40 YEARS OF EMINENCE IN EDUCATION

Knowledge with Success

Xam idea®

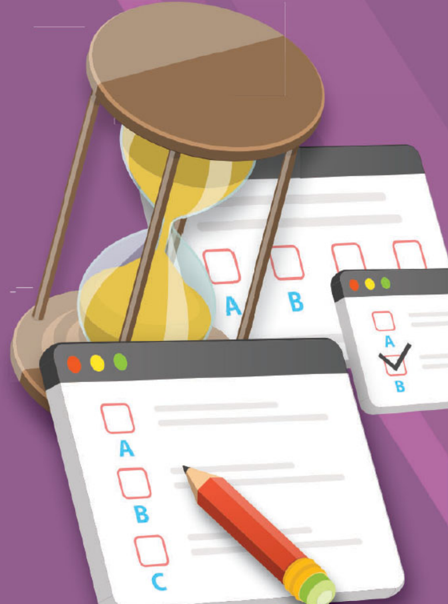
PHYSICS

MULTIPLE CHOICE QUESTIONS

TERM-1

Class-12

Compiled by:
PRABHAKAR RAY
RAVI RANJAN



- Case-based MCQs
- Assertion-Reason type MCQs
- 3 Practice Paper with OMR Sheets

As per special scheme of assessment released by CBSE dated July 05, 2021; Circular No. Acad-51/2021 and the term-wise syllabus dated July 22, 2021; Circular No. Acad-53/2021 for the session 2021-22

Printing History:
First Edition: 2021-22

Syllabus Covered:
CBSE, Delhi

Price:
Two Hundred Fifty Two Rupees (₹ 252/-)

ISBN:
978-93-91003-30-2

Published By:

VK Global Publications Pvt. Ltd.

Regd. Office:

4323/3, Ansari Road, Darya Ganj, New Delhi-110002
Ph: 91-11-23250105, 23250106 Fax: 91-11-23250141

Corporate Office:

15/1, Main Mathura Road, Faridabad-121003 (NCR) Haryana
Phone: 0129-7117719-48 lines, Fax: 0129-2250322
Email: mail@vkpublications.com
www.vkpublications.com

Printed At:
Rave Scans Pvt. Ltd.

Contents

TERM–I

1. Electric Charges and Fields 5

2. Electrostatic Potential and Capacitance 27

3. Current Electricity 57

4. Moving Charges and Magnetism 79

5. Magnetism and Matter 107

6. Electromagnetic Induction 117

7. Alternating Current 135

- Blue Prints 157
- Practice Paper – 1 159
- Practice Paper – 2 165
- Practice Paper – 3 171
- OMR Sheets

PHYSICS

Class-XII (Code No. 042) (2021-22)

Physics Theory and Practical course will be done in two terms. Each term will be assessed individually.

Syllabus assigned for Term-1 (Theory)

Time: 90 minutes **Max Marks: 35**

<table>
<tr><th></th><th></th><th>No. of Periods</th><th>Marks</th></tr>
<tr><td rowspan="3">Unit–I</td><td>Electrostatics</td><td rowspan="3">23</td><td rowspan="5">17</td></tr>
<tr><td>Chapter–1: Electric Charges and Fields</td></tr>
<tr><td>Chapter–2: Electrostatic Potential and Capacitance</td></tr>
<tr><td rowspan="2">Unit–II</td><td>Current Electricity</td><td rowspan="2">15</td></tr>
<tr><td>Chapter–3: Current Electricity</td></tr>
<tr><td rowspan="3">Unit-III</td><td>Magnetic Effects of Current and Magnetism</td><td rowspan="3">16</td><td rowspan="6">18</td></tr>
<tr><td>Chapter–4: Moving Charges and Magnetism</td></tr>
<tr><td>Chapter–5: Magnetism and Matter</td></tr>
<tr><td rowspan="3">Unit-IV</td><td>Electromagnetic Induction and Alternating Currents</td><td rowspan="3">19</td></tr>
<tr><td>Chapter–6: Electromagnetic Induction</td></tr>
<tr><td>Chapter 7: Alternating currents</td></tr>
<tr><td colspan="2">Total</td><td>73</td><td>35</td></tr>
</table>

Unit I: Electrostatics 23 Periods

Chapter–1: Electric Charges and Fields

Electric Charges; Conservation of charge, Coulomb's law-force between two-point charges, forces between multiple charges; superposition principle and continuous charge distribution. Electric field, electric field due to a point charge, electric field lines, electric dipole, electric field due to a dipole, torque on a dipole in uniform electric field. Electric flux, statement of Gauss's theorem and its applications to find field due to infinitely long straight wire, uniformly charged infinite plane sheet.

Chapter–2: Electrostatic Potential and Capacitance

Electric potential, potential difference, electric potential due to a point charge, a dipole and system of charges; equipotential surfaces, electrical potential energy of a system of two-point charges and of electric dipole in an electrostatic field. Conductors and insulators, free charges and bound charges inside a conductor. Dielectrics and electric polarisation, capacitors and capacitance, combination of capacitors in series and in parallel, capacitance of a parallel plate capacitor with and without dielectric medium between the plates, energy stored in a capacitor.

Unit II: Current Electricity 15 Periods

Chapter–3: Current Electricity

Electric current, flow of electric charges in a metallic conductor, drift velocity, mobility and their relation with electric current; Ohm's law, electrical resistance, V-I characteristics (linear and non-linear), electrical energy and power, electrical resistivity and conductivity; temperature dependence of resistance. Internal resistance of a cell, potential difference and emf of a cell, combination of cells in series and in parallel, Kirchhoff's laws and simple applications, Wheatstone bridge, metre bridge(qualitative ideas only). Potentiometer - principle and its applications to measure potential difference and for comparing EMF of two cells; measurement of internal resistance of a cell (qualitative ideas only).

Unit III: Magnetic Effects of Current and Magnetism 16 Periods

Chapter–4: Moving Charges and Magnetism

Concept of magnetic field, Oersted's experiment. Biot-Savart law and its application to current carrying circular loop. Ampere's law and its applications to infinitely long straight wire. Straight and toroidal solenoids (only qualitative treatment), force on a moving charge in uniform magnetic and electric fields. Force on a current-carrying conductor in a uniform magnetic field, force between two parallel current-carrying conductors-definition of ampere, torque experienced by a current loop in uniform magnetic field; moving coil galvanometer-its current sensitivity and conversion to ammeter and voltmeter.

Chapter–5: Magnetism and Matter

Current loop as a magnetic dipole and its magnetic dipole moment, magnetic dipole moment of a revolving electron, bar magnet as an equivalent solenoid, magnetic field lines; earth's magnetic field and magnetic elements.

Unit IV: Electromagnetic Induction and Alternating Currents 19 Periods

Chapter–6: Electromagnetic Induction

Electromagnetic induction; Faraday's laws, induced EMF and current; Lenz's Law, Eddy currents. Self and mutual induction.

Chapter–7: Alternating Current

Alternating currents, peak and RMS value of alternating current/voltage; reactance and impedance; LC oscillations (qualitative treatment only), LCR series circuit, resonance; power in AC circuits. AC generator and transformer.

TERM–1

PHYSICS

IMPORTANT FORMULAE

MULTIPLE CHOICE QUESTIONS
(Including Competency-based MCQs)

CASE-BASED QUESTIONS

ASSERTION-REASON QUESTIONS

01 ELECTRIC CHARGES AND FIELDS

IMPORTANT FORMULAE

1. Coulomb's force F between two point charges kept in a medium of electric constant,

$$F = \frac{1}{4\pi\varepsilon_0 K}\frac{q_1 q_2}{r^2}$$

For air between the charges, dielectric constant $K = 1$.

$$F_{air} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

In vector form $$\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\hat{r}_{21}$$

Where F_{21} is the force on charge q_1 due to q_2 and $\hat{r}_{21}$ is the unit vector in the direction from q_1 to q_2.

2. Electric field strength $\vec{E}$ at any point in the field where $\vec{F}$ is the force experienced by a test charge q_0 kept at that point, $\vec{E} = \lim_{q_0 \to 0}\frac{\vec{F}}{q_0}$

(*a*) Electric field strength due to a point charge at a distance r

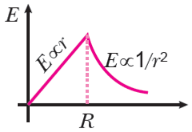
$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^3}\vec{r} \quad \left[\text{where } \hat{r} \text{ is unit vector along } \vec{r};\ \hat{r} = \frac{\vec{r}}{r}\right]$$

(*b*) Due to sphere charge

(*i*) Inside point $(r \le R)$ $\quad E = \frac{1}{4\pi\varepsilon_0}\frac{q}{R^3}r;\ E \propto r$

(*ii*) Outside point $(r \ge R)$ $\quad E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2};\ E \propto \frac{1}{r^2}$

(*iii*) On the surface $(r = R)$ $\quad E = \frac{1}{4\pi\varepsilon_0}\frac{q}{R^2}$

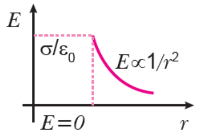


(*c*) Due to hollow sphere of charge

(*i*) Inside point $(r \le R)$, $E = 0$

(*ii*) Outside, $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$

(*iii*) On the surface, $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{R^2} = \frac{\sigma}{\varepsilon_0}$



(d) Electric field strength due to infinite line charge having linear charge density (λ) coulomb/metre.

$$E = \frac{1}{4\pi\varepsilon_0}\frac{2\lambda}{r}$$

(e) Electric field strength near an infinite thin sheet of charge.

$$E = \frac{\sigma}{2\varepsilon_0}$$

(f) Electric field strength near a conductor $\vec{E} = \frac{\sigma}{\varepsilon_0}\hat{n}$, where $\hat{n}$ is a unit vector normal to the surface in the outer direction. Electric field strength inside a conductor $E = 0$.

7. Electric Dipole:

(a) Dipole moment $|\vec{p}| = q.2l$ ($2l$ being the separation from $-q$ to $+q$)

(b) Torque on a dipole in uniform electric field $\vec{\tau} = \vec{p}\times\vec{E}$

(c) Potential energy of dipole, $U = -\vec{p}.\vec{E} = -pE\cos\theta$
where θ is the angle between $\vec{p}$ and $\vec{E}$

(d) Work done in rotating the dipole in uniform electric field from orientation θ_1 to θ_2 is

$$W = U_2 - U_1 = pE(\cos\theta_1 - \cos\theta_2)$$

Work done in rotating the dipole from equilibrium position $\theta = 0$ to orientation θ is

$$W = pE\,(1 - \cos\theta)$$

(e) **Electric field** due to a short dipole.

(i) at axial point $E_{axis} = \frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$

(ii) at an equitorial point $E = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^3}$

8. Total electric flux, $\phi = \int_S \vec{E}.d\vec{S} = \frac{1}{\varepsilon_0}\times$ net charge enclosed by the closed surface.

MULTIPLE CHOICE QUESTIONS

Choose and write the correct option in the following questions.

1. A body can be negatively charged by

(a) giving excess of electrons to it
(b) removing some electron from it
(c) giving some protons to it
(d) removing some neutrons from it.

2. The unit of permittivity of free space (ε_0) is

(a) $CN^{-1}m^{-1}$
(b) Nm^2C^{-2}
(c) $C^2N^{-1}m^{-2}$
(d) $C^2N^{-2}m^{-2}$

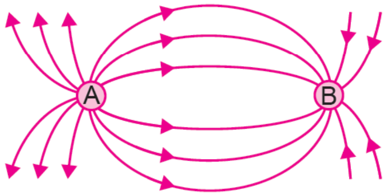
3. Which of the following is not a property of field lines?

(a) Field lines are continuous curves without any breaks
(b) Two field lines cannot cross each other
(c) Field lines start at positive charges and end at negative charges
(d) They form closed loops

4. Gauss's law is valid for

(a) Any closed surface
(b) Only regular closed surfaces
(c) Any open surface
(d) Only irregular open surfaces.

5. **The spatial distribution of the electric field due to two charges (A, B) is shown in figure.**



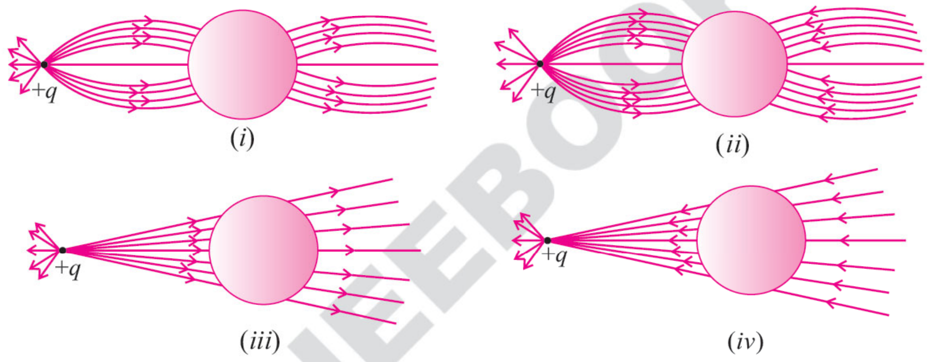
Which one of the following statements is correct?

(a) A is + ve and B is – ve and $|A| > |B|$
(b) A is – ve and B is + ve, $|A| = |B|$
(c) Both are + ve but $A > B$
(d) Both are – ve but $A > B$

6. **When air is replaced by a medium of dielectric constant K, the force of attraction between two charges separated by a distance r**

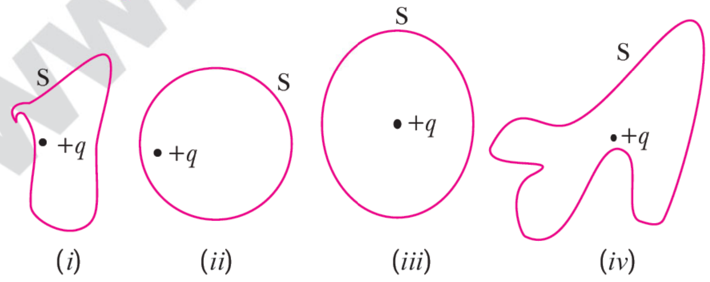
(a) decreases K times
(b) remains unchanged
(c) increases K times
(d) increases K^{-2} times

7. **A point positive charge is brought near an isolated conducting sphere (Fig. given below). The electric field is best given by** [*NCERT Exemplar*]



(a) Fig (i)
(b) Fig (ii)
(c) Fig (iii)
(d) Fig (iv)

8. **The Electric flux through the surface** [*NCERT Exemplar*]

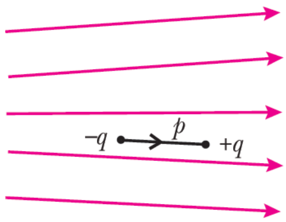


(a) in Fig. (iv) is the largest.
(b) in Fig. (iii) is the least.
(c) in Fig. (ii) is same as Fig. (iii) but is smaller than Fig. (iv)
(d) is the same for all the figures.

9. **A hemisphere is uniformly charged positively. The electric field at a point on a diameter away from the centre is directed** [*NCERT Exemplar*]

(a) perpendicular to the diameter
(b) parallel to the diameter
(c) at an angle tilted towards the diameter
(d) at an angle tilted away from the diameter

10. Figure shows electric field lines in which an electric dipole *p* is placed as shown. Which of the following statements is correct? [*NCERT Exemplar*]



(*a*) the dipole will not experience any force.

(*b*) the dipole will experience a force towards right.

(*c*) the dipole will experience a force towards left.

(*d*) the dipole will experience a force upwards.

11. A point charge +*q*, is placed at a distance *d* from an isolated conducting plane. The field at a point *P* on the other side of the plane is [*NCERT Exemplar*]

(*a*) directed perpendicular to the plane and away from the plane.

(*b*) directed perpendicular to the plane but towards the plane.

(*c*) directed radially away from the point charge.

(*d*) directed radially towards the point charge.

12. There are two kinds of charges—positive charge and negative charge. The property which differentiates the two kinds of charges is called

(*a*) amount of charge (*b*) polarity of charge

(*c*) strength of charge (*d*) field of charge

13. A method for charging a conductor without bringing a charged object in contact with it is called

(*a*) electrification (*b*) magnetisation

(*c*) electromagnetic induction (*d*) electrostatic induction

14. If $\oint \vec{E}.d\vec{S} = 0$ over a surface, then [*NCERT Exemplar*]

(*a*) the electric field inside the surface and on it is zero.

(*b*) all charges must necessarily be outside the surface.

(c) the number of flux lines entering the surface must be equal to the number of flux lines leaving it.

(*d*) both (*b*) and (*c*)

15. A cup contains 250 g of water. The number of negative charges present in the cup of water is

(*a*) 1.34×10^{7} C (*b*) 1.34×10^{19} C

(*c*) 3.34×10^{7} C (*d*) 1.34×10^{-19} C

16. When the distance between two charged particles is halved, the Coulomb force between them becomes

(*a*) one-half (*b*) one-fourth (*c*) double (*d*) four times.

17. Two charges are at distance *d* apart in air. Coulomb force between them is *F*. If a dielectric material of dielectric constant *K* is placed between them, the Coulomb force now becomes

(*a*) F/K (*b*) FK (*c*) F/K^2 (*d*) K^2F

18. Two point charges q_1 and q_2 are at separation *r*. The force acting between them is given by $F = K\dfrac{q_1 q_2}{r^2}$. The constant *K* depends upon

(*a*) only on the system of units (b) only on medium between charges

(*c*) both on (*a*) and (*b*) (*d*) neither on (*a*) nor on (*b*)

19. Three charges +4q, Q and q are placed in a straight line of length l at points at distance 0, l/2, and l respectively. What should be Q in order to make the net force on q to be zero?

(*a*) $-q$ (*b*) $-2q$ (*c*) $-\frac{q}{2}$ (*d*) $4q$

20. An electron falls from the rest through a vertical distance h in a uniform and vertically upward directed electric field E. The direction of electric field is now reversed, keeping its magnitude the same. A proton is allowed to fall from rest in it through the same vertical distance h. The time of fall of the electron, in comparison to the time of fall of the proton is

(*a*) smaller (*b*) 5 times bigger
(*c*) 10 times bigger (*d*) equal

21. Which of the following is the unit of electric charge?

(*a*) Coulomb (C) (*b*) Statcoulomb (stat C)
(*c*) Abcoulomb (abC or aC) (*d*) All the above

22. A body is positively charged. It has

(*a*) excess of positrons (*b*) excess of electrons
(*c*) deficiency of electrons (*d*) deficiency of protons

23. A proton at rest has a charge e. When it moves with a high speed, its charge

(*a*) $> e$ (*b*) $< e$
(*c*) $= e$ (*d*) may increase or decrease

24. Two charges 3×10^{-5} C and 5×10^{4} C are placed at a distance of 10 cm from each other. Find the value of electrostatic force acting between them.

(*a*) 13.5×10^{11} N (*b*) 40×10^{11} N (*c*) 180×10^{9} N (*d*) 13.5×10^{10} N

25. What is the value of minimum force (in N)acting between two charges placed at 1 m apart from each other?

(*a*) ke^2 (*b*) ke (*c*) $\frac{ke}{4}$ (*d*) $\frac{ke^2}{2}$

26. A glass rod acquires charge by rubbing it with silk cloth. The charge on glass rod is due to

(*a*) friction (*b*) conduction (*c*) induction (*d*) radiation

27. Find the thickness of a dielectric material which has relative permittivity ε_r when two charges experience the same force as in air by a distance r.

(*a*) $t = \sqrt{\varepsilon_r}\, r$ (*b*) $t = \sqrt{r\varepsilon_r}$ (*c*) $t = r\varepsilon_r$ (*d*) $t = \frac{r}{\sqrt{\varepsilon_r}}$

28. What will be the value of electric field at the centre of the electric dipole?

(*a*) Zero
(*b*) Equal to the electric field due to one charge at centre
(*c*) Twice the electric field due to one charge at centre
(*d*) Half the value of electric field due to one charge at centre

29. Which physical quantity have unit newton /coulomb?

(*a*) Electric charge (*b*) Electric field
(*c*) Electric force (*d*) Electric potential

30. In the process of charging, the mass of the negatively charged body

(*a*) increases (*b*) decreases
(*c*) remains constant (*d*) none of the above

31. Charge on a body is integral multiple of $\pm e$. It is given by the law of

(*a*) conservation of charge (*b*) conservation of mass
(*c*) conservation of energy (*d*) quantisation of charge

32. Electric field intensity due to a short dipole remains directly proportional to (r is the distance of a point from centre of dipole)

(*a*) r^2 (*b*) r^3 (*c*) r^{-2} (*d*) r^{-3}

33. Electric field lines contracts lengthwise, It shows

(*a*) repulsion between same charges

(*b*) attraction between opposite charges

(*c*) no relation between force & contraction

(*d*) electric field lines does not move in straight path

34. Force F between charges Q_1 and Q_2 separated by r is 25 N. It can be reduced to 5 N if the separation between them is made

(*a*) $\frac{r}{\sqrt{5}}$ (*b*) $\frac{r}{2}$ (*c*) 2r (*d*) $\sqrt{5}\,r$

35. Which of the following is the unit of electric field intensity?

(*a*) NC (*b*) Nm (*c*) NC^{-2} (*d*) NC^{-1}

36. The unit of electric dipole moment is

(*a*) C/m (*b*) C-m (*c*) C/m^2 (*d*) $C\text{-}m^2$

37. A slab of dielectric is introduced between two equal positive charges with a fixed separation. As a result

(*a*) the force between the two charges decreases

(*b*) the two charges start attracting each other

(*c*) the slab starts moving

(*d*) an electric current passes from one charge to the other

38. Two like point charges separated by a certain distance exert a force of 0.04 N on each other. When the distance of separation between them is halved, the force exerted by each on the other will be

(*a*) 0.16 N (*b*) 0.02 N (*c*) 0.08 N (*d*) 0.01 N

39. When a glass rod is rubbed with a dry silk cloth, the glass rod is positively charged due to the transfer of

(*a*) protons from silk cloth to glass rod (*b*) electrons from silk cloth to glass rod

(*c*) protons from glass rod to silk cloth (*d*) electrons from glass rod to silk cloth

40. The unit of electric permittivity ε of a medium is

(*a*) Nm^2/C^2 (*b*) Nm^2/C (*c*) C^2/Nm^2 (*d*) C/Nm^2

41. The dimensions of electric permittivity is

(*a*) $ML^3T^4A^{-2}$ (*b*) $ML^{-3}T^4A^2$ (*c*) $M^{-1}L^3T^4A^2$ (*d*) $M^{-1}L^{-3}T^4A^2$

42. An insulated conical shaped metallic conductor is charged positively. The surface charge density on it is

(*a*) uniform throughout (*b*) minimum at the apex

(*c*) maximum at the apex (*d*) maximum at its base

43. The magnitude of force experienced by an electron placed at a point in the electric field $\vec{E}$ is equal to its weight mg. The magnitude of $\vec{E}$ is

(*a*) mge (*b*) $e/(mg)$ (*c*) mg/e (*d*) mg/e^2

44. An electric dipole is placed at an angle of 30° with an electric field intensity 2×10^5 NC^{-1}. It experiences a torque equal to 4 Nm. The charge on the dipole, if the dipole length is 2 cm, is

(*a*) 8 mC (*b*) 2 mC (*c*) 5 mC (*d*) 7 mC

45. What is the SI unit of electric flux?

(a) $\frac{N}{C} \times m^2$ (b) $N \times m^2$

(c) $\frac{N}{m^2} \times C$ (d) $\frac{N^2}{m^2} \times C^2$

46. The dimentional formula of electric flux is

(a) $[M^1L^1T^{-2}]$ (b) $[M^1L^3T^{-3}A^{-1}]$

(c) $[M^2L^2T^{-2}A^{-2}]$ (d) $[M^1L^{-3}T^3A^1]$

47. Which of the following statements is not true about Gauss's law?

(a) Gauss's law is true for any closed surface.

(b) The term q on the right side of Gauss's law includes the sum of all charges enclosed by the surface.

(c) Gauss's law is not much useful in calculating electrostatic field when the system has some symmetry.

(d) Gauss's law is based on the inverse square dependence on distance contained in the Coulomb's law.

48. The surface considered for Gauss's law is called

(a) closed surface (b) spherical surface

(c) Gaussian surface (d) plane surface

49. Charge on a conducting metal sphere is present

(a) on the surface of sphere (b) inside the sphere

(c) outside the sphere (d) both inside and outside of sphere

50. Charge Q is kept in a sphere of 5 cm first, then it is kept in a cube of side 5 cm, the outgoing flux will be

(a) more in case of sphere (b) more in case of cube

(c) same in both case (d) information incomplete

51. A sphere encloses an electric dipole within it. The total flux across the sphere is

(a) zero (b) half that due to a single charge

(c) double that due to a single charge (d) dependent on the position of the dipole

52. A charge q is placed at the centre of a cube, what is the electric flux passing through one of its faces?

(a) $\frac{q}{6\varepsilon_0}$ (b) $\frac{q}{\varepsilon_0}$ (c) $\frac{6q}{\varepsilon_0}$ (d) $\frac{q}{3\varepsilon_0}$

53. According to Gauss law, electric field of an infinitely long straight wire is proportional to

(a) r (b) $\frac{1}{r^2}$ (c) $\frac{1}{r^3}$ (d) $\frac{1}{r}$

54. A charge q μC is placed at the centre of a cube of side 0.1 m. Then the electric flux diverging from each face of this cube is

(a) $\frac{q \times 10^{-6}}{\varepsilon_0}$ (b) $\frac{q}{\varepsilon_0} \times 10^{-4}$ (c) $\frac{q \times 10^{-6}}{6\varepsilon_0}$ (d) $\frac{q \times 10^{-4}}{6\varepsilon_0}$

55. An electric charge q is placed at one of the corners of a cube of side a. The electric flux on one of its faces will be

(a) $\frac{q}{a\varepsilon_0}$ (b) $\frac{q}{\varepsilon_0 a^2}$ (c) $\frac{q}{4\pi\varepsilon_0 a^2}$ (d) $\frac{q}{24\varepsilon_0}$

56. Consider a region inside in which there are various types of charges but the total charge is zero. At points outside the region

(*a*) the electric field is necessarily zero.

(*b*) the electric field is due to the dipole moment of the charge distribution only.

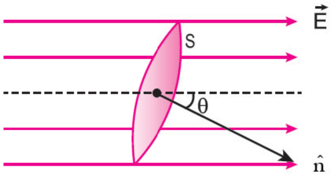
(*c*) the work done to move a charged particle along a closed path, away from the region, will be zero.

(*d*) None of these

57. If electric field is uniform, then the electric lines of forces are

(*a*) divergent (*b*) convergent (*c*) circular (*d*) parallel

58. A plane of surface area S is placed in an electric field such that the direction of normal on surface 'S' makes an angle 'θ' with the direction of electric field $\vec{E}$. The electric flux through the surface is



(*a*) ES (*b*) $ES \sin\theta$

(*c*) $ES \cos\theta$ (*d*) zero

59. In which of the following cases the electric field strength is independent of distance?

(*a*) Due to a point charge (*b*) Due to a line charge

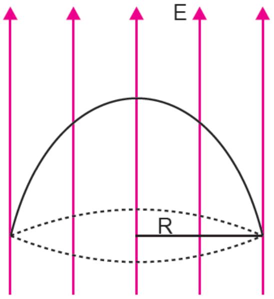
(*c*) Due to a spherical charge (*d*) Due to infinite flat sheet of charge

60. A cylinder of radius R and length L is placed in a uniform electric field E parallel to cylinder axis. The total flux through the surface of the cylinder is given by

(*a*) $2\pi R^2E$ (*b*) $2\pi RLE$

(*c*) $(2\pi R^2 + 2\pi RL)E$ (*d*) zero

61. A hemispherical surface of radius R is placed with its cross-section perpendicular to a uniform electric field as shown in figure. The electric flux through the surface is



(*a*) πR^2E

(*b*) $2\pi R^2E$

(*c*) $4\pi R^2E$

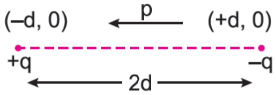
(*d*) zero

62. A small metal ball is suspended in a uniform electric field with the help of an insulated thread. If high energy X-ray beam falls on the ball, it will

(*a*) be deflected in the direction of field (*b*) be deflected opposite to direction of field

(*c*) not deflect at all (*d*) fly to infinity

63. Two point charges $+q$ and $-q$ are held fixed at $(-d, 0)$ and $(+d, 0)$ respectively of a (x, y) coordinate system. Then



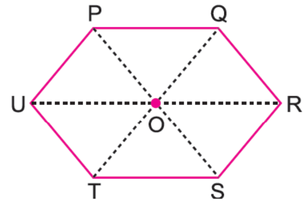
(*a*) the dipole moment is qd along positive X-axis

(*b*) the dipole moment is $q(2d)$ along positive X-axis

(*c*) the dipole moment is $q(2d)$ along positive Y-axis

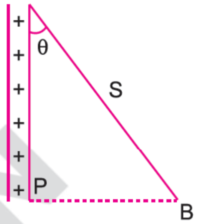
(*d*) the dipole moment is $q(2d)$ along negative X-axis

64. Six charges, three positive and three negative are to be placed at the vertices of a regular hexgon such that the electric field at *O* is double the electric field when only one positive charge of same magnitude is placed at *R*. Which of the following arrangements of charges is possible for *P, Q, R, S, T* and *U* respectively?



(*a*) +, –, +, –, –, –
(*b*) +, –, +, –, +, –
(*c*) +,+, –, +, –, –
(*d*) –, +, +, –, +, –

65. A charged ball *B* hangs from a silk thread *S*, which makes an angle θ with a large conducting sheet *P*, as shown in fig., the surface charge density σ of the sheet is proportional to



(*a*) cot θ
(*b*) cos θ
(*c*) tan θ
(*d*) sin θ

66. Force between two identical charges placed at a distance *r* in vacuum is *F*. Now a slab of dielectric of dielectric constant 4 is inserted between these two charges. If the thickness of the slab is $\frac{r}{2}$ then the force between the charges will become

(*a*) F
(*b*) $\frac{F}{4}$
(*c*) $\frac{F}{2}$
(*d*) $\frac{4}{9}F$

67. Electric flux is

(*a*) scalar quantity
(*b*) vector quantity
(*c*) sometimes scalar and sometimes vector
(*d*) neither scalar nor vector.

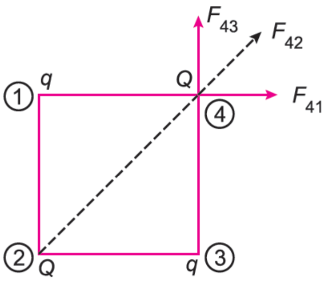
68. The minimum value of charge on any charged body may be

(*a*) 1.6×10^{-19} coulomb
(*b*) 1 coulomb
(*c*) 1μC
(*d*) 4.8×10^{-12} coulomb

69. The number of electrons contained in 1 coulomb of charge is equal to

(*a*) 6.25×10^{17}
(*b*) 6.25×10^{18}
(*c*) 1.6×10^{-19}
(*d*) 0.625×10^{18}

70. A charge *Q* is placed at each of the opposite corners of a square. A charge *q* is placed at each of the other two corners. If the net electrical force on *Q* is zero, then $\frac{Q}{q}$ equals

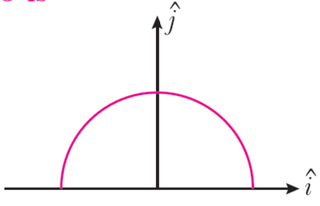


(*a*) $-2\sqrt{2}$
(*b*) –1
(*c*) 1
(*d*) $-\frac{1}{\sqrt{2}}$

71. Three concentric metallic spherical shells of radii *R*, 2*R* and 3*R* are given charges Q_1, Q_2, Q_3 respectively. It is found that the surface charge densities on the outer surfaces of the shells are equal. Then the ratio of the charges given to the shells $Q_1 : Q_2 : Q_3$ is

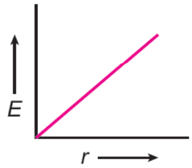
(*a*) 1 : 2 : 3
(*b*) 1 : 3 : 5
(*c*) 1 : 4 : 9
(*d*) 1 : 8 : 18

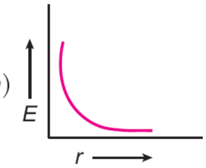
72. A thin semicircular ring of radius *r* has a positive charge '*q*' uniformly distributed over it. The net electric field $\vec{E}$ at centre *O* is

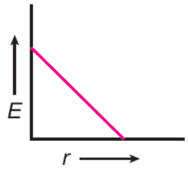


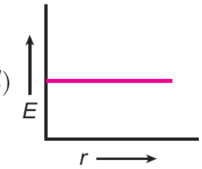
(*a*) $\frac{q}{2\pi^2\varepsilon_0 r^2}\hat{j}$
(*b*) $\frac{q}{4\pi^2\varepsilon_0 r^2}\hat{i}$
(*c*) $-\frac{q}{4\pi^2\varepsilon_0 r^2}\hat{i}$
(*d*) $\frac{-q}{2\pi^2\varepsilon_0 r^2}\hat{j}$

73. For a point charge, the graph between electric field versus distance is given by

(*a*)


(*b*)


(*c*)


(*d*)


74. An infinite number of identically charged bodies are kept along the *x*-axis at points x = 0, 1 m, 2 m, 4 m, 8 m, 16 m and so on. All other charges repel the charge at the origin with a force of 1.2 N. Find magnitude of each charge.

(*a*) 9 μC (*b*) 10 μC (*c*) 11 μC (*d*) 12 μC

75. If the net electric flux through a closed surface is zero, then we can infer [*CBSE 2020 (55/1/1)*]

(*a*) no net charge is enclosed by the surface.
(*b*) uniform electric field exists within the surface.
(*c*) electric potential varies from point to point inside the surface.
(*d*) charge is present inside the surface.

76. An electric dipole placed in a non-uniform electric field can experience [*CBSE 2020 (55/1/2)*]

(*a*) a force but not a torque. (*b*) a torque but not a force.
(*c*) always a force and a torque. (*d*) neither a force nor a torque.

77. A point charge is situated at an axial point of a small electric dipole at a large distance from it. The charge experiences a force *F*. If the distance of the charge is doubled, the force acting on the charge will become [*CBSE 2020 (55/1/3)*]

(*a*) $2F$ (*b*) $F/2$ (*c*) $F/4$ (*d*) $F/8$.

78. The electric flux emerging out from 1C charge is [*CBSE 2020 (55/3/1)*]

(*a*) $\frac{1}{\varepsilon_0}$ (*b*) 4π (*c*) $\frac{4\pi}{\varepsilon_0}$ (*d*) ε_0

79. An electric dipole consisting of charges $+q$ and $-q$ separated by a distance r, is kept symmetrically at the centre of an imaginary sphere of radius R (> r), Another point charge Q is also kept is also kept at the centre of the sphere. The net electric flux coming out of the sphere will be [*CBSE 2020 (55/3/2)*]

(*a*) $\frac{-(2q+Q)}{4\pi\varepsilon_0}$ (*b*) $\frac{Q}{\varepsilon_0}$ (*c*) $\frac{2q+Q}{\varepsilon_0}$ (*d*) $\frac{-Q}{\varepsilon_0}$

80. Two large conducting spheres carrying charges Q_1 and Q_2 are kept with their centres r distance apart. The magnitude of electrostatic between them is not exactly $\frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$ because [*CBSE 2020 (55/3/3)*]

(*a*) these are not point charges.
(*b*) charge distribution on the spheres is not uniform.
(*c*) charges on spheres will shift towards the centres of their respective spheres.
(*d*) charges will shift towards the portions of the spheres which are closer and facing towards each other.

