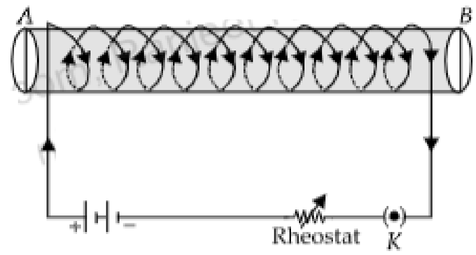
(iv) A long solenoid carrying a current produces a magnetic field B along its axis. If the current is double and the number of turns per cm is halved, then new value of magnetic field is

(a) B (b) $2B$ (c) $4B$ (d) $B/2$

(v) A soft iron bar is enclosed by a coil of insulated copper wire as shown in figure. When the plug of the key is closed, the face B of the iron bar marked as



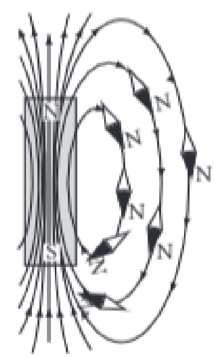
(a) N–pole (b) S–pole

(c) N–pole if current is large (d) S–pole if current is small

2

Read the following and answer any four questions from 2(i) to 2(v).

A magnetic field is described by drawing the magnetic field lines. When a small north magnetic pole is placed in the magnetic field created by a magnet, it will experience a force. And if the north pole is free, it will move under the influence of magnetic field. The path traced by a north magnetic pole free to move under the influence of a magnetic field is called a magnetic field line. Since the direction of magnetic field line is the direction of force on a north pole, so the magnetic field lines always begin from the N-pole of a magnet and end on the S-pole of the magnet. Inside the magnet, however the direction of magnetic field lines is from the S-pole of the magnet to the N-pole of the magnet. Thus, the magnetic field lines are closed curves. When a small compass is moved along a magnetic field line, the compass needle always sets itself along the line tangential to it. So, a line drawn from the south pole of the compass needle to its north pole indicates the direction of the magnetic field at that point.



(i) The magnetic field lines

(a) intersect at right angle to one another

(b) intersect at an angle of 45° to each other

(c) do not cross one another

(d) cross at an angle of 60° to one another.

(ii) A strong bar magnet is placed vertically above a horizontal wooden board. The magnetic lines of force will be

(a) only in horizontal plane around the magnet

(b) only in vertical plane around the magnet

(c) in horizontal as well as in vertical planes around the magnet

(d) in all the planes around the magnet.

(iii) Magnetic field lines can be used to determine

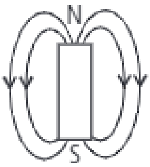
(a) the shape of the magnetic field

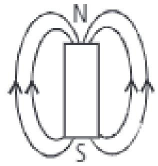
(b) only the direction of the magnetic field

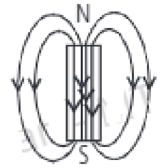
(c) only the relative strength of the magnetic field

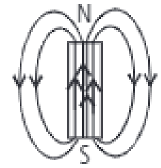
(d) both the direction and the relative strength of the magnetic field.

(iv) The magnetic field lines due to a bar magnet are correctly shown in figure

(a) 

(b) 

(c) 

(d) 

(v) Which of the following is not true about magnetic field lines?

(a) Magnetic field lines are the closed and continuous curve.

(b) No two field lines can cross each other.

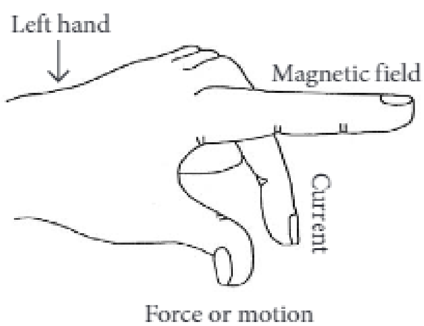
(c) Crowdness of field lines represents the strength of magnetic field.

(d) The direction of field lines is from the north pole to the south pole inside a bar magnet.

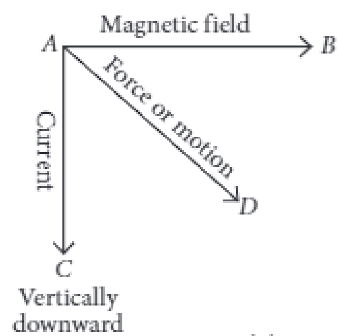
3

Read the following and answer any four questions from 3(i) to 3(v).

