetic compass needle and bar magnet both have magnetic field. When they brought near to each other, these magnetic fields interact each other giving deflection in needle.

Question 1:

Draw magnetic field lines around a bar magnet.

Answer 1:



Field lines around a bar magnet

Question 2:

List the properties of magnetic lines of force.

Answer 2:

Properties of magnetic lines of force (also known as magnetic field lines) are listed below:

- Outside the magnet, the magnetic field lines are directed from N-pole of magnet towards S-pole. However, inside a magnet the field lines are directed from S-pole to N-pole. Thus magnetic field lines form a close loop.
- The magnetic field line at any point points in the direction of magnetic field at that point.
- The relative strength of magnetic fields is given by degree of closeness of the field lines. The magnetic field is strong in the region where the field lines are crowded.
- No two magnetic field lines can ever intersect with each other.

Question 3:

Why don't two magnetic lines of force intersect each other?

Answer 3:

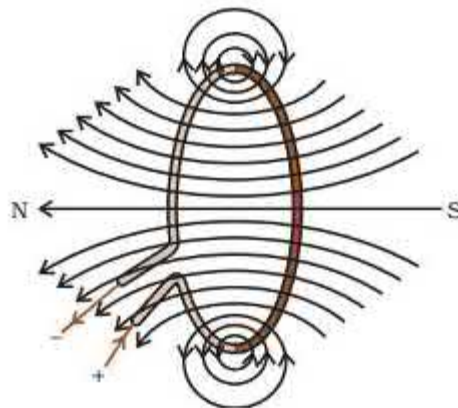
No two field-lines are found to cross each other. If they did, it would mean that at the point of intersection, the compass needle would point towards two directions, which is not possible.

Question 1:

Consider a circular loop of wire lying in the plane of the table. Let the current pass through the loop clockwise. Apply the right-hand rule to find out the direction of the magnetic field inside and outside the loop.

Answer 1:

The magnetic field lines have been shown in Figure given below. As per right-hand rule, we find that inside the loop, the magnetic field lines are directed perpendicular to the plane of paper in the inward direction. Outside the loop magnetic field lines are directed out of the plane of paper.



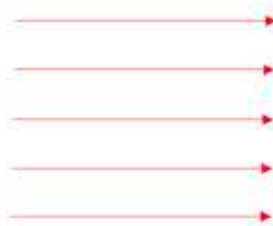
Magnetic field lines of the field produced by a current-carrying circular loop

Question 2:

The magnetic field in a given region is uniform. Draw a diagram to represent it.

Answer 2:

The uniform magnetic field is represented by parallel, equidistant lines of equal length as shown in Figure.



Uniform Magnetic Field Lines

Question 3:

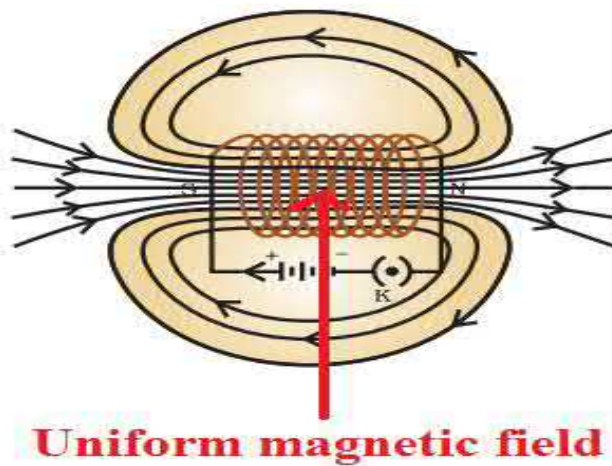
Choose the correct option.

The magnetic field inside a long straight solenoid-carrying current

- (a) is zero.
- (b) decreases as we move towards its end.
- (c) increases as we move towards its end.
- (d) is the same at all points.

Answer 3:

- (d) is the same at all points.



Question 1:

Which of the following property of a proton can change while it moves freely in a magnetic field? (There may be more than one correct answer.)

- (a) Mass (b) Speed
(c) Velocity (d) Momentum

Answer 1:

(c) Velocity and (d) Momentum

Question 2:

In Activity 13.7, how do we think the displacement of rod AB will be affected if (i) current in rod AB is increased; (ii) a stronger horse-shoe magnet is used; and (iii) length of the rod AB is increased?

Answer 2:

- (i) If current in rod AB is increased, the displacement will also increase.
(ii) If we use a stronger horse-shoe magnet then the displacement of rod AB will increase.
(iii) If length of the rod is increased, force acting on it will increase and, hence, displacement of the rod increases.

Question 3:

A positively-charged particle (alpha-particle) projected towards west is deflected towards north by a magnetic field. The direction of magnetic field is

- (a) towards south (b) towards east
(c) downward (d) upward

Answer 3:

(d) upward

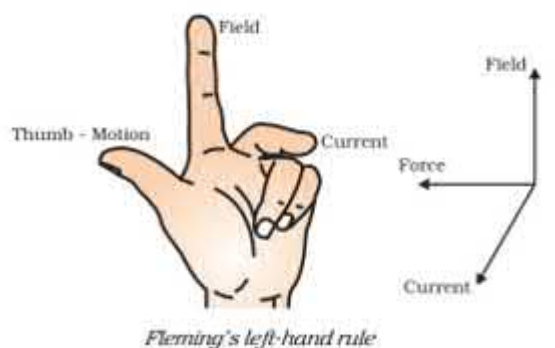
In accordance with Fleming's left-hand rule, the direction of magnetic field is vertically upward.

Question 1:

State Fleming's left-hand rule.