81. The electric flux through a closed Gaussian surface depends upon *[CBSE 2020 (55/5/1)]*

(*a*) net charge enclosed and permittivity of the medium

(*b*) net charge enclosed, permittivity of the medium and the size of the Gaussian surface

(*c*) net charge enclosed only

(*d*) permittivity of the medium only

Answers

1. (*a*)	**2.** (*c*)	**3.** (*d*)	**4.** (*a*)	**5.** (*a*)	**6.** (*a*)	**7.** (*a*)	**8.** (*d*)
9. (*a*)	**10.** (*c*)	**11.** (*a*)	**12.** (*b*)	**13.** (*d*)	**14.** (*d*)	**15.** (*a*)	**16.** (*d*)
17. (*a*)	**18.** (*c*)	**19.** (*a*)	**20.** (*a*)	**21.** (*d*)	**22.** (*c*)	**23.** (*c*)	**24.** (*a*)
25. (*a*)	**26.** (*a*)	**27.** (*d*)	**28.** (*c*)	**29.** (*b*)	**30.** (*a*)	**31.** (*d*)	**32.** (*d*)
33. (*b*)	**34.** (*d*)	**35.** (*d*)	**36.** (*c*)	**37.** (*a*)	**38.** (*a*)	**39.** (*d*)	**40.** (*c*)
41. (*d*)	**42.** (*c*)	**43.** (*c*)	**44.** (*b*)	**45.** (*a*)	**46.** (*b*)	**47.** (*c*)	**48.** (*c*)
49. (*a*)	**50.** (*c*)	**51.** (*a*)	**52.** (*a*)	**53.** (*d*)	**54.** (*c*)	**55.** (*d*)	**56.** (*c*)
57. (*d*)	**58.** (*c*)	**59.** (*d*)	**60.** (*d*)	**61.** (*a*)	**62.** (*a*)	**63.** (*d*)	**64.** (*d*)
65. (*c*)	**66.** (*d*)	**67.** (*a*)	**68.** (*a*)	**69.** (*b*)	**70.** (*a*)	**71.** (*b*)	**72.** (*d*)
73. (*b*)	**74.** (*b*)	**75.** (*a*)	**76.** (*c*)	**77.** (*d*)	**78.** (*a*)	**79.** (*b*)	**80.** (*b*)
81. (*a*)							

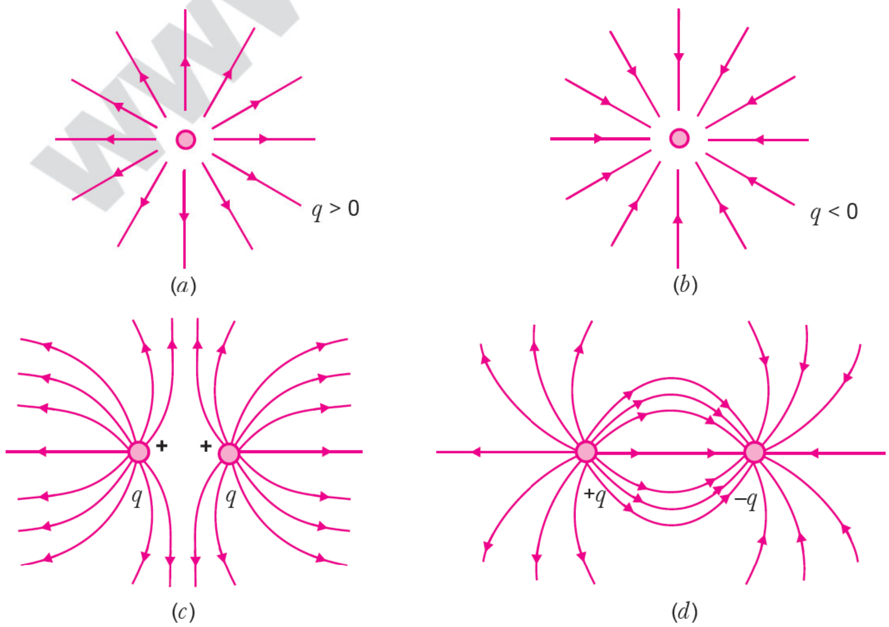
CASE-BASED QUESTIONS

Attempt any 4 sub-parts from each question. Each question carries 1 mark.

1. COULOMB'S FIELD:

The electrostatic field around an electrically charged body or particle is called Coulomb field. According to Coulomb's law, "The force of attraction or repulsion between two point charges is directly proportional to the product of the charges and inversely proportional to the square of distance between them. The direction of this force is along the line of joining the two charges."

After all, for any system of charges, the measurable quantity is the force on a charge which can be directly determined using Coulomb's law and the superposition principle.



For electrostatic, the concept of electric field is convenient, but not really necessary. Electrical field is an elegant way of characterising the electrical environment of a system of charges. Electric field at a point in the space around a system of charges tells you the force a unit positive test charge would experience if placed at that point. The true physical significance of the concept of electric field, however, emerges only when we go beyond electrostatics and deal with time dependent electromagnetic phenomena. The concept of field was first introduced by Faraday and is now the central concept in physics.

(*i*) The vector form of Coulomb's force ($\vec{F}_{12}$) is

(*a*) $\frac{1}{4\pi\varepsilon_0} \times \frac{q_1 q_2}{r_{12}^2}\hat{r}_{12}$ (*b*) $\frac{1}{4\pi\varepsilon_0} \times \frac{q_1 q_2}{r_{12}}\hat{r}_{12}$

(*c*) $\frac{1}{4\pi\varepsilon_0} \times \frac{q_1 q_2}{r_{12}^3}\hat{r}_{12}$ (*d*) none of these

(*ii*) The Coulomb force between a proton and an electron separated by 0.8×10^{-15} m is

(*a*) 300 N (*b*) 320 N

(*c*) 340 N (*d*) 360 N

(*iii*) The Coulomb field at a point is

(*a*) always continuous

(*b*) continuous if there is no charge at that point

(*c*) discontinuous only if there is a negative charge at that point

(*d*) continuous if there is a charge at that point

(*iv*) A point charge $+q$, is placed at a distance d from an isolated conducting plane. The field at a point P on the other side of the plane is

(*a*) directed radially towards the point charge

(*b*) directed radially away from the point charge

(*c*) directed perpendicular to the plane but towards the plane

(*d*) directed perpendicular to the plane and away from the plane

(*v*) An infinite number of charges each equal to 4 μC are placed along the X-axis at $x = 1$ m, $x = 2$ m, $x = 4$ m, $x = 8$ m, and so on, the Coulomb field at origin for all these charges is

(*a*) 4.8×10^3 N/C (*b*) 4.8×10^4 N/C

(*c*) 4.8×10^5 N/C (*d*) 4.8×10^6 N/C

Answers

1. (*i*) (*a*); The Coulomb's force is directly proportional to the product of charges and inversely proportional to the square of distance between them. In vector form, it is represented as

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0} = \frac{q_1 q_2}{r_{12}^2}\hat{r}_{12}$$

(*ii*) (*d*); According to Coulomb's law, $F_e = K\frac{q_1 q_2}{r^2}$

where, charge on particle, $e^- = -1.6 \times 10^{-19}$ C, $p^+ = +1.6 \times 10^{-19}$ C

$$K = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$$

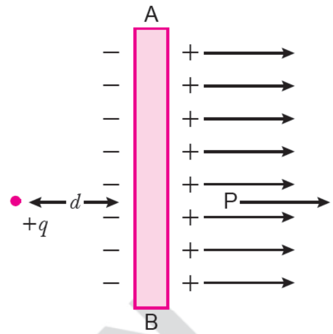
$$\therefore \quad F_e = \frac{9 \times 10^9 (-1.6 \times 10^{-19}) \times 1.6 \times 10^{-19}}{(0.8 \times 10^{-15})^2}$$

$$F_e = -360 \text{ N}$$

$$|F_e| = 360 \text{ N}$$

(*iii*) (*b*); Either positive or negative charges will interact with the lines of electric field to make the electric field discontinuous.

If there is no charge inside the electric field then the lines will not be affected. So, electric field becomes continuous.



(*iv*) (*d*); Let charge $+q$ is placed to the left of isolated conducting plane *AB* vertical to plane of paper.

Due to induction by $+q$, R.H.S. of plane acquire positive charge. So, lines of force will emerge perpendicularly outward and parallel to each other.

(*v*) (*b*); Electric field (Coulomb field) due to point charge,

$$E = \frac{KQ}{r^2}$$

Now, Coulomb field due to system of charges, $Q = 4\ \mu C$

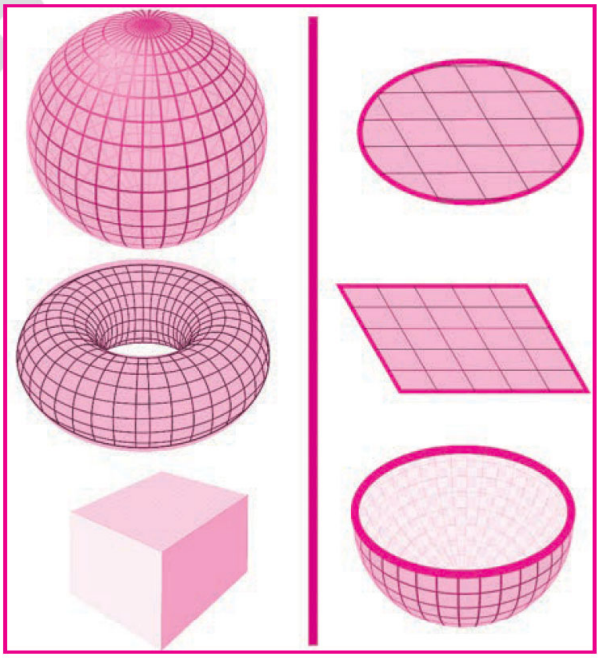
i.e., $$E = KQ\left[\frac{1}{r_1^2} + \frac{1}{r_2^2} + \frac{1}{r_3^2} + \ldots\ldots\ldots + \infty\right]$$

$$E = 9\times10^9\times4\times10^{-6}\left[1+\frac{1}{4}+\frac{1}{16}+\frac{1}{64}+\ldots.\infty\right]$$

$$E = \frac{36\times10^3}{1-1/4} = 4.8\times10^4\ \text{N/C}$$

2. GAUSSIAN SURFACES:

Johann Carl Friendrich Gauss (1777–1855) was German mathematician and physicist who made significant contribution to many fields in mathematics and science. In physics Gauss's law, also known as Gauss's flux theorem, is a law relating the distribution of electric charge to the resulting electric field. In the integral form, it states that the flux of the electric field out of an arbitrary closed surface is proportional to the electric charge enclosed by the surface, irrespective of how that charge is distributed.



A Gaussian surface (sometimes abbreviated as G.S) is a closed surface in three-dimensional space through which the flux of a vector field is calculated, usually gravitational field, the electric field, or magnetic field. It is an arbitrary closed surface used in conjunction with Gauss's law for the corresponding field by performing a surface integral, in order to calculate the total amount of the sources quantity enclosed; *e.g.*, amount of electric charge as the source of the electrostatic field.

(*i*) The type of physical quantity electric flux and its dimensions respectively are

(*a*) vector, $[M^2L^2T^3A^1]$ (*b*) scalar, $[M^2L^2T^3A^1]$

(*c*) vector, $[ML^3T^{-3}A^{-1}]$ (*d*) scalar, $[ML^3T^{-3}A^{-1}]$

(*ii*) **The electric flux through a cubical Gaussian surface enclosing net charge q is q/ε_0, while the electric flux through one face of the cube is**

(*a*) q/ε_0 (*b*) $q/4\varepsilon_0$

(*c*) $q/6\varepsilon_0$ (*d*) $q/8\varepsilon_0$

(*iii*) **The electric flux of a flat square having an area of 10 m^2 placed in a uniform electric field of 8000 N/C passing perpendicular to it is**

(*a*) 8×10^5 Nm^2/C (*b*) 8×10^4 Nm^2/C

(*c*) 16×10^5 Nm^2/C (*d*) 4×10^4 Nm^2/C

(*iv*) **Gauss's law is valid for**

(*a*) any open surface (*b*) any closed surface

(*c*) only regular closed surface (*d*) only irregular open surface

(*v*) **If the electric flux entering and leaving an enclosed surface respectively is f_1 and f_2. The electric charge inside the surface will be**

(*a*) $\dfrac{\phi_2 - \phi_1}{\varepsilon_0}$ (*b*) $\varepsilon_0 (\phi_2 - \phi_1)$

(*c*) $\dfrac{\phi_1 - \phi_2}{\varepsilon_0}$ (*d*) $\varepsilon_0(\phi_1 + \phi_2)$

Answers

2. (*i*) (*d*); scalar quantity, $[\phi_E] = [ML^3T^{-3}A^{-1}]$

(*ii*) (*c*); According to Gauss's law, $\phi = \dfrac{q}{\varepsilon_0}$. In cubical Gaussian surface, electric flux passes equally from each face. So, electric flux through one face is $\dfrac{q}{6\varepsilon_0}$ (*as the* no. of faces of cube = 6).

(*iii*) (*b*); $\phi_E = EA\cos\theta$ $[\because \theta = 0° \Rightarrow \cos\theta = 1]$

$\phi_E = EA \Rightarrow \phi_E = 8000 \times 10 = 8 \times 10^4$ Nm^2/C

(*iv*) (*b*); Gauss's law is applicable for all types of closed surfaces.

(*v*) (*b*) Net flux diverging $\phi_2 - \phi_1 = \dfrac{q}{\varepsilon_0}$

$\Rightarrow q = \varepsilon_0(\phi_2 - \phi_1)$

ASSERTION-REASON QUESTIONS

In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct answer out of the following choices.

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

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

(c) A is true but R is false.

(d) A is false and R is also false.

1. Assertion (A) : The charge given to a metallic sphere does not depend on whether it is hollow or solid.

Reason (R) : Since the charge resides only on the surface of the conductor.

2. Assertion (A) : Charge is quantized because only integral number of electrons can be transferred.

Reason (R) : There is no possibility of transfer of some fraction of electron.

3. **Assertion (A) :** Electrons moves away from a region of lower potential to a region of higher potential.

Reason (R) : An electron has a negative charge.

4. **Assertion (A) :** When a body acquires negative charge, its mass decreases.

Reason (R) : A body acquires positive charge when it gains electrons.

5. **Assertion (A) :** Surface charge density of an irregularly shaped conductor in non-uniform.

Reason (R) : Surface density is defined as charge per unit area.

6. **Assertion (A) :** Total flux through a closed surface is zero if no charge is enclosed by the surface.

Reason (R) : Gauss law is true for any closed surface, no matter what its shape or size is.

7. **Assertion (A) :** Net electric field inside a conductor is zero. *[AIIMS 2018]*

Reason (R) : Total positive charge equals to total negative charge in a charged conductor.

8. **Assertion (A) :** If the bob of a simple pendulum is kept in a horizontal electric field, its period of oscillation will remain same, *[AIIMS 2012]*

Reason (R) : If bob is charged and kept in horizontal electric field, then the time period will be decreased.

9. **Assertion (A) :** All the charge in a conductor gets distributed on whole of its outer surface. *[AIIMS 2018]*

Reason (R) : In a dynamic system, charges try to keep their potential energy minimum.

10. **Assertion (A) :** Acceleration of charged particle in non-uniform electric field does not depend on velocity of charged particle. *[AIIMS 2017]*

Reason (R) : Charge is an invariant quantity. That is the amount of charge on particle does not depend on frame of reference.

Answers

1. (*a*) **2.** (*b*) **3.** (*a*) **4.** (*d*) **5.** (*a*) **6.** (*a*) **7.** (*c*) **8.** (*c*)
9. (*a*) **10.** (*a*)

HINTS/SOLUTIONS OF SELECTED MCQs

1. (*a*) A body can be negatively charged by giving excess of electrons to it.

2. (*c*) According to Coulomb's law,

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

$$\varepsilon_0 = \frac{q_1 q_2}{4\pi F r^2}$$

$$\text{SI unit of } \varepsilon_0 = \frac{\text{C.C}}{\text{Nm}^2} = \text{C}^2\text{N}^{-1}\text{m}^{-2}$$

3. (*d*) Electrostatic field lines do not form any closed loops.

4. (*a*) Gauss's law is valid for any closed surface.

5. (*a*) The electric field lines start from charge A and on charge B. So A is +ve and B is –ve.

6. (*a*) In air, the force of attraction between two charges in given by

$$F_{\text{air}} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

In dielectric medium, the force of attraction between two charges is given by

$$F_{mid} = \frac{1}{4\pi\varepsilon_0 K}\frac{q_1 q_2}{r^2}$$
$$= \frac{F_{air}}{K}$$

So, force decreases K-times.

7. (*a*) When a point positive charge is brought near an isolated conducting sphere, then due to induction there develops some negative charge on the leftside of the sphere and an equal positive charge on the right side of the sphere. The electric field lines emanating from the point positive charge end normally on the left side of the sphere. Due to accumulation of positive charge on the right side of the sphere, the field lines emerge outward normally. So, option (*a*) is correct.

As electric field lines are not perpendicular to the surface of sphere, so (*iii*) and (*iv*) are rejected.

8. (*d*) According to Gauss law, the electric flux (ϕ) through the closed surface depends only on the amount of charge enclosed inside the surface. It does not depend on size and shape of the surface.

Here, charge enclosed inside all the figures are same.

So, electric flux $\left(\phi = \frac{q}{\varepsilon_0}\right)$ will remain same.

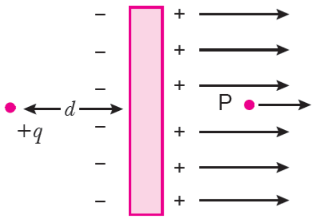
9. (*a*) As the diameter of hemisphere is plane surface, and whole hemisphere is uniformally charged positively, so the electric field lines emerging outward will be perpendicular to the surface.

10. (*c*) The density of electric field lines decreases from left to right, so electric field (E) on $+q$ charge will be smaller than $-q$ charge.

Since, $\vec{F} = q\vec{E}$, therefore force on $+q$ will be smaller than $-q$.

The direction of force $+q$ charge is along the direction of electric field, so the force on $-q$ will be towards left. Hence net force on dipole will be towards left.

11. (*a*) When a point charge $+q$ is placed at a distance d from an isolated conducting plane, due to induction by $+q$ charge, the other side (RHS) of the plane acquire positive charge, so, field lines will emerge perpendicular to the plane and away from the plane.



15. (*a*) Let us assume that the mass of one cup of water is 250 g.

The molecular mass of water is 18 g.

Number of molecules in 18 g of water = 6.02×10^{23}

Number of molecules in one cup of water = $\frac{250}{18} \times 6.02 \times 10^{23}$

Each molecule of water contains two hydrogen atoms and one oxygen atom, *i.e.*, 10 electrons and 10 protons. Hence, the total positive and total negative chage has the same magnitude and is

$$= \frac{250}{18} \times 6.02 \times 10^{23} \times 10 \times 1.6 \times 10^{-19}\,\text{C}$$
$$= 1.34 \times 10^7\ \text{C}.$$

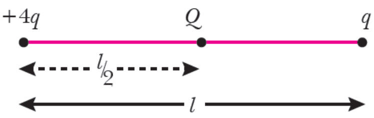
17. (*a*) In air, $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{d^2}$ ...(1)

In material, $F' = \frac{1}{4\pi\varepsilon_0 K}\frac{q_1 q_2}{d^2}$ ...(2)

Dividing equation (1) and (2)

$$\frac{F'}{F} = \frac{1}{K} \Rightarrow F' = \frac{F}{K}$$

19. (*a*) For net force on q to be zero



$$\frac{k(4q)(q)}{l^2} + \frac{k(Q)(q)}{(l/2)^2} = 0$$

$$\Rightarrow \quad \frac{4kq^2}{l^2} + \frac{4kQq}{l^2} = 0$$

$$\Rightarrow \quad Q = -q$$

20. (*a*) Force experienced by a charged particle in an electric field, $F = qE$

As $F = ma$

$$\therefore \quad ma = qE \Rightarrow a = \frac{qE}{m} \quad \text{... }(i)$$

As electron and proton both fall from same height at rest, then initial velocity, $u = 0$.

From $s = ut + \frac{1}{2}at^2$

$$\therefore \quad h = \frac{1}{2}at^2 \quad (\because u = 0)$$

$$\Rightarrow \quad h = \frac{1}{2}\frac{qE}{m}t^2 \quad [\text{Using } (i)]$$

$\therefore \; t = \sqrt{\frac{2hm}{qE}} \quad \Rightarrow t \propto \sqrt{m}$ as 'q' is same for electron and proton.

$\therefore$ Electron has smaller mass so it will take smaller time.

21. (*d*) Unit of charge is coulomb, statcoulomb and abcoulomb.

22. (*c*) A body can be charged negatively or positively by giving or taking out the electrons respectively. Positive charge indicates that some electrons are taken out and the body has deficiency of electrons.

23. (*c*) As charge is invariant.

24. (*a*)

$k = 9 \times 10^9$ N– ms^2/C^2, $q_1 = 3 \times 10^{-5}$ C, $q_2 = 5 \times 10^4$ C, $r = 10$ cm $= 0.1$ m

As we know that

$$F = \frac{kq_1q_2}{r^2} = \frac{9\times10^9\times3\times10^{-5}\times5\times10^4}{(0.1)^2}$$

$$= \frac{3\times45\times10^8}{0.1\times0.1} = 135 \times 10^{10} \text{ N} = 13.5 \times 10^{11} \text{ N}$$

25. (*a*) Smallest charge $= e = 1.6 \times 10^{-19}$

As charge is small force is minimum

$$F = \frac{k\times e\times e}{(1)^2} = ke^2$$

26. (*a*) As glass rod is rubbed with silk, so relative motion and friction comes to play.

27. (*d*) $F_{air} = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}$

$$F_{medium} = \frac{1}{4\pi\varepsilon_0\varepsilon_r}\frac{q_1q_2}{t^2}$$

According to question

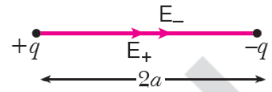
$$F_{air} = F_{medium}$$

$$\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2} = \frac{1}{4\pi\varepsilon_0 \varepsilon_r}\frac{q_1 q_2}{t^2}$$

$$\varepsilon_r t^2 = r^2$$

$$t = \frac{r}{\sqrt{\varepsilon_r}}$$

28. (*c*) As we know that



$$E_{axial} = \frac{2kp}{r^2}$$

$$E_+ = E_- = \frac{k \times q}{a^2} = \frac{kq}{a^2}$$

$$E_{net} = \sqrt{E_+^2 + E_-^2 + 2E_+ . E_- \cos 0}$$

$$= E_+ + E_-$$

$$= \frac{2\,kq}{a^2}$$

As due to point charge $E = kq/a^2$

29. (*b*) As $E = \frac{F}{q}$; unit = N/C

30. (*a*) A negatively charged body has more electrons than the neutral body and these excess electrons results in an increase in mass.

31. (*d*) Quantisation mean integral multiple of any smallest thing

32. (*d*) As electric field due to dipole

$E_a = \frac{2kp}{r^3}$ in both cases $E \propto \frac{1}{r^3}$

$$E_{eq} = \frac{kp}{r^3}$$

33. (*b*) Electric field lines initiate from positive charge and terminate on negative charge.

34. (*d*) $F = \frac{kQ_1 Q_2}{r^2}$

$$25 = \frac{KQ_1 Q_2}{r^2} \quad ...(i)$$

$$5 = \frac{KQ_1 Q_2}{(r')^2} \quad ...(ii)$$

$$= \sqrt{5}\,r$$

Divide equation (*i*) and (*ii*)

$$5 = \left(\frac{r'}{r}\right)^2 \Rightarrow r' = \sqrt{5}\,r$$

35. (*d*) $E = \frac{F}{q} \quad \Rightarrow$ N/C

36. (*b*) $\vec{p} = q.2a = \text{C - m}$

37. (*a*) Force between two charges, $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$

When dielectric slab is introduced

$$F' = \frac{1}{4\pi\varepsilon}\frac{q_1 q_2}{r^2}, \quad \text{Here } \varepsilon > \varepsilon_0$$

$\Rightarrow \quad F' < F$

38. (*a*) $F = \dfrac{kq_1 q_2}{r^2}$

$$0.04 = \frac{kq_1 q_2}{r^2} \qquad ...(i)$$

When $r' = r/2$

$$F' = \frac{kq_1 q_2}{(r/2)^2} \qquad ...(ii)$$

Divide equation (*i*) and (*ii*)

$$\frac{F'}{0.04} = \frac{4r^2}{r^2} = 4$$

$F' = 0.16$ N

39. (*d*) Electrons from glass rod to silk cloth

40. (*c*) $F = \dfrac{q_1 q_2}{4\pi\varepsilon_0 r^2} \Rightarrow \varepsilon_0 = \dfrac{q_1 q_2}{4\pi F.r^2}$

$$\text{Unit} = \frac{\text{C}}{\text{Nm}^2}$$

41. (*d*) $[\varepsilon_0] = \dfrac{[\text{AT}][\text{AT}]}{[\text{MLT}^{-2}][\text{L}^2]} = \text{A}^2\text{T}^2\text{M}^{-1}\text{L}^{-3}\text{T}^2$

$$= \text{M}^{-1}\,\text{L}^{-3}\,\text{T}^4\,\text{A}^2$$

42. (*c*) $\sigma = \dfrac{Q}{A}$

$$\sigma \propto \frac{1}{r^2}$$

43. (*c*) As $F = q\vec{E}$

$$mg = e\vec{E}$$

$$\vec{E} = mg/e$$

44. (*b*) Given, $t = 4$ Nm, $l = 2$ cm $= 0.02$ m, $E = 2 \times 10^5$ N/C, $\theta = 30°$

$$t = pE\sin\theta = qlE\sin\theta$$

$\Rightarrow \quad 4 = q(0.02) \times 2 \times 10^5 \times \sin 30°$

$\Rightarrow \quad q = \dfrac{4}{0.02 \times 2 \times 10^5 \times \frac{1}{2}}$ C

$\Rightarrow \quad q = 0.002$ C

$\Rightarrow \quad q = 2$ mC

45. (*a*) $\phi = \vec{E}\,.\,d\vec{S}$

$$= \frac{\text{N}}{\text{C}} \times \text{m}^2$$

46. (*b*) ϕ = Electric field. Area

$= [ML\,T^{-3}\,A^{-1}]\,[L^2]$

$= [M1L^3\,T^{-3}\,A^{-1}]$

47. (*c*) Gauss's law is based on the inverse square dependence on distance contained in the Coulomb's law.

48. (*c*) Gaussian surface encloses the charge.

49. (*a*) Electric field inside a conductor is zero.

50. (*c*) According to Gauss's law electric flux is $\frac{1}{\varepsilon_0}$ times the charge enclosed by the surface and is independent of the shape and size of the surface.

51. (*a*) Net charge carried by electric dipole = 0

$\therefore$ flux = 0.

52. (*a*) Electric flux through whole cube $= \frac{q}{\varepsilon_0}$

Electric flux through one surface $= \frac{q}{6\varepsilon_0}$

53. (*d*) As we know

$$E = \frac{2k\lambda}{r} \quad \Rightarrow \quad E \propto \frac{1}{r}$$

54. (*c*) Flux through whole cube $= \frac{q}{\varepsilon_0}$

through one surface $= \frac{q}{6\varepsilon_0} = \frac{q \times 10^{-6}}{6\varepsilon_0}$

55. (*d*) As we know that one face 4 corner $\frac{1}{4} \times q_{\text{face}}$

$$\frac{1}{4} \times \frac{q}{6\varepsilon_0} = \frac{q}{24\varepsilon_0}$$

59. (*d*) For an infinite sheet to charge, $E = \frac{\sigma}{2\varepsilon_0}$ (independent of distance)

60. (*d*) The electric flux entering and leaving the cylindrical surface is same $\phi = E\pi R^2 - E\pi R^2 = 0$

61. (*a*) $\phi = E \times$ (Normal surface area) $= E \times \pi R^2 = \pi R^2 E$

63. (*d*) The direction of dipole moment from $-q$ to $+q$.

66. (*a*) $F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$

For a dielectric of dielectric constant K between the charges, the effective separation in air r_{eff} is given by

$$\frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r_{eff}^2} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{Kr^2}$$

$$\Rightarrow \quad r_{\text{eff}} = \sqrt{K}\,r$$

$$\therefore \quad F' = \frac{1}{4\pi\,\varepsilon_0} \frac{q_1 q_2}{\left(\frac{r}{2} + \frac{\sqrt{K}\,r}{2}\right)^2}$$

$$\Rightarrow \quad \frac{F'}{F} = \frac{1}{\left(\frac{1}{2} + \frac{\sqrt{4}}{2}\right)^2} = \frac{4}{9}$$

$$\Rightarrow \quad F' = \frac{4}{9} F$$

68. (*a*) The smallest charge is charge on electron = 1.6×10^{-19} C.

69. (*b*) $Q = ne$

$1 = n \times 1.6 \times 10^{-19}$

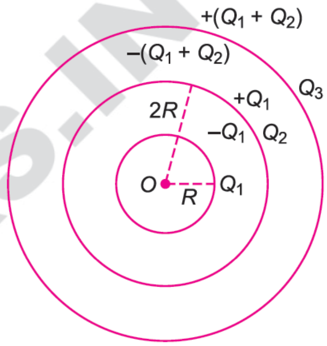
$n = 6.25 \times 10^{18}$

70. (*a*) Here, $|\vec{F}_{42}| = |\vec{F}_{43} + \vec{F}_{41}|$

$$\Rightarrow \frac{KQ^2}{(\sqrt{2}a)^2} = \frac{2KQq}{a^2} \times \frac{1}{\sqrt{2}}$$

$$\Rightarrow \frac{Q}{q} = 2\sqrt{2} \text{ (where } Q \text{ and } q \text{ is opposite in sign)}$$

71. (*b*) Charges given plus charges induced on outer surfaces of the spheres are Q_1, $Q_1 + Q_2$ and $Q_1 + Q_2 + Q_3$.



As surface charge densities on outer surfaces of the spheres are equal, *i.e.*,

$s_1 = s_2 = s_3$

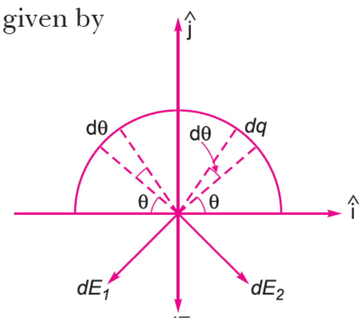
$$\Rightarrow \frac{Q_1}{4\pi R^2} = \frac{Q_1 + Q_2}{4\pi(2R)^2} = \frac{Q_1 + Q_2 + Q_3}{4\pi(3R)^2}$$

$$\Rightarrow \frac{Q_1}{1} = \frac{Q_1 + Q_2}{4} = \frac{Q_1 + Q_2 + Q_3}{9}$$

By Solving, we get

$$\frac{Q_1}{1} = \frac{Q_2}{3} = \frac{Q_3}{5} \Rightarrow Q_1 : Q_2 : Q_3 = 1 : 3 : 5$$

72. (*d*) By symmetry, the net electric field is in negative y-axis and is given by



$$\vec{E} = -\int dE_1 \sin\theta \, \hat{j}$$

$$= -\int \frac{dq}{4\pi\varepsilon_0 r^2} \sin\theta . \hat{j}$$

But $d\theta = \frac{q}{\pi r} . r \, d\theta = \frac{q}{\pi} d\theta$

$$\vec{E} = \int_0^{\pi} \frac{(q/\pi) d\theta}{4\pi\varepsilon_0 r^2} \sin\theta \, \hat{j}$$

$$= \frac{q}{4\pi^2 \varepsilon_0 r^2} \int_0^{\pi} \sin\theta \, d\theta \, \hat{j} = \frac{q}{4\pi^2 \varepsilon_0 r^2} [-\cos\theta]_0^{\pi} \hat{j}$$

$$= \frac{q}{4\pi^2 \varepsilon_0 r^2} (-2) \hat{j} = \frac{-q}{2\pi^2 \varepsilon_0 r^2} \hat{j}$$

73. (*b*) As we know that electric field due to point change

$$E = \frac{KQ}{r^2} \quad i.e., \quad E \propto \frac{1}{r^2}$$

74. (*b*) Given: $F = 1.2$ N; $x = 0$, 1 m, 4 m, 8 m, 16 m....

Now, $F = \frac{kq^2}{x^2}$

So, net force that is sum of forces by other charges is given as:

$$F = kq^2\left[\frac{1}{1^2}+\frac{1}{2^2}+\frac{1}{4^2}+\frac{1}{8^2}+\frac{1}{16^2}+.....\right]$$

$$\Rightarrow \quad F = kq^2\left[\frac{1}{1^2}+\frac{1}{2^2}+\frac{1}{2^4}+\frac{1}{2^6}+\frac{1}{2^8}+.....\right] = kq^2\left[\frac{1}{1-\frac{1}{4}}\right] = kq^2\times\frac{4}{3}$$

$$\Rightarrow \quad q^2 = \frac{3}{4}\times\frac{F}{k} \quad = \frac{3}{4}\times\frac{1.2}{9\times10^9} \;\Rightarrow\; q^2 = \frac{1}{10\times10^9} = 10^{-10}$$

$$\because \quad q = 10^{-5}\,\text{C} = 10\,\mu\text{C}$$

75. (*a*) no net charge is enclosed by the surface.

76. (*c*) always a force and a torque

78. (*a*) Electric flux $= \dfrac{Q_{\text{enclosed}}}{\varepsilon_0}$

$Q_{\text{enclosed}} = 1\text{ C}$

$\therefore \quad \phi = \dfrac{1}{\varepsilon_0}$

80. (*b*) Charge distribution on the spheres is not uniform.

81. (*a*) $Flux = \dfrac{Q_{enc}}{E_0}$

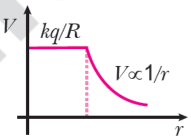
Net charge enclosed and permittivity of medium.

02 ELECTROSTATIC POTENTIAL AND CAPACITANCE

IMPORTANT FORMULAE

1. Electric Potential:

Due to a charged conducting sphere or charged spherical shell of radius R.



(*i*) Inside, $V_{inside} = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}\ (r \le R)$ (*ii*) Outside, $V_{out} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}\ (r > R)$

2. Relation between electric field and potential,

$$E = -\frac{dV}{dr} = \frac{V}{r} \text{ (numerically)}$$

3. Work done in taking a charge q from one point to another in electric field.

$$W = q(V_2 - V_1) \text{ joule}$$

where V_1 = potential at initial point,

V_2 = potential at final point.

4. Work done in carrying a charge on equipotential surface is always zero.

5. Electric potential due to dipole,

(*i*) at axial point $V_{axis} = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$,

(*ii*) at an equatorial point $V = 0$

6. Capacitance for isolated conductor, $C = \frac{Q}{V}$

7. Dielectric constant $K = \frac{\varepsilon}{\varepsilon_0} = \frac{C_{medium}}{C_{air}}$

8. Capacitance of parallel plate capacitor

(*i*) $C = \frac{\varepsilon_0 A}{d}$ in air

(*ii*) $C = \frac{K\varepsilon_0 A}{d}$ when medium of dielectric constant K fills the space between plates.

(*iii*) When the space between the plates is partly filled with a dielectric of thickness t, then capacitance $C = \frac{\varepsilon_0 A}{d - t\left(1 - \frac{1}{K}\right)}$

11. Combination of Capacitors:

(*a*) Capacitors in series:

(*i*) Net capacitance C is given by

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

(*ii*) In series charge is the same on all capacitors

$$q_1 = q_2 = q_3$$

(*iii*) Net potential difference $V = V_1 + V_2 + V_3$

(*b*) Capacitors in Parallel:

(*i*) Net capacitance, $C = C_1 + C_2 + C_3$

(*ii*) Potential difference is same across all capacitors

$$V_1 = V_2 = V_3 = \text{V (same for all)}$$

(*iii*) Charge, $q = q_1 + q_2 + q_3$

12. Energy stored in a capacitor,

$$U = \frac{1}{2}CV^2 = \frac{Q^2}{2C} = \frac{1}{2}QV$$

13. Electrostatic energy density,

$$U_e = \frac{1}{2}\varepsilon_0 E^2 \text{(in air) and } \frac{1}{2}\varepsilon E^2 \text{ (in medium)}$$

Effect of Introducing a dielectric between plates of a charged parallel plate capacitor

S. No.	Physical Quantity	When battery remains connected	When battery is removed before introduction of dielectric
(1)	Capacitance (*C*)	increases *K*-times	increases *K*-times
(2)	Charge (*Q*)	increases *K*-times	remains constant
(3)	Electric Field	remains constant	decreases $\frac{1}{K}$ times
(4)	Electric Potential (*V*)	remains constant	decreases $\frac{1}{K}$ times
(5)	Electrostatic Energy Stored	increases *K*-times	decreases $\frac{1}{K}$ times

MULTIPLE CHOICE QUESTIONS

Choose and write the correct option in the following questions.

1. The ratio of charge to potential of a body is known as

(*a*) capacitance (*b*) inductance

(*c*) conductance (*d*) resistance

2. On moving a charge of 20 C by 2 cm, 2 J of work is done. Then the potential difference between the points is

(*a*) 0.1 V (*b*) 8 V

(*c*) 2 V (*d*) 0.5 V

3. In brining an electron towards another electron, the electrostatic potential energy of the system

(*a*) increases (*b*) decreases

(*c*) remains unchanged (*d*) becomes zero

4. Electric potential of earth is taken to be zero, because earth is a good

(*a*) insulator (*b*) conductor

(*c*) semi-conductor (*d*) dielectric

5. Some charge is being given to a conductor. Then, its potential

(*a*) is maximum at surface.

(*b*) is maximum at centre.

(*c*) remains the same throughout the conductor.

(*d*) is maximum somewhere between surface and centre.

6. Equipotential surface associated with an electric field, which is increasing in magnitude along the X-direction, are

(*a*) planes parallel to YZ-plane.

(*b*) planes parallel to XZ-plane.

(*c*) planes parallel to XY-plane.

(*d*) coaxial cylinder of increasing radii around the X-axis.

7. What is angle between electric field and equipotential surface?

(*a*) $90°$ always (*b*) $0°$ always

(*c*) $0°$ to $90°$ (*d*) $0°$ to $180°$

8. A positively charged particle is released from rest in an uniform electric field. The electric potential energy of the charge [*NCERT Exemplar*]

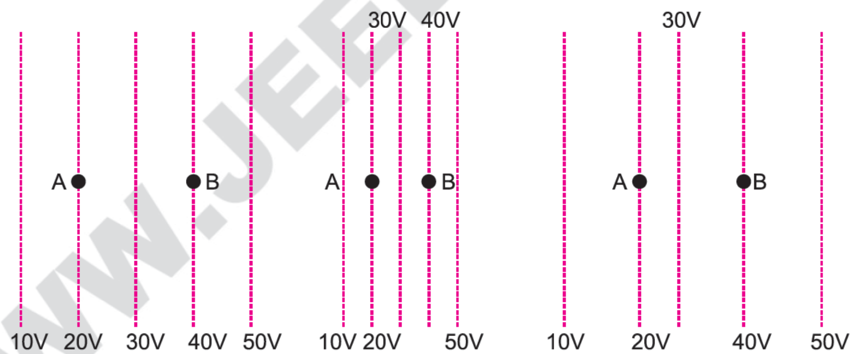
(*a*) remains a constant because the electric field is uniform.