Andre Marie Ampere suggested that a magnet must exert an equal and opposite force on a current carrying conductor, which was experimentally found to be true. But we know that current is due to charges in motion. Thus, it is clear that a charge moving in a magnetic field experience a force, except when it is moving in a direction parallel to it. If the direction of motion is perpendicular to the direction of magnetic field, the magnitude of force experienced depends on the charge, velocity (v), strength of magnetic field (B), and sine of the angle between v and B. Direction of magnetic force is given by Fleming's left hand rule.



(*i*)



(*ii*)

(i) If an electron is travelling horizontally towards east. A magnetic field in vertically downward direction exerts a force on the electron along

(a) east (b) west (c) north (d) south.

(ii) If a charged particle is moving along a magnetic field line. The magnetic force on the particle is

(a) along its velocity

(b) opposite to its velocity

(c) perpendicular to its velocity

(d) zero.

(iii) A magnetic field exerts no force on

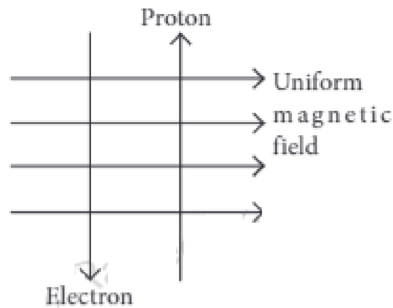
(a) a stationary electric charge

(b) a magnet

(c) an electric charge moving perpendicular to its direction

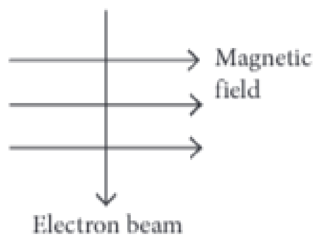
(d) an unmagnetised iron bar.

(iv) A uniform magnetic field exists in the plane of paper pointing from left to right as shown in figure. In the field an electron and a proton move as shown. The electron and the proton experience



(a) forces both pointing into the plane of paper
(b) forces both pointing out of the plane of paper
(c) forces pointing into the plane of paper and out of the plane of paper, respectively
(d) force pointing opposite and along the direction of the uniform magnetic field respectively.

(v) An electron beam enters a magnetic field at right angles to it as shown in the figure. The direction of force acting on the electron beam will be

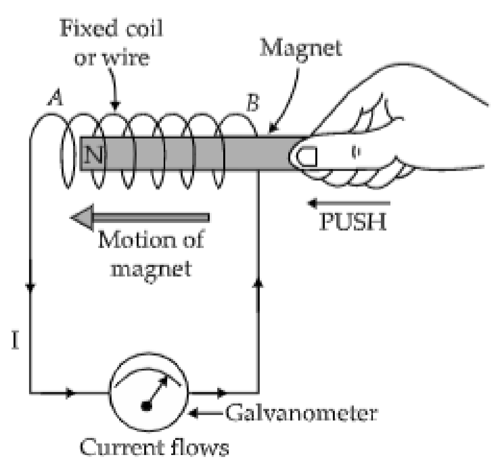


(a) to the left (b) to the right (c) into the page (d) out of the page.

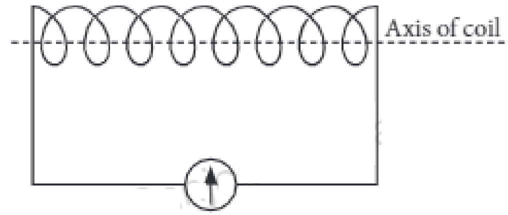
4

Read the following and answer any four questions from 4(i) to 4(v).

A current carrying wire produces magnetic field around it. The phenomena in which an electromotive force and current (if the conductor is in the form of a closed circuit) is induced by changing magnetic field (or by passing magnetic field lines) through it is called electromagnetic induction. The emf so developed is called induced emf and current made to flow is called induced current. The cause of induced emf carried out by Faraday and Henry. It can be concluded that the induced current flows in a conductor as long as the magnetic lines of force change within the conductor. In case of relative motion *i.e.*, motion of coil w.r.t to magnet or vice versa, the direction of the current flowing in the conductor is determined by the direction of the relative motion of the conductor with respect to the magnetic field. The induced emf or current is directly proportional to the rate of change in magnetic field.