Answer 1:

According to Fleming's left-hand rule, stretch the thumb, forefinger and middle finger of your left hand such that they are mutually perpendicular. If the first finger points in the direction of magnetic field and the second finger in the direction of current, then the thumb will point in the direction of motion or the force acting on the conductor.



Question 2:

What is the principle of an electric motor?

Answer 2:

The working principle of an electric motor is based on the magnetic effect of current. A current-carrying loop experiences a force and rotates when placed in a magnetic field. The direction of rotation of the loop is given by the Fleming's left-hand rule.

Question 3:

What is the role of the split ring in an electric motor? (*This question is out of syllabus*)

Answer 3:

The split ring in the electric motor acts as a commutator. The commutator reverses the direction of current flowing through the coil after each half rotation of the coil. Due to this reversal of the current, the coil continues to rotate in the same direction.

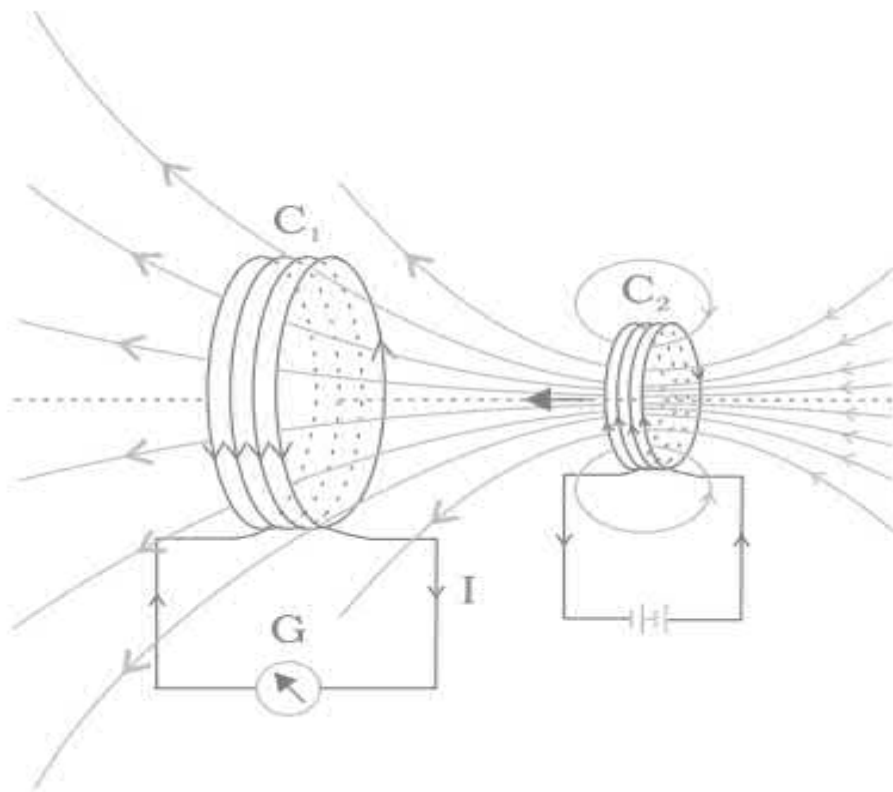
Question 1:

Explain different ways to induce current in a coil.

Answer 1:

Different ways to induce current in a coil are as given below:

- If a magnetic field is changed around a coil then an induced current is set up in the coil. It can be done by taking a bar magnet and bringing it closer to the coil or taking it away from the coil.
- If a coil is moved in a magnetic field, then again an induced current is set up in the coil.
- If a coil is rotated in a uniform magnetic field, it may also produce an induced current in the coil.



Question 1:

State the principle of an electric generator.

Answer 1:

An electric generator is based on the principle of electromagnetic induction. When a rectangular coil is rotated in a uniform magnetic field, an induced voltage is generated between the ends of the coil.

Question 2:

Name some sources of direct current.

Answer 2:

Some sources of direct current are a cell, a battery and a D.C. generator.

Question 3:

Which sources produce alternating current?

Answer 3:

A.C. generator and invertors (used in house for emergency power supply) produces alternating current.

Question 4:

Choose the correct option.

A rectangular coil of copper wires is rotated in a magnetic field. The direction of the induced current changes once in each

- | | |
|---------------------|---------------------------|
| (a) two revolutions | (b) one revolution |
| (c) half revolution | (d) one-fourth revolution |

Answer 4:

(c). When a rectangular coil of copper wire is rotated in a magnetic field, the direction of the induced current changes once in each half revolution.

Question 1:

Name two safety measures commonly used in electric circuits and appliances.

Answer 1:

Two safety measures are:

- Use of earth wire and proper earthing.
- Use of fuse (now a days fuse wire is replaced by MCB).

Question 2:

An electric oven of 2 kW power rating is operated in a domestic electric circuit (220 V) that has a current rating of 5 A. What result do you expect? Explain.

Answer 2:

Power rating of electric oven $P = 2 \text{ kW} = 2000 \text{ W}$

Supply voltage $V = 220 \text{ V}$

So, the current drawn by electric oven $I = \frac{P}{V} = \frac{2000 \text{ W}}{220 \text{ V}} = 9 \text{ A}$

As the current rating of domestic electric circuit is only 5 A and the oven draws a current 9 A, which is more than the current rating, hence the circuit will be damaged due to overheating/overloading.

Question 3:

What precaution should be taken to avoid the overloading of domestic electric circuits?

Answer 3:

The precautions that should be taken to avoid the overloading of domestic circuits are as follows:

- Too many appliances should not be connected to a single socket.
- Too many appliances should not be used at the same time.
- Faulty appliances should not be connected in the circuit.
- Fuse should be connected in the circuit.