(*b*) increases because the charge moves along the electric field.

(*c*) decreases because the charge moves along the electric field.

(*d*) decreases because the charge moves opposite to the electric field.

9. Figure shows some equipotential lines distributed in space. A charged object is moved from point A to point B. [*NCERT Exemplar*]



(i) (ii) (iii)

(*a*) The work done in Fig. (*i*) is the greatest.

(*b*) The work done in Fig. (*ii*) is least.

(*c*) The work done is the same in Fig. (*i*), Fig. (*ii*) and Fig. (*iii*).

(*d*) The work done in Fig. (*iii*) is greater than Fig. (*ii*) but equal to that in Fig. (*i*).

10. The electrostatic potential on the surface of a charged conducting sphere is 100 V. Two statements are made in this regard: [*NCERT Exemplar*]

S_1 : At any point inside the sphere, electric intensity is zero.

S_2 : At any point inside the sphere, the electrostatic potential is 100 V.

Which of the following is a correct statement?

(*a*) S_1 is true but S_2 is false.

(*b*) Both S_1 and S2 are false.

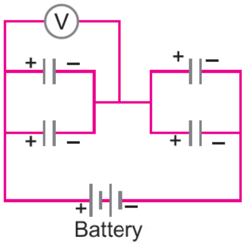
(c) S_1 is true, S_2 is also true and S_1 is the cause of S_2.

(*d*) S_1 is true, S_2 is also true but the statements are independent.

11. Equipotentials at a great distance from a collection of charges whose total sum is not zero are approximately *[NCERT Exemplar]*

(*a*) spheres (*b*) planes (*c*) paraboloids (*d*) ellipsoids

12. Four capacitors, each 50 μF are connected as shown. The DC voltmeter V reads 100 V. The charge on each plate of each capacitor is



(*a*) 2×10^{-3} C (*b*) 5×10^{-3} C (*c*) 0.2 C (*d*) 0.5 C

13. A parallel plate capacitor is made of two dielectric blocks in series. One of the blocks has thickness d_1 and dielectric constant k_1 and the other has thickness d_2 and dielectric constant k_2 as shown in figure. This arrangement can be thought as a dielectric slab of thickness d (= d_1+d_2) and effective dielectric constant k. The k is *[NCERT Exemplar]*

(*a*) $\frac{k_1d_1+k_2d_2}{d_1+d_2}$ (*b*) $\frac{k_1d_1+k_2d_2}{k_1+k_2}$

(*c*) $\frac{k_1k_2(d_1+d_2)}{k_1d_1+k_2d_2}$ (*d*) $\frac{2k_1k_2}{k_1+k_2}$

14. Equipotential surfaces *[NCERT Exemplar]*

(*a*) are closer in regions of large electric fields compared to regions of lower electric fields.

(*b*) will be more crowded near sharp edges of a conductor.

(*c*) will be more crowded near regions of large charge densities.

(*d*) all of the above

15. A 2 μF capacitor is charged to 200 volt and then the battery is disconnected. When it is connected in parallel to another uncharged capacitor, the potential difference between the plates of both is 40 volt. The capacitance of the other capacitor is

(*a*) 2 μF (*b*) 4 μF (*c*) 8 μF (*d*) 16 μF

16. Two identical metal plates, separated by a distance *d* form a parallel-plate capacitor. A metal sheet of thickness *d*/2 is inserted between the plates. The ratio of the capacitance after the insertion of the sheet to that before insertion is

(*a*) $\sqrt{2}$:1 (*b*) 2 : 1 (*c*) 1 : 1 (*d*) 1 : 2

17. *n* identical capacitors joined in parallel are charged to a common potential *V*. The battery is disconnected. Now, the capacitors are separated and joined in series. For the new combination:

(*a*) energy and potential difference both will remain unchanged

(*b*) energy will remain same, potential difference will become nV

(*c*) energy and potential both will become n times

(*d*) energy will become n times, potential difference will remain V.

18. The capacitance of a capacitor becomes $\frac{7}{6}$ times its original value if a dielectric slab of thickness $t = \frac{2}{3}d$ is introduced in between the plates, where d is the separation between the plates. The dielectric constant of the slab is

(*a*) $\frac{14}{11}$ (*b*) $\frac{11}{14}$ (*c*) $\frac{7}{11}$ (*d*) $\frac{11}{7}$

19. Two capacitors of capacitances 3 μF and 6 μF are charged to a potential of 12 V each. They are now connected to each other, with the positive plate of each joined to the negative plate of the other. The potential difference across 3 μF will be

(*a*) 3 V (*b*) zero (*c*) 6 V (*d*) 4 V

20. The plates of a parallel plate capacitor are 4 cm apart, the first plate is at 300 V and the second plate at – 100 V. The voltage at 3 cm from the second plate is

(*a*) 200 V (*b*) 400 V (*c*) 250 V (*d*) 500 V

21. The potential of a charged spherical conductor of radius r is 10 V. The potential at a point $\frac{r}{2}$ from its centre is

(*a*) 20 V (*b*) 0 (*c*) 10 V (*d*) 40 V

22. Proton has a mass of 1840 times that of an electron. If a proton is accelerated from rest by a potential difference of 1 volt, its kinetic energy is

(*a*) 1840 eV (*b*) 1 eV (*c*) 1 meV (*d*) 0

23. When charge is supplied to a conductor, its potential depends upon

(*a*) the amount of charge (*b*) geometry and size of conductor
(*c*) both (*a*) and (*b*) (*d*) only on (*a*)

24. A dipole is placed parallel to electric field. If W is the work done in rotating the dipole from 0° to 60°, then work done in rotating it from 0° to 180° is

(*a*) $2W$ (*b*) $3W$ (*c*) $4W$ (*d*) $\frac{W}{2}$

25. A charge Q is supplied to a metallic conductor. Which of the following statements is correct?

(*a*) Electric field inside it is same as on the surface.
(*b*) Electric potential inside is zero.
(*c*) Electric potential on the surface is zero.
(*d*) Electric potential inside it is constant.

26. Work done to bring a unit positive charge un-accelerated from infinity to a point inside electric field is called

(*a*) electric field (*b*) electric potential
(*c*) capacitance (*d*) electric flux

27. Electric potential due to a point charge $-q$ at distance x from it is given by

(*a*) $\frac{kq}{x^2}$ (*b*) $\frac{kq}{x}$
(*c*) $\frac{-kq}{x^2}$ (*d*) $\frac{-kq}{x}$

28. Electric field is always

(*a*) parallel to equipotential surface
(*b*) perpendicular to equipotential surface
(*c*) it can be perpendicular and parallel as well
(*d*) it does not depends on distribution of charge

29. The electric potential due to an electric dipole at an axial point, distant r from the dipole is related to r as

(a) r^1 (b) r^{-1} (c) r^2 (d) r^{-2}

30. A positive charge Q' is moved around another positive charge Q on circular path. If the radius of the circular path is r, the work done on the charge Q' in making one complete revolution is

(a) $\frac{Q}{4\pi\varepsilon r}$ (b) $\frac{QQ'}{4\pi\varepsilon r}$ (c) zero (d) $\frac{Q'}{4\pi\varepsilon r}$

31. The electric potential at a point in an electric field has the unit of

(a) Nm^2/C (b) Nm/C (c) NC/m (d) Cm/N

32. An electron is accelerated under a potential difference of 200 V. Energy gained by it in electron volt is

(a) 50 eV (b) 100 eV (c) 200 eV (d) 400 eV

33. There exists a potential difference of 5 V between two points in an electric field. Work done in moving a charge of 7 C from one point to the other is

(a) 5/7 J (b) 7/5 J (c) 35 J (d) 1/35 J

34. A charge q contain n electrons each of mass m. This charge is accelerated under the potential difference V. The speed acquired by the charge is

(a) $\sqrt{\frac{2eV}{m}}$ (b) $\sqrt{\frac{2qV}{m}}$ (c) $\sqrt{\frac{2e}{mV}}$ (d) $\sqrt{\frac{2q}{mnV}}$

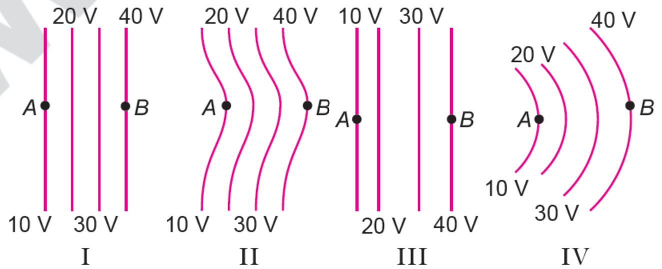
35. A test charge q_0 is brought from infinity along the perpendicular bisector of an electric dipole. The work done on q_0 by the electric field of the dipole is

(a) zero (b) negative
(c) positive (d) proportional to q_0

36. If 1000 droplets each of charge q and radius r are combined to form a big drop, then the potential of big drop, as compared to small droplet will be

(a) 1000 times (b) 100 times (c) 10 times (d) 10^4 times

37. The diagrams below show regions of equipotentials.



A positive charge is moved from A to B in each diagram.

(a) In all the four cases the work done is the same.
(b) Minimum work is required to move q in figure (I).
(c) Maximum work is required to move q in figure (II).
(d) Maximum work is required to move q in figure (III).

38. Capacitor is a device used to store

(a) charge (b) electrostatic energy
(c) electric field (d) none of these

39. Unit of capacitance is

(*a*) volt (*b*) coulomb

(*c*) ohm (*d*) farad

40. A parallel plate capacitor is charged by a battery. Once it is charged, the battery is removed. Now a dielectric material is inserted between the plates of the capacitor, which of the following does not change?

(*a*) Electric field between the plates (*b*) Potential difference across the plates

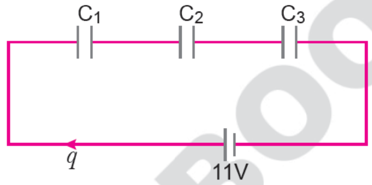
(*c*) Charge on the plates (*d*) Energy stored in the capacitor

41. A parallel plate capacitor C has a charge Q. The actual charges on the plates are

(*a*) Q, Q (*b*) $\frac{Q}{2}, \frac{Q}{2}$

(*c*) $Q, -Q$ (*d*) $\frac{Q}{2}, \frac{-Q}{2}$

42. Three capacitors of capacitances 1 μF, 2 μF & 3 μF are connected in series and a potential difference of 11V is applied across the combination then the potential difference across the plates of 1 μF capacitor is



(*a*) 2 V (*b*) 3 V (*c*) 4 V (*d*) 6 V

43. On reducing potential across a capacitor, its capacitance

(*a*) decreases (*b*) increases

(*c*) remains constant (*d*) first increases then decreases

44. A charge Q is supplied to a metallic conductor. Which of the following is correct?

(*a*) More in case of sphere (*b*) More in case of cube

(*c*) Same in both cases (*d*) Information incomplete

45. Energy stored in a in a charged capacitor is given by:

(*a*) $\frac{CV}{2}$ (*b*) $\frac{CV^2}{2}$ (*c*) $2\,CV^2$ (*d*) $\frac{VC^2}{2}$

46. If n number of equal capacitors each of capacitance C are connected in series then equivalent capacitance will be given as:

(*a*) $n \times C$ (*b*) $\frac{C}{n}$ (*c*) $n + C$ (*d*) n^2C

47. Capacitance of parallel plate capacitor when there is no medium between the plates is C_0. If capacitor is now completely filled with dielectric matter of constant K then capacitance is

(*a*) $\frac{C_0}{K}$ (*b*) KC_0 (*c*) K^2C_0 (*d*) $2KC_0$

48. A parallel plates capacitor is charged by connecting a battery across its plates. If the battery remains connected and a dielectric material is inserted in between the plates of the capacitor, then

(*a*) potential difference across the capacitor increases

(*b*) electric field remains the same

(*c*) capacitance increases

(*d*) all the above

49. The capacitance of spherical conductor of radius 10 m is

(*a*) 10 farad (*b*) 19×10^9 farad

(*c*) $\frac{1}{9\times10^9}$ farad (*d*) $\frac{1}{9\times10^8}$ farad

50. Four capacitors, each of capacitance 0.5 μF are connected in parallel. The resultant capacitance of the combination is

(*a*) 0.5 μF (*b*) 0.125 μF (*c*) 2 μF (*d*) 4 μF

51. Three capacitors, each of capacitance 1 μF are connected in series. The resultant capacitance of the combination is

(*a*) $\frac{1}{3}\mu$F (*b*) $\frac{2}{3}\mu$F (*c*) 3 μF (*d*) 0.5 μF

52. The relation between the capacitance of an isolated spherical conductor situated in air and its radius is:

(*a*) $C \propto r$ (*b*) $C \propto 1/r$ (*c*) $C \propto r^2$ (*d*) $C \propto r^{-2}$

53. Two points *P* and *Q* are maintained at the potential of 10 V and –4 V respectively. The work done in moving 100 electrons from *P* to *Q* is

(*a*) -10×10^{-17} J (*b*) 9.60×10^{-17} J

(*c*) -2.24×10^{-16} J (*d*) 2.24×10^{-16} J

54. A parallel-plate capacitor, with air between the plates has capacitance 3 μF. If the capacitor is immersed in liquid of dielectric constant 4.0, its capacitance will be

(*a*) 0.75 μF (*b*) 1.5 μF (*c*) 6 μF (*d*) 12 μF

55. The distance between the plates of a parallel plate capacitor of capacitance *C* is doubled. Its new capacitance will be

(*a*) $2C$ (*b*) $\frac{1}{2}C$ (*c*) C^2 (*d*) $4C$

56. Which of the following is the correct relation among the capacitance, potential & charge?

(*a*) $q = CV$ (*b*) $q = C^{-1}V$ (*c*) $q = C^{-1}V^{-1}$ (*d*) $q = CV^{-1}$

57. What is the area of the plates of a 3F parallel plate capacitor, if the separation between the plates is 5 mm?

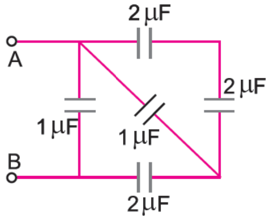
(*a*) 1.694×10^9 m^2 (*b*) 4.529×10^9 m^2

(*c*) 9.281×10^9 m^2 (*d*) 12.281×10^9 m^2

58. A parallel plate capacitor has plates with area *A* and separation *d*. A battery charges the plates to a potential difference V_0. The battery is then disconnected and a dielectric slab of dielectric constant *K* and thickness *d* is introduced. The ratio of energy stored in the capacitor before and after the slab is introduced is

(*a*) K (*b*) $\frac{1}{K}$ (*c*) K^2 (*d*) $\frac{1}{K^2}$

59. Five capacitors are connected as shown in the figure. The equivalent capacitance between A and B is



(*a*) 1 μF (*b*) 2 μF (*c*) 3 μF (*d*) 4 μF

60. A capacitor is charged by a battery. The battery is removed and another identical uncharged capacitor is connected in parallel. The total electrostatic energy of resulting system

(*a*) decreases by a factor of 2 (*b*) remains the same
(*c*) increases by a factor of 2 (*d*) increases by a factor of 4

61. 8 small droplets of water of same size and same charge form a large spherical drop. The potential of the large drop, in comparison to potential of a small drop, will be

(*a*) 2 times (*b*) 4 times (*c*) 8 times (*d*) same

62. A capacitor is charged through a p.d. of 200 volts and possesses charge of 0.1 coulomb. When discharged it would release an energy of

(*a*) 1 J (*b*) 2 J (*c*) 10 J (*d*) 20 J

63. A 500 μF capacitor is charged at a steady rate of 100 μC per second. A potential difference of 10 V will be developed between the capacitor plates after

(*a*) 5 s (*b*) 10 s (*c*) 20 s (*d*) 50 s

64. A parallel-plate capacitor has a plate area of 2 m^2 and a plate separation of 10 cm. It carries a charge of 8.85×10^{-10} C. The electric field is

(*a*) zero between the plates
(*b*) zero outside the plates
(*c*) different at different points between the plates
(*d*) 25 NC^{-1} between the plates

65. A capacitor of capacitance 2μF has been charged to 200 V. It is now discharged through a resistance, the heat produced in the wire is

(*a*) 400 J (*b*) 0.02 J (*c*) 0.04 J (*d*) 0.08 J

66. An air filled parallel plate capacitor has a capacitance 1 pF. The separation of the plates is doubled and wax inserted between them, which makes the capacitance 2 pF. This implies that dielectric constant of wax is

(*a*) 2.0 (*b*) 4/3 (*c*) 4.0 (*d*) 8.0

67. Three capacitors of capacitance 3 μF, 9 μF and 18 μF are connected first in series and then in parallel. The ratio of equivalent capacitance in two cases (C_s/C_p) will be

(*a*) 1 : 15 (*b*) 15 : 1 (*c*) 1 : 1 (*d*) 1 : 3

68. Two identical capacitors joined in parallel are charged to a common potential $V/2$. The battery is disconnected. Now, the capacitors are separated and joined in series. For the new combination:

(*a*) Energy and p.d. both will remain unchanged.
(*b*) Energy will remain same, p.d. will become V.
(*c*) Energy and potential both will become 2 times.
(*d*) Energy will become 2 times, p.d. will remain V.

69. A parallel plate capacitor with air between the plates has a capacitor of 9 pF. The separation between its plates is 'd'. The space between its plates is now filled with two dielectric. One of the dielectrics has dielectric constant $K_1 = 3$ and thickness $\frac{d}{3}$ while the other one has dielectric constant $K_2 = 6$ and thickness $\frac{2d}{3}$. Capacitance of the capacitor is now

(*a*) 40.5 pF (*b*) 20.25 pF
(*c*) 1.8 pF (*d*) 4.5 pF

70. **The capacitance of a capacitor becomes $\frac{8}{9}$ times its original value if a dielectric slab of thickness $t = \frac{1}{3}d$ is introduced in between the plates, where d is the separation between the plates. The dielectric constant of the slab is**

(*a*) $\frac{14}{11}$ (*b*) $\frac{11}{14}$ (*c*) $\frac{8}{11}$ (*d*) $\frac{11}{8}$

71. **Two capacitors of capacitances 3 μF and 6 μF are charged to a potential of 12 V each. They are now connected to each other, with the positive plate of each joined to the negative plate of the other. The potential difference across each will be**

(*a*) 3 V (*b*) zero (*c*) 6 V (*d*) 4 V

72. **The plates of a parallel plate capacitor are 4 cm apart, the first plate is at 300 V and the second plate at – 100 V. The voltage at 1 cm from the first plate is**

(*a*) 200 V (*b*) 400 V (*c*) 250 V (*d*) 500 V

73. **If the potential of a capacitor having capacitance 6 μF is increased from 10 V to 20 V, the increase in energy is**

(*a*) 9×10^{-4} J (*b*) 4.5×10^{-6} J

(*c*) 12×10^{-6} J (*d*) 2.25×10^{-6} J

74. **A battery is used to charge a parallel plate capacitor till the potential difference between the plates becomes equal to the emf of the battery. The ratio of the energy stored in the capacitor and the work done by the battery will be**

(*a*) 2 (*b*) $\frac{1}{4}$ (*c*) $\frac{1}{2}$ (*d*) 1

75. **Three concentric spherical shells have radii a, b and c ($a < b < c$) and have surface charge densities σ, – σ, σ respectively. If V_A,V_B and V_C denote the potentials of the three shells, then for $c = a + b$, we have**

(*a*) $V_C = V_B \neq V_A$ (*b*) $V_C = V_B \neq V_A$

(*c*) $V_C = V_B = V_A$ (*d*) $V_C = V_A \neq V_B$

76. **The electric potential at a point (x, y, z) is given by $V = -x^2y - xz^3 + 4$. The electric field $\vec{E}$ at that point is**

(*a*) $\vec{E} = 2xy\,\hat{i} + (x^2 + y^2)\,\hat{j} + (3xz - y^2)\,\hat{k}$ (*b*) $\vec{E} = z^3\,\hat{i} + xyz\,\hat{j} + z^2\,\hat{k}$

(*c*) $\vec{E} = (2xy - z^3)\,\hat{i} + xy^2\,\hat{j} + 3z^2x\,\hat{k}$ (*d*) $\vec{E} = (2xy + z^3)\,\hat{i} + x^2\,\hat{j} + 3xz^2\,\hat{k}$

77. **Three capacitors each of capacitance C and of breakdown voltage V are joined in series. The equivalent capacitance and breakdown voltage of the combination will be**

(*a*) $3C, \frac{V}{3}$ (*b*) $\frac{C}{3}, 3V$ (*c*) $3C, 3V$ (*d*) $\frac{C}{3}, \frac{V}{3}$

78. **A particle A has charge $+ q$ and particle B has charge $+ 4q$ with each of them having the same mass m. When allowed to fall from rest through same electrical potential difference, the ratio of their speeds $v_A : v_B$ will become**

(*a*) 2 : 1 (*b*) 1 : 2 (*c*) 1 : 4 (*d*) 4 : 1

79. **The electric potential V at any point x, y, z (all in metres) in space is given by $V = 4x^2$ volt. The electric field at the point (1 m, 0, 2 m) in volt/metre is**

(*a*) 8 along negative X-axis (*b*) 8 along positive X-axis

(*c*) 16 along negative X-axis (*d*) 16 along positive Z-axis

80. Two identical thin rings, each of radius R metre are co-axially placed at distance R metre apart. If Q_1 and Q_2 coulomb are respectively the charges uniformly spread on the two rings, the work done in moving a charge q from the centre of one ring to that of the other is

(a) zero

(b) $\dfrac{q(Q_1 - Q_2)(\sqrt{2}-1)}{\sqrt{2}.4\pi\varepsilon_0 R}$

(c) $\dfrac{q\sqrt{2}(Q_1 - Q_2)}{4\pi\varepsilon_0 R}$

(d) $\dfrac{q(Q_1 - Q_2)(\sqrt{2}+1)}{\sqrt{2}.4\pi\varepsilon_0 R}$

81. A particle of mass 2 g and charge 1 μC is held at rest on a frictionless horizontal surface at a distance of 1 m from the fixed charge of 1 milli coulomb (mC). If the particle is released it will be repelled. The speed of the particle when it is at a distance of 10 m from the fixed charge is

(a) 100 m/s (b) 90 m/s (c) 60 m/s (d) 45 m/s

82. A hollow charged metal sphere has radius r. If the potential difference between its surface and a point at distance $3r$ from the centre is V, then the electric field intensity at a distance $3r$ from the centre is

(a) $\dfrac{V}{6r}$ (b) $\dfrac{V}{4r}$ (c) $\dfrac{V}{3r}$ (d) $\dfrac{V}{2r}$

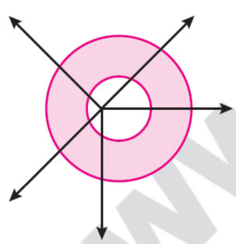
83. When a charge of 3 C is placed in a uniform electric field it experiences a force of 3000 N. The potential difference between two points separated by a distance of 1 cm within this field is

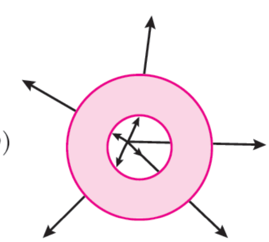
(a) 10 volt (b) 90 volt (c) 1000 volt (d) 3000 volt

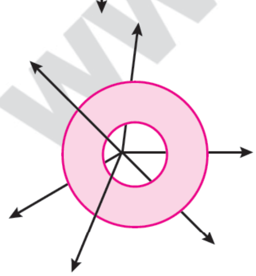
84. A uniform electric field having magnitude and direction along positive X-axis exists. If the electric potential V is zero at $x = 0$, then its value at $x = +x$ will be

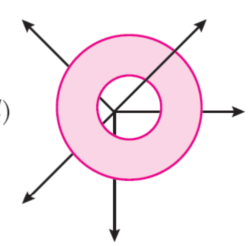
(a) $V_x = xE_0$ (b) $V_x = -xE_0$ (c) $V_x = -x^2E_0$ (d) $V_x = -x^2E_0$

85. A metallic shell has a point charge q kept inside a cavity. Which one of the following diagrams correctly represents the electric lines of force?

(a) 

(b) 

(c) 

(d) 

86. Two thin wire rings, each having a radius R are placed at a distance 'd' apart with their axes coinciding. The charge on the two rings are $+q$ and $-q$. The potential difference between the centres of the two rings is

(a) $\dfrac{q}{2\pi\varepsilon_0}\left[\dfrac{1}{R} - \dfrac{1}{\sqrt{R^2+d^2}}\right]$

(b) $\dfrac{qR}{4\pi\varepsilon_0 d^2}$

(c) $\dfrac{q}{4\pi\varepsilon_0}\left[\dfrac{1}{R} - \dfrac{1}{\sqrt{R^2+d^2}}\right]$

(d) zero

87. An electric charge of 10^{-3} μC is placed at the origin (0, 0) of *XY* coordinate system. Two points *A* and *B* are situated at ($\sqrt{2}$, $\sqrt{2}$) and (2, 0) respectively. The potential difference between the points *A* and *B* will be

(*a*) zero (*b*) 2 V (*c*) 4.5 V (*d*) 9 V

88. A parallel plate air capacitor is connected to a battery. The quantities charge, voltage, electric field and energy associated with the capacitor are given by Q_0, V_0, E_0 and U_0 respectively. A dielectric slab is now introduced to fill the space between the plates with a battery still in connection. The corresponding quantities now given by *Q*. *V*, *E* and *U* are related to previous ones as

(*a*) $Q = Q_0$ (*b*) $V > V_0$ (*c*) $E > E_0$ (*d*) $U > U_0$

89. A number of condensers, each of capacitance 1μF and each one of which gets punctured if a p.d. just exceeding 500 V is applied, are provided. Then an arrangement suitable for giving a capacitor of capacitance 1μF across which 3000 volts may be applied requires at least

(*a*) 6 component capacitors (*b*) 12 component capacitors

(*c*) 72 component capacitors (*d*) 36 component capacitors

90. A parallel-plate capacitor of plate area *A* and plate separation *d* is charged to a potential difference *V* and then the battery is disconnected. A slab of dielectric constant *K* is then inserted between the plates of the capacitor so as to fill the space between the plates. If *q*, *E* and *W* denote respectively the magnitude of charge on each plate, the electric field between the plates (after the slab is inserted) and work done by the system, in question, in the process of inserting the slab, then which of the following is false?

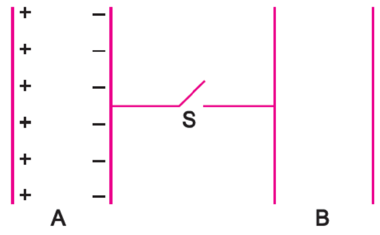
(*a*) $q = \frac{\varepsilon_0 AV}{d}$ (*b*) $q = \frac{\varepsilon_0 KAV}{d}$

(*c*) $E = \frac{V}{Kd}$ (*d*) $W = \frac{\varepsilon_0 AV^2}{2d}\left(1 - \frac{1}{K}\right)$

91. Two identical metallic plates are given positive charges Q_1 and Q_2 ($Q_2 < Q_1$). If these plates are brought together to form a parallel plate capacitor, then potential difference between them will be

(*a*) $\frac{Q_1 + Q_2}{2C}$ (*b*) $\frac{Q_1 + Q_2}{C}$ (*c*) $\frac{Q_1 - Q_2}{C}$ (*d*) $\frac{Q_1 - Q_2}{2C}$

92. Consider a situation shown in figure. The capacitor *A* has charge *q* on it whereas *B* is uncharged. The charge appearing on the capacitor *B*, a long time after the switch *S* is closed is

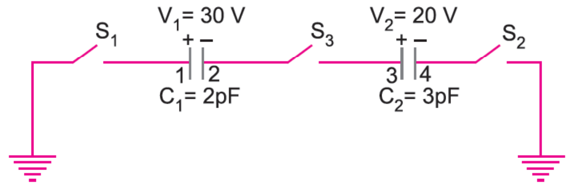


(*a*) zero (*b*) $\frac{q}{2}$ (*c*) *q* (*d*) 2*q*

93. Each of two identical capacitors has capacitance *C*, one of them is charged to a potential V_1 and the other to a potential V_2. The negative terminals of capacitors are connected together. When their positive terminals are also connected together, then energy loss of whole system is

(*a*) $\frac{1}{4}C(V_1^2 - V_2^2)$ (*b*) $\frac{1}{4}C(V_1^2 + V_2^2)$ (*c*) $\frac{1}{4}C(V_1 - V_2)^2$ (*d*) $\frac{1}{4}C(V_1 + V_2)^2$

94. Which one of the following statements is true for the given circuit?



(*a*) With S_1 closed, $V_1 = 15$ V, $V_2 = 20$ V.
(*b*) With S_3 closed, $V_1 = V_2 = 25$ V.
(*c*) With S_1 and S_2 closed, $V_1 = V_2 = 0$.
(*d*) With S_1 and S_3 closed, $V_1 = 30$ V, $V_2 = 20$ V.

95. A parallel plate capacitor is made by stacking *n* equally spaced plates connected alternatively. If the capacitance between any two adjacent plates is '*C*', then the resultant capacitance is

(*a*) $(n + 1)\,C$ (*b*) $(n - 1)\,C$ (*c*) nC (*d*) C

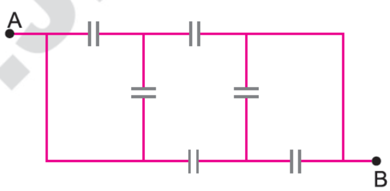
96. A fully charged capacitor has a capacitance *C*. It is discharged through a small coil of resistance wire embedded in a thermally insulated block of specific heat capacity '*s*' and mass '*m*'. If the temperature of the block is raised by ΔT the potential difference *V* across the capacitance is

(*a*) $\dfrac{mC\,\Delta T}{s}$ (*b*) $\sqrt{\dfrac{2mC\,\Delta T}{s}}$ (*c*) $\sqrt{\dfrac{2ms\,\Delta T}{C}}$ (*d*) $\dfrac{ms\,\Delta T}{C}$

97. Two spherical conductors *A* and *B* of radii 1 mm and 2 mm are separated by a distance of 5 cm and are uniformly charged. If the spheres are connected by a conducting wire, then in equilibrium condition, the ratio of the magnitudes of the electric fields at the surfaces of spheres *A* and *B* is:

(*a*) 4: 1 (*b*) 1: 2 (*c*) 2: 1 (*d*) 1: 4

98. A network of six identical capacitors, each of value *C* is made as shown in fig. The equivalent capacitance between points *A* and *B* is



(*a*) $\dfrac{C}{4}$ (*b*) $\dfrac{3C}{4}$ (*c*) $\dfrac{3}{2}C$ (*d*) $\dfrac{4}{3}C$

99. A parallel plate capacitor with a dielectric of dielectric constant *K* between the plates has a capacitance *C* and is charged to a potential *V* volts. The dielectric slab is slowly removed from between the plates and then reinserted. The net work done by the system in this process is

(*a*) $\dfrac{CV^2\,(K-1)}{K}$ (*b*) $(K - 1)\,CV^2$ (*c*) zero (*d*) $\dfrac{1}{2}(K - 1)\,CV^2$

100. If 343 droplets each of charge *q* and radius *r* are combined to form a big drop, then the potential of big drop, as compared to small droplet will be

(*a*) 343 times (*b*) 49 times (*c*) 7 times (*d*) none of the above

101. An electric dipole consisting of charges $+\,q$ and $-\,q$ separated by a distance *L* is in stable equilibrium in a uniform electric field $\vec{E}$. The electrostatic potential energy of the dipole is [*CBSE 2020 (55/1/1)*]

(*a*) qLE (*b*) zero (*c*) $-\,qLE$ (*d*) $-\,2\,qEL$

102. If a positive charge in displaced against the electric field in which it was situated, then [*CBSE 2020 (55/3/1)*]

(*a*) work will be done by the electric field on the charge.
(*b*) the intensity of the electric field decreases.
(*c*) energy of the system will decrease.
(*d*) energy will be provided by external source displacing the charge.

103. The capacitors of capacitances C_1 and C_2 are connected in parallel. If a charge Q is given to the combination, the ratio of the charge on the capacitor C_1 to the charge on C_2 will be [*CBSE 2020 (55/3/1)*]

(*a*) $\frac{C_1}{C_2}$ (*b*) $\sqrt{\frac{C_1}{C_2}}$ (*c*) $\sqrt{\frac{C_2}{C_1}}$ (*d*) $\frac{C_2}{C_1}$

104. A charge Q is kept at the centre of a circle of radius r. A test charge q_0, is carried from a point X to the point Y on this circle such that are XY subtends an angle of 60° at the centre of the circle. The amount s of work done in this process will be [*CBSE 2020 (55/3/2)*]

(*a*) $\frac{1}{4\pi\varepsilon_0}\frac{Qq_0}{2r}$ (*b*) $\frac{1}{4\pi\varepsilon_0}\frac{\sqrt{3}Qq_0}{2r}$

(*c*) zero (*d*) $\frac{1}{4\pi\varepsilon_0}\frac{\sqrt{3}Qq_0}{r}$

105. A parallel plate capacitor is charged to V volt by a battery. The battery is disconnected and the separation between the plates is halved. The new potential difference across the capacitor will be [*CBSE 2020 (55/3/2)*]

(*a*) $\frac{V}{2}$ (*b*) V

(*c*) $2V$ (*d*) $\frac{V}{4}$

106. A charge Q is uniformly distributed over the surface of a spherical shell of radius R. The work done in bringing a test charge Q_0 from its centre to its surface is [*CBSE 2020 (55/3/3)*]

(*a*) $\frac{1}{4\pi\varepsilon_0}\frac{QQ_0}{R}$ (*b*) $\frac{1}{4\pi\varepsilon_0}\frac{QQ_0}{2R}$

(*c*) $\frac{QQ_0}{\varepsilon_0 R}$ (*d*) zero

Answers

1. (*a*)	**2.** (*a*)	**3.** (*a*)	**4.** (*b*)	**5.** (*c*)	**6.** (*a*)	**7.** (*a*)	**8.** (*c*)
9. (*c*)	**10.** (*c*)	**11.** (*a*)	**12.** (*b*)	**13.** (*c*)	**14.** (*d*)	**15.** (*c*)	**16.** (*b*)
17. (*b*)	**18.** (*a*)	**19.** (*d*)	**20.** (*a*)	**21.** (*c*)	**22.** (*b*)	**23.** (*c*)	**24.** (*c*)
25. (*d*)	**26.** (*b*)	**27.** (*d*)	**28.** (*b*)	**29.** (*d*)	**30.** (*c*)	**31.** (*b*)	**32.** (*c*)
33. (*c*)	**34.** (*b*)	**35.** (*a*)	**36.** (*b*)	**37.** (*a*)	**38.** (*b*)	**39.** (*d*)	**40.** (*c*)
41. (*c*)	**42.** (*d*)	**43.** (*c*)	**44.** (*c*)	**45.** (*b*)	**46.** (*b*)	**47.** (*b*)	**48.** (*c*)
49. (*d*)	**50.** (*c*)	**51.** (*a*)	**52.** (*a*)	**53.** (*d*)	**54.** (*d*)	**55.** (*b*)	**56.** (*a*)
57. (*a*)	**58.** (*b*)	**59.** (*b*)	**60.** (*a*)	**61.** (*b*)	**62.** (*c*)	**63.** (*d*)	**64.** (*b*)
65. (*c*)	**66.** (*c*)	**67.** (*a*)	**68.** (*b*)	**69.** (*a*)	**70.** (*c*)	**71.** (*b*)	**72.** (*a*)
73. (*a*)	**74.** (*c*)	**75.** (*d*)	**76.** (*d*)	**77.** (*b*)	**78.** (*b*)	**79.** (*a*)	**80.** (*b*)
81. (*b*)	**82.** (*a*)	**83.** (*a*)	**84.** (*b*)	**85.** (*c*)	**86.** (*a*)	**87.** (*a*)	**88.** (*d*)
89. (*d*)	**90.** (*b*)	**91.** (*c*)	**92.** (*c*)	**93.** (*c*)	**94.** (*d*)	**95.** (*b*)	**96.** (*c*)
97. (*c*)	**98.** (*d*)	**99.** (*c*)	**100.** (*b*)	**101.** (*c*)	**102.** (*d*)	**103.** (*a*)	**104.** (*c*)
105. (*a*)	**106.** (*d*)						

CASE-BASED QUESTIONS

Attempt any 4 sub-parts from each question. Each question carries 1 mark.

1. FARADAY CAGE:

A Faraday cage or Faraday shield is an enclosure made of a conducting material. The fields within a conductor cancel out with any external fields, so the electric field within the enclosure is zero. These Faraday cages act as big hollow conductors you can put things in to shield them from electrical fields. Any electrical shocks the cage receives, pass harmlessly around the outside of the cage. [*CBSE Sample Paper 2021*]

(*i*) Which of the following material can be used to make a Faraday cage?

(*a*) Plastic (*b*) Glass
(*c*) Copper (*d*) Wood

(*ii*) Example of a real-world Faraday cage is

(*a*) car (*b*) plastic box
(*c*) lightning rod (*d*) metal rod

(*iii*) What is the electrical force inside a Faraday cage when it is struck by lightning?