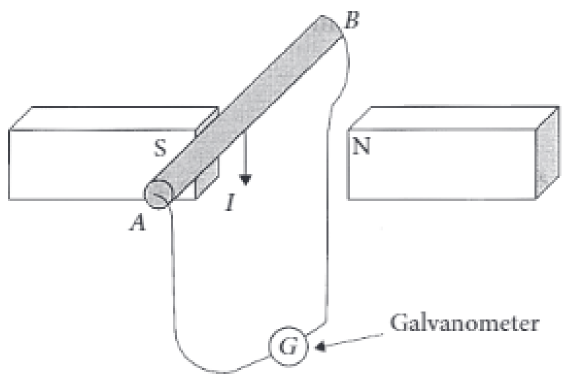


(i) A student connects a coil of wire with a sensitive galvanometer as shown in figure. He will observe the deflection in the galvanometer if bar magnet is



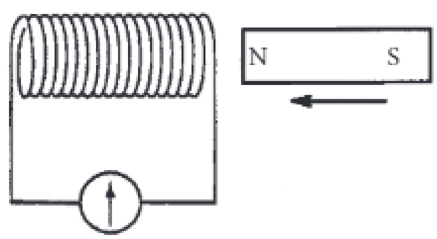
(a) placed near one of the faces of the coil and parallel to the axis of the coil
(b) placed near one of the faces of the coil and perpendicular to the axis of the coil
(c) placed inside the coil
(d) moved towards or away from the coil parallel to the axis of the coil.

(ii) A conducting rod *AB* moves across two magnets as shown in figure and the needle in the galvanometer deflects momentarily. What is the name of this physical phenomenon?



(a) Electromagnetism
(b) Induced magnetism
(c) Electromagnetic induction
(d) Static induction

(iii) A bar magnet is pushed steadily into a long solenoid connected to a sensitive meter.



Which of the following would affect the magnitude of the deflection of the meter?
(a) How fast the magnet is pushed into the coil.
(b) The direction in which the coil is wound.
(c) The end of the solenoid the magnet enters.
(d) The pole of the magnet enters the coil first.

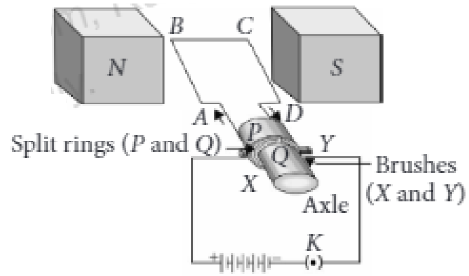
(iv) What is the condition of an electromagnetic induction?
(a) There must be a relative motion between galvanometer and coil of wire.
(b) There must be a relative motion between galvanometer and a magnet.
(c) There must be a relative motion between galvanometer and electric motor.
(d) There must be a relative motion between the coil of wire and a magnet.

(v) An induced emf is produced when a magnet is plunged into a coil. The magnitude of induced emf does not depend on
(a) the number of turns in the coil
(b) the speed with which the magnet is moved
(c) the strength of the magnet
(d) the resistivity of the material of the coil.

5

Read the following and answer any four questions from 5(i) to 5(v).

An electric motor is a rotating device that converts electrical energy into mechanical energy. Electric motor is used as an important component in electric fans, refrigerators, mixers, washing machines, computers, MP3 players, etc.



An electric motor consists of a rectangular coil *ABCD* of insulated copper wire. The coil is placed between the two poles of a magnetic field such that the arm *AB* and *CD* are perpendicular to the direction of the magnetic field. The ends of the coil are connected to the two halves *P* and *Q* of a split ring. The inner sides of these halves are insulated and attached to an axle. The external conducting edges of *P* and *Q* touch two conducting stationary brushes *X* and *Y*, respectively, as shown in the figure.

Commercial motors use an electromagnet in place of a permanent magnet, a large number of turns of conducting wire in the current carrying coil and a soft iron core on which the coil is wound.

(i) Choose incorrect statement from the following regarding split rings.
- (a) Split rings are used to reverse the direction of current in coil.
- (b) Split rings are also known as commutator.
- (c) Split ring is a discontinuous or a broken ring.
- (d) Both (a) and (b)

(ii) Which of the following has no effect on the size of the turning effect on the coil of an electric motor?
- (a) The amount of the current in the coil.
- (b) The direction of the current in the coil.
- (c) The number of turns in the coil.
- (d) The strength of the magnetic field.