(*a*) The same as the lightning (*b*) Half that of the lightning
(*c*) Zero (*d*) A quarter of the lightning

(*iv*) An isolated point charge $+q$ is placed inside the Faraday cage. Its surface must have charge equal to

(*a*) zero (*b*) $+q$
(*c*) $-q$ (*d*) $+2q$

(*v*) A point charge of 2 μC is placed at centre of Faraday cage in the shape of cube with surface of 9 cm edge. The number of electric field lines passing through the cube normally will be

(*a*) 1.9×10^5 Nm^2/C entering the surface
(*b*) 1.9×10^5 Nm^2/C leaving the surface
(*c*) 2.0×10^5 Nm^2/C leaving the surface
(*d*) 2.0×10^5 Nm^2/C entering the surface

Answers

1. (*i*) (*c*) Copper (Electric field inside a conductor is zero.)

(*ii*) (*a*) car (Body of the car is made up of conductor.)\

(*iii*) (*c*) Zero (As electric field inside it is zero.)

(*iv*) (*c*) $-q$ (As from Gauss's law q_{in} must be zero for electric field inside it is zero.)

(*v*) (*c*) $q = 2\ \mu C = 2 \times 10^{-6}$ C

$$\varepsilon_0 = 8.85 \times 10^{-12} \frac{Nm^2}{C^2}$$

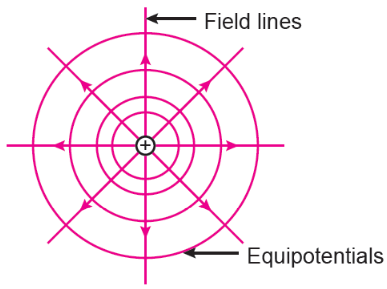
Now, total number of electric field lines $= \dfrac{q_{in}}{\varepsilon_0} = \dfrac{2 \times 10^{-6}}{8.85 \times 10^{-12}}$

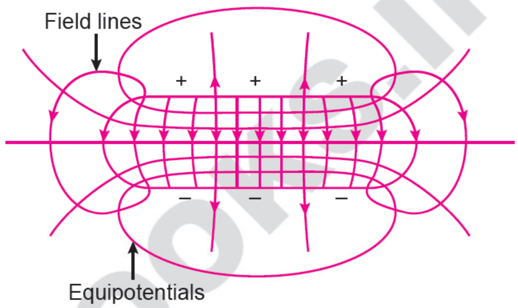
$$= 2.2 \times 10^5 \frac{Nm^2}{C} \text{ leaving the surface}$$

2. EQUIPOTENTIAL SURFACES:

All points in a field that have the same potential can be imagined as lying on a surface called an equipotential surface. When a charge moves on such a surface no energy transfer occurs and no work is done. The force due to the field must therefore act at right angles to the equipotential surfaces and field lines always intersect at right angles.

Equipotential surfaces for a point charge are concentric spheres; there is a spherical symmetry. If the equipotential are drawn so that the change of potential from one to the next is constant, then the spacing will be closer where the field is stronger. The closer the equipotentials, the shorter the distance that need be travelled to transfer a particular amount of energy. The surface of a conductor in electrostatics (*i.e.*, one in which no current is flowing) must be an equipotential surface since any difference of potential would cause a redistribution of charge in the conductor until no field exist in it.





(*i*) Equipotential surface at a great distance from a collection of charges whose total sum is not zero are approximately

(*a*) spheres (*b*) planes

(*c*) paraboloids (*d*) ellipsoids

(*ii*) Two equipotential surfaces have a potential of – 20 V and 80 V respectively, the difference in potential between these surfaces is

(*a*) 100 V (*b*) 90 V

(*c*) 80 V (*d*) 0 V

(*iii*) Equipotential surfaces

(*a*) are closer in regions of higher electric fields compared to the regions of lower electric fields

(*b*) will be more crowded near sharp edges of a conductor

(*c*) will be more crowded near regions of large charge densities

(*d*) all of the above

(*iv*) The work done to move a charge along an equipotential from *A* to *B*

(*a*) cannot be defined as $-\int_A^B E.dl$ (*b*) must be defined as $-\int_A^B E.dl$

(*c*) is zero (*d*) can have a non-zero value

(*v*) The shape of equipotential surface for an infinite line charge is

(*a*) parallel plane surface

(*b*) parallel plane surface perpendicular to lines of force

(*c*) coaxial cylindrical surface

(*d*) none of these

Answers

2. (*i*) (*a*) A collection of charge located at a very large distance may be considered as a point charge. Also, the equipotential surfaces for a point charge are spherical. Therefore, the equipotential surfaces for a collection of charge form spheres.

(*ii*) (*a*) Equipotential surface has same voltage (potential) at every point on the surface.

i.e., $V_1 = -20$ V, $V_2 = 80$ V

$\Delta V = V_2 - V_1 = 80 - (-20) = 100$ V

So, $\Delta V = 100$ V

(*iii*) (*d*)

(*I*) Relation between electric field E and potential gradient is $E = -\dfrac{dV}{dr}$. So, electric field intensity is inversely proportional to the separation between equipotential surfaces.

(*II*) The electric field is larger near the sharp edges, due to larger charge density as A is very small.

$\because\ \sigma = \dfrac{q}{A}$, so, equipotential surfaces are closer or crowded.

(*III*) As the electric field $E = \dfrac{Kq}{r^2}$ and potential or field decreases as size of body increases or (vice-versa). So, equipotential surfaces are more crowded if the charge density $\left(\sigma = \dfrac{q}{A}\right)$ increases.

(*iv*) (*c*); As the potential on equipotential surface does not change so $(V_2 - V_1) = 0$

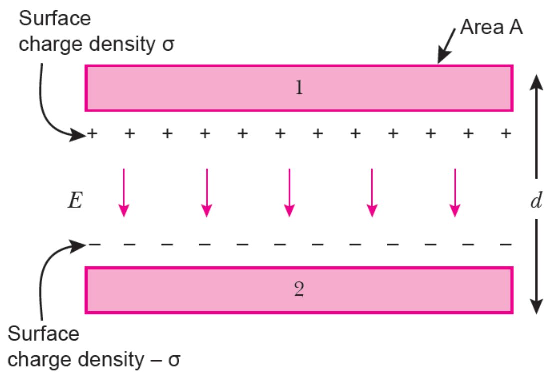
and $W = (V_2 - V_1)\, q = 0$

So, work done in moving a charge on equipotential surface is zero.

(*v*) (*c*); The shape of equipotential surface for infinite line charge is coaxial cylindrical surface.

3. THE PARALLEL-PLATE CONDENSATOR:

A condensator is a device that stores electrical energy in an electric field. It is a passive electronic component with two terminals. Condenser or condensator are commercial names of capacitor. The effect of a capacitor is known as capacitance.



Today capacitors (condensator) are widely used in electronic circuits for blocking *dc* current while allowing *ac* current to pass. In electric power transmission system, they stablize voltage and power flow. The property of energy storage in capacitor was exploited as dynamic memory in early digital computers, and still in modern DRAM.

The simplest model of capacitor consist of two thin parallel conductive plates each with an area filled with a dielectric with permittivity ε. It is assumed that the gap d is much smaller than the dimensions of the plates. Since, the separations between the plates is uniform over the plate area, the electric field between the plates E is constant and directed perpendicularly to the plate surface, except for an area near the edges of the plate where field decreases because the electric field lines bulge out of the sides of capacitor.

(i) If a parallel plate capacitor has n number of interleaved plates, area of plates is A and separation between them is d, then the total capacitance would be

(a) $\frac{\varepsilon_0 A}{d}$ (b) $\frac{\varepsilon_0 n A}{d}$

(c) $\frac{\varepsilon_0 (n-1)A}{d}$ (d) $\frac{\varepsilon_0 n^2 A}{d}$

(ii) A capacitor's dielectric material has dielectric strength U_d which sets the capacitor's breakdown voltage at $V = U_d d$. The maximum energy stored in the capacitor is

(a) $\frac{1}{2}\varepsilon A d U_d$ (b) $\varepsilon A d U_d$

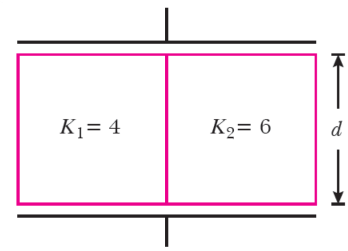
(c) $\frac{1}{2}\varepsilon A d U_d^2$ (d) $\varepsilon A d U_d^2$

(iii) A capacitor is constructed from two conductive metal plates having 30 cm × 50 cm dimension which are spaced 6 mm apart from each other and use dry air as its only dielectric material, then the capacitance of the capacitor is

(a) 0.22 μF (b) 0.221 nF

(c) 2.21 μF (d) 2.21 nF

(iv) A capacitor of capacitance 1 μF is filled with two dielectric of dielectric constant 4 and 6. The new capacitance would be



(a) 10 μF

(b) 7 μF

(c) 5 μF

(d) 4 μF

(v) A parallel plate capacitor is charged. If the plates are pulled apart

(a) the charge and potential difference remain the same

(b) the total charge increases

(c) the potential difference increases

(d) the capacitance increases

Answers

3. (i) (c); For n number of plates in an interleaved capacitor, the total capacitance would be

$$C = \frac{\varepsilon_0 A}{d}(n-1) = (n-1)C_0$$

where $C_o = \varepsilon_0 A/d$ is the capacitance for a single plate and n is the number of interleaved plates.

(ii) (c); A parallel plate capacitor can only store a finite amount of energy before dielectric breakdown occurs. The maximum energy that the capacitor can store is therefore,

$$E = \frac{1}{2}CV^2$$

$$E = \frac{1}{2}\frac{\varepsilon A}{d}(U_d d)^2 = \frac{1}{2}\varepsilon A d U_d^2 \qquad \left[\because C = \frac{\varepsilon A}{d}\right]$$

(iii) (b); The capacitance of parallel plate capacitor is given as

$$C = \frac{\varepsilon_0 A}{d} = \frac{8.85\times10^{-12}\times30\times50\times10^{-4}}{6\times10^{-3}} = 0.221\times10^{-9}\ \text{F}$$

$\therefore$ C = 0.221 nF

(iv) (c); The arrangement is equivalent to a parallel combination of two capacitors, each with plate area $A/2$ and separation d,

$$C = C_1 + C_2 = \frac{\varepsilon_0 A}{2d}(K_1 + K_2)$$

$$= \frac{1}{2}(K_1 + K_2) \qquad [\because C_0 = \frac{\varepsilon_0 A}{d} = 1\mu F \text{ (given)}]$$

$$\therefore \quad C = \frac{1}{2}(4 + 6) = 5\,\mu F$$

(v) (c) $\because V = Ed$,

As E remains the same, so V increases as distance increases.

ASSERTION-REASON QUESTIONS

In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct answer out of the following choices.

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

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

(c) A is true but R is false.

(d) A is false and R is also false.

1. **Assertion (A) :** A capacitor can be given only a limited amount of charge.

   Reason (R) : After a limited value of charge, the dielectric strength of dielectric between the capacitor plates breaks down.

2. **Assertion (A) :** An applied electric field polarises a polar dielectric.

   Reason (R) : The molecules of a polar dielectric possess a permanent dipole moment, but in the absence of electric field, these dipoles are randomly oriented and when electric field is applied these dipoles align along the direction of electric field.

3. **Assertion (A) :** The capacitance of a parallel plate capacitor increases with increase of distance between the plates.

   Reason (R) : Capacitance of a parallel plate capacitor *i.e.*, $C \propto d$

4. **Assertion (A) :** The capacitance of a parallel plate capacitor increases when a dielectric constant of medium between the plates.

   Reason (R) : Capacitance of a parallel plate capacitor is directly proportional to dielectric constant of medium between the plates.

5. **Assertion (A) :** When a charged capacitor is filled completely with a metallic slab, its capacitance is increased by a large amount.

   Reason (R) : The dielectric constant for metal is infinite.

6. **Assertion (A) :** When charged capacitors are connected in parallel, the algebraic sum of charges remains constant but there is a loss of energy.

   Reason (R) : During sharing a charges, the energy conservation law does not hold.

7. **Assertion (A) :** Change never flows from a condenser of higher capacity to the condenser of lower capacity. *[AIIMS 2018]*

   Reason (R) : Flow of charge between two bodies connected by a thin wire is determined by the charges on them.

8. **Assertion (A) :** The force between the plates of a parallel plane capacitor is proportional to charge on it. *[AIIMS 2018]*

   Reason (R) : Electric force is equal to charge per unit area.

9. **Assertion (A) :** In the absence of an externally applied electric field, the displacement per unit volume of a polar dielectric material is always zero. *[AIIMS 2018]*

Reason (R) : In polar dielectrics, each molecule has a permanent dipole moment but these are randomly oriented in the absence of an externally applied electric field.

10. **Assertion (A) :** Lines of force are perpendicular to conductor surface. *[AIIMS 2016]*

Reason (R) : Generally electric field is perpendicular to equipotential surface.

Answers

1. (*a*) **2.** (*a*) **3.** (*d*) **4.** (*a*) **5.** (*a*) **6.** (*c*) **7.** (*d*) **8.** (*c*)
9. (*a*) **10.** (*a*)

HINTS/SOLUTIONS OF SELECTED MCQs

1. (*a*) $C = \dfrac{Q}{V}$

2. (*a*) $W = q(\Delta V) \Rightarrow \Delta V = \dfrac{qV}{q} = \dfrac{2}{20} = 0.1\text{ V}$

3. (*a*) Due to repulsion between two electrons. The potential energy of the system increases.

4. (*b*) Because earth is a good conductor.

5. (*c*) Charge are reside on the surface of conductor. So, $E = 0$ inside the conductor then, $\boldsymbol{W} = q(\Delta \boldsymbol{V}) = 0 \Rightarrow \Delta V = 0$, so, $V =$ Constant.

6. (*a*) Electric field lines are always perpendicular to the equipotential surface.

7. (*a*) Electric field lines are always perpendicular to the equipotential surface.

8. (*c*) The positively charged particle experience electrostatic force along the direction of electric field, *i.e.*, from high electrostatic potential to low electrostatic potential. Thus, the work done by the electric field on the positive charge, hence potential energy of positive charge decreases.

9. (*c*) The work done by an electrostatic force is given by $W = q(\Delta V)$. Here initial and final potentials are same in all three cases and same charge is moved, so work done is same in all three cases.

10. (*c*) $E = -\dfrac{dV}{dr} \Rightarrow E = 0$ then, $\dfrac{dV}{dr} = 0 \Rightarrow V =$ constant

Thus, $E = 0$ inside the charged conducting sphere causes, the same electrostatic potential 100 V at any point inside the sphere.

11. (*a*) The equipotential due to point charge are spherical in shape as electric potential due to point charge q is given by, $V = \dfrac{Kq}{r}$

12. (*b*) $C_{eq} = \dfrac{100 \times 100}{100 + 100} = 50\,\mu\text{F}$

$V_{\text{voltmeter}} = V_{AB} = \dfrac{Q}{C} = 100\text{ V}$

In parallels, $V =$ same.

Then, $Q = CV = 50 \times 10^{-6} \times 100 = 5 \times 10^{-3}$ C.

13. (*c*) In series combination,

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} \Rightarrow C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

$$C_{eq} = \frac{\frac{K_1\varepsilon_0 A}{d} \times \frac{K_2\varepsilon_0 A}{d_2}}{\frac{K_1\varepsilon_0 A}{d_1} + \frac{K_2\varepsilon_0 A}{d_2}} = \frac{K_1 K_2 \varepsilon_0 A}{K_1 d_2 + K_2 d_1}$$

By comparing with $C_{eq} = \frac{K\varepsilon_0 A}{d_1 + d_2}$ then $K = \frac{K_1 K_2 (d_1 + d_2)}{K_1 d_2 + K_2 d_1}$

14. (*d*) $E = \frac{-dv}{dr}$, since the electric field (E) is inversely proportional to the separation between equipotential surface. So, equipotential surface are closer in regions of large E.

15. (*c*) $V_{common} = \frac{C_1 V_1 + C_2 V_2}{C_1 C_2} \Rightarrow 40 = \frac{2 \times 200 + 0}{2 + C_2}$

$\Rightarrow C_2 = \frac{320}{40} = 8\,\mu F$

16. (*b*) $C = \frac{\varepsilon_0 A}{d}$, $C' = \frac{\varepsilon_0 A}{d - t(1 - \frac{1}{K})} = \frac{\varepsilon_0 A}{d - \frac{d}{2}\left(1 - \frac{1}{\infty}\right)} = \frac{2\varepsilon_0 A}{d}$

$\Rightarrow C' = 2C \Rightarrow \frac{C'}{C} = \frac{2}{1} = 2:1$

17. (*b*) In series potential difference are additive, $V' = nV$.

$V_i = \frac{1}{2}(nC_0)V^2$, where C_0 = Capacitance of each capacitor

$V_f = \frac{1}{2}\left(\frac{C_0}{n}\right)(nV)^2 = V_i$

18. (*a*) $C' = \frac{\varepsilon_0 A}{d - t\left(1 - \frac{1}{K}\right)}$, $C = \frac{\varepsilon_0 A}{d}$

$\Rightarrow \frac{C'}{C} = \frac{d}{d - t\left(1 - \frac{1}{K}\right)} = \frac{d}{d - \frac{2}{3}d\left[1 - \frac{1}{K}\right]} = \frac{3K}{K + 2}$

$\Rightarrow \frac{7}{6} = \frac{3K}{K + 2} \Rightarrow K = \frac{14}{11}$

19. (*d*) $V = \frac{C_2 V_2 - C_1 V_1}{C_1 + C_2} = \frac{6 \times 12 - 3 \times 12}{6 + 3} = \frac{36}{9} = 4$ V

then, $V_{3\mu F} = \frac{Q}{C} = \frac{4 \times 3 \times 10^{-6}}{3 \times 10^{-6}} = 4$ V

20. (*a*) $E = \frac{\Delta V}{d} = \frac{300 - (-100)}{4} = 100$ V/cm

$\therefore$ Voltage at 3 cm from second plate = 300 – (1 × 100) = 200 V.

21. (*c*) The given point lies inside the conductor and electric field intensity inside the conductor is zero. So, no work is done in bringing the charge from the surface to the given point. Therefore, the potential is same *i.e.*, 10 V.

22. (*b*) K.E $= W = q \cdot V$

$= 1\ e \times V = 1$ eV

23. (*c*) Amount of change, geometry and size of conductor

24. (*c*) $W = PE\ (\cos\theta_1 - \cos\theta_2)$

$= PE\ (\cos 0° - \cos 60°)$

$= PE\left(1-\frac{1}{2}\right) = \frac{1}{2}PE$

$W' = PE\ (\cos 0° - \cos 180°)$

$= PE\ \{1-(-1)\} = 2PE$

$$\frac{W}{W'} = \frac{\frac{1}{2}PE}{2PE} = \frac{1}{4}$$

$W' = 4\ W$

28. (*b*) As work done to move a charge on equipotential surface is zero.

29. (*d*) $V_{axial} = \frac{kp}{r^2}$

30. (*c*) As the charge returned to the initial position.

32. (*c*) $E = W = qV$

$= e \times 200\ \text{V} = 200$ eV

33. (*c*) $W = qV = 7 \times 5 = 35$ J

34. (*b*) $\frac{1}{2}mv^2 = W = qV$

36. (*b*) Let radius of bigger drop $= R$, radius of smaller droplet $= r$

$$\frac{4}{3}\pi R^3 = 1000 \times \frac{4}{3}\pi r^3$$

$\Rightarrow R = 10r.$

$\therefore$ Potential of big drop $= \frac{k(1000\,q)}{10r} = \frac{100\,kq}{r}$

Potential of small drop $= \frac{kq}{r}$

$$\therefore \quad \frac{V_{\text{big drop}}}{V_{\text{small drop}}} = 100$$

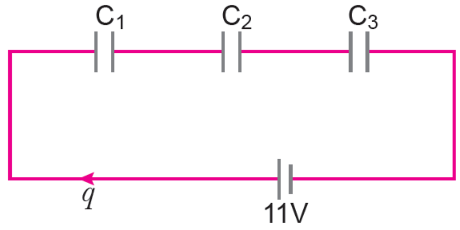
37. (*a*) Work done is given as $W = q\Delta V$

$\because$ In all the four cases the potential difference from A to B is same.

$\therefore$ In all the four cases the work done is same.

39. (*d*) $\frac{C}{V}$ called farad (F)

42. (*d*)



$$\frac{1}{C_{eq}} = \frac{1}{1} + \frac{1}{2} + \frac{1}{3}$$

$$= \frac{11}{6} \Rightarrow C_{eq} = \frac{6}{11}\,\mu\text{F}$$

$$q = C_{eq}\text{V} = \frac{6}{11} \times 11 = 6\,\mu\text{C}$$

Also, $q = C_1V_1 \Rightarrow 6 = 1 \times V_1$

$V_1 = 6$ V

43. (*c*) As $Q = CV$

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

It is a ratio so doesn't depends on either Q or V and thus remains constant.

44. (*c*) In all conductors charge is same.

46. (*b*) $\frac{1}{C_{eq}} = \frac{1}{C} + \frac{1}{C} + ...\ n$ times

$$= \frac{1 + 1 + ...n \text{ times}}{C}$$

$$\frac{1}{C_{eq}} = \frac{n}{C}$$

$$C_{eq} = \frac{C}{n}$$

47. (*b*) As we know by inserting dielectric material capacitance increases K times.

$C = KC_0$

49. (*d*) $C_{\text{Sphere}} = 4\,\pi\varepsilon_0 r = \frac{1}{9 \times 10^9} \times 10 = \frac{1}{9 \times 10^8}$ farad

50. (*c*) $C_{eq} = nC = 4 \times 0.5 = 2\,\mu\text{F}$

51. (*a*) $C_{eq} = \frac{C}{n} = \frac{1}{3}\mu\text{F}$

52. (*a*) $C = 4\pi\varepsilon_0 r$

53. (*d*) $W = Q(V_Q - V_P)$

$= -100e(-4 - 10)$

$= -100 \times 1.6 \times 10^{-19} \times (-14)$

$= 2.24 \times 10^{-16}$ J

54. (*d*) As $C = KC_0 = 4 \times 3 = 12\ \mu\text{F}$

55. (*b*) As $C = \frac{A\varepsilon_0}{d}$

$$C \propto \frac{1}{d}$$

Now if distance be double capacitance will be half.

57. (*a*) As $C = \frac{A\varepsilon_0}{d}$

$$A = \frac{C \times d}{\varepsilon_0} = \frac{3 \times 5 \times 10^{-3}}{8.85 \times 10^{-12}} = 1.694 \times 10^9\,\text{m}^2$$

58. (*b*) We know that

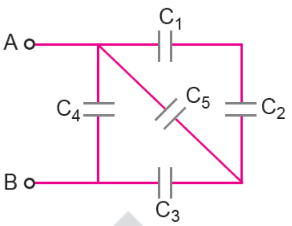
$U_0 = \frac{1}{2}C_0V_0^2$ (Initial energy)

Also capacitance after introducing dielectric $= KC_0$ and potential $\frac{1}{K}$ times

So $U_f = \frac{1}{2}CV^2$

$$= \frac{1}{2}(KC_0)\left(\frac{1}{K}V_0\right)^2 = \frac{1}{K}.U_0$$

59. (*b*) C_1 and C_2 are connected in series, their equivalent capacitance is



$$C_{12} = \frac{C_1 C_2}{C_1 + C_2}$$

$$= \frac{2 \times 2}{2 + 2} = 1\,\mu\text{F}$$

Similarly, capacitance of C_3 and C_4

$C_{34} = 1\ \mu$F

The circuit represents Wheatstone's bridge and capacitor C_5 is neglected.

Equivalent capacitance of circuit

$C_{eq} = C_{12} + C_{34} = 1 + 1 = 2\ \mu$F.

60. (*a*) $U_i = \frac{1}{2}CV^2 = \frac{Q^2}{2C}$

After connecting another capacitor in parallel,

$$\frac{q_1}{C} = \frac{q_2}{C} \Rightarrow q_1 = q_2$$

$$q_1 + q_2 = Q \quad \Rightarrow \quad q_1 = \frac{Q}{2}$$

$\Rightarrow$ Battery is disconnected,

Therefore, charge is constant $\Rightarrow U_f = \dfrac{\left(\frac{Q}{2}\right)^2}{2C} + \dfrac{\left(\frac{Q}{2}\right)^2}{2C} = \dfrac{Q^2}{4C} = \dfrac{U_i}{2}$

Hence, total electrostatic energy of resulting system is decreased by a factor of 2.

61. (*b*) Charge is invariant $Q = 8q$ and mass is invariant

$$M = 8m \quad \Rightarrow \quad \frac{4}{3}\pi R^3 \rho = 8.\frac{4}{3}\pi r^3 \rho \Rightarrow R = 2r$$

$$V' = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R} \text{ and } V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

$$\frac{V'}{V} = \frac{Q}{q}.\frac{r}{R} = 8 \times \frac{1}{2} = 4 \quad \Rightarrow V' = 4V$$

62. (*c*) $U = \frac{1}{2}QV = \frac{1}{2} \times 0.1 \times 200 = 10$ J

63. (*d*) $V = \frac{Q}{C} = \frac{qt}{C}$

$$\Rightarrow \quad t = \frac{VC}{q} = \frac{10 \times 500}{100} = 50\ \text{s}$$

64. (*b*) Electric field outside the plates $= \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{2\varepsilon_0} = 0$

Electric field inside the plates $= \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0}$

$$= \frac{\sigma}{\varepsilon_0} = \frac{q/A}{\varepsilon_0} = \frac{q}{A\varepsilon_0} = 50\ \text{N/C}$$

65. (*c*) $W=\frac{1}{2}CV^2=\frac{1}{2}\times 2\times 10^{-6}\times(200)^2 = 4\times 10^{-2}\text{ J} = 0.04\text{ J}$

66. (*c*) $C=\frac{\varepsilon_0 A}{d}=1\text{pF}$

$$C'=\frac{K\varepsilon_0 A}{d'}=\frac{K\varepsilon_0 A}{2d}=\frac{K}{2}\times\left(\frac{\varepsilon_0 A}{d}\right)$$

$$\frac{C'}{C}=\frac{2\text{ pF}}{1\text{ pF}}=\frac{K}{2}\Rightarrow K=4$$

67. (*a*) $\frac{1}{C_s}=\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}=\frac{1}{3}+\frac{1}{9}+\frac{1}{18}=\frac{9}{18}$

$C_s = 2\,\mu\text{F}$

$\Rightarrow\ C_p = 3+9+18 = 30\,\mu\text{F}\qquad \therefore\ \frac{C_s}{C_p}=\frac{2}{30}=\frac{1}{15}$

68. (*b*) In series potential differences are additive, $V'=\frac{2V}{2}=V$

Initial energy $U_i=\frac{1}{2}(2C_0)\left(\frac{V}{2}\right)^2$, where C_0 is capacitance of each capacitor

Final energy, $U_f=\frac{1}{2}\left(\frac{C_0}{2}\right)(V)^2=U_i$

69. (*a*) $C=\frac{\varepsilon_0 A}{d}=9\text{ pF}$

$$C'=\frac{\varepsilon_0 A}{d-\left[t_1\left(1-\frac{1}{K_1}\right)+t_2\left(1-\frac{1}{K_2}\right)\right]}$$

$$t_1=\frac{d}{3},\ t_2=\frac{2d}{3},\ K_1=3,\ K_2=6$$

$$\Rightarrow C'=\frac{9}{2}\frac{\varepsilon_0 A}{d}=\frac{9}{2}\times 9\text{ pF}=40.5\text{ pF}$$

70. (*c*) $C=\frac{\varepsilon_0 A}{d},\quad C'=\frac{\varepsilon_0 A}{d-t\left(1-\frac{1}{K}\right)}$

$$\frac{C'}{C}=\frac{d}{d-t\left(1-\frac{1}{K}\right)}=\frac{d}{d-\frac{2}{3}d\left[1-\frac{1}{K}\right]}=\frac{3K}{2K+1}$$

$$\Rightarrow \frac{8}{9}=\frac{3K}{2K+1}\ \Rightarrow\ K=\frac{8}{11}$$

71. (*b*) $V=\frac{Q_2-Q_1}{C_2+C_1}=\frac{(4-1)\times 10}{4+1}=6\text{ V}$

72. (*a*) $E=\frac{V}{d}=\frac{300-(-100)V}{4\text{ cm}}=100\text{ V/cm}$

$\therefore$ Voltage at 1 cm from first plate = 300 – (1 × 100) = 200 V

73. (*a*) $U=\frac{1}{2}CV_2^2-\frac{1}{2}CV_1^2=\frac{1}{2}C(V_2^2-V_1^2)=\frac{1}{2}\times 6\times 10^{-6}[(20)^2-(10)^2]=9\times 10^{-4}\text{ J}$

74. (*c*) Energy stored in capacitor, $U_1 = \frac{1}{2}CV^2$

Energy supplied by battery, $U_2 (= qV) = CV^2$

$$\frac{U_1}{U_2} = \frac{1}{2}$$

75. (*d*) Potential (V) due to a charged sphere at internal point is same as on its surface and at external point, $V \propto \frac{1}{r}$.

$$\therefore \quad V_A = \frac{1}{4\pi\varepsilon_0}\left[\frac{4\pi a^2\sigma}{a} - \frac{4\pi b^2\sigma}{b} + \frac{4\pi c^2\sigma}{c}\right]$$

$$V_B = \frac{1}{4\pi\varepsilon_0}\left[\frac{4\pi a^2\sigma - 4\pi b^2\sigma}{b} + \frac{4\pi c^2\sigma}{c}\right]$$

$$V_C = \frac{1}{4\pi\varepsilon_0}\left[\frac{4\pi a^2\sigma - 4\pi b^2\sigma + 4\pi c^2\sigma}{c}\right]$$

with $c = a + b$, we note $V_A = V_C \neq V_B$

76. (*d*) $E = -\left(\hat{i}\frac{\partial V}{\partial x} + \hat{j}\frac{\partial V}{\partial y} + \hat{k}\frac{\partial V}{\partial z}\right)$

Here $V = -x^2y - xz^2 + 4$

$$\therefore \quad \vec{E} = -[\hat{i}(-2xy - z^3) + \hat{j}(-x^2) + \hat{k}(-3xz^2)]$$

$$= (2xy + z^3)\hat{i} + x^2\hat{j} + 3xz^2\hat{k}$$

77. (*b*) In series $C_{eq} = \frac{C}{3}$

and $V_{max} = V_1 + V_2 + V_3 = 3V$

78. (*b*) Work done = Gain in K.E.

$$\Rightarrow \quad QV = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2QV}{m}}$$

$$\therefore \quad v_A = \sqrt{\frac{2qV}{m}}, \; v_B = \sqrt{\frac{2(4q)V}{m}}$$

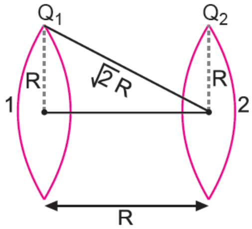
$$\frac{v_A}{v_B} = \frac{1}{2}$$

79. (*a*) $E_x = -\frac{dV}{dx} = -\frac{d}{dx}(4x^2)$

$= -8x = -8 \times 1 = -8$

$\vec{E} = -8\hat{x}$ or 8 V/m along negative x-axis

80. (*b*) Potential at centre of ring 1



$$V_1 = \frac{1}{4\pi\varepsilon_0}\left(\frac{Q_1}{R} + \frac{Q_2}{\sqrt{2}R}\right)$$

Potential at centre of ring 2

$$V_2 = \frac{1}{4\pi\varepsilon_0}\left(\frac{Q_2}{R} + \frac{Q_1}{\sqrt{2}R}\right)$$

$\therefore$ Potential difference,

$$V_1 - V_2 = \frac{1}{4\pi\varepsilon_0}\left(\frac{Q_1 - Q_2}{R} - \frac{Q_1 - Q_2}{\sqrt{2}R}\right)$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{(Q_1 - Q_2)}{\sqrt{2}R}(\sqrt{2} - 1)$$

Work done, $W = q(V_1 - V_2)$

$$= \frac{q}{4\pi\varepsilon_0}\frac{(Q_1 - Q_2)}{\sqrt{2}R}(\sqrt{2} - 1)$$

81. (*b*) Initial energy = Final energy

$$\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_1} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_2} + \frac{1}{2}mv^2$$

$$\frac{1}{2}mv^2 = \frac{q_1 q_2}{4\pi\varepsilon_0}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$v^2 = \frac{2q_1 q_2}{4\pi\varepsilon_0 m}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$= \frac{2 \times 1 \times 10^{-6} \times 1 \times 10^{-3} \times 9 \times 10^9}{2 \times 10^{-3}}\left(\frac{1}{1} - \frac{1}{10}\right)$$

$$= 9 \times 10^2 \times 9$$

$$v = 90 \text{ m/s}$$

82. (*a*) $V = \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{r} - \frac{q}{3r}\right) = \frac{1}{4\pi\varepsilon_0}\frac{2}{3}\frac{q}{r}$

$$\Rightarrow \frac{1}{4\pi\varepsilon_0}\frac{q}{r} = \frac{3}{2}V$$

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{(3r)^2} = \frac{1}{4\pi\varepsilon_0}\frac{q}{9r^2} = \frac{V}{6r}$$

83. (*a*) $V = \frac{W}{q} = \frac{Fd}{q} = \frac{3000 \times 1 \times 10^{-2}}{3} = 10 \text{ V}$

84. (*b*) $E_x = -\frac{dV}{dx} \Rightarrow E_0 = -\frac{V_x - 0}{x - 0} \Rightarrow V_x = -xE_0$

85. (*c*) Electric field is zero within the metal, so there should be no line of force within metal and lines are always normal to equipotential surface.

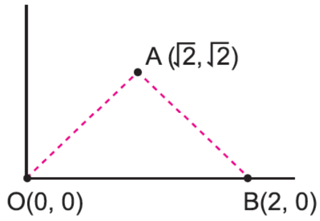
86. (*a*) $V_1 = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{R} - \frac{q}{\sqrt{R^2 + d^2}}\right]$

$$V_2 = \frac{1}{4\pi\varepsilon_0}\left(-\frac{q}{R} + \frac{q}{\sqrt{R^2 + d^2}}\right)$$

$$V_1 - V_2 = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{R} - \frac{q}{\sqrt{R^2 + d^2}} + \frac{q}{R} - \frac{q}{\sqrt{R^2 + d^2}}\right]$$

$$= \frac{q}{2\pi\varepsilon_0}\left[\frac{1}{R} - \frac{1}{\sqrt{R^2 + d^2}}\right]$$

87. (*a*) Potential difference between A and B



$$V_A - V_B = \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{OA} - \frac{q}{OB}\right)$$

$$OA = \sqrt{(\sqrt{2})^2 + (\sqrt{2})^2} = 2\text{ m}$$

$$OB = 2\text{ m}$$

$$\therefore V_A - V_B = 0$$

88. (*d*) $U_0 = \frac{1}{2}CV^2,\ U = \frac{1}{2}(KC)V^2 \Rightarrow U = KU_0 > U_0$

89. (*d*) Potentials are added in series. Number of capacitors in series arrangement,

$$n = \frac{3,000}{500} = 6$$

If m identical rows are connected in parallel, then

$$m = \frac{1}{(1/6)} = 6$$

Least number of capacitors $mn = 6 \times 6 = 36$

90. (*b*) When battery is disconnected charge remains same

$$Q = CV = \frac{\varepsilon_0 AV}{d}$$

$$E = \frac{\sigma}{K\varepsilon_0} = \frac{Q}{AK\varepsilon_0} = \frac{\varepsilon_0 AV}{dAK\varepsilon_0} = \frac{V}{Kd}$$

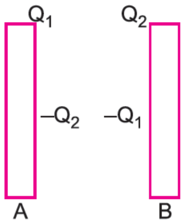
Initial energy, $U_i = \frac{1}{2}CV^2 = \frac{1}{2}\frac{\varepsilon_0 A}{d}V^2$

Final energy, $U_f = \frac{Q^2}{2C} = \frac{(\varepsilon_0 AV/d^2)}{2(\varepsilon_0 KA/d)} = \frac{\varepsilon_0 AV^2}{2dK}$

$\therefore$ Work done by system, $W = U_i - U_f = \frac{\varepsilon_0 AV^2}{2d}\left[1 - \frac{1}{K}\right]$

So, '*b*' is false

91. (*c*) Charge induced on plate A due to charge Q_2 on plate B is $-Q_2$, charge induced on plate B due to charge Q_1 on plate A is $-Q_1$.



Net charge on plate A

$$A = Q_1 - Q_2$$

Net charge on plate B

$$B = Q_2 - Q_1 = -(Q_1 - Q_2)$$

So charge on capacitor $= Q_1 - Q_2$

P.d. between the plates, $V = \frac{Q_1 - Q_2}{C}$

92. (*a*) The charges on the plates of the capacitor A are bound to each other, so no charge will flow to B, so there will be only equal and opposite induced charges on second plate of capacitor A are held by strong electrostatic force. Hence, charge on capacitor B is zero..

93. (*c*) Common potential, $V = \frac{CV_1 + CV_2}{C + C} = \frac{V_1 + V_2}{2}$

$$\therefore \text{ Energy loss, } \Delta U = \frac{1}{2}C(V_1^2 + V_2^2) - \frac{1}{2}(2C)\left(\frac{V_1 + V_2}{2}\right)^2$$

$$= \frac{1}{4}C(V_1 - V_2)^2$$

94. (*d*) Initial charge on $C_1 = 30 \times 2 = 60$ pC

Initial charge on $C_2 = 20 \times 3 = 60$ pC

Clearly initial charges on C_1 and C_2 are same; so when S_1 and S_3 are closed; the capacitors are connected in series, so charges do not redistribute and potential differences across C_1 and C_2 remain as before $V_1 = 30$ V, $V_2 = 20$ V.

95. (*b*) n-plates form $(n - 1)$ capacitors in parallel.

$\therefore$ Net capacitance $= (n - 1)\,C$

96. (*c*) Electrostatic energy = Thermal energy

$$\frac{1}{2}CV^2 = ms\,\Delta T$$

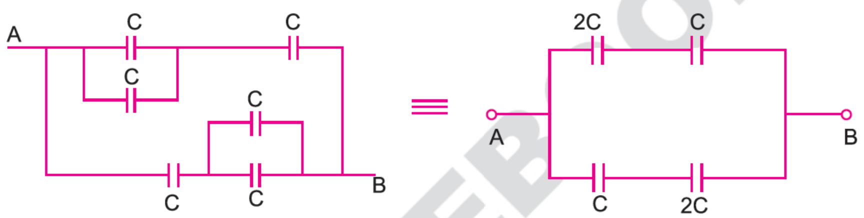
$$\Rightarrow \qquad V = \sqrt{\frac{2ms\,\Delta T}{C}}$$

97. (*c*) In equilibrium potentials of spheres are equal, *i.e.*,

$$V_1 = V_2$$

$$\frac{E_1}{E_2} = \frac{V/R_1}{V/R_2} = \frac{R_2}{R_1} = \frac{2\text{ mm}}{1\text{ mm}} = \frac{2}{1}$$

98. (*d*) Equivalent circuit is shown in figure



Effective capacitance of each row,

$$C' = \frac{C \times 2C}{C + 2C} = \frac{2}{3}C$$

$$\therefore \quad C_{eff} = \frac{2}{3}C + \frac{2}{3}C = \frac{4}{3}C$$

99. (*c*) Initially work is done on the system and while reinserting the slab equal work is done by the system. So, net work done by the system is zero.

100. (*b*) Let radius of bigger drop $= R$.

i.e., $$\frac{4}{3}\pi R^3 = 343 \times \frac{4}{3}\pi r^3$$

$\Rightarrow \quad R = 7r$

$\therefore$ Potential of big drop $= \dfrac{k(343q)}{10r} = \dfrac{49kq}{r}$

Potential of small drop $= \dfrac{kq}{r}$

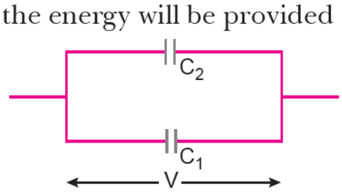
$$\therefore \quad \frac{V_{\text{big drop}}}{V_{\text{small drop}}} = 49 \Rightarrow V_{\text{big drop}} = 49V_{\text{small drop}}$$

101. (*c*) $-\,qLE$

102. (*d*) Since the positive charge is displaced against the electric field so the energy will be provided by external source in displacing the charge.

103. (*a*) Potential difference across C_1 = V

Potential difference across C_2 = V



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

$$\frac{Q_1}{C_1} = \frac{Q_2}{C_2} \Rightarrow \frac{Q_1}{Q_2} = \frac{C_1}{C_2}$$

105. (*a*) $V/2$

When the battery is disconnected the charge on the capacitor, $Q = CV$

Capacitance of parallel plate capacitor, $C = \frac{\varepsilon_0 A}{d}$

When the separation between the plates is halved, $C' = \frac{\varepsilon_0 A}{d/2} = 2C$

New potential difference $V = \frac{Q}{C'} = \frac{CV}{2C} = \frac{V}{2}$

106. (*d*) Zero

Potential at the center is equal to the potential at the surface so the work done in moving the test charge from its centre to its surface is zero.

03 CURRENT ELECTRICITY

IMPORTANT FORMULAE

1. **Drift velocity**, $\vec{v}_d = -\frac{e\vec{E}}{m}\tau$

   where $\vec{E}$ is electric field strength, τ is relation time, e is the charge on electron and m is the mass of electron.

2. **Relation between Current and Drift Velocity:**

$$I = -neAv_d$$

   where n = number of free electrons per m^3, A = cross-sectional area

3. **Ohm's law** $V = RI$

4. **Resistance** $R = \frac{\rho l}{A}$

5. **Specific resistance** $\rho = \frac{RA}{l} = \frac{m}{ne^2\tau}$

6. **Current density** $J = \frac{I}{A}$

7. **Electrical conductivity** $\sigma = \frac{1}{\rho}$

8. $J = \sigma E$ (alternative forms of Ohm's law)

9. **(*i*) Resistances in series**

   Net resistance $R_S = R_1 + R_2 + R_3$

   Current is the same in each resistance $V = V_1 + V_2 + V_3$

   (*ii*) Resistances in parallel: Net resistance R_p is given by

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

   Voltage is the same across each resistance

$$I = I_1 + I_2 + I_3$$

10. **Temperature dependence of resistance**

$$R_t = R_0\,(1 + a\Delta \boldsymbol{t})$$

   where a is the temperature coefficient of resistance

   or $$R_2 = R_1\,[1 + a\,(t_2 - t_1)]$$

11. **Internal resistance of a cell** $r = \left(\frac{E}{V} - 1\right)R$

   where E is emf of cell, V = terminal p.d. across external resistance R.

Combination of Cells

(*i*) When n-identical cells are connected in series

$$\text{Current, } i\left(=\frac{E_{net}}{R_{ext}+R_{int}}\right)=\frac{nE}{R+nr}$$

For useful series combination, the condition is $R_{\text{ext}} >> R_{\text{int}}$

(*ii*) When m-identical cells are connected in parallel

$$i=\frac{E_{net}}{R_{ext}+R_{\text{int}}}=\frac{E}{R+r/m}$$

Condition of useful parallel combination is $R < r/m$.

(*iii*) When $N = mn$, cells are connected in mixed grouping (m-rows in parallel, each row containing n cells in series)

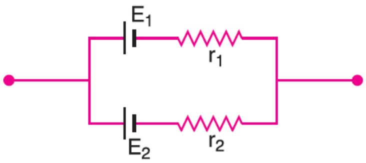
$$\text{Current, } i=\frac{nE}{R+\frac{nr}{m}}=\frac{mnE}{mR+nr}$$

Condition for useful mixed grouping is $R_{\text{ext}} = R_{\text{int}}$

i.e., $$R=\frac{nr}{m}$$

(*iv*) When two cells of different emfs E_1 and E_2 and different internal resistances r_1 and r_2 are connected in parallel as shown in fig. then net emf of combination is

$$E=\frac{\frac{E_1}{r_1}+\frac{E_2}{r_2}}{\frac{1}{r_1}+\frac{1}{r_2}}=\frac{E_1r_2+E_2r_1}{r_1+r_2}$$



Net internal resistance r_{int}

$$\frac{1}{r_{int}}=\frac{1}{r_1}+\frac{1}{r_2}\Rightarrow r_{int}=\frac{r_1r_2}{r_1+r_2}$$

12. Joule's Law of heating effect of current:

$$W=I^2Rt=\frac{V^2}{R}t=VIt \text{ joule.}$$

13. Electric Power

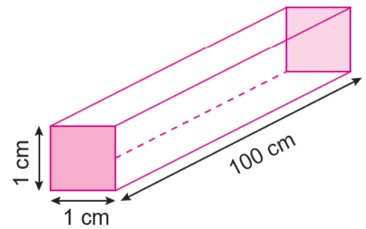
$$P=VI=I^2R=\frac{V^2}{R} \text{ watt.}$$

Value of External Resistance	Current from the Cell	Terminal Potential Difference	Power Consumed in External Resistance
R	$I=\frac{E}{R+r}$	$V = E - Ir$	$P = I^2R$
$R = 0$ (Short circuit)	$I=\frac{E}{r}$ (Maximum)	$V=E-\frac{E}{r}r$ $\Rightarrow V = 0$	$P = 0$
$R = r$	$I=\frac{E}{2r}$	$V=E-\frac{E}{2r}r$ $V=\frac{E}{2}$	$P=\frac{E^2}{4r}$ Maximum
Open circuit, $R = \infty$	$I = 0$	$V = E - 0$ $V = E$	$P = 0$

MULTIPLE CHOICE QUESTIONS

Choose and write the correct option in the following questions.

1. Dimensions of a block are 1 cm × 1 cm × 100 cm. If specific resistance of its material is 3×10^{-7} Ω m, then the resistance between the opposite rectangular faces is



(*a*) $3 \times 10^{-9}\ \Omega$ (*b*) $3 \times 10^{-7}\ \Omega$

(*c*) $3 \times 10^{-5}\ \Omega$ (*d*) $3 \times 10^{-3}\ \Omega$

2. In a Wheatstone bridge, all the four arms have equal resistance *R*. If resistance of the galvanometer arm is also *R*, then equivalent resistance of the combination is

(*a*) R (*b*) $2R$ (*c*) $\frac{R}{2}$ (*d*) $\frac{R}{4}$

3. A potentiometer is an accurate and versatile device to make electrical measurement of EMF because the method involves

(*a*) potential gradients

(*b*) a condition of no current flow through the galvanometer

(*c*) a combination of cells, galvanometer and resistance

(*d*) cells

4. Consider a current carrying wire (current *I*) in the shape of a circle. Note that as the current progresses along the wire, the direction of *j* (current density) changes in an exact manner, while the current *I* remain unaffected. The agent that is essentially responsible for is [*NCERT Exemplar*]

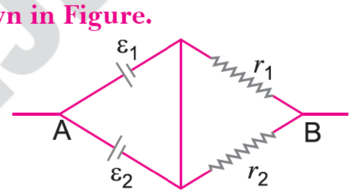
(*a*) source of emf.

(*b*) electric field produced by charges accumulated on the surface of wire.

(*c*) the charges just behind a given segment of wire which push them just the right way by repulsion.

(*d*) the charges ahead.

5. Two batteries of emf ε_1 and ε_2 ($\varepsilon_2 > \varepsilon_1$) and internal resistances r_1 and r_2 respectively are connected in parallel as shown in Figure. [*NCERT Exemplar*]



(*a*) The equivalent emf ε_{eq} of the two cells is between ε_1 and ε_2, *i.e.*, $\varepsilon_1 < \varepsilon_{eq} < \varepsilon_2$

(*b*) The equivalent emf ε_{eq} is smaller than ε_1.

(*c*) The ε_{eq} is given by $\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2$ always.

(*d*) ε_{eq} is independent of internal resistances r_1 and r_2.

6. The drift velocity of the free electrons in a conducting wire carrying a current *I* is *v*. If in a wire of the same metal, but of double the radius, the current be 2*I*, then the drift velocity of the electrons will be

(*a*) $v/4$ (*b*) $v/2$ (*c*) v (*d*) $4v$

7. A resistance *R* is to be measured using a meter bridge. Student chooses the standard resistance *S* to be 100 Ω. He finds the null point at l_1 = 2.9 cm. He is told to attempt to improve the accuracy. Which of the following is a useful way? [*NCERT Exemplar*]

(*a*) He should measure l_1 more accurately.

(*b*) He should change *S* to 1000 Ω and repeat the experiment.

(*c*) He should change *S* to 3 Ω and repeat the experiment.

(*d*) He should give up hope of a more accurate measurement with a meter bridge.

8. Two cells of emf's approximately 5 V and 10 V are to be accurately compared using a potentiometer of length 400 cm. **[*NCERT Exemplar*]**

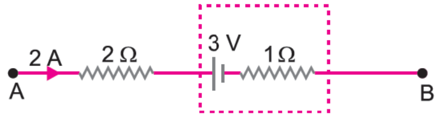
(*a*) The battery that runs the potentiometer should have voltage of 8V.

(*b*) The battery of potentiometer can have a voltage of 15 V and R adjusted so that the potential drop across the wire slightly exceeds 10 V.

(*c*) The first portion of 50 cm of wire itself should have a potential drop of 10 V.

(*d*) Potentiometer is usually used for comparing resistances and not voltages.

9. Figure represents a part of a closed circuit. The potential difference between points *A* and *B* ($V_A - V_B$) is



(*a*) +9 *V* (*b*) – 9 *V*

(*c*) +3 *V* (*d*) + 6 *V*

10. A metal rod of length 10 cm and a rectangular cross-section of 1cm × $\frac{1}{2}$ cm is connected to a battery across opposite faces. The resistance will be **[*NCERT Exemplar*]**

(*a*) maximum when the battery is connected across 1 cm × $\frac{1}{2}$ cm faces.

(*b*) maximum when the battery is connected across 10 cm × 1 cm faces.

(*c*) maximum when the battery is connected across 10 cm × $\frac{1}{2}$ cm faces.

(*d*) same irrespective of the three faces.

11. Which of the following characteristics of electrons determines the current in a conductor? **[*NCERT Exemplar*]**

(*a*) Drift velocity alone

(*b*) Thermal velocity alone

(*c*) Both drift velocity and thermal velocity

(*d*) Neither drift nor thermal velocity.

12. Temperature dependence of resistivity ρ(T) of semiconductors insulators and metals is significantly based on the following factors. **[*NCERT Exemplar*]**

(*a*) Number of charge carriers can change with temperature *T*.

(*b*) Time interval between two successive collision can depend on *T*.

(*c*) Length of material can be a function of *T*.

(*d*) Both (*a*) and (*b*)

13. Kirchhoff's junction rule is a reflection of **[*NCERT Exemplar*]**

(*a*) conservation of current density vector.

(*b*) conservation of charge.

(*c*) the fact that there is no accumulation of charged at a junction.

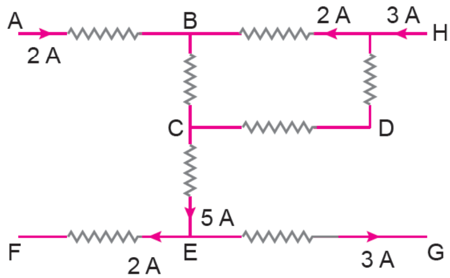
(*d*) Both (*b*) and (*c*)

14. The current in electrolyte is due to

(*a*) positive ions only (*b*) negative ions only

(*c*) both positive and negative ions (*d*) holes

15. In the circuit diagram the electric current through branch BC is



(*a*) 1 A (*b*) 2 A (*c*) 4 A (*d*) 5 A

16. The temperature coefficient of resistance for a wire is 0.00125/°C. At 27° C its resistance is 1 ohm. The temperature at which the resistance becomes 2 ohm is

(*a*) 1154 K (*b*) 1100 K (*c*) 1400 K (*d*) 1127 K

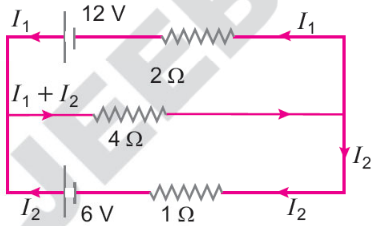
17. Drift velocity v_d varies with the intensity of electric field as per the relation

(*a*) $v_d \propto E$ (*b*) $v_d \propto \frac{1}{E}$ (*c*) v_d = constant (*d*) $v_d \propto E^2$

18. The resistance of a wire is '*R*' ohm. If it is melted and stretched to '*n*' times its original length, its new resistance will be

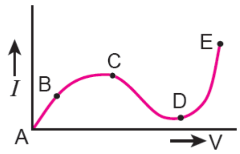
(*a*) $\frac{R}{n}$ (*b*) n^2R (*c*) $\frac{R}{n^2}$ (*d*) nR

19. Electric current through resistance 4 Ω, in the given circuit is:



(*a*) 0 A (*b*) 0.5 A (*c*) 12/7 A (*d*) 2/7 A

20. From the graph between current *I* and voltage *V* shown below, identify the portion corresponding to negative resistance



(*a*) AB (*b*) BC (*c*) CD (*d*) DE

21. Two wires of same material have length *L* and 2*L* and cross-sectional areas 4*A* and *A* respectively. The ratio of their specific resistance would be

(*a*) 1 : 2 (*b*) 8 : 1 (*c*) 1 : 8 (*d*) 1 : 1

22. A wire of non-uniform cross-section is carrying a steady current. Along the wire

(*a*) current and current density are constant

(*b*) only current is constant

(*c*) only current density is constant

(*d*) neither current nor current density is constant

23. A conducting wire of diameter 0.5 mm has a resistance of 8 Ω. The resistance of a wire of same length and material having a diameter 1mm will be

(*a*) 32 Ω (*b*) 16 Ω (*c*) 4 Ω (*d*) 2 Ω

24. 12 coulombs/minute can be written as

(*a*) 2 A (*b*) 0.2 A (*c*) 0.02 A (*d*) 0.002 A

25. A wire of uniform area of cross-section A, length *l* and resistance *R* is cut at the middle into two equal parts of length *l*/2 each. Then the resistivity of each piece compared to that of the original becomes

(*a*) half (*b*) double

(*c*) unchanged (*d*) unpredictable

26. Drift velocity of electrons in a conductor is of the order of

(*a*) a few millimeters per second (*b*) a few meters per second

(*c*) a few kilometers per second (*d*) 3×10^{10} cms^{-1}

27. A 220 V-100 W bulb is connected to a source of 180 V. The power consumed by it will be nearly

(*a*) 100 W (*b*) 82 W (*c*) 75 W (*d*) 67 W

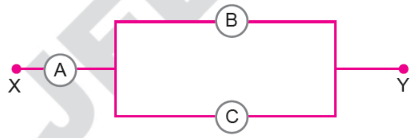
28. Two bulbs one of 50 watts and another of 25 watts are connected in series to the mains. The ratio of the current through them is

(*a*) 1 : 1 (*b*) 1 : 2 (*c*) 2 : 2 (*d*) 1 : 4

29. A 100 W, 200 V bulb is being operated at 160 V, the power dissipation is

(*a*) 32 W (*b*) 64 W (*c*) 100 W (*d*) 160 W

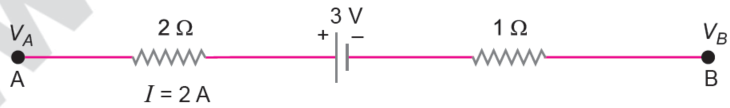
30. *A, B* and *C* are voltmeters of resistance *R*, 1.5*R* and 3*R* respectively as shown in the figure. When some potential difference is applied between *X* and *Y*, the voltmeter readings are V_A, V_B and V_C respectively. Then



(*a*) $V_A = V_B \neq V_C$ (*b*) $V_A \neq V_B \neq V_C$

(*c*) $V_A = V_B = V_C$ (*d*) $V_A \neq V_B = V_C$

31. The potential difference ($V_A - V_B$) between the points A and B in the given figure is



(*a*) – 3 V (*b*) +3 V (*c*) –13 V (*d*) +13 V

32. Kirchhoff's II law for the electric network is based on

(*a*) law of conservation of charge (*b*) law of conservation of energy

(*c*) law of conservation of angular momentum (*d*) law of conservation of mass

33. Three cells each of emf 1.5 V and terminal resistance 1 Ω are connected in parallel. The combination will have an emf of

(*a*) 4.5 V (*b*) 3 V (*c*) 1.5 V (*d*) 0.5 V

34. For a cell, the terminal potential difference is 3.6 V, when the circuit is open. If the potential difference reduces to 3 V, when cell is connected to a resistance of 5 Ω, the internal resistance of cell is

(*a*) 1 Ω (*b*) 2 Ω (*c*) 4 Ω (*d*) 8 Ω

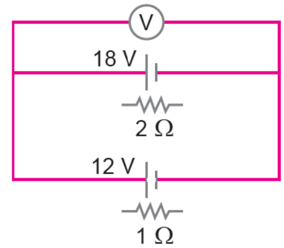
35. Kirchhoff's I law for the electric junction is based on

(*a*) law of conservation of charge (*b*) law of conservation of energy
(*c*) law of conservation of angular momentum (*d*) law of conservation of mass

36. A potentiometer wire is 100 cm long and a constant potential difference is maintained across it. Two cells are connected in series first to support one another and then in opposite direction. The balance points are obtained at 50 cm and 10 cm from the positive end of the wire in the two cases. The ratio of emf's is

(*a*) 3 : 4 (*b*) 3 : 2 (*c*) 5 : 1 (*d*) 5 : 4

37. Two batteries, one of emf 18 V and internal resistance 2 Ω and the other of emf 12 V and internal resistance 1 Ω, are connected as shown. The voltmeter *V* will record a reading of



(*a*) 30 V (*b*) 18 V (*c*) 15 V (*d*) 14 V

38. *n* cells each of emf *E* and internal resistance *r* send the same current through an external resistance *R* whether the cells are connected in series or parallel. Then

(*a*) $R = nr$ (*b*) $R = r$
(*c*) $r = nR$ (*d*) $R = (\sqrt{n})\,r$

39. A wire of length 100 cm is connected to a cell of emf 2 V and negligible internal resistance. The resistance of the wire is 3 Ω. The additional resistance required to produce a potential drop of 1 millivolt per cm is

(*a*) 60 Ω (*b*) 47 Ω (*c*) 57 Ω (*d*) 55 Ω

40. The internal resistance of a 2.1 V cell which gives a current of 0.2 A through a resistance of 10 Ω is

(*a*) 0.8 Ω (*b*) 1.0 Ω (*c*) 0.2 Ω (*d*) 0.5 Ω

41. If a copper wire is stretched to make it 0.1% longer, the percentage increase in resistance will be

(*a*) 0.2 (*b*) 2 (*c*) 1 (*d*) 0.1

42. According to Joule's law, if potential difference across a conductor of material of resistivity ρ remains constant, then heat produced in the conductor is directly proportional to

(*a*) $\frac{1}{\sqrt{\rho}}$ (*b*) ρ (*c*) ρ^{-1} (*d*) ρ^2

43. Two bulbs each marked 100 W, 220 V are connected in series across 220 V supply. The power consumed by the combination will be

(*a*) 220 W (*b*) 100 W (*c*) 50 W (*d*) zero

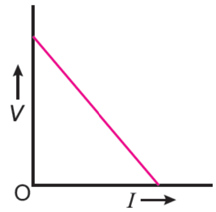
44. Two bulbs each marked 100 W, 220 V are connected in parallel across 220 V supply. The power consumed by the combination will be

(*a*) 200 W (*b*) 100 W (*c*) 50 W (*d*) zero

45. A 5°C rise in temperature is observed in a conductor by passing a current. If the current is doubled, the rise in temperature of the conductor will be nearly

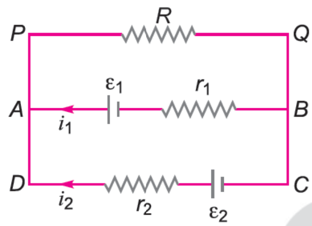
(*a*) 10°C (*b*) 20°C (*c*) 40°C (*d*) 2.5°C

46. A student measures the terminal potential difference (V) of a cell of emf E and internal resistance r as a function of the current (I) flowing through it. The slope and intercept, of the graph between V and I, then respectively, equal



(a) $-r$ and ε (b) r and $-\varepsilon$ (c) $-\varepsilon$ and r (d) ε and $-r$

47. See the electrical circuit shown in fig. Which one of the following is the correct equation for it?



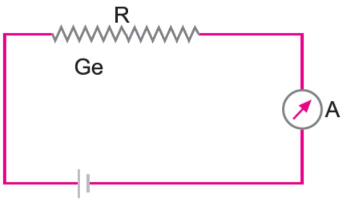
(a) $\varepsilon_2 - i_2 r_2 - \varepsilon_1 - i_1 r_1 = 0$ (b) $-\varepsilon_2 - (i_1 + i_2) R + i_2 r_2 = 0$

(c) $\varepsilon_1 - (i_1 + i_2) R + i_1 r_1 = 0$ (d) $\varepsilon_1 - (i_1 + i_2) R - i_1 r_1 = 0$

48. The resistance of a mercury column in a cylindrical container is R. This mercury is poured into another cylindrical container with half the radius of cross-section. The resistance of other mercury column will be

(a) R (b) $4R$ (c) $16R$ (d) $R/4$

49. A current is passed by a battery of constant voltage through the germanium wire at room temperature. Now the temperature of germanium wire is decreased. The reading of ammeter will



(a) increase
(b) decrease
(c) remain unchanged
(d) increase and decrease alternatively

50. A steady current flows in a metallic conductor of non-uniform cross-section. The quantity/ quantities constant along the length of the conductor is/are

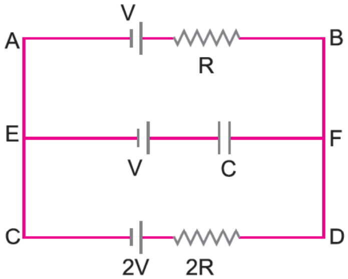
(a) current, electric field and drift speed (b) current, current density and drift speed

(c) drift speed only (d) current only

51. The electric current in a conductor varies with time t as $I = 2t + 3t^2$, where I is in ampere and t in seconds. Electric charge flowing through a section of the conductor during $t = 2$ s to $t = 3$ s is

(a) 10 C (b) 24 C (c) 33 C (d) 44 C

52. In the given circuit, with steady current, the potential drop across the capacitor C must be



(a) V (b) $\frac{V}{2}$

(c) $\frac{V}{3}$ (d) $\frac{2V}{3}$

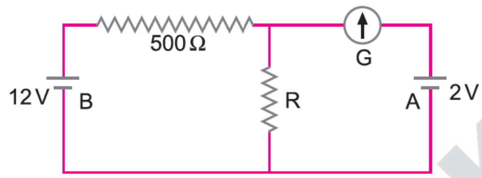
53. In a metre bridge experiment null point is obtained at 20 cm from one end of the wire, when resistance X is balanced against another resistance Y. If then where will be the new position of null point from the same end if one decides to balance a resistance of $4X$ against Y?

(a) 50 cm (b) 80 cm (c) 40 cm (d) 70 cm

54. The length of a potentiometer wire is 100 cm and the emf of the standard cell is E volt. It is employed to measure the emf of a battery of internal resistance 0.5 Ω. If the balance point is obtained at length 30 cm from the positive end, the emf of the battery is (i = current in potentiometer wire)

(a) $\frac{30E}{100.5}$ (b) $\frac{30E}{100-0.5}$ (c) $\frac{30(E-0.5i)}{100}$ (d) $\frac{30E}{100}$

55. In the circuit the galvanometer shows zero deflection. If the batteries A and B have negligible internal resistance, the value of resistance R will be



(a) 100 Ω (b) 200 Ω (c) 500 Ω (d) 1000 Ω

56. An uncharged capacitor of capacitance 4μF a battery of emf 12 V and a resistor of 2.5 MΩ are connected in series. The time after which the p.d. across capacitor becomes 3-times across resistor (*i.e.*, $V_C = 3V_R$) is ($log_e 2 = 0.693$)

(a) 6·93 s (b) 13·86 s (c) 10·86 s (d) none of above

57. An electric bulb rated 500 W at 100 V is used in a circuit fed by a 200 V supply; then the resistance R to be put in series with the bulb, so that bulb delivers 500 W is

(a) 40 Ω (b) 20 Ω (c) 10 Ω (d) 80 Ω

58. Time taken by a 836 W heater to heat one litre of water from 10°C to 40°C is

(a) 50 s (b) 100 s (c) 150 s (d) 200 s

59. An electric bulb is marked 100 W, 230 V. If the supply voltage drops to 115 V, what is the total energy produced by the bulb in 10 minutes?

(a) 30 kJ (b) 15 kJ (c) 10 kJ (d) 5 kJ

60. In a Wheatstone bridge, three resistances P, Q and R are connected in the three arms and the fourth arm is formed by two resistances S_1 and S_2 connected in parallel. The condition for the bridge to be balanced will be

(a) $\frac{P}{Q} = \frac{2S}{S_1 + S_2}$ (b) $\frac{P}{Q} = \frac{R(S_1 + S_2)}{S_1 S_2}$

(c) $\frac{P}{Q} = \frac{R(S_1 + S_2)}{2S_1 S_2}$ (d) $\frac{P}{Q} = \frac{R}{S_1 S_2}$

61. If the ratio of concentration of electrons to that of hole in a semiconductor is $\frac{7}{5}$ and the ratio of currents is $\frac{7}{4}$, then what is the ratio of their drift velocities?

(a) $\frac{5}{8}$ (b) $\frac{4}{5}$ (c) $\frac{5}{4}$ (d) $\frac{4}{7}$

62. Two conductors have the same resistance at 0°C but their temperature coefficients are α_1 and α_2 the respective temperature coefficients of their series and parallel combination are nearly

(a) $\frac{\alpha_1 + \alpha_2}{2}, \alpha_1 + \alpha_2$ (b) $\alpha_1 + \alpha_2, \frac{\alpha_1 + \alpha_2}{2}$

(c) $\alpha_1 + \alpha_2, \frac{\alpha_1 \alpha_2}{\alpha_1 + \alpha_2}$ (d) $\frac{\alpha_1 + \alpha_2}{2}, \frac{\alpha_1 + \alpha_2}{2}$

63. A potentiometer can measure emf of a cell because [CBSE 2020 (55/1/1)]

(a) the sensitivity of potentiometer is large.

(b) no current is drawn from the cell at balance.

(c) no current flows in the wire of potentiometer at balance.

(d) internal resistance of cell is neglected.

64. The resistance of a metal wire increases with increasing temperature on account of [CBSE 2020 (55/1/2)]

(a) decrease in free electron density. (b) decrease in relaxation time.

(c) increase in mean free path. (d) increase in the mass of electron.

65. Kirchhoff's first rule at a junction in an electrical network, deals with conservation of [CBSE 2020 (55/1/2)]

(a) energy (b) charge

(c) momentum (d) both energy and charge.

66. The conductivity of a metal decreases with the increase in temperature on account of [CBSE 2020 (55/1/3)]

(a) decrease in number density of electrons. (b) decrease in resistivity.

(c) decrease in relaxation time. (d) increase in mean free path.

67. A cell of internal resistance r is connected across an external resistance R can supply maximum current when [CBSE 2020 (55/2/1)]

(a) $R = r$ (b) $R > r$ (c) $R = \frac{r}{2}$ (d) $R = 0$

68. In a current carrying conductor, the ratio of the electric field and the current density at a point is called [CBSE 2020 (55/2/1)]

(a) Resistivity (b) Conductivity (c) Resistance (d) Mobility

69. Resistivity of a given conductor depends upon [CBSE 2020 (55/2/2)]

(a) temperature. (b) length of conductor.

(c) area of cross-section. (d) shape of the conductor.

70. The ratio of current density and electric field is called [CBSE 2020 (55/2/2)]

(a) Resistivity (b) Conductivity

(c) Drift velocity (d) Mobility

71. For a fixed potential difference applied across a conductor, the drift speed of free electrons does not depend upon [CBSE 2020 (55/2/3)]

(a) free electron density in the conductor. (b) mass of the electrons.

(c) length of the conductor (d) temperature of the conductor.

72. Ohm's law is obeyed by [CBSE 2020 (55/2/3)]

(a) extrinsic semiconductors. (b) intrinsic semiconductors.

(c) metals at low temperature. (d) metals at high temperature.

73. The electrical resistance of a conductor [CBSE 2020 (55/3/1)]

(a) varies directly proportional to its area of cross-section.

(b) decreases with increase in its temperature.

(c) decreases with increase in its conductivity.

(d) independent or its shape but depends only on its volume.

74. The element of a heater is rated (*P*, *V*). If it is connected across a source of voltage *V*/2, then the power communed by it will be [CBSE 2020 (55/3/1)]

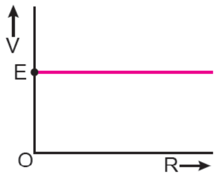
(a) P (b) $2P$ (c) $\frac{P}{2}$ (d) $\frac{P}{4}$

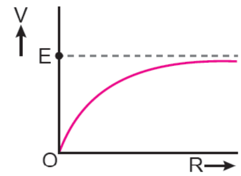
75. **$m^2V^{-1}s^{-1}$ is the SI unit of which of the following?** *[CBSE 2020 (55/3/1)]*

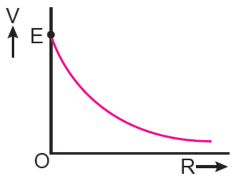
(*a*) Drift velocity (*b*) Mobility

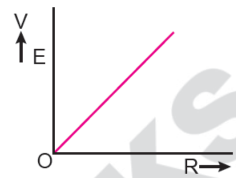
(*c*) Resistivity (*d*) Potential gradient

76. **A cell of emf (*E*) and internal resistance *r* is connected across a variable external resistance *R*. The graph of terminal potential difference *V* as a function of *R* is** *[CBSE 2020 (55/4/1)]*

(*a*)


(*b*)


(*c*)


(*d*)


Answers

1. (*b*)	**2.** (*a*)	**3.** (*b*)	**4.** (*b*)	**5.** (*a*)	**6.** (*b*)	**7.** (*c*)	**8.** (*b*)
9. (*a*)	**10.** (*a*)	**11.** (*a*)	**12.** (*d*)	**13.** (*d*)	**14.** (*c*)	**15.** (*c*)	**16.** (*b*)
17. (*a*)	**18.** (*b*)	**19.** (*c*)	**20.** (*c*)	**21.** (*d*)	**22.** (*b*)	**23.** (*d*)	**24.** (*b*)
25. (*c*)	**26.** (*a*)	**27.** (*d*)	**28.** (*a*)	**29.** (*b*)	**30.** (*c*)	**31.** (*d*)	**32.** (*b*)
33. (*c*)	**34.** (*a*)	**35.** (*a*)	**36.** (*b*)	**37.** (*d*)	**38.** (*b*)	**39.** (*c*)	**40.** (*d*)
41. (*a*)	**42.** (*c*)	**43.** (*c*)	**44.** (*a*)	**45.** (*b*)	**46.** (*a*)	**47.** (*d*)	**48.** (*c*)
49. (*b*)	**50.** (*d*)	**51.** (*b*)	**52.** (*c*)	**53.** (*a*)	**54.** (*c*)	**55.** (*a*)	**56.** (*b*)
57. (*b*)	**58.** (*c*)	**59.** (*b*)	**60.** (*b*)	**61.** (*c*)	**62.** (*d*)	**63.** (*c*)	**64.** (*b*)
65. (*b*)	**66.** (*c*)	**67.** (*d*)	**68.** (*a*)	**69.** (*a*)	**70.** (*b*)	**71.** (*a*)	**72.** (*c*)
73. (*c*)	**74.** (*d*)	**75.** (*b*)	**76.** (*b*)				

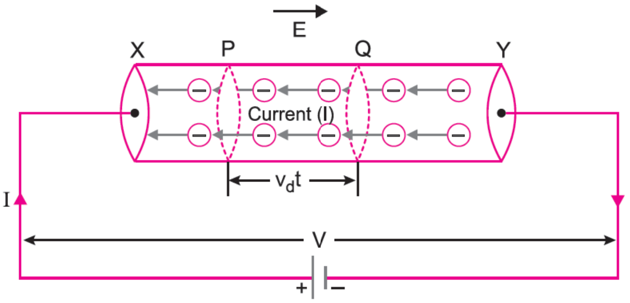
CASE-BASED QUESTIONS

Attempt any 4 sub-parts from each question. Each question carries 1 mark.

1. ELECTRON DRIFT:

An electric charge (electron, ions) will experience a force if an electric field is applied. If we consider solid conductors, then of course the atoms are tightly bound to each other so that the current is carried by the negative charged electrons. Consider the first case when no electric field is present, the electrons will be moving due to thermal motion during which they collide with the fixed ions. An electron colliding with an ion emerges with same speed as before the collision. However, the direction of its velocity after the collision is completely random. At a given time, there is no preferential direction for the velocities of the electrons. Thus, on an average, the number of electrons travelling in any direction will be equal to the number of electrons travelling in the opposite direction. So, there will be no net electric current. If an electric field is applied, the electrons will be accelerated due to this field towards positive charge. The electrons, as long as they are moving, will constitute an electric current.

The free electrons in a conductor have random velocity and move in random directions. When current is applied across the conductor, the randomly moving electrons are subjected to electrical forces along the direction of electric field. Due to this electric field, free electrons still have their random moving nature, but they will move through the conductor with a certain force. The net velocity in a conductor due to the moving of electrons is referred to as the drift of electrons.



(i) When a potential difference V is supplied across a conductor at temperature T, the drift velocity of electrons is proportional to

(a) V (b) $\sqrt{V}$

(c) $\sqrt{T}$ (d) T

(ii) A steady current flows in a metallic conductor of non-uniform cross-section. Which of the following quantities is constant along the conductor?

(a) Current density (b) Drift speed

(c) Current (d) None of these

(iii) Relation between drift velocity (v_d) of electron and thermal velocity (v_T) of an electron at room temperature is

(a) $v_d = v_T = 0$ (b) $v_d > v_T$

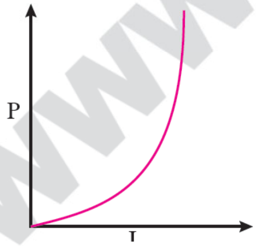
(c) $v_d < v_T$ (d) $v_d = v_T$

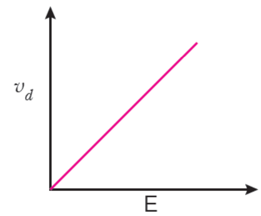
(iv) Which of the following characteristics of electrons determines the current in a conductor?

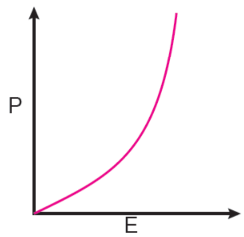
(a) Thermal velocity alone (b) Drift velocity alone

(c) Both drift velocity and thermal velocity (d) Neither drift nor thermal velocity

(v) If E denotes electric field in a uniform conductor, I corresponding current through it, v_d drift velocity of electrons and P denotes thermal power produced in the conductor, then which of the following graphs is/are correct?