(iii) When current is switched ON, an electric fan converts
- (a) mechanical energy to chemical energy
- (b) electrical energy to mechanical energy
- (c) chemical energy to mechanical energy
- (d) mechanical energy to electrical energy.

(iv) In an electric motor, device that makes contact with the rotating rings and through them to supply current to coil is
- (a) axle
- (b) brushes
- (c) coil
- (d) split rings.

(v) In an electric motor, the direction of current in the coil changes once in each
- (a) two rotations
- (b) one rotation
- (c) half rotation
- (d) one-fourth rotation.

ASSERTION & REASON

For question numbers 6-20, two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below :

(a) Both A and R are true, and R is correct explanation of the assertion.

(b) Both A and R are true, but R is not the correct explanation of the assertion.

(c) A is true, but R is false.

(d) A is false, but R is true.

6. **Assertion :** Force experienced by moving charge will be maximum if direction of velocity of charge is parallel to applied magnetic field.
Reason : Force on moving charge is depends on direction of applied magnetic field.

7. **Assertion :** In electric circuits, wires carrying currents in opposite directions are often twisted together.
Reason : If the wire are not twisted together, the combination of the wires forms a current loop. The magnetic field generated by the loop might affect adjacent circuits or components.

8. **Assertion :** When two long parallel wires, hanging freely are connected in parallel to a battery, they come closer to each other.
Reason : Wires carrying current in opposite directions repel each other.

9. **Assertion :** Magnetic field lines show the direction (at every point) along which a small magnetised needle aligns (at the point).
Reason : Magnetic field lines certainly represent the direction of magnetic field, but not the direction of force, this is because force is always perpendicular to magnetic field B.

10. **Assertion :** When a charged particle moves perpendicular to magnetic field then its kinetic energy and momentum gets affected.
Reason : Force does not change velocity of charged particle.

11. **Assertion :** The direction of force is given by Fleming's left hand rule.
Reason : A magnetic field exert a force on a moving charge in the same direction as the direction of field itself.

12. **Assertion :** A moving coil galvanometer is based on magnetic effect of current.
Reason : On heating, the coil starts to rotate in direction of moving coil galvanometer.

13. **Assertion :** Magnetic field lines forms closed loops in nature.
Reason : Mono-magnetic pole does not exist in nature.

14. **Assertion :** Magnetic field interacts with a moving charge and not with a stationary charge.
Reason : A moving charge produces a magnetic field.

15. **Assertion :** The magnetic field intensity at the centre of a circular coil carrying current changes, if the current through the coil is doubled.
Reason : The magnetic field intensity is dependent on current in conductor.

16. **Assertion :** For a point on the axis of a circular coil carrying current, magnetic field is maximum at the centre of the coil.
Reason : Magnetic field is proportional to the distance of point from the circular coil.

17. **Assertion :** A solenoid tends to expand, when a current passes through it.
Reason : Two straight parallel metallic wires carrying current in same direction attract each other.

18. **Assertion :** No net force acts on a rectangular coil carrying a steady current when suspended freely in a uniform magnetic field.
Reason : Forces acting on each pair of the opposite sides of the coil are equal and opposite.

19. **Assertion :** In a conductor, free electrons keep on moving but no magnetic force acts on a conductor in a magnetic field.
Reason : Force on free electron due to magnetic field always acts perpendicular to its direction of motion.

20. **Assertion :** The magnetic field produced by a current carrying solenoid is independent of its length and cross sectional area.
Reason : The magnetic field inside the solenoid is uniform.

HINTS & EXPLANATIONS

1. **(c)**: Magnetic field inside infinite solenoid is uniform. Hence it is same at all points.

(ii) **(c)**

(iii) **(c)**: The pattern of the magnetic field associated with solenoid is same as the pattern of the magnetic field around a bar magnet.

(iv) **(a)**: For a long solenoid, magnetic field $B \propto In$; where I is the flowing current and n is number of turns per unit length in the solenoid. Therefore, in the given case magnetic field will remain unchanged.

(v) **(a)**

2. **(i)** **(c)**: No two magnetic field lines are found to cross each other. If two field lines crossed each other, it would mean that at the point of intersection, the compass needle would point in two directions at the same time, which is not possible.

(ii) **(d)**: The magnetic field and hence the magnetic line of force exist in all the planes all around the magnet.