(a) 

(b) 

(c) 

(d) All of the above

Answers

1. (i) (a); We know that drift velocity, $v_d \alpha E$ [$\because E = VL$] So, $v_d \propto E \propto V$. So for a particular conductor of a particular length, the drift velocity will directly depend on the voltage.

(*ii*) (*c*); When a steady current flows through a metallic conductor of non uniform cross-section, then drift velocity, $v_d = \frac{I}{neA}$

i.e., $v_d \propto \frac{I}{A}$, and $v_d \propto E$ so $E \propto \frac{I}{A}$

Both v_d and E change with A, only current I remains constant.

(*iii*) (*c*); Electrons with the fermi energy carry considerable kinetic energy. Their mean thermal velocity at temperature T should be $v_T = \sqrt{3KT/m}$, which generally turns out to be quite large. The average velocity with which electrons must pass along a conductor to carry a current is called drift velocity and is given by $v_d = \frac{I}{neA}$ which is much less than the thermal velocity, or $v_d < v_T$.

(*iv*) (*b*); As $I = neAv_d$, so current $I \propto v_d$. Although I also depends on n, the number of free electrons which increases on increasing temperature that causes more collision between electrons which in turn increases resistance or decreases current. So, $I \propto v_d$.

(*v*) (*d*); $v_d = \frac{eE}{m}\tau$ *i.e.*, $v_d \propto E$

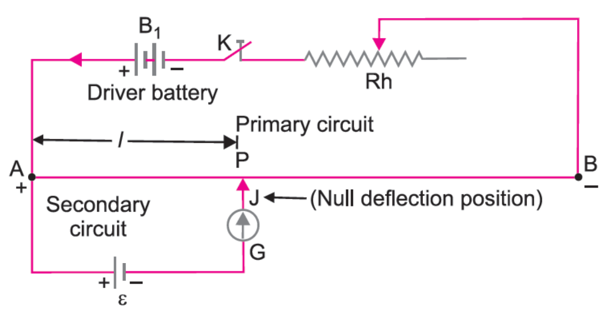
or $P = \frac{V^2}{R} = \frac{\left(\frac{E}{d}\right)^2}{R} = \frac{E^2}{d^2R}$ *i.e.*, $P \propto E^2$

or $P = VI = I^2R$; *i.e.*, $P \propto I^2$

2. THE POTENTIOMETER:

The potentiometer is an instrument that can be used to measure the emf of a source without drawing any current from the source it also has a number of other useful applications. Essentially, it balances an unknown potential difference against an adjustable, measurable potential difference.

Potentiometer is based on the principle that when a constant current flows through a wire of uniform area of cross-section, the potential drop across any length of the wire is directly proportional to the length. A resistance wire AB of total resistance R_{AB} is permanently connected to the terminals of a source of known emf ε_1. A sliding jockey J is connected through the galvanometer G to a second source whose emf ε_2 is to be measured. As jockey J is moved along the resistance wire, the resistance R_{PB} between points P and B varies; if the resistance wire is uniform, R_{PB} is proportional to the length of wire between P and B. To determine the value of ε_2, J is moved until a position is found at which the galvanometer shows no deflection; this corresponds to zero current passing through ε_2.



The term potentiometer is also used for any variable resistor, usually having a circular resistance element and a sliding contact controlled by a rotating shaft and knob.

(*i*) Two cells of emfs approximately 5 V and 10 V are to be accurately compared using a potentiometer of length 400 cm. Choose the correct option.

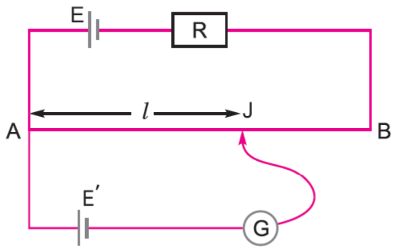
(*a*) potentiometer is usually used for comparing resistance and not voltages.

(*b*) the first portion of 50 cm of wire itself should have a potential drop of 10 V.

(*c*) the battery of potentiometer can have a voltage of 15 V and R adjusted so that the potential drop across the wire slightly exceeds 10 V.

(*d*) the battery that runs the potentiometer should have voltage of 8 V.

(*ii*) AB is a potentiometer wire of a potentiometer. If the value of *R* is increased, in which direction will the balance point J shift?



(*a*) Towards A (*b*) Towards B

(*c*) Same as initial point (*d*) None of these

(*iii*) The current in a potentiometer wire is adjusted to give a null point at 56 cm with a standard cell of 1.02 V. The emf of another cell for which a null point at 70 cm is

(*a*) 1 V (*b*) 1.02 V

(*c*) 1.275 V (*d*) 1.5 V

(*iv*) Potentiometer is an electrical measuring device which measure

(*a*) emf of the cell (*b*) internal resistance of the cell

(*c*) both (*a*) and (*b*) (*d*) none of these

(*v*) The current in the primary circuit of a potentiometer is 0.2 A. The specific resistance and cross-section area of the potentiometer wire are 4×10^{-7} ohm metre and 8×10^{-7} m^2 respectively. The potential gradient will be equal to

(*a*) 0.1 Vm^{-1} (*b*) 0.2 Vm^{-1}

(*c*) 0.5 Vm^{-1} (*d*) 1 Vm^{-1}

Answers

2. (*i*) (*c*); Here emf of primary cells are 5 V and 10 V. So, the potential drop across potentiometer wire must be slightly more than the larger emf 10 V. So, the battery should be 15 V and about 4 V potential is dropped by using rheostat or resistance.

(*ii*) (*b*); If R is increased, current in main circuit will decrease (by $V = IR$) as the potential (E) is constant. So, in turn potential difference across AB will decrease (by $V = IR$). As R of AB is constant so potential gradient $K = \frac{V}{AB}$ will decrease. So, to balance potential across AB equal to potential of secondary circuit (E'), the length AJ' must be larger than earlier AJ. So, the point J shifts towards B.

(*iii*) (*c*); In potentiometer, comparison of emfs,

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

$$\Rightarrow \quad \frac{1.02}{E_2} = \frac{56}{70}$$

$$\therefore E_2 = \frac{70}{56} \times 1.02 = 1.275 \text{ V}$$

(*iv*) (*c*); The potentiometer is an electrical measurement device which measure emf of the cell and internal resistance of the cell.

i.e., $V = \left(\frac{\varepsilon}{R+r}\right)\frac{r}{L}l$ and $r = \left(\frac{l_1 - l_2}{l_2}\right)R$

(*v*) (*a*); Let l be the length of potentiometer wire and V be the potential drop across length l.

Potential gradient, $k = \frac{V}{l} = \frac{IR}{l} = \frac{I}{l}\left(\rho\frac{l}{A}\right) = \frac{I\rho}{A}$

$$\therefore k = \frac{0.2 \times 4 \times 10^{-7}}{8 \times 10^{-7}} = 0.1 \text{ Vm}^{-1}$$

ASSERTION-REASON QUESTIONS

In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct answer out of the following choices.

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

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

(c) A is true but R is false.

(d) A is false and R is also false.

1. Assertion (A) : Electric current is a scalar quantity.

Reason (R) : Electric current arises due to continuous flow of charged particles.

2. Assertion (A) : The current density is a vector quantity.

Reason (R) : Current density has magnitude current per unit area and is directed along the direction of current.

3. Assertion (A) : The connecting wires are made of copper.

Reason (R) : Copper has very high electrical conductivity.

4. Assertion (A) : With increase in drift velocity, the current flowing through a metallic conductor decreases.

Reason (R) : The current flowing in a conductor is inversely proportional to drift velocity.

5. Assertion (A) : The current flows in a conductor when there is an electric field within the conductor.

Reason (R) : The electrons in a conductor drift only in the presence of electric field.

6. Assertion (A) : In a metre bridge experiment, null point for an unknown resistance is put inside an enclosure maintained at a higher temperature. The null point can be obtained at the same point as before by decreasing the value of standard resistance. *[AIIMS 2015]*

Reason (R) : Resistance of metal increases with increase in temperature.

7. Assertion (A) : The conductivity of an electrolyte is very low as compared to a metal at room temperature. *[AIIMS 2015]*

Reason (R) : The number density of free ions in electrolyte is much smaller as compared to number density of free electrons in metals. Further, ions drift much more slowly, being heavier.

8. Assertion (A) : An electrical bulb starts glowing instantly as it is switched on. *[AIIMS 2017]*

Reason (R) : Drift speed of electrons in a metallic wire is very large.

9. **Assertion (A) :** A wire carrying an electric current has no electric field around it. [*AIIMS 2013*]

Reason (R) : Rate of flow of electrons in one direction is equal to the rate of flow of protons in opposite direction.

10. **Assertion (A) :** Electrons move from a region of higher potential to a region of lower potential. [*AIIMS 2013*]

Reason (R) : An electron has less potential energy at a point where potential is higher and vice-versa.

Answers

1. (*b*)	**2.** (*a*)	**3.** (*a*)	**4.** (*d*)	**5.** (*a*)	**6.** (*d*)	**7.** (*a*)	**8.** (*c*)
9. (*c*)	**10.** (*a*)						

HINTS/SOLUTIONS OF SELECTED MCQs

1. (*b*) $l = 1$ cm $= 10^{-2}$ m, A $= (1 \times 100)$ cm^2 $= 10^{-2}$ m^2

$$R = \rho\frac{l}{A} = 3\times10^{-7}\times\frac{10^{-2}}{10^{-2}} = 3\times10^{-7}\,\Omega$$

2. (*a*) $\frac{P}{Q} = \frac{R}{S}$, so resistance of the galvanometer can be omitted ($P + Q$ are in series $= 2R$, R and S are also in series $= 2R$). Now the equivalent resistance $= \frac{2R}{R} = R$.

3. (*b*) It is based on null deflection and measure accurate emf because the method involves a condition of no current flow through the galvanometer.

4. (*b*) The current density is also directed along E and is also a vector and relationship is given by $\vec{J} = \sigma\vec{E}$.

The J changes due to electric field produces by charge accumulated on the surface of the wire.

5. (*c*) $E_{eq} = \frac{\varepsilon_2 r_1 + \varepsilon_1 r_2}{r_1 + r_2}$, this gives $\varepsilon_1 < \varepsilon_{eq} < \varepsilon_2$.

6. (*b*) $I = \text{Ane}\, v_d' \quad \Rightarrow \quad v_d \propto \frac{I}{A}$

$$\text{Now, } \frac{v_d'}{v_d} = \left(\frac{I'}{I}\times\frac{A}{A'}\right) = \frac{2I}{I}\times\frac{\pi r^2}{\pi(2r)^2} = \frac{1}{2} \Rightarrow v_d = \frac{v_d}{2} = \frac{v}{2}$$

7. (*c*) By Wheatstone bridge, $\frac{R}{S} = \frac{Rl_1}{R(100-\lambda_1)} = \frac{\lambda_1}{100-\lambda_1}$

since, here $R : S = 2.9 : 97.1 \Rightarrow S \simeq 33R$. In order to make the ratio 1 : 1, it is necessary to reduce the value of $s \approx \frac{1}{33}$ times, *i.e.*, 3 Ω.

8. (*b*) The potential drop across wires of potentiometer should be greater than emfs of primary cells. So, the potential drop along potentiometer wire must be more than 10 V.

9. (*a*) According to Kirchoff's loop rule,

$$V_A - (2 \times 2) - 3 - (2 \times 1) - V_B = 0$$

$$\Rightarrow V_A - V_B = 4 + 3 + 2 = 9 \text{ V.}$$

10. (*a*) The resistance of wire depends on its geometry of wire/metallic rod. So, for greater value of R, l must be higher and A should be lower, *i.e.*, $R = \rho\frac{l}{A}$

11. (*a*) $I = Anev_d \Rightarrow I \propto v_d$

Thus, only drift velocity determines the current in conductor.

12. (*d*) $\rho = \frac{m}{ne^2\tau}$, when temperature increases, than successive collision between electrons will be increases and relaxation time (τ) will be decreases.

13. (*d*) Kirchhoff's junction rule states that algebraic sum of current flowing towards any point in an electric network is zero, *i.e.*, charges are conserved in electric network.

so, it is a reflection of conservation of charge.

14. (*c*) As electrolyte carry +ve as well as –ve charge.

15. (*c*) $i = 2\text{ A} + 2\text{ A} = 4\text{ A}$

16. (*b*) $R_2 = R_1[1 + \alpha(t_2 - t_1)]$

$2 = 1\,[1 + 0.00125(t_2 - 27)] \Rightarrow t_2 = 827°\text{ C or }1100\text{ K}$

17. (*a*) $v_d = \frac{e}{m} \times \frac{V}{l}\tau$ or $v_d = \frac{e}{m}.\frac{El}{l}\tau$ (Since $v = El$)

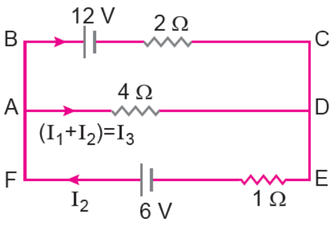
$\therefore v_d \propto E$

18. (*b*) As length increases n time area decreases by n times so

$$R = \frac{\rho l}{A}, \quad R' = \frac{\rho l'}{A'} = \frac{\rho nl}{\frac{A}{n}}$$

$$R' = n^2\frac{\rho l}{A} = n^2 R \quad R' = n^2 R$$

19. (*c*) In loop *ABCDA*



$$-12 + 2I_1 + 4(I_1 + I_2) = 0$$

$$6I_1 + 4I_2 = 12$$

$$3I_1 + 2I_2 = 6 \quad ...(i)$$

In loop *FADEF*

$$-4(I_1 + I_2) - I_2 + 6 = 0$$

$$4I_1 + 5I_2 = 6 \quad ...(ii)$$

Solving (*i*) and (*ii*) $\quad I_1 = \frac{18}{7}\text{A}, I_2 = \frac{-6}{7}\text{A}$

So, $\quad I_3 = I_1 + I_2$

$$= \frac{18}{7} - \frac{6}{7} = \frac{12}{7}\text{A}$$

20. (*c*) CD because slope of this portion is negative.

21. (*d*) Specific resistance doesn't depend upon length and area.

23. (*d*) $R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2}$

$$R \propto \frac{1}{r^2} \propto \frac{1}{d^2}$$

$$\frac{R_1}{R_2} = \frac{d_2^2}{d_1^2}$$

$$\frac{8}{R_2} = \left(\frac{1}{0.5}\right)^2$$

$$R_2 = \frac{8}{4} = R_2 = 2\,\Omega$$

24. (*b*) $12\dfrac{\text{C}}{\text{min}} = \dfrac{12}{60}\dfrac{\text{C}}{\text{sec}} = 0.2\text{ A}$

25. (*c*) Resistivity depends on material only

27. (*d*) $P = \dfrac{V^2}{R}, \; R = \dfrac{(220)^2}{100}$

Now,

$$P' = \frac{V^2}{R} = \frac{(180)^2}{\frac{(220)^2}{(100)}} = \frac{180\times180\times100}{220\times220} = \frac{8100}{121} = 67\text{ W (approx)}$$

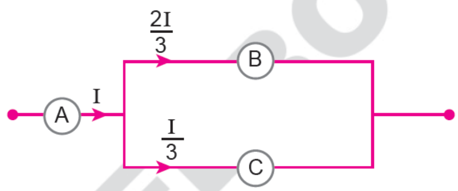
28. (*a*) In series current is same.

29. (*b*) $R = \dfrac{V^2}{P}$ (from rating)

$= \dfrac{(200)^2}{100}$

Now, $P' = \dfrac{V^2}{R} = \dfrac{(160)^2}{\frac{(200)^2}{100}} = \dfrac{160\times160\times100}{200\times200} = \dfrac{6400}{100} = 64\text{ W}$

30. (*c*) The current following in the different branches of circuit is shown in figure.



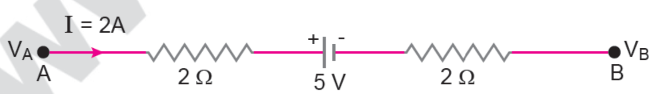
$V_A = IR$

$V_B = \dfrac{2I}{3}\times\dfrac{3R}{2} = IR$

$V_C = \dfrac{I}{3}\times 3R = IR$

Hence, $V_A = V_B = V_C$

31. (*d*)



$V_{AB} = V_A - V_B = 2\times2 + 5 + 2\times2$

$= 4 + 5 + 4 = 13\text{ V}$

33. (*c*) As in parallel p.d. is same

34. (*a*) $r = R\left(\dfrac{E-V}{V}\right) = 5\left(\dfrac{3.6-3}{3}\right) = 1\,\Omega$

36. (*b*) Suppose two cells have emfs ε_1 and ε_2 (also $\varepsilon_1 > \varepsilon_2$).

Potential difference per unit length of the potentiometer wire = k (say)

When ε_1 and ε_2 are in series and support each other then

$\varepsilon_1 + \varepsilon_2 = 50\times k$ ...(*i*)

When ε_1 and ε_2 are in opposite direction

$$\varepsilon_1 - \varepsilon_2 = 10 \times k$$

On adding eqn. (*i*) and eqn. (*ii*)

$$2\varepsilon_1 = 60k \Rightarrow \varepsilon_1 = 30k \text{ and } \varepsilon_2 = 50k - 30k = 20k$$

$$\therefore \quad \frac{\varepsilon_1}{\varepsilon_2} = \frac{30k}{20k} = \frac{3}{2}$$

37. (*d*) $V_{eff} = \dfrac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$

$$= \frac{18 \times 1 + 12 \times 2}{2+1} = \frac{42}{3} = 14 \text{ V}$$

38. (*b*) As according to maximum power theorem

$$R = r$$

internal resistance = external load

39. (*c*) For the full length of wire, total drop required $= \dfrac{1\,\text{mV}}{1\,\text{cm}} \times 100\,\text{cm} = 100\,\text{mV}$

$$I = \frac{100}{3}\text{mA} = \frac{1}{30}\text{A}$$

$$V = 2 \text{ V}$$

$$R = \frac{V}{I} = \frac{2}{\frac{1}{30}} = 60\,\Omega$$

Now required resistance = 60 – 3 = 57 Ω

40. (*d*) $V = \varepsilon - ir$

$iR = \varepsilon - ir$

$0.2 \times 10 = 2.1 - 0.2r$

$r = \dfrac{0.1}{0.2} = 0.5\,\Omega$

41. (*a*) For same mass if a wire is stretched, $R \propto l^2$

$$\frac{\Delta R}{R} = \frac{2\Delta l}{l} = 2 \times 0.1\% = 0.2\%$$

42. (*c*) $Q = \dfrac{V^2}{R}t = \dfrac{V^2}{(\rho l / A)}t \propto \dfrac{1}{\rho}$

43. (*c*) In series, the combined power P is given by

$$P = \frac{P_1 P_2}{P_1 + P_2} = \frac{100 \times 100}{100 + 100} = 50 \text{ W}$$

44. (*a*) In parallel, $P = P_1 + P_2 = 100 + 100 = 200$ W

45. (*b*) $H = I^2 Rt = ms\Delta t$

$$\Rightarrow \frac{I_1^2}{I_2^2} = \frac{\Delta T_1}{\Delta T_2} \quad \Rightarrow \Delta T_2 = \frac{I_2^2}{I_1^2}\Delta T_1$$

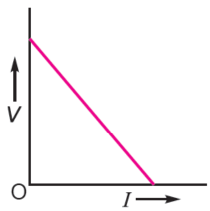
$$\Delta T_2 = \frac{(2I)^2}{I^2} \times 5 = 20°\text{ C}$$

46. (*a*) $V = \varepsilon - Ir$

Slope $\dfrac{dV}{dI} = -r$

When $I = 0$, $V = \varepsilon$,

$\therefore$ Intercept = ε



47. (*d*) Applying Kirchhoff's law in mesh *ABQPA*

$$-\varepsilon_1 + i_1 r_1 + (i_1 + i_2) R = 0$$

$$\Rightarrow \varepsilon_1 - (i_1 + i_2) R - i_1 r_1 = 0$$

48. (*c*) For same mass of mercury $R \propto \frac{1}{r^4}$

$$\therefore \quad R' = \left(\frac{r}{r'}\right)^4 R = 16R$$

49. (*b*) On cooling resistance of semiconductor Ge increases, so current $I = \frac{V}{R}$ decreases.

50. (*d*) $i = neAv_d$, for given i, $v_d \propto \frac{1}{A}$

So only current is same

51. (*b*) $I = \frac{dq}{dt} \Rightarrow q = \int_2^3 I dt = \int_2^3 (2t + 3t^2)\, dt$

$$= \left[\frac{2t^2}{2} + \frac{3t^3}{3}\right]_2^3 = [t^2 + t^3]_2^3$$

$$= [(3)^2 + (3)^3] - [(2)^2 + (2)^3] = 24 \text{ C}$$

52. (*c*) There is no current in capacitor branch. Current I in circuit *ABCD* (ignoring branch *EF*) is

$$I = \frac{2V - V}{R + 2R} = \frac{V}{3R}$$

p.d. across $AB = EF = V + IR = V + \frac{V}{3R}R = \frac{4}{3}V$

$$\therefore \quad V_E + V + V_C = V_F \Rightarrow V_C = \frac{4}{3}V - V = \frac{1}{3}V$$

53. (*a*) $\frac{X}{Y} = \frac{l}{100 - l} = \frac{20}{80} \Rightarrow \frac{X}{Y} = \frac{1}{4}$

$$\frac{4X}{Y} = \frac{l_1}{100 - l_1} \Rightarrow 4 \times \frac{1}{4} = \frac{l_1}{100 - l_1} \Rightarrow l_1 = 50 \text{ cm}$$

54. (*c*) Potential gradient, $k = \frac{V_{AB}}{L_{AB}} = \frac{E - ir}{100}$ V/ cm

EMF, $E = kl = \left(\frac{E - ir}{100}\right) \times 30 = \frac{30(E - 0.5\, i)}{100}$

55. (*a*) P.d. across $R = \frac{2}{I}$

$\therefore$ P.d. across 500 Ω = 12 – 2 = 10 V

$$I = \frac{10}{500} = \frac{1}{50} \text{ A}$$

$\therefore$ This is also current in R

$$R = \frac{2}{(1/50)} = 100\ \Omega$$

56. (*b*) $q = q_0 (1 - e^{-t/RC})$

$T = RC = 2.5 \times 10^6 \times 4 \times 10^{-6} = 10$ s

$$\therefore \quad V_C + V_R = 12 \Rightarrow V_C + \frac{V_C}{3} = 12 \Rightarrow V_C = 9 \text{ V}$$

From equation of growth of charge,

$$V_C = E(1 - e^{-t/T})$$

$$9 = 12(1 - e^{-t/10}) \Rightarrow e^{-t/10} = \frac{1}{4}$$

$$\Rightarrow t = 10 \times \log_e 4 = 10 \times 2 \times 0.693 = 13.86 \text{ s}$$

57. (*b*) $R = \frac{V^2}{P} = \frac{(100)^2}{500} = 20\,\Omega$

Current in bulb, $I = \frac{P}{V} = \frac{500}{100} = 5$ A

Resistance required for 200 V supply,

$$R' = \frac{V'}{I} = \frac{200}{5} = 40\,\Omega$$

Additional Resistance required = 40 – 20 = 20 Ω

58. (*c*) Mass of 1 litre of water = 1 kg

$$Pt = Jmc\,\Delta\theta \Rightarrow t = \frac{Jmc\,\Delta\theta}{P}$$

or $t = \frac{4.18 \times 10^3 \times 1 \times 1 \times 30}{836} = 150$ seconds

59. (*b*) $P = \frac{V^2}{R} \propto V^2 \Rightarrow \frac{P'}{P} = \left(\frac{V'}{V}\right)^2 = \left(\frac{115}{230}\right)^2 = \frac{1}{4}$

$P' = 25$ W

$W = P't = 25 \times 10 \times 60$ J $= 15 \times 10^3$ J = 15 kJ

60. (*b*) Resistance of fourth arm S = S_1 and S_2 connected in parallel = $\frac{S_1 S_2}{S_1 + S_2}$

$$\therefore \quad \frac{P}{Q} = \frac{R}{S} \Rightarrow \frac{P}{Q} = \frac{R(S_1 + S_2)}{S_1 S_2}$$

61. (*c*) $\frac{(v_d)_1}{(v_d)_2} = \left(\frac{i_1}{i_2}\right)\left(\frac{n_2}{n_1}\right) = \left(\frac{7}{4}\right) \times \left(\frac{5}{7}\right) = \frac{5}{4}$

62. (*d*) $R_1 = R_0(1 + \alpha_1 \theta)$ and $R_2 = R_0(1 + \alpha_2 \theta)$

In series combination $R_S = R_1 + R_2$

$$R_{os}(1 + \alpha_s \theta) = R_o(1 + \alpha_1 \theta) + R_o(1 + \alpha_2 \theta)$$

$$R_{os} = 2R_o$$

$$\therefore \; 2R_o(1 + \alpha_s \theta) = 2R_o\left[1 + \left(\frac{\alpha_1 + \alpha_2}{2}\right)\theta\right]$$

$$\therefore \alpha_s = \frac{\alpha_1 + \alpha_2}{2}$$

Similarly,

$$R_{op}\left(1 + \alpha_p \theta\right) = \frac{R_o\left(1 + \alpha_1 \theta\right) . R_0(1 + \alpha_2 \theta)}{R_o\left(1 + \alpha_1 \theta\right) + R_0(1 + \alpha_2 \theta)}$$

Solving for α_p and neglecting $(\alpha_1 + \alpha_2)^2$,

we get $\alpha_p = \frac{\alpha_1 + \alpha_2}{2}$

63. (*c*) no current flows in the potentiometer wire at balance.

73. (*c*) $R = \frac{\rho L}{A} = \frac{L}{\sigma A}$

$R \propto \frac{1}{\sigma}$

74. (*d*) $P = \frac{V^2}{R}$

when heater is connected across a source of voltage $\frac{V}{2}$, then power consumed

$$P' = \frac{(V/2)^2}{R} = \frac{1}{4}\frac{V^2}{R} = \frac{P}{4}$$

75. (*b*) Mobility, $\mu = \frac{v_d}{E}$

$$\frac{\text{m}/s}{\text{V/m}} = \text{m}^2\,\text{V}^{-1}\,\text{s}^{-1}$$

76. (*b*) $V = IR = E - Ir$

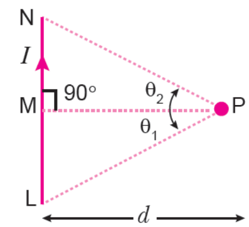
04 MOVING CHARGES AND MAGNETISM

IMPORTANT FORMULAE

1. **Biot–Savart Law:** Magnetic field due to a current element

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\,\vec{dl}\times\vec{r}}{r^3}$$

2. **Magnetic field due to a straight current carrying wire,**



$$B = \frac{\mu_0 I}{4\pi R}(\sin\theta_1 + \sin\theta_2)$$

where q_1 and q_2 are the angles substended by ends of the conductor at the reference point with the normal. For infinitely long wire $B = \frac{\mu_0 I}{2\pi R}$

3. **Magnetic field due to a current carrying circular coil**

(*i*) At centre $B_c = \frac{\mu_0 NI}{2R}$

(*ii*) At a point on the axis $B_{axis} = \frac{\mu_0 NIa^2}{2(a^2+x^2)^{3/2}}$ (where a = radius of coil) and x is the distance of the point)

4. **Ampere's circuital law:** $\int \vec{B}.\vec{dl} = \mu_0 I$

5. **Magnetic field strength within solenoid**

$B = \mu_0\, nI$ where n = number of turns per metre length.

6. **Magnetic field due to toroid**

(*i*) Within the coils $B = \frac{\mu_0 NI}{2\pi r}$

(*ii*) Outside the toroid $B = 0$.

7. **Magnetic force on a moving charge in a magnetic field**

$$\vec{F}_m = q\,\vec{v}\times\vec{B}$$

8. **Magnetic force on a current carrying conductor**

$$\vec{F}_m = I\,\vec{l}\times\vec{B}$$

9. **Force per unit length between parallel currents:**

$$\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi r}\,N/m$$

10. **Torque experienced by a current carrying loop in a uniform magnetic field**

$$\vec{\tau} = NI\,\vec{A}\times\vec{B} = \vec{M}\times\vec{B}$$

11. Magnetic moment of a current loop

$$\vec{M} = NI\vec{A} \text{ ampere} \times \text{metre}^2$$

12. Deflection in moving coil galvanometer

$$\phi = \frac{NAB}{C} I$$

Current sensitivity of a galvanometer $S = \frac{\theta}{I} = \frac{NAB}{C}$

13. For conversion of galvanometer into ammeter,

Shunt resistance required $S = \frac{I_g}{I - I_g} G \approx \frac{I_g}{I} G$

14. For conversion of galvanomter into voltmeter,

Series resistance required $R = \frac{V}{I_g} - G$

MULTIPLE CHOICE QUESTIONS

Choose and write the correct option in the following questions.

1. If a conducting wire carries a direct current through it, the magnetic field associated with the current will be __________ .

(*a*) both inside and outside the conductor
(*b*) neither inside nor outside the conductor
(*c*) only outside the conductor
(*d*) only inside the conductor

2. A compass needle is placed above a straight conducting wire. If current passes through the conducting wire from South to North. Then the deflection of the compass __________ .

(*a*) is towards West
(*b*) is towards East
(*c*) keeps oscillating in East-West direction
(*d*) no deflection

3. When a charged particle moving with velocity $\vec{v}$ is subjected to a magnetic field of induction $\vec{B}$, the force on it is non-zero.

This implies that

(*a*) angle between is either zero or 180°
(*b*) angle between is necessarily 90°
(*c*) angle between can have any value other than 90°
(*d*) angle between can have any value other than zero and 180°

4. Consider the following two statements about the Oersted's experiment.

Statement P: The magnetic field due to a straight current carrying conductor is in the form of circular loops around it.

Statement Q: The magnetic field due to a current carrying conductor is weak at near points from the conductor, compared to the far points.

(*a*) Both P and Q are true
(*b*) Both P and Q are false
(*c*) P is true, but Q is false
(*d*) P is false, but Q is true

5. Consider the following statements about the representation of the magnetic field

Statement P: The magnetic field emerging out of the plane of the paper is denoted by a dot (⊙).

Statement Q: The magnetic field going into the plane of the paper is denoted by a cross (⊗).

(*a*) Both P and Q are true
(*b*) P is true, but Q is false
(*c*) P is false, but Q is true
(*d*) Both P and Q are false

6. Two charged particles traverse identical helical paths in a completely opposite sense in a uniform magnetic field $B = B_0\hat{k}$. *[NCERT Exemplar]*

(*a*) They have equal z-components of momenta

(*b*) They must have equal charges

(*c*) They necessarily represent a particle, anti-particle pair

(*d*) The charge to mass ratio satisfy: $\left(\frac{e}{m}\right)_1 + \left(\frac{e}{m}\right)_2 = 0$

7. Biot-Savart law indicates that the moving electrons (velocity v) produce a magnetic field B such that *[NCERT Exemplar]*

(*a*) B is perpendicular to v

(*b*) B is parallel to v

(*c*) it obeys inverse cube law

(*d*) it is along the line joining the electron and point of observation

8. An electron is projected with uniform velocity along the axis of a current carrying long solenoid. Which of the following is true? *[NCERT Exemplar]*

(*a*) The electron will be accelerated along the axis

(*b*) The electron path will be circular about the axis

(*c*) The electron will experience a force at 45° to the axis and hence execute a helical path

(*d*) The electron will continue to move with uniform velocity along the axis of the solenoid

9. A micro-ammeter has a resistance of 100 Ω and a full scale range of 50 μA. It can be used as a higher range ammeter or voltmeter provided resistance is added to it. Pick the correct range and resistance combinations.

(*a*) 50 V range and 10 kΩ resistance in series

(*b*) 10 V range and 200 kΩ resistance in series

(*c*) 5 mA range with 1 Ω resistance in parallel

(*d*) Both (*b*) and (*c*)

10. A current carrying circular loop of radius R is placed in the x-y plane with centre at the origin. Half of the loop with $x > 0$ is now bent so that it now lies in the y-z plane. *[NCERT Exemplar]*

(*a*) The magnitude of magnetic moment now diminishes.

(*b*) The magnetic moment does not change.

(*c*) The magnitude of B at $(0,0,z)$, $z >> R$ increases.

(*d*) The magnitude of B at $(0,0,z)$, $z >> R$ is unchanged.

11. A current carrying loop is placed in a uniform magnetic field. The torque acting on it does not depend upon the

(*a*) shape of the loop (*b*) area of the loop

(*c*) value of current (*d*) magnetic field

12. A circular coil of 50 turns and radius 7 cm is placed in a uniform magnetic field of 4 T normal to the plane of the coil. If the current in the coil is 6 A then total torque acting on the coil is

(*a*) 14.78 Nm (*b*) 0 (*c*) 7.39 Nm (*d*) 3.69 Nm

13. The gyro-magnetic ratio of an electron in an H-atom, according to Bohr model, is

(*a*) independent of which orbit it is in (*b*) negative

(*c*) positive (*d*) both (*a*) and (*b*)

14. The sensitivity of a moving coil galvanometer increases with the decrease in:

(*a*) number of turns (*b*) area of coil

(*c*) magnetic field (*d*) torsional rigidity

15. A voltmeter of range 2V and resistance 300 Ω cannot be converted to an ammeter of range:

(*a*) 5 mA (*b*) 8 mA (*c*) 1 A (*d*) 10 A

16. In an ammeter 4% of the mains current is passing through galvanometer. If the galvanometer is shunted with a 5 Ω resistance, then resistance of galvanometer will be

(*a*) 116 Ω (*b*) 117 Ω (*c*) 118 Ω (*d*) 120 Ω

17. The SI unit of magnetic flux density is

(*a*) weber (*b*) tesla (*c*) maxwell (*d*) gauss

18. Newton meter per ampere is the unit of

(*a*) magnetic induction (*b*) magnetic susceptibility

(*c*) magnetic permeability (*d*) magnetic flux

19. A moving electron enters normally into a uniform magnetic field; its

(*a*) direction of motion will change (*b*) speed will increase

(*c*) speed will decrease (*d*) velocity will remain the same

20. In a magnetic field acting along x-axis, a conductor carries a current along the y-axis. The force experienced by the conductor is along

(*a*) the +ve z-axis (*b*) the –ve z-axis

(*c*) the –ve x-axis (*d*) the –ve y-axis

21. For conversion of a galvanometer into an ammeter, one should use

(*a*) a high resistance in series (*b*) a high resistance in parallel

(*c*) a low resistance in series (*d*) a low resistance in parallel

22. The time rate of work done by a magnetic field on a charged particle moving on a helical path is

(*a*) qB (*b*) qB/v^2 (*c*) qBv^2 (*d*) zero

23. In a certain region of space, electric field $\vec{E}$ and magnetic field $\vec{B}$ are perpendicular to each other. An electron enters perpendicularly to both the fields and moves undeflected. The velocity of electron is

(*a*) $\frac{\vec{B}}{\vec{E}}$ (*b*) $\vec{E} \times \vec{B}$ (*c*) $\vec{E} \cdot \vec{B}$ (*d*) $\frac{\vec{E}}{\vec{B}}$

24. A deuteron of kinetic energy 50 keV is describing a circular orbit of radius 0.5 m in a plane perpendicular to the magnetic field $\vec{B}$. The kinetic energy of the proton that describes a circular orbit of same radius and inside same $\vec{B}$ is

(*a*) 25 keV (*b*) 100 keV (*c*) 200 keV (*d*) 50 keV

25. Current sensitivity of a galvanometer can be increased by decreasing

(*a*) torsional constant K (*b*) area A

(*c*) magnetic field B (*d*) number of turns N

26. An electric current passes through a long straight copper wire. At a distance 5 cm from the straight wire, the magnetic field is B. The magnetic field at 20 cm from the straight wire would be

(*a*) $\frac{B}{2}$ (*b*) $\frac{B}{6}$ (*c*) $\frac{B}{4}$ (*d*) $\frac{B}{3}$

27. A wire in the form of a circular loop, of one turn carrying a current, produces magnetic induction B at the centre. If the same wire is looped into a coil of two turns and carries the same current, the new value of magnetic induction at the centre is

(*a*) $4B$ (*b*) $2B$ (*c*) B (*d*) $8B$

28. A circular coil of radius a carries an electric current. The magnetic field due the coil at a point on the axis of the coil located at a distance r from centre of the coil, such that $r >> a$ varies

(a) $\frac{1}{r^{3/2}}$ (b) $\frac{1}{r^3}$ (c) $\frac{1}{r^2}$ (d) $\frac{1}{r}$

29. A solenoid has 1000 turns per metre length. If a current of 5 A is flowing through it, then magnetic field inside the solenoid is

(a) $2\pi \times 10^{-3}$ T (b) $4\pi \times 10^{-5}$ T (c) $2\pi \times 10^{-5}$ T (d) $4\pi \times 10^{-3}$ T

30. If distance between two current- carrying wires is doubled, then force between them is

(a) halved (b) doubled (c) tripled (d) quadrupled

31. The coil of a moving coil galvanometer is wound over a metal frame in order to

(a) increase moment of inertia
(b) provide electromagnetic damping
(c) reduce hysteresis
(d) increase sensitivity

32. If in a moving coil galvanometer, a current I in its coil produces a deflection θ, then

(a) $I \propto \tan\theta$ (b) $I \propto \theta^2$ (c) $I \propto \sqrt{\theta}$ (d) $I \propto \theta$

33. The ratio of voltage sensitivity (V_S) and current sensitivity (I_S) of a moving coil galvanometer is

(a) $\frac{1}{G}$ (b) G (c) G^2 (d) $\frac{1}{G^2}$

34. Two thin, long and parallel wires separated by a distance 'd' carry a current 'i' ampere each. The magnitude of the force per unit length exerted by one wire on the other is

(a) $\frac{\mu_0 i^2}{2\pi d}$ (b) $\frac{\mu_0 i}{2\pi d}$ (c) $\frac{\mu_0 i^2}{2\pi d^2}$ (d) $\frac{\mu_0 i}{2\pi d^2}$

35. Two parallel wires carrying current in the same direction attract each other due to

(a) magnetic force
(b) electric force
(c) mutual induction
(d) electromagnetic emf

36. A strong magnetic field is applied to a proton at rest. Then

(a) the particle moves in opposite direction of the applied field.
(b) the particle moves in the direction of the applied field.
(c) the particle continues to be at rest (consider the proton as a charged particle only).
(d) the particle executes circular motion in magnetic field.

37. A charge of +5 mC enters a uniform magnetic field parallel to the direction of the field. What will happen to the motion of the charge?

(a) It will move undedicated.
(b) It will perform circular motion in a plane parallel to the field.
(c) It will perform circular motion in a plane perpendicular to the field.
(d) It will continue to move in the field direction with acceleration.

38. Which one decides the direction of magnetic lines of force due to a straight wire carrying current?

(a) Right hand thumb rule
(b) Fleming's left hand rule
(c) Ampere's rule
(d) Fleming's right hand rule

39. A small bar magnet held vertically is allowed to fall from a height through a metal ring of radius 0.1m. The acceleration of the magnet shall be

(a) greater than g
(b) equal to g
(c) zero
(d) less than g

40. The expression for magnetic force per unit charge $\vec{F}_m$, when a charge q moves with a velocity $\vec{v}$ in a magnetic field $\vec{B}$ is given by

(*a*) $\vec{F}_m = (\vec{v}.\vec{B})$ (*b*) $\vec{F}_m = (\vec{v} \times \vec{B})$ (*c*) $\vec{F}_m = \frac{1}{q}(\vec{v} \times \vec{B})$ (*d*) $\vec{F}_m = q(\vec{v} \times \vec{B})$

41. The force between two parallel current carrying conductors separated by a distance x is F. If the current in each conductor is doubled and the distance between them is halved, then the force between them becomes

(*a*) F (*b*) $8F$ (*c*) $4F$ (*d*) $2F$

42. Time period of a charged particle undergoing a circular motion in a uniform magnetic field is independent of

(*a*) speed of the particle (*b*) mass of the particle

(*c*) charge of the particle (*d*) magnetic field

43. A current loop in a magnetic field

(*a*) can be in equilibrium in two orientations, both the equilibrium states are unstable.

(*b*) can be in equilibrium in two orientations, one stable while the other is unstable.

(*c*) experiences a torque whether the field is uniform or non uniform in all orientations.

(*d*) can be in equilibrium in one orientation.

44. Two circular coils 1 and 2 are made from the same wire but the radius of the first coil is twice that of the second coil. What ratio of the potential difference (in volt) should be applied across them, so that the magnetic field at their centres is the same?

(*a*) 2 (*b*) 3 (*c*) 4 (*d*) 6

45. A square current carrying loop is suspended in a uniform magnetic field acting in the plane of the loop. If the force on one arm of the loop is $\vec{F}$, the net force on the remaining three arms of the loop is

(*a*) $-\vec{F}$ (*b*) $-3\vec{F}$ (*c*) $\vec{F}$ (*d*) $3\vec{F}$

46. A particle of mass m, charge Q and kinetic energy J enters a transverse uniform magnetic field of induction B. After 3 seconds, the kinetic energy of the particles will be:

(*a*) 3J (*b*) 2J (*c*) J (*d*) 4J

47. A galvanometer has a coil of resistance 100 Ω and gives a full scale deflection for a current of 30 mA. If it is to work as a voltmeter of 30 V range, the resistance required to be added will be

(*a*) 500 Ω (*b*) 900 Ω (*c*) 1000 Ω (*d*) 1800 Ω

48. When a charged particle moving with velocity $\vec{v}$ is subjected to a magnetic field of induction $\vec{B}$, the force on it is non-zero. This implies that

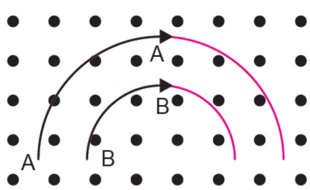
(*a*) angle between $\vec{v}$ and $\vec{B}$ can have any value other than zero and 180°

(*b*) angle between $\vec{v}$ and $\vec{B}$ is either zero or 180°

(*c*) angle between $\vec{v}$ and $\vec{B}$ is necessarily 90°

(*d*) angle between $\vec{v}$ and $\vec{B}$ can have any value other than 90°

49. Two particles and of masses m_A and m_B respectively and having the same charge are moving in a plane. A uniform magnetic field exists perpendicular to this plane. The speeds of particles are v_A and v_B respectively and trajectories are shown in figure. Then



(*a*) $m_A v_A < m_B v_B$ (*b*) $m_A v_A > m_B v_B$

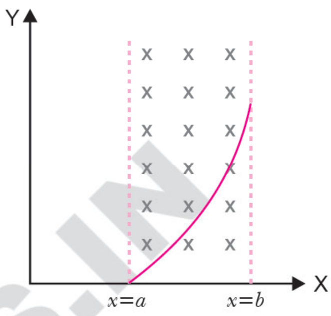
(*c*) $m_A < m_B$ and $v_A v_B$ (*d*) $m_A = m_B, v_A = v_B$

50. A coil having *N*-turns is wound tightly in the form of a spiral with inner and outer radii '*a*' and '*b*' respectively. When the current '*I*' passes through the coil, the magnetic field at the centre is

(*a*) $\frac{\mu_0 NI}{b}$ (*b*) $\frac{\mu_0 NI}{a}$

(*c*) $\frac{\mu_0 NI}{2(b-a)}\log_e\frac{b}{a}$ (*d*) $\frac{\mu_0 NI}{b-a}\log_e\frac{b}{a}$

51. A particle of mass *m* and charge *q* moves with a constant velocity *v* along positive *X*-axis. It enters a region containing a uniform magnetic field *B* directed along the negative *Z*-axis, extending from $x = a$ to $x = b$. The minimum value of *v* required so that the particle can just enter the region $x > b$ is



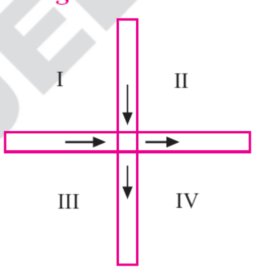
(*a*) $\frac{qbB}{M}$ (*b*) $\frac{q(b-a)B}{m}$

(*c*) $\frac{qaB}{m}$ (*d*) $\frac{q(b+a)B}{2m}$

52. A proton of mass 1.67×10^{-27} kg and charge 1.6×10^{-19} C is projected with a speed of 2×10^6 m/s at an angle 60° with *x*-axis. If a uniform magnetic field of 0.104 T is applied along *y*-axis, the path of the proton is:

(*a*) a circle of radius 0·1 m and time period $2\pi \times 10^{-7}$ s
(*b*) a circle of radius 0·2 m and time period 15×10^{-7} s
(*c*) a helix of radius 0·1 m and time period $2\pi \times 10^{-7}$ s
(*d*) a helix of radius 0·2 m and time period $4\pi \times 10^{-7}$ s

53. Two thin metallic strips carrying currents in the direction shown, cross each other perpendicularly without touching but being close to each other, as shown in fig. The regions which contain some point of zero magnetic induction are:



(*a*) I and II (*b*) I and III (*c*) II and III (*d*) I and IV

54. Two particles having masses in the ratio 1: 1 and charge 1: 2 are projected into a uniform magnetic field perpendicular to field with speeds in the ratio 2: 3. The ratio of the radii of circular path along which the two particles move is

(*a*) 4: 3 (*b*) 2: 3 (*c*) 3: 1 (*d*) 1: 4

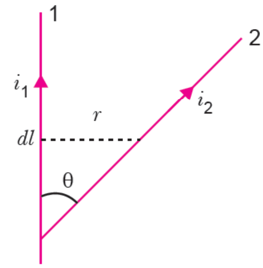
55. A long wire carries a steady current. It is bent into a circle of one turn and the magnetic field at the centre of the coil is *B*. It is then bent into a circular loop of *n*-turns. The magnetic field at the centre of the coil will now be

(*a*) nB (*b*) n^2B (*c*) $2nB$ (*d*) $2n^2$

56. Two long conductors separated by a distance '*d*' carry currents I_1 and I_2 in the same direction and exert force *F* on each other. Now the current in one of them is increased two times and its direction is reversed. The distance is also increased to 3*d*. The new value of the force between them is

(*a*) $-2F$ (*b*) $\frac{F}{3}$ (*c*) $-\frac{2F}{3}$ (*d*) $-\frac{F}{3}$

57. **Wires 1 and 2 carrying currents i_1 and i_2 respectively are inclined at an angle θ to each other. What is the attractive force on a small element *dl* of wire 2 at a distance *r* from wire 1 (as shown in fig.) due to magnetic field of wire 1.**



(*a*) $\dfrac{\mu_0 i_1 i_2 dl \tan\theta}{2\pi r}$ (*b*) $\dfrac{\mu_0 i_1 i_2 dl \sin\theta}{2\pi r}$

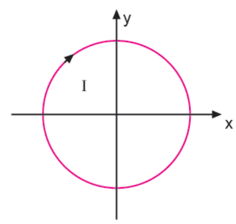
(*c*) $\dfrac{\mu_0 i_1 i_2 dl \cos\theta}{2\pi r}$ (*d*) $\dfrac{\mu_0 i_1 i_2 dl \sin\theta}{4\pi r}$

58. **A long straight wire along *z*-axis carries a current '*i*' in the negative *z*-direction. The magnetic vector field $\vec{B}$ at a point having coordinates (*x*, *y*) on *z* = 0 plane is**

(*a*) $\dfrac{\mu_0 i (y\hat{i} - x\hat{j})}{2\pi(x^2+y^2)}$ (*b*) $\dfrac{\mu_0 i (x\hat{i} + y\hat{j})}{2\pi(x^2+y^2)}$

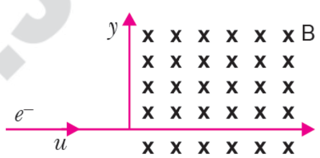
(*c*) $\dfrac{\mu_0 i (x\hat{j} - y\hat{i})}{2\pi(x^2+y^2)}$ (*d*) $\dfrac{\mu_0 i (x\hat{i} - y\hat{j})}{2\pi(x^2+y^2)}$

59. **A conducting loop carrying current *I* is placed in a uniform magnetic field pointing into the plane of the paper as shown in fig. The loop will have a tendency to**



(*a*) contract
(*b*) expand
(*c*) move towards positive *x*-axis
(*d*) move towards negative *x*-axis

60. **A uniform magnetic field $B = -B_{oz}$ exists in the region $x > 0$. An electron with velocity *u* travels along the positive *x*-axis. When the electron emerges out of the field, its *y*-component and velocity *v* will be**



(*a*) $y > 0,\ v > u$ (*b*) $y < 0,\ v > u$

(*c*) $y < 0,\ v = u$ (*d*) $y > 0,\ v = u$

61. **Two particles each of mass *m* and charge *q* are attached to the two ends of a light rod of length 2*R*. The rod is rotated at a constant angular speed about a perpendicular axis passing through its centre. The ratio of the magnitude of the magnetic moment of the system and its angular momentum about the centre of the rod is**

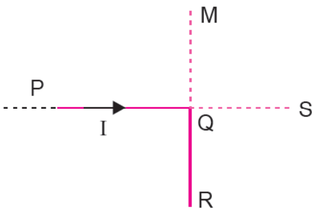
(*a*) $\dfrac{q}{2m}$ (*b*) $\dfrac{q}{m}$ (*c*) $\dfrac{2q}{m}$ (*d*) $\dfrac{q}{\pi m}$

62. **Two concentric coils each of radius equal to 2π cm are placed at right angles to each other. Currents of 3 A and 4 A are flowing in the coils respectively. The magnetic induction in Wb/m² at the centre of the coils will be ($\mu_0 = 4\pi \times 10^{-7}$ Wb/A–m)**

(*a*) 10^{-5} (*b*) 12×10^{-5}

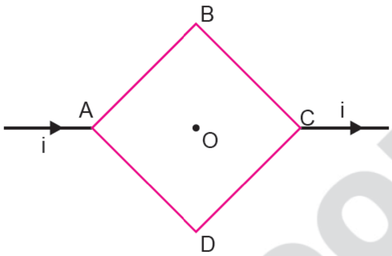
(*c*) 7×10^{-5} (*d*) 5×10^{-5}

63. An infinitely long conductor *PQR* is bent to form a right angle as shown in fig. A current *I* flows through *PQR*. The magnetic field due to this current at *M* is B_1 Now another infinitely long straight conductor *QS* is connected at *Q*, so that current is $\frac{1}{2}$ in *QR* as well as in *QS*, the current in *PQ* remaining unchanged. The magnetic field at *M* is now B_2. The ratio $\frac{B_1}{B_2}$ is



(*a*) $\frac{1}{2}$ (*b*) 1 (*c*) $\frac{2}{3}$ (*d*) 2

64. A square loop *ABCD* of each side is formed of wire *ABC* of resistance *r* and *ADC* of resistance 2*r*. The magnetic field *B* at the centre *O* of the loop is



(*a*) 0 (*b*) $\frac{\sqrt{2}\mu_0 i}{6\pi a}$ (*c*) $\frac{\sqrt{2}\mu_0 i}{3\pi a}$ (*d*) $\frac{2\sqrt{2}\mu_0 i}{3\pi a}$

65. A moving coil galvanometer has 150 equal divisions. Its current sensitivity is 10 divisions per mA and voltage sensitivity is 2 divisions per mV. In order that each division reads 1 volt, the resistance in ohm needed to be connected in series with the coil will be

(*a*) 105 Ω (*b*) 103 Ω (*c*) 9995 Ω (*d*) 99995 Ω

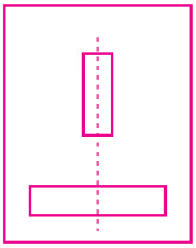
66. A galvanometer has a resistance 100 Ω and it requires current 100 μA for full scale deflection. A resistor 0.1 Ω is connected to make it ammeter. The smallest current in the circuit to produce full scale deflection is

(*a*) 1000·1 mA (*b*) 1·1 mA (*c*) 10·1 mA (*d*) 100·1 mA

67. Two small magnets, each of magnetic moment of 10 A–m^2 are placed in end on position 0·1 m apart from their centres. The force acting between them is

(*a*) $0{\cdot}6 \times 10^7$ N (*b*) 6×10^7 N (*c*) 0·6 N (*d*) 0·06 N

68. Two short magnets are placed on a piece of cork which floats on water. The magnets are so placed that the axis of one produced bisects the axis of the other at right angles. Then the cork



(*a*) rotates only

(*b*) moves along a straight line only

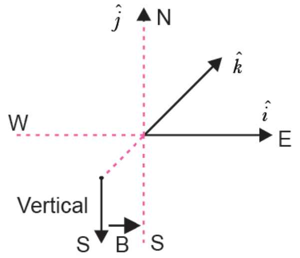
(*c*) has rotational as well as translational motion

(*d*) has neither translational nor rotational motion

69. A long solenoid has 200 turns per cm and carries a current i. The magnetic field at its centre is $6{\cdot}28 \times 10^{-2}$ Wb/m^2. Another long solenoid has 100 turns per cm and it carries a current of $\frac{i}{3}$. The value of the magnetic field at its centre is

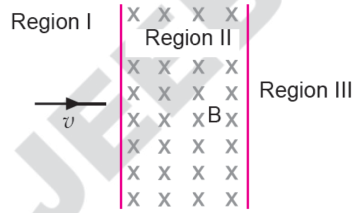
(*a*) $1{\cdot}05 \times 10^{-2}$ Wb / m^2
(*b*) $1{\cdot}05 \times 10^{-5}$ Wb / m^2
(*c*) $1{\cdot}05 \times 10^{-3}$ Wb / m^2
(*d*) $1{\cdot}05 \times 10^{-4}$ Wb / m^2

70. A horizontal overhead power line is at a height of 4 m from the ground and carries a current of 100 A from east to west. The magnetic field directly below it on the ground is ($\mu_0 = 4\pi \times 10^{-7}$ Tm A^{-1})



(*a*) 5×10^{-6} T southward
(*b*) $2{\cdot}5 \times 10^{-7}$ T northward
(*c*) $2{\cdot}5 \times 10^{-7}$ T southward
(*d*) 5×10^{-6} T northward

71. A particle of mass m and charge q, moving with velocity v enters region II normal to boundary as shown in fig. Region II has a uniform magnetic field B, perpendicular to the plane of the paper. The length of the region II is l. Then which of the following is incorrect.



(*a*) The particle enters region III only if its velocity is $v > \frac{qlB}{m}$.

(*b*) The particle enters region III only if $v < \frac{qlB}{m}$.

(*c*) Path length of particle in region II is maximum when velocity $v = \frac{qlB}{m}$.

(*d*) Time spent in region II is same for any velocity v as long as the particle returns to region I.

72. A charged particle with charge q enters a region of constant uniform and mutually orthogonal fields $\vec{E}$ and $\vec{B}$ with velocity $\vec{v}$ perpendicular to both $\vec{E}$ and $\vec{B}$ and comes out without any change in magnitude or direction of $\vec{v}$. Then

(*a*) $\vec{v} = \frac{\vec{B} \times \vec{E}}{E^2}$
(*b*) $\vec{v} = \frac{\vec{E} \times \vec{B}}{E^2}$
(*c*) $\vec{v} = \frac{\vec{B} \times \vec{E}}{E^2}$
(*d*) $\vec{v} = \frac{\vec{E} \times \vec{B}}{B^2}$

73. A charged particle moves through a magnetic field perpendicular to its direction. Then

(*a*) both momentum and kinetic energy of the particles are not constant
(*b*) both momentum and kinetic energy of the particles are constant

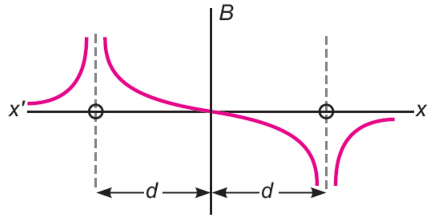
(*c*) kinetic energy changes but momentum remains constant

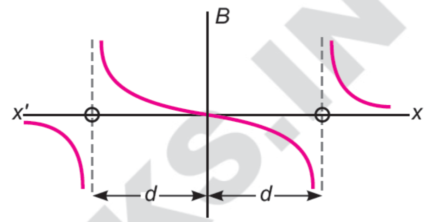
(*d*) momentum changes but kinetic energy remains constant

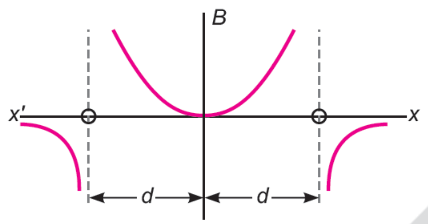
74. A long straight wire of radius *a* carries a steady current *i*. The current is uniformly distributed over its cross-section. The ratio of the magnetic field at $\frac{a}{2}$ and $2a$ is

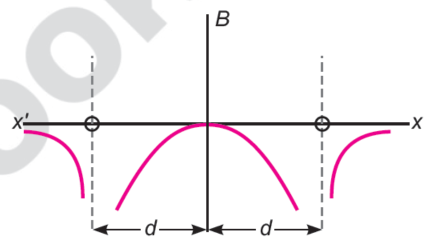
(*a*) 4 (*b*) 1 (*c*) $\frac{1}{2}$ (*d*) $\frac{1}{4}$

75. Two long parallel wires are at a distance 2*d* apart. They carry steady currents flowing out of the plane of paper as shown. The variation of the magnetic field B along the line X'X is given by

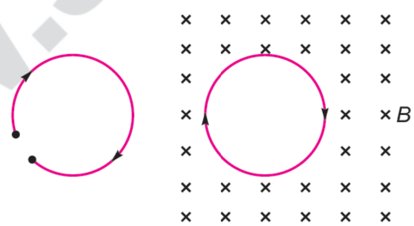
(*a*)


(*b*)


(*c*)


(*d*)


76. A thin flexible wire of length *L* is connected to two adjacent fixed points and carries a current *I* in the clockwise direction as shown in Fig. When the system is put in a uniform magnetic field of strength *B* going into the plane of the paper, the wire takes the shape of a circle. The tension in the wire is



(*a*) *IBL* (*b*) *IBL*/π (*c*) $\frac{IBL}{2\pi}$ (*d*) $\frac{IBL}{4\pi}$

77. A moving charge produces

(*a*) electric and magnetic fields both (*b*) electric field only

(*c*) magnetic field only (*d*) neither electric nor magnetic field

78. A proton charge (+*e* coulomb) enters in a magnetic field of strength *B* (tesla) perpendicular to the magnetic lines of force, with speed *v*. The force on the proton is

(*a*) *evB* (*b*) zero (*c*) ∞ (*d*) *evB*/2

79. A proton charge (+*e* coulomb) enters in a magnetic field of strength *B* tesla making an angle 30° with the direction of magnetic field with speed *v*. The magnetic force on the proton is

(*a*) *evB* (*b*) zero (*c*) ∞ (*d*) *evB*/2

80. A charged particle enters in a magnetic field perpendicular to the magnetic lines of force. The path of the particle is

(*a*) straight line (*b*) circular

(*c*) elliptical (*d*) spiral

81. A charged particle enters at 30° to the magnetic field. Its path becomes

(*a*) circular (*b*) helical

(*c*) elliptical (*d*) straight line

82. A current carrying wire produces

(*a*) only electric field (*b*) only magnetic field

(*c*) both electric and magnetic fields (*d*) no field

83. Two parallel wires carrying currents in the same direction attract each other because of

(*a*) potential difference between them (*b*) mutual inductance between them

(*c*) electric forces between them (*d*) magnetic forces between them

84. A uniform electric field and a uniform magnetic field are produced, pointed in the same direction in a certain region. An electron is projected with its velocity pointed in the same direction

(*a*) the electron will turn to its left

(*b*) the electron will turn to its right

(*c*) the electron velocity will increase in magnitude

(*d*) the electron velocity will decrease in magnitude

85. A conducting circular loop of radius r carries a constant current i. It is placed in a uniform magnetic field B such that B is perpendicular to the plane of loop. The magnetic force acting on the loop is

(*a*) Bir (*b*) $2\pi irB$

(*c*) 0 (*d*) μirB

86. When a straight conductor is carrying an electric current

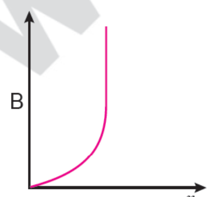
(*a*) there are circular magnetic lines of force around it.

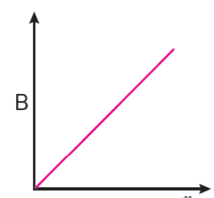
(*b*) there are no magnetic lines of force near it.

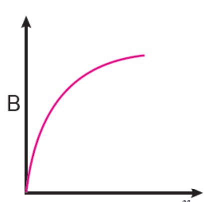
(*c*) there are magnetic lines of force parallel to conductor along the direction of current.

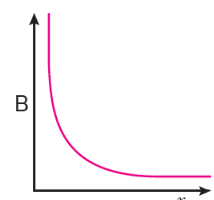
(*d*) there are magnetic lines of force parallel to conductor opposite to the direction of current.

87. Which of the following correctly represents the variation of magnetic flux density B with distance r of a long straight wire carrying a steady current?

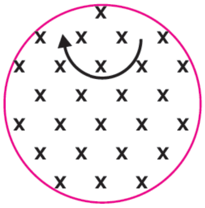
(*a*)


(*b*)


(*c*)


(*d*)


88. There is a magnetic field acting in a plane downward perpendicular to sheet of paper (Fig.). Particles in vacuum move in the plane of paper from left to right. The path indicated by an arrow could be travelled by



(*a*) proton
(*b*) neutron
(*c*) electron
(*d*) α-particle

89. A stream of electrons is projected horizontally to the right. A straight conductor carrying a current is supported parallel to electron stream and above it. If the current in the conductor is from left to right, then what will be the effect on electron stream?

(*a*) The electron stream will be speeded up towards the right.
(*b*) The electron stream will be retarded.
(*c*) The electron stream will be pulled upward.
(*d*) The electron stream will be pulled downward.

90. The Lorentz force experienced by a charged particle of charge q, moving with velocity $\vec{v}$ in a magnetic field $\vec{B}$ is given by

(*a*) $\vec{F} = q(\vec{v} \cdot \vec{B})$
(*b*) $\vec{F} = q(\vec{v} \times \vec{B})$
(*c*) $\vec{F} = q(\vec{B} \times \vec{v})$
(*d*) $\vec{F} = \vec{v} \times \vec{B} / q$

91. The force on a charged particle in a magnetic field is maximum when the angle between the direction of motion and the magnetic field is

(*a*) 0°
(*b*) 90°
(*c*) 45°
(*d*) 180°

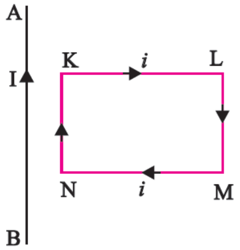
92. Two magnetic lines of force

(*a*) intersect at the neutral point
(*b*) intersect near north or south poles
(*c*) cannot intersect at all
(*d*) depend on the position of the magnet.

93. The radius of the path of a charged particle moving in a magnetic field is proportional to

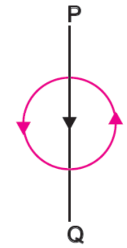
(*a*) mass
(*b*) charge
(*c*) energy
(*d*) momentum of the particle

94. A rectangular loop carrying a current i is situated near a long straight wire such that the wire is parallel to one of the sides of the loop and is in the plane of the loop. If a steady current I is established in the wire, as shown in fig., the loop will



(*a*) rotate about an axis parallel to the wire
(*b*) move away from the wire
(*c*) move towards the wire
(*d*) remain stationary

95. In the adjoining figure, *PQ* is a long current-carrying wire which is placed near a current-carrying coil. The direction of the force acting on *PQ* will be:



(*a*) parallel to *PQ* towards *P*

(*b*) parallel to *PQ* towards *Q*

(*c*) perpendicular to *PQ* towards right

(*d*) perpendicular to *PQ* towards left

96. Two thin, long, parallel wires separated by a distance *b* are carrying a current *i* each in the same direction. The force per unit length exerted by one wire on the other is

(*a*) $\frac{\mu_0 i^2}{2\pi b^2}$ N/m (repulsive)

(*b*) $\frac{\mu_0}{2\pi b} i^2$ N/m (attractive)

(*c*) $\frac{\mu_0 i}{2\pi b^2}$ N/m (repulsive)

(*d*) $\frac{\mu_0 i^2}{2\pi b^2}$ N/m (attractive)

97. A charge moves with velocity $\vec{v}$ in a region where electric field $\vec{E}$ and magnetic field $\vec{B}$ both exist. The force on the particle is

(*a*) $q(\vec{v} \times \vec{B})$

(*b*) $q\vec{E} + q(\vec{v} \times \vec{B})$

(*c*) $q\vec{E} + q(\vec{B} \times \vec{r})$

(*d*) $q\vec{E} + q(\vec{E} \times \vec{v})$

98. The magnetic force acting on a charged particle of charge –2μC moving with velocity $(2\hat{i} + 3\hat{j}) \times 10^6$ ms^{-1} in a magnetic field of 2 T directed in *y*-direction is

(*a*) 4 N in *z*-direction

(*b*) 8 N in *y*-direction

(*c*) 8 N in *z*-direction

(*d*) 8 N in negative *z*-direction

99. The magnetic field is made radial in a galvanometer

(*a*) to make field stronger

(*b*) to make field weaker

(*c*) to make scale linear

(*d*) to reduce its resistance

100. The magnetic dipole moment of a current carrying coil does not depend upon [*CBSE 2020 (55/1/1)*]

(*a*) number of turns of the coil.

(*b*) cross-sectional area of the coil.

(c) current flowing in the coil.

(*d*) material of the turns of the coil.

101. An electron is released from rest in a region of uniform electric and magnetic fields acting parallel to each other. The electron will [*CBSE 2020 (55/2/1)*]

(*a*) move in a straight line.

(*b*) move in a circle.

(*c*) remain stationary.

(*d*) move in a helical path.

102. A straight current carrying conductor is placed inside a uniform magnetic field. The force per unit length acting on the conductor is [*CBSE 2020 (55/2/3)*]

(*a*) maximum when the conductor is perpendicular to the direction of magnetic field.

(*b*) maximum when the conductor is along the direction of magnetic field.

(*c*) minimum when the conductor is perpendicular to the direction of magnetic field.

(*d*) minimum when the conductor makes an angle of 45° with the direction of magnetic field.

103. A region has a uniform magnetic field in it. A proton enters into the region with velocity making an angle of 45° with the direction of the magnetic field. In this region the proton will move on a path having the shape of a [*CBSE 2020 (55/3/1)*]

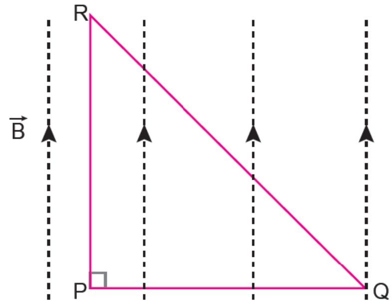
(*a*) straight line

(*b*) circle

(*c*) spiral

(*d*) helix

104. **An isosceles right angled current carrying loop *PQR* is placed in a uniform magnetic field $\vec{B}$ pointing along *PR*. If the magnetic force acting on the arm *PQ* is *F*, then the magnetic force which acts on the arm *QR* will be** [*CBSE 2020 (55/3/1)*]

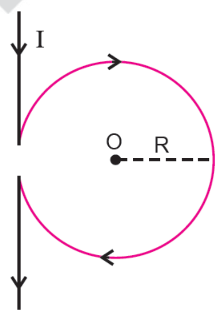


(*a*) F (*b*) $\frac{F}{\sqrt{2}}$ (*c*) $\sqrt{2}F$ (*d*) $-F$

105. **A current *I* flows through a long straight conductor which is bent into circular loop of radius *R* in the middle as shown in the figure.**

The magnitude of the net magnetic field at point O will be

[*CBSE 2020 (55/4/1)*]



(*a*) zero (*b*) $\frac{\mu_0 I}{2R}(1+\pi)$

(*c*) $\frac{\mu_0 I}{4\pi R}$ (*d*) $\frac{\mu_0 I}{2R}\left(1-\frac{1}{\pi}\right)$

106. **A current of 10 A is flowing from east to west in a long straight wire kept on a horizontal table. The magnetic field developed at a distance of 10 cm due north on the table is:**

[*CBSE 2020 (55/4/1)*]

(*a*) 2×10^{-5} T, acting downwards (*b*) 2×10^{-5} T, acting upwards

(*c*) 4×10^{-5} T, acting downwards (*d*) 4×10^{-5} T, acting upwards

107. **An electron and a proton are moving along the same direction with the same kinetic energy. They enter a uniform magnetic field acting perpendicular to their velocities. The dependence of radius of their paths on their masses is:** [*CBSE 2020 (55/4/2)*]

(*a*) $r \propto m$ (*b*) $r \propto \sqrt{m}$ (*c*) $r \propto \frac{1}{m}$ (*d*) $r \propto \frac{1}{\sqrt{m}}$

108. **A charge particle after being accelerated through a potential difference '*V*' enters in a uniform magnetic field and moves in a circle of radius *r*. If *V* is doubled, the radius of the circle will become** [*CBSE 2020 (55/5/1)*]

(*a*) $2r$ (*b*) $\sqrt{2}r$ (*c*) $4r$ (*d*) $r/\sqrt{2}$

Answers

1. (*c*)	**2.** (*a*)	**3.** (*d*)	**4.** (*c*)	**5.** (*a*)	**7.** (*d*)	**7.** (*a*)	**8.** (*d*)
9. (*d*)	**10.** (*a*)	**11.** (*a*)	**12.** (*b*)	**13.** (*d*)	**14.** (*d*)	**15.** (*a*)	**16.** (*d*)
17. (*b*)	**18.** (*d*)	**19.** (*a*)	**20.** (*b*)	**21.** (*d*)	**22.** (*d*)	**23.** (*d*)	**24.** (*b*)
25. (*a*)	**26.** (*c*)	**27.** (*a*)	**28.** (*b*)	**29.** (*a*)	**30.** (*a*)	**31.** (*b*)	**32.** (*d*)
33. (*a*)	**34.** (*a*)	**35.** (*a*)	**36.** (*c*)	**37.** (*a*)	**38.** (*a*)	**39.** (*d*)	**40.** (*b*)
41. (*b*)	**42.** (*a*)	**43.** (*b*)	**44.** (*c*)	**45.** (*a*)	**46.** (*c*)	**47.** (*b*)	**48.** (*a*)
49. (*b*)	**50.** (*c*)	**51.** (*b*)	**52.** (*c*)	**53.** (*d*)	**54.** (*a*)	**55.** (*b*)	**56.** (*c*)
57. (*c*)	**58.** (*a*)	**59.** (*b*)	**60.** (*c*)	**61.** (*a*)	**62.** (*d*)	**63.** (*c*)	**64.** (*c*)

65. (*c*)	**66.** (*d*)	**67.** (*c*)	**68.** (*d*)	**69.** (*a*)	**70.** (*a*)	**71.** (*b*)	**72.** (*d*)
73. (*d*)	**74.** (*b*)	**75.** (*b*)	**76.** (*c*)	**77.** (*a*)	**78.** (*a*)	**79.** (*d*)	**80.** (*b*)
81. (*b*)	**82.** (*b*)	**83.** (*d*)	**84.** (*d*)	**85.** (*c*)	**86.** (*a*)	**87.** (*d*)	**88.** (*c*)
89. (*b*)	**90.** (*b*)	**91.** (*b*)	**92.** (*c*)	**93.** (*d*)	**94.** (*c*)	**95.** (*d*)	**96.** (*b*)
97. (*b*)	**98.** (*d*)	**99.** (*c*)	**100.** (*d*)	**101.** (*a*)	**102.** (*a*)	**103.** (*d*)	**104.** (*d*)
105. (*d*)	**106.** (*a*)	**107.** (*b*)	**108.** (*b*)				

CASE-BASED QUESTIONS

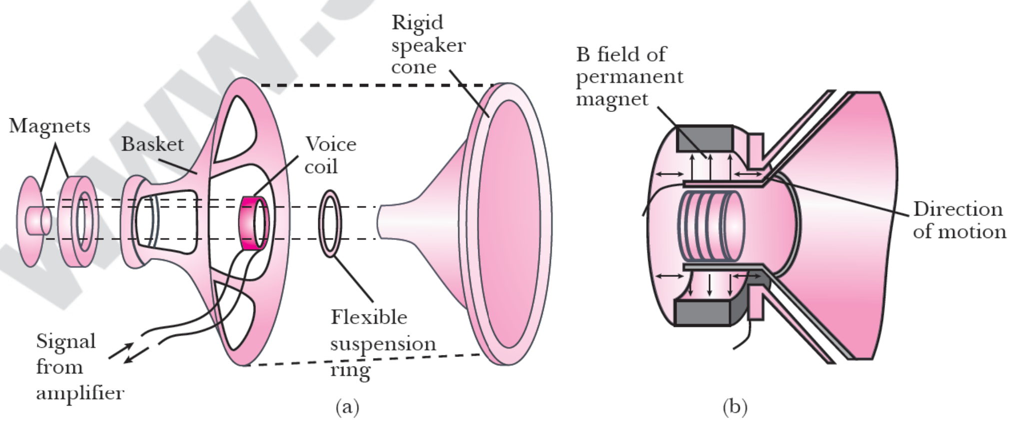
Attempt any 4 sub-parts from each question. Each question carries 1 mark.

1. LOUDSPEAKERS:

A common application of the magnetic force on a current carrying wire is found in loudspeakers. The magnetic field created by the permanent magnet exerts a force on the voice coil that is proportional to the current in the coil; the direction of the force is either to the left or to the right, depending on the direction of the current. The signal coming from the amplifier causes the current to oscillate in direction and magnitude. The coil and the speaker cone to which it is attached respond by oscillating with an amplitude proportional to the amplitude of the current in the coil. Turning up the volume knob on the amplifier increases the current amplitude and hence the amplitudes of the cone's oscillation and of the sound wave produced by the moving cone.

The force is always perpendicular to both the conductor and the field, with the direction determined by the same right-hand rule we used for a moving positive charge. Hence, this force can be expressed as a vector product, just like the force on a single moving charge. We represent the segment of wire with a vector $\vec{l}$ along the wire in the direction of the current, then force $\vec{F}$ on this segment is

$$\vec{F} = I\vec{l} \times \vec{B} \quad (i.e., \text{ magnetic force on a straight wire segment})$$



(*i*) Loudspeaker works on the principle of

(*a*) detector
(*b*) generator
(*c*) amplifier
(*d*) motor

(*ii*) Electrodynamic speaker can handle which type of audio power relative to permanent magnet type speaker?