(iii) **(d)**: The relative strength of the magnetic field is shown by the degree of closeness of the field lines and the direction of the magnetic field is obtained by tangent to the field lines at the point of intersect.

(iv) **(d)**: The magnetic field lines due to a bar magnet are closed continuous curves directed from N to S outside the magnet and directed from S to N inside the magnet. Hence option (d) is correct.

(v) **(d)**: Inside a bar magnet, the direction of field lines is from south pole to north pole.

3. **(i)** **(d)**: Fleming's left hand rule is used to determine the direction of force on electron *i.e.*, in south direction.

(ii) **(d)**: The angle between velocity and magnetic field is zero. Therefore, magnetic force on the particle is zero.

(iii) **(a)**

(iv) **(a)**: As the direction of current is taken opposite to the direction of motion of electrons, therefore, current from the motion of electron and proton is in the same direction, *i.e.*, from bottom to top. Now, according to Fleming's left hand rule, the electron and the proton experience forces both pointing into the plane of paper.

(v) **(c)**

4. **(i)** **(d)**: The deflection in galvanometer can be seen if bar magnet moved towards or away from coil parallel to the axis of the coil.

(ii) **(c)**: If the needle of the galvanometer deflects it means there is change in magnetic field and current is induced.

(iii) **(a)**: By Faraday's law of electromagnetic induction, the e.m.f. induced in a conductor is proportional to the rate of change of magnetic lines of force linking the circuit. Hence, by pushing in the magnet faster, the rate of change of magnetic lines will increase. This results in a larger induced e.m.f. and hence, larger deflection of the meter.

(iv) **(d)**

(v) **(d)**: Resistivity of coil will determine the resistance of the coil and induced current through it, as induced

$$\text{current} = \frac{\text{emf}}{\text{resistance}}$$

5. **(i)** **(d)**

(ii) **(b)**: The direction of the current has no effect on the size of the turning effect on the coil.

(iii) **(b)**: Electric fan works on the principle of electric motor. It converts electrical energy to mechanical energy.

(iv) **(b)** **(v)** **(c)**

6. **(d)**: Force on moving charge will be maximum if direction of velocity of charge is perpendicular to direction of magnetic field.

7. **(a)**: If the wires are twisted together, they can be modelled as a single wire carrying current in the opposite directions. In this model, no magnetic field is induced in the wires which does not affect adjacent circuits.

8. **(b):** The wires are parallel to each other but the direction of current in it is in same direction so they attract each other. If the current in the wires is in opposite directions then wires repel each other. When the currents are in opposite directions, the magnetic forces are reversed and the wires repels each other.

9. **(b)**

10. **(d):** When a charged particle moves perpendicular to magnetic field, it experiences a force which changes the direction of motion of the particle without changing the magnitude of velocity of the particle. Hence kinetic energy remains constant but momentum of electron changes.

11. **(c):** According to Fleming's left hand rule, the direction of the magnetic force on a moving charge is always perpendicular to the magnetic field.

12. **(c):** A moving coil galvanometer is based on magnetic effect of current. A force acts on every side of the coil due to magnetic field when current is passed through the coil. Due to these forces, a couple is exerted on the coil.

13. **(a):** The magnetic field lines form closed loops unlike electrostatic field lines which originate from the charge and end at charge. Mono-magnetic pole does not exist in nature.

14. **(a):** An electric current is equivalent to the charges (or electrons) in motion. Such charges produce magnetic interaction. The magnetic field produced by current interacts with magnetic needle and deflects it.

15. **(a):** The magnetic field at the centre of circular coil is directly proportional to the current flowing through it.
So if current through coil is doubled then magnetic field becomes double.

16. **(c):** The magnitude of magnetic field produced by a current carrying circular coil is maximum at the centre and is not proportional to the distance of a point from the circular coil.

17. **(d):** When current flows through a solenoid, the currents in the various turns of the solenoid are parallel and in the same direction. Since the currents flowing through parallel wires in the same direction lead to force of attraction between them, the turns of the solenoid will also attract each other and as a result,the solenoid tends to contract.

18. **(a):** In a rectangular coil carrying a steady current, the direction of current in opposite sides of coil is opposite to each other, therefore, forces acting on each pair of the opposite sides of the coil are equal and opposite, *i.e.*, net force on the coil is equal to zero.

19. **(c):** In a conductor, the average velocity of electrons is zero. Hence no current flows through the conductor. Hence, no force acts on this conductor.

20. **(b)**