(*a*) Lower
(*b*) Equal
(*c*) Higher
(*d*) Both (*a*) and (*b*)

(*iii*) To increase the power handling capacity in loudspeakers which type of magnet is used?

(*a*) Temporary magnet (*b*) Permanent magnet

(*c*) Electromagnet (*d*) None of these

(*iv*) A horizontal wire 0.1 m long carries a current of 5 A. Find the magnitude and direction of the magnetic field, which can balance the weight of wire. Given the mass of the wire is 3×10^{-3} kg/m and g = 10 m/s^2.

(*a*) 6×10^{-3} T, acting horizontally perpendicular to wire

(*b*) 6×10^{-3} T, acting vertically upwards

(*c*) 6×10^{-2} T, acting vertically downwards

(*d*) 6×10^{-2} T, acting horizontally perpendicular to wire

(*v*) A square current carrying loop is suspended in a uniform magnetic field acting in the plane of the loop. If the force on one arm of the loop is $\vec{F}$, the net force on the remaining three arms of the loop is

(*a*) $\vec{F}$ (*b*) $-\vec{F}$

(*c*) $3\vec{F}$ (*d*) $-3\vec{F}$

Answers

1. (*i*) (*d*); A common application of the magnetic force on a current carrying wire is found in loudspeakers as similar case in motor in which current carrying coil experience force in presence of magnetic field.

(*ii*) (*c*); It is a type of higher audio power relative to permanent magnet type speaker.

(*iii*) (*c*); The electromagnet is used to increase the power handling capacity in loudspeakers.

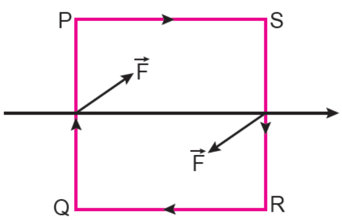
(*iv*) (*a*); Here, mass of wire, $m = 0.1 \times (3 \times 10^{-3})$ kg

In equilibrium position, $F = IlB = mg$

$$\Rightarrow \qquad B = \frac{mg}{Il} = \frac{(0.1 \times 3 \times 10^{-3}) \times 10}{5 \times 0.1} = 6 \times 10^{-3}\ \text{T}$$

The weight is wire be supported by force F if it acts vertically upwards. It will be so if the direction of $\vec{B}$ is horizontal and perpendicular to wire carrying current.

(*v*) (*b*); As clear from figure, force on arm PS and arm RQ is zero. If $\vec{F}$ is force on arm RS, the force on arm PQ is $-\vec{F}$. Therefore, net force on the remaining three arms of the loop $= -\vec{F}$.

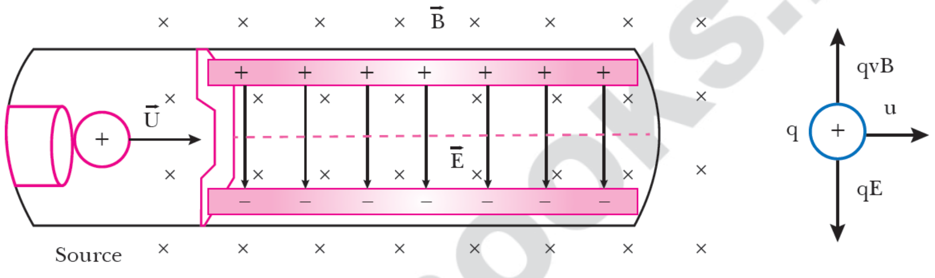


2. VELOCITY SELECTOR:

In a beam of charged particles produced by a heated cathode or a radioactive material, not all particles move with the same speed. Particles of a specific speed can be selected from the beam using an arrangement of electric and magnetic fields called a velocity selector. A charged particle with mass m, charge q and speed v enters a region of space where the electric and magnetic fields are perpendicular to the particle's velocity and to each other. The electric field $\vec{E}$ is vertically downward and the magnetic field $\vec{B}$ is into the plane. If q is positive, the electric force is downward with magnitude qE, and the magnetic force is upward with magnitude qvB. For given field magnitude E and B, for a particular value of v the electric and magnetic force will be equal in magnitude the total force is then zero, and the particles travels in a straight line with constant velocity. For zero total force, $\Sigma Fy = 0$, we need $-qE + qvB = 0$. Solving for the speed v for which there is no deflection, we find

$$v = \frac{E}{B}$$

Only particles with speeds equal to $\frac{E}{B}$ can pass through without being deflected by the fields. By adjusting E and B appropriately, we can select particles having a particular speed for use in other experiments. Because q divides out, a velocity selector for positively charged particles also works for electrons or other negatively charged particles. Therefore, from the above discussion, a velocity selector is a region in which there is a uniform electric field and uniform magnetic field. The fields are perpendicular to one another, and perpendicular to the initial velocity of the charged particles that are passing through the region.



(a) (b)

(i) An electron is projected with uniform velocity along the axis of a current carrying long solenoid. Which of the following is true?

(a) The electron will continue to move with uniform velocity along the axis of the solenoid.
(b) The electron will experience a force at 45° to the axis and hence execute a helical path.
(c) The electron path will be circular about the axis.
(d) The electron will be accelerated along the axis.

(ii) A cubical region of space is filled with some uniform electric and magnetic fields. An electron enters the cube across one of its faces with velocity v and a positron enters via opposite face with velocity $-v$. At this instant

(a) the motion of the centre of mass (CM) is determined by B alone.
(b) both particles gain or loose energy at the same rate.
(c) the magnetic forces on both the particles cause equal accelerations.
(d) all of the above

(iii) A charged particle would continue to move with a constant velocity in velocity selector, where in

(a) $E \neq 0, B \neq 0$ (b) $E = 0, B \neq 0$
(c) both (a) and (b) (d) none of these

(iv) A charged particle goes undeflected in a region of velocity selector containing electric and magnetic field. It is possible that

(a) $\vec{E}$ is not parallel to $\vec{B}$ and $\vec{v}$ (b) $\vec{E} \parallel \vec{B}, \vec{v} \parallel \vec{E}$
(c) $\vec{v} \parallel \vec{B}$ but $\vec{E}$ is not parallel to $\vec{E}$ (d) $\vec{E} \parallel \vec{B}$ but $\vec{v}$ is not parallel to $\vec{E}$

(*v*) **A charged particle with charge q enters a region of constant, uniform and mutually orthogonal field $E = 50\ NC^{-1}$ and magnetic field, $B = 2.5 \times 10^{-5}$ weber m^{-1} with a velocity v perpendicular to both E and B. It comes out without any change in velocity with a magnitude of**

(*a*) 0.5×10^6 m/s
(*b*) 10^6 m/s
(*c*) 2×10^6 m/s
(*d*) 2.5×10^6 m/s

Answers

2. (*i*) (*a*); The Lorentz force acting on a charged particle in a magnetic and electric field is $\vec{F} = q[\vec{E} + \vec{v} \times \vec{B}]$. As there is no E, force due to electric field is zero and force due to B is perpendicular to the direction of v and B which will be perpendicular to the direction of motion (v), so, will not affect the velocity of moving charge particle.

(*ii*) (*a*); As $F = q(\vec{v} \times \vec{B})$, *i.e.*, F is perpendicular to velocity and magnetic field, so particle revolves perpendicular to both $\vec{B}$ and $\vec{v}$ with uniform speed. But magnitude of acceleration by magnetic field is equal as magnitude of charge, $\vec{v}, \vec{E}$ and $\vec{B}$ are constant. So, it gain or loose the energy at the same rate. There is no change in centre of mass of particle therefore the motion of centre of mass is determined by B alone.

(*iii*) (*c*); When a single moving charge is placed with some uniform electric and magnetic fields in space, then they experience a force called Lorentz force given by $F_{net} = qE + q(v \times B)$.

Force experienced by charged particle = due to electric field, $F_e = qE$

Force experienced by charged particle due to magnetic field, $F_m = q\ (v \times B)$

The particle is moving with constant velocity that means acceleration of particle is zero and also it is not changing its direction of motion. This will happen when the net force is zero *i.e.*,

(*a*) If $E = 0$, and $v \parallel B$, then $F_{net} = 0$

(*b*) If $E \neq 0$, and $B \neq 0$, and E, v and B are mutually perpendicular.

(*iv*) (*b*); A charged particle will go undeflected in an electric field if the direction of force on particle due to electric field only acts in the direction of motion of the particle *i.e.*, the charged particle moves parallel to the electric field. A moving charged particle cannot be deflected while passing through a region if the force on it due to electric field is equal and opposite to the force due to magnetic field. It will be so if magnetic field is perpendicular to electric field and is perpendicular to the direction of motion of charged particle.

(*v*) (*c*); When charged particle goes undeflected then,

$$qE = qvB \Rightarrow v = \frac{E}{B}$$

$$\therefore v = \frac{50\ NC^{-1}}{2.5 \times 10^{-5}} = 2 \times 10^6\ m/s$$

$$\therefore v = 2 \times 10^6\ m/s$$

ASSERTION-REASON QUESTIONS

In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct answer out of the following choices.

(a) *Both A and R are true and R is the correct explanation of A.*
(b) *Both A and R are true but R is not the correct explanation of A.*
(c) *A is true but R is false.*
(d) *A is false and R is also false.*

1. Assertion (A) : Motion of electron around a positively charged nucleus is different from the motion of a planet around the sun.
Reason (R) : The force acting in both the cases is same in nature.

2. Assertion (A) : When a magnetic dipole is placed in a non uniform magnetic field, only a torque acts on the dipole.
Reason (R) : Force would not act on dipole if magnetic field were non uniform.

3. Assertion (A) : Magnetic field lines always form closed loops.
Reason (R) : Moving charges or currents produce a magnetic field.

4. Assertion (A) : Galvanometer cannot as such be used as an ammeter to measure the value of the current in a given circuit.
Reason (R) : It gives a full-scale deflection for a current of the order of micro ampere.

5. Assertion (A) : Magnetic lines of force form continuous closed loops whereas electric lines of force do not.
Reason (R) : Magnetic poles always occur in pairs as north pole and south pole.

6. Assertion (A) : Magnetic field is caused by current element.
Reason (R) : Magnetic field due to a current element $I\,\vec{dl}$ is $\vec{dB} = \frac{\mu_0}{4\pi}\frac{I\vec{dl}\times\vec{r}}{r^3}$

7. Assertion (A) : A charge, whether stationary or in motion produces a magnetic field around it. *[AIIMS 2009]*
Reason (R) : Moving charges produce only electric field in the surrounding space.

8. Assertion (A) : If a proton and an α-particle enter a uniform magnetic field perpendicularly with the same speed, the time period of revolution of α-particle is double that of proton. *[AIIMS 2010]*
Reason (R) : In a magnetic field, the period of revolution of a charged particle is directly proportional to the mass of the particle and is inversely proportional to charge of particle.

9. Assertion (A) : The resistance of an ideal voltmeter should be infinite. *[AIIMS 2011]*
Reason (R) : The lower resistance of voltmeter gives a reading lower than the actual potential difference across the terminals.

10. Assertion (A) : Magnetic field cannot change kinetic energy of a moving charge. *[AIIMS 2018]*
Reason (R) : Magnetic field cannot change velocity vector.

Answers

1. (*d*) **2.** (*d*) **3.** (*b*) **4.** (*a*) **5.** (*a*) **6.** (*b*) **7.** (*d*) **8.** (*a*)
9. (*a*) **10.** (*c*)

HINTS/SOLUTIONS OF SELECTED MCQs

1. (*c*) $B_{in} = O, B_{out} = \dfrac{\mu_0 I}{2\pi r}$, where r = radius of cross-section loop

2. (*a*) According to right hand thumb rule, magnetic field produced along East to West.

3. (*d*) $\vec{F} = q\vec{V} \times \vec{B} \Rightarrow F = qVB\sin\theta$

For $F \neq 0$, θ lies between 0 to 180°.

4. (*c*) P is true and the magnetic field due to a current carrying wire is strong at near points from the conductor as compared to the far points.

6. (*d*) For given pitch d, $d = \dfrac{2\pi mv\cos\theta}{qB}$

So, charge by mass ratio, $\dfrac{q}{m} = \dfrac{2\pi v\cos\theta}{dB}$

Now, change partially traverse identical helical path in a completely opposite direction in a magnetic field B. Two particles should be same and of opposite sign, therefore,

$i.e., \left(\dfrac{e}{m}\right)_1 + \left(\dfrac{e}{m}\right)_2 = 0$

7. (*a*) In Biot-Savart's law, magnetic field B parallel to $i\vec{dl} \times \vec{r}$ and $i\,dl$ due to flow of electron is in opposite direction of v and by direction of vector product of two vectors, $\vec{B} \perp \vec{v}$

8. (*d*) Magnetic Lorontz force, electron is projected with uniform velocity along the axis of a current carrying long solenoid $F = -eVB\sin 180° = 0$ and also ($\theta = 0°$), as $\vec{B} \,||\, \vec{v}$. The electron will continue to move with uniform velocity along the axis of the solenoid.

9. (*d*) $R_{total} = R + r = \dfrac{v}{i}$ and $s = \dfrac{G}{\dfrac{i}{i_g} - 1}$

By checking the option (*b*) and (*c*), has satisfied their range.

(*b*); $R = \dfrac{v}{i} = \dfrac{10}{50 \times 10^{-6}} \simeq 200\text{ k}\Omega$

(*c*); $S = \dfrac{100}{\dfrac{i}{50\times 10^{-6}} - 1} \Rightarrow 1 = \dfrac{100}{\dfrac{i}{50\times 10^{-6}} - 1} \Rightarrow i \simeq 5\text{ mA}$

10. (*a*) The magnetic moment of circular loop and the net magnitudes of moment of each semi-circular loop of radius R lie in x-y plane and y-z plane.

So, $M_{net} = \sqrt{M'^2 + M'^2} = \sqrt{2}M' = \sqrt{2}\ IA' = \sqrt{2}I(\pi r^2)/4$

where, $M = I(\pi r^2)$, so, $M_{net} < M$.

11. (*a*) $\tau = MB\sin\theta = NIAB\sin\theta$.

Hence, τ acting on it does not depend upon shape of the loop.

12. (*b*) $\tau = MB\sin\theta = NIAB\sin 0° = 0$, as ($\theta = 0°$)

13. (*d*) The gyro-magnetic ratio of an electron in H-atom is negative and independent of orbit which electron revolves around it.

14. (*d*) Sensitivity, $S = \dfrac{NBa}{K}$, where K = torsional rigidity

Hence, S increases when K is decreases.

15. (*a*) $I_g = \frac{2}{300} = \frac{2}{300} \times 1000\,\text{mA} = \frac{20}{3}\text{mA} = 6.67\text{ mA}$

As range of ammeter cannot be decreased but increased only. So the instrument cannot be converted to measure the range 5 mA.

16. (*d*) Shunt is a low resistance connected in parallel with the galvanometer or ammeter.

i.e., $S = \frac{I_g G}{I - Ig} \Rightarrow 5 = \frac{\left(\frac{4}{100}\right) IG}{I - \left(\frac{4}{100}\right) I} = \frac{4G}{96}$ $\left[\text{Where } I_g = 4\% \text{ of } I = \frac{4}{100} I\right]$

or $G = \frac{96 \times 5}{4} = 120\Omega$

21. (*d*) Shunting (a low resistance in parallel)

23. (*d*) $\vec{E} = c\vec{B}$

24. (*b*) $K = \frac{q^2 B^2 r^2}{2m} \Rightarrow K \propto \frac{1}{m} \Rightarrow K_2 = 100\,\text{keV}$

26. (*c*) $B = \frac{\mu_0 i}{2\pi r} \Rightarrow B \,\alpha\, \frac{1}{r} \Rightarrow \frac{B_1}{B_2} = \frac{r_2}{r_1} = \frac{20}{5}$

$\frac{B}{B_2} = 4 \quad \Rightarrow B_2 = \frac{B}{4}$

27. (*a*) $B = \frac{\mu_0 I}{2r}, B' = \frac{\mu_0 (2) I}{2(r/2)} = 4B$

29. (*a*) $B = \mu_0 nI = 4\pi \times 10^{-7} \times 5 \times 1000 = 2\pi \times 10^{-3}$ T

30. (*a*) $F_m = \frac{\mu_0 I_1 I_2 l}{2\pi d}, F_m \propto \frac{1}{d}$

31. (*b*) Arrangement provides electromagnetic damping due to production of eddy currents

33. (*a*) $V_s = \frac{I_s}{G} \Rightarrow \frac{V_s}{I_s} = \frac{1}{G}$

34. (*b*) We know that $\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi d} = \frac{\mu_0 i^2}{2\pi d}$, $[I_1 = I_2 = i]$

37. (*a*) As $\theta = 0° \Rightarrow F = qVB \sin\theta = 0$

39. (*d*) Less than g as $a_{\text{net}} = g - a$

41. (*b*) $F = \frac{\mu_0 i_1 i_2 l}{2\pi x}$

$F' = \frac{\mu_0 2i_1 . 2i_2 . l}{2\pi \frac{x}{2}} = 8F$

42. (*a*) $T = \frac{2\pi m}{qB}$

43. (*b*) $\theta = 0°$ & $180°$

44. (*c*) Let the radii of the two coils be $2a$ and a, then their resistances will be $2R$ and R respectively.

Given $B_1 = B_2$

or $\dfrac{\mu_0 I_1}{2\times 2a}=\dfrac{\mu_0 I_2}{2a}$

or $\dfrac{\mu_0}{4a}\cdot\dfrac{V_1}{2R}=\dfrac{\mu_0}{2a}\cdot\dfrac{V_2}{R}$

or $\dfrac{V_1}{V_2}=4$

45. (*a*) Net force on a square circular loop in a uniform magnetic field is zero.

$$\vec{F_1}+\vec{F_2}+\vec{F_3}+\vec{F_4}=0$$

$$\Rightarrow \vec{F_2}+\vec{F_3}+\vec{F_4}=\left(-\vec{F_1}\right)=-\vec{F}$$

46. (*c*) K.E. of charged particle remains unchanged in a uniform magnetic field.

47. (*b*) $I_g=\dfrac{V}{R+G}$

$$30\times 10^{-3}=\frac{30}{R+100}$$

$$R+100=1000$$

$$\Rightarrow \quad R=900\ \Omega$$

48. (*a*) For non-zero force $\sin\theta\neq 0$ or $\theta\neq 0°$ or $180°$

49. (*b*) $r=\dfrac{mv}{qB}\propto mv$; As $r_A>r_B \Rightarrow m_A v_A > m_B v_B$

50. (*c*) The spiral may be supposed to be formed of a number of thin charged rings.

Consider a ring of radius x and thickness dx then $dN=\left(\dfrac{N}{b-a}\right)dx$

$$\therefore\ dB=\frac{\mu_0 dNI}{2x}=\frac{\mu_0\left(\dfrac{N\,dx}{b-a}\right)I}{2x}$$

$$B=\int_a^b dB=\frac{\mu_0 NI}{2(b-a)}\int_a^b\frac{dx}{x}=\frac{\mu_0 NI}{2(b-a)}\log_e\frac{b}{a}$$

51. (*b*) For entering the particle in the region $x>b$, the radius of circular path $x\geq b-a$

or $\dfrac{mv}{qB}\geq(b-a) \quad\Rightarrow\quad v_{\min}=\dfrac{qB(b-a)}{m}$

52. (*c*) The path of particle is a helix of radius

$$r=\frac{mv\sin\theta}{qB},\quad T=\frac{2\pi m}{qB}$$

$$r=\frac{1.67\times10^{-27}\times2\times10^{6}\times\sqrt{3}}{1.6\times10^{-19}\times0.104\times2}=0.1\text{ m}$$

$$T=\frac{2\pi\times1.67\times10^{-27}}{1.6\times10^{-19}\times0.104}=2\pi\times10^{-7}\text{ s}$$

53. (*d*) In regions I and IV, the magnetic fields due to two currents are opposite.

54. (*a*) $r=\dfrac{mv}{qB}\Rightarrow\dfrac{r_1}{r_2}=\dfrac{m_1}{m_2}\cdot\dfrac{v_1}{v_2}\cdot\dfrac{q_2}{q_1}=1\times\left(\dfrac{2}{3}\right)\times\left(\dfrac{2}{1}\right)=\dfrac{4}{3}$

55. (*b*) Initially $B = \dfrac{\mu_0 I}{2r_1}$

If r_2 is new radius, then

$$2\pi r_1 = n.2\pi r_2 \;\Rightarrow\; r_2 = \frac{r_1}{n}$$

Finally, $B' = \dfrac{\mu_0 nI}{2r_2} = \dfrac{\mu_0 n^2 I}{2r_1} = n^2 B$

56. (*c*) $F = \dfrac{\mu_0 I_1 I_2}{2\pi d}$ N / m

Now $I_1' = -2I_1$ and $d' = 3d$

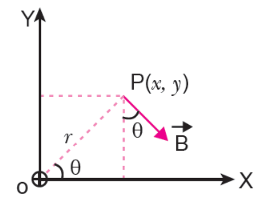
$$\therefore\; F' = \frac{\mu_0(-2I_1)I_2}{2\pi(3d)} = -\frac{2}{3}F$$

57. (*c*) Component of current element $i_2\,\vec{dl}$ parallel to wire.

$= i_2\, dl\cos\theta$

$$\therefore\; F\,(\text{attractive}) = \frac{\mu_0 i_1 i_2 dl\cos\theta}{2\pi r}$$

58. (*a*) The direction of magnetic field $\vec{B}$ is shown in fig.



$$\vec{B} = B\sin\theta\,\hat{i} - B\cos\theta\,\hat{j}$$

$$B = \frac{\mu_0 i}{2\pi r},\ \sin\theta = \frac{y}{r},\ \cos\theta = \frac{x}{r};$$

$$r = \sqrt{x^2 + y^2}$$

$$\therefore\; \vec{B} = \frac{\mu_0 i}{2\pi r}(\sin\theta\,\hat{i} - \cos\theta\,\hat{j})$$

$$= \frac{\mu_0 i}{2\pi r}\left[\frac{y}{r}\hat{i} - \frac{x}{r}\hat{j}\right] = \frac{\mu_0 i}{2\pi}\frac{(y\,\hat{i} - x\,\hat{j})}{x^2 + y^2}$$

59. (*b*) By Fleming left hand rule, magnetic force on any current element is directed radially outwards, so loop has tendency to expand.

60. (*c*) In a uniform magnetic field the velocity of charged particle remains unchanged.

Magnetic force on electron $(= q\,\vec{v} \times \vec{B})$

$$= -e(v\,\hat{i}) \times (-B\,\hat{k}) = -evB\,\hat{j}$$

As force is along negative y-axis, so y-coordinate will be $y < 0$ and $v = u$.

61. (*a*) Magnetic moment of system

$$M = IA = \left(\frac{q}{T} + \frac{q}{T}\right)\pi R^2 = \frac{2\pi}{T}qR^2 = \omega qR^2$$

Angular momentum about axis of rotation

$$L = I\omega = (mR^2 + mR^2)\,\omega = 2mR^2\omega$$

$$\frac{M}{L} = \frac{\omega qR^2}{2mR^2\omega} = \frac{q}{2m}$$

62. (*d*) $B = \sqrt{B_1^2 + B_2^2} = \sqrt{\left(\frac{\mu_0 I_1}{2r_1}\right)^2 + \left(\frac{\mu_0 I_2}{2r_2}\right)^2} = \frac{\mu_0}{2}\sqrt{\frac{I_1^2}{r_1^2} + \frac{I_2^2}{r_2^2}}$

$$= \frac{4\pi \times 10^{-7}}{2}\sqrt{\left(\frac{3}{2\pi \times 10^{-2}}\right)^2 + \left(\frac{4}{2\pi \times 10^{-2}}\right)^2}$$

$= 5 \times 10^{-5}$ Wb / m^2

63. (*c*) A point M, no magnetic field is caused due to QR.

$$B_1 = \frac{\mu_0 I}{4\pi d}, B_2 = \frac{\mu_0 I}{4\pi d} + \frac{\mu_0 (I/2)}{4\pi d} \Rightarrow \frac{B_1}{B_2} = \frac{2}{3}$$

64. (*c*) If i_1 and i_2 are currents in arms ABC and ADC respectively, then $\frac{i_1}{i_2} = \frac{2r}{r} = \frac{2}{1}$ and $i_1 + i_2 = i$.

$\therefore \ i_1 = \frac{2}{3}i$ and $i_2 = \frac{1}{3}i$

Magnetic field due to ABC,

$$B_1 = 2\left[\frac{\mu_0 i_1}{4\pi\left(\frac{a}{2}\right)}(\sin 45° + \sin 45°)\right]$$

$$= \frac{\sqrt{2}\mu_0 i_1}{\pi a} \text{ downward}$$

Magnetic field due to ADC,

$$B_2 = \frac{\sqrt{2}\mu_0 i_2}{\pi a}, \text{upward}$$

Net Magnetic field,

$$B = \frac{\sqrt{2}\mu_0}{\pi a}(i_1 - i_2) = \frac{\sqrt{2}\mu_0 (i/3)}{\pi a} = \frac{\sqrt{2}\mu_0 i}{3\pi a}$$

65. (*c*) $i_g = \frac{150}{10}$ mA = 15 mA,

$v_g = \frac{150}{2}$ mV = 75 mV

$V = 150 \times 1 = 150$ V

$$G = \frac{v_g}{i_g} = \frac{75 \text{ mA}}{15 \text{ mA}} = 5\,\Omega$$

Series resistance,

$$R = \frac{V}{i} - G = \frac{150}{15 \times 10^{-3}} - 5 = 9995\,\Omega$$

66. (*d*) $\frac{i_g}{i} = \frac{S}{S + G}$

$$\Rightarrow \ i = \frac{S + G}{S} i_g = \frac{(0 \cdot 1 + 100)}{0 \cdot 1} \times 100 \times 10^{-6} \text{ A}$$

$= 100.1$ mA

67. (*c*) Magnetic force between two magnets

$$F = \frac{\mu_0}{4\pi}\frac{6m_1 m_2}{r^4} = 0\cdot 6\text{ N}$$

68. (*d*) The internal interaction can not cause external motion

69. (*a*) For a solenoid

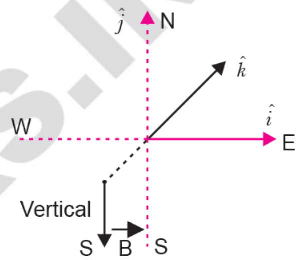
$$B = \mu_0 ni$$

$$\Rightarrow \quad \frac{B_2}{B_1} = \left(\frac{n_2}{n_1}\right)\left(\frac{i_2}{i_1}\right) \quad \therefore \; B_2 = \left(\frac{n_2}{n_1}\right)\left(\frac{i_2}{i_1}\right)B_1$$

$$= \left(\frac{100}{200}\right).\left(\frac{i/3}{i}\right)\times 6.28\times 10^{-2}$$

$$= \left(\frac{6\cdot 28\times 10^{-2}}{6}\right) = 1\cdot 05\times 10^{-2}\text{ Wb}/\text{m}^2$$

70. (*a*) $B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi\times 10^{-7}\times 100}{2\pi\times 4} = 5\times 10^{-6}\text{ T}$



Direction of $\vec{B}$

As $\vec{B} = \frac{\mu_0 I}{4\pi}\frac{\vec{dl}\times\vec{r}}{r^3}$

$\Rightarrow \quad \hat{B} = (-\hat{i}\times -\hat{k}) = -\hat{j}$ (or southward)

71. (*b*) $r = \frac{mv}{qB}$ For entry in region III, $r > l$

$\Rightarrow \quad \frac{mv}{qB} > l \;\Rightarrow\; v > \frac{qBl}{m}$ [Choice (*a*) is correct.]

Maximum path length in region II

$$L_{\max} = \pi r_{\max} = \pi l$$

It is the case for $v = \frac{qBl}{m}$ [Choice (*c*) is correct.]

The particle transverses half the circle, when it return to region I.

$$t = \frac{T}{2} = \frac{1}{2}\left(\frac{2\pi m}{qB}\right) = \frac{\pi m}{qB} \text{ (independent or } r)$$

[Choice (*d*) is correct.]

So, (*b*) is incorrect answer.

72. (*d*) $q\vec{E} + q\vec{v}\times\vec{B} = 0 \Rightarrow \vec{v}\times\vec{B} = -\vec{E}$

$$\vec{B}\times(\vec{v}\times\vec{B}) = -\vec{B}\times\vec{E}$$

or $(\vec{B}\cdot\vec{B})\vec{v} - (\vec{B}\cdot\vec{v})\vec{B} = \vec{E}\times\vec{B}$

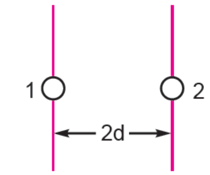
$\Rightarrow$ As $\vec{B}$ is perpendicular to $\vec{v}$; $\vec{B}\cdot\vec{v} = 0$

$$\therefore \quad \vec{v} = \frac{\vec{E}\times\vec{B}}{B^2}$$

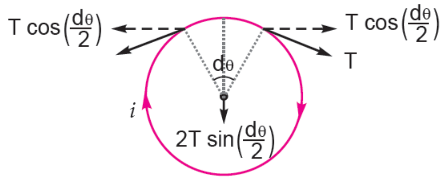
73. (*d*) Magnetic force changes the direction of particle, so momentum of particle changes.

74. (*b*) $B_1 = \frac{\mu_0 ix}{2\pi a^2} = \frac{\mu_0 i\left(\frac{a}{2}\right)}{2\pi a^2}$, $B_2 = \frac{\mu_0 i}{2\pi x} = \frac{\mu_0 i}{2\pi(2a)} = \frac{B_1}{B_2} = 1$

75. (*b*) By Maxwell right hand rule the magnetic field to the loop of wire '1' will be downward and to the right of wire '2' it is upward $\left(B \propto \frac{1}{r}\right)$. On the right of wire '1' it is upward and on the left of wire '2' it is downward. The field between the two wires at the centre is zero



76. (*c*)



$$2T\sin\left(\frac{d\theta}{2}\right) = BI(Rd\theta)$$

For small $d\theta$; $2T\left(\frac{d\theta}{2}\right) = BIRd\theta$

$\Rightarrow \quad T = BIR$

But $\quad R = \frac{L}{2\pi}$

$\therefore \quad T = \frac{BIL}{2\pi}$

78. (*a*) $F = q(\vec{v} \times \vec{B}) = qvB\sin\theta = e \times vB \times \sin 90° = evB$

79. (*d*) $F = qvB\sin\theta = evB\sin 30° = \frac{1}{2}evB$

80. (*b*) circular at 90°

81. (*a*) At any angle except 0° & 90° the path is always helical.

84. (*d*) As force by electric field on electron is opposite to motion so velocity will decrease.

85. (*c*) $F = ilB\sin\theta$ Here $\theta = 0$

87. (*d*) $B \propto \frac{1}{r}$

89. (*b*) Electron stream will be retarded as force is acting opposite to the motion of electron.

91. (*b*) $\theta = 90°$ $F = qvB\sin\theta$, $\sin\theta$ (max) = 1 at $\theta = 90°$

93. (*d*) $r = \frac{mv}{qB} = \frac{p}{qB} \Rightarrow r \propto p$

94. (*c*) Move towards the wire as force on *KL* & *MN* are equal & opposite so cancel each other while force on *KN* is more than *LM* towards the wire from Fleming left hand rule.

98. (*d*) $\vec{F} = q(\vec{v} \times \vec{B})$

$$= -2\times10^{-6}(2\hat{i} + 3\hat{j})\times10^{6}\times 2\hat{j} \quad (\because\ B = 2\hat{j})$$

$$= -8\hat{k} = 8\,\text{N}(-\hat{k})$$

104. (*d*) $F_{PQ} = Il_{PQ}B$

$F_{QR} = I\,l_{QR}B\sin\theta$

$\theta = 45°$

$L_{QR} = \sqrt{2}\,l_{PQ}$

$$F_{QR} = I\sqrt{2}\,l_{PQ}B\frac{1}{\sqrt{2}} = Il_{PQ}B = F_{PQ}$$

Since FQR and FPQ have opposite direction FQR = –F.

105. (*d*) Magnetic field due to straight part of the wire is,

$B_1 = \frac{\mu_0}{2\pi}\frac{I}{R}$, normally into the plane of paper.

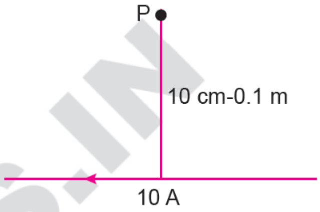
Magnetic field at the centre O due to the current loop of radius R is

$B_2 = \frac{\mu_0 I}{2R}$, normally into the plane of paper.

Resultant field at O is $B = B_2 - B_1 = \frac{\mu_0 I}{2R}\left(1 - \frac{1}{\pi}\right)$

106. (*a*) $d = 0.1$ m

Magnetic field at P is,



$$B = \frac{\mu_0 I}{2\pi d}$$

$$= 2 \times 10^{-7} \times \frac{10}{0.1}$$

$= 2 \times 10^{-5}$ T, acting downwards.

107. (*b*) $r = \frac{mv}{qB}$

$$KE = \frac{mv^2}{2} = \frac{(mv)^2}{2m}$$

$$mv = \sqrt{2mKE}$$

$$r = \frac{\sqrt{2mKE}}{qB} \Rightarrow r \propto \sqrt{m}$$

108. (*b*) Radius of circular path $r = \frac{mv}{qB} = \frac{\sqrt{2\,mE_k}}{qB}$

$$E_k = eV \Rightarrow r \propto \sqrt{V}$$

$$\frac{r'}{r} = \sqrt{\frac{V'}{V}}$$

As $V' = 2V$

$$r' = \sqrt{2}\,r$$

05 MAGNETISM AND MATTER

IMPORTANT FORMULAE

1. **Magnetic dipole moment,** $m = q_m \times 2l$
2. **Magnetic dipole moment of a current loop,** $m = NIA$
3. **Magnetic field due to a short magnetic dipole**

   (*i*) At axis $\quad B_{axis} = \frac{\mu_0}{4\pi}\frac{2M}{r^3}$

   (*ii*) At equatorial, $\quad B_{eqt.} = \frac{\mu_0}{4\pi}\frac{M}{r^3}$
4. **Elements of earth's magnetic field**

   Horizontal component $\quad H = B_e \cos\theta$

   Vertical component $\quad V = B_e \sin\theta$

   where θ = angle of dip.

   $\Rightarrow \tan\theta = \frac{V}{H}$ and $B_e = \sqrt{H^2 + V^2}$
5. **Magnetic moment of an orbital electron**

   $$\mu_l = \frac{evr}{2} = \frac{e}{2m}L$$
6. **Orbital magnetic dipole moment of an electron in *n*th orbital,**

   $$\mu_l = \frac{evr}{2} = \frac{e}{2m_e}l = n\left(\frac{eh}{4\pi m_e}\right)$$
7. **Magnetic susceptibility** $\chi_m = \frac{M}{H}$

MULTIPLE CHOICE QUESTIONS

Choose and write the correct option in the following questions.

1. **Magnetism in substances is caused by**

   (*a*) orbital motion of electrons only

   (*b*) spin motion of electrons only

   (*c*) due to spin and orbital motions of electrons both

   (*d*) hidden magnets

2. **A toroid of *n* turns, mean radius *R* and cross-sectional radius *a* carries current *I*. It is placed on a horizontal table taken as *X*-*Y* plane. Its magnetic moment $\vec{m}$** *[NCERT Exemplar]*

   (*a*) is non-zero and points in the *Z*-direction by symmetry.

   (*b*) points along the axis of the toroid ($\vec{m} = m\phi$).

   (*c*) is zero, otherwise there would be a field falling as $\frac{1}{r^3}$ at large distances outside the toroid.

   (*d*) is pointing radially outwards.

3. The magnetic field of Earth can be modelled by that of a point dipole placed at the centre of the Earth. The dipole axis makes an angle of 11.3° with the axis of Earth. At Mumbai, declination is nearly zero. Then, [*NCERT Exemplar*]

(*a*) the declination varies between 11.3° W to 11.3° E.

(*b*) the least declination is 0°.

(*c*) the plane defined by dipole axis and Earth axis passes through Greenwich.

(*d*) declination averaged over Earth must be always negative.

4. In a plane perpendicular to the magnetic meridian, the dip needle will be

(*a*) vertical

(*b*) horizontal

(*c*) inclined equal to the angle of dip at that place

(*d*) pointing in any direction

5. If the horizontal and vertical components of earth's magnetic field are equal at a certain place, the angle of dip is

(*a*) 90° (*b*) 60° (*c*) 45° (*d*) 0°

6. Magnetism in a substance is due to

(*a*) orbital motion of electrons only (*b*) spin motion of electrons only

(*c*) both orbital and spin motion of electrons (*d*) none of the above cause magnetism

7. A stationary magnet does not interact with

(*a*) magnet (*b*) stationary charge

(*c*) iron rod (*d*) moving charge

8. A bar magnet AB with magnetic moment M is cut into two equal parts perpendicular to its axis. One part is kept over the other so that end B is exactly over A. What will be the magnetic moment of the combination so formed?

(*a*) $\frac{M}{4}$ (*b*) $\frac{3M}{4}$ (*c*) M (*d*) Zero

9. SI unit of magnetic pole strength is

(*a*) ampere-meter (*b*) $\frac{\text{ampere}}{\text{meter}^2}$ (*c*) $\frac{\text{ampere}}{\text{meter}}$ (*d*) $\frac{\text{volt}}{\text{meter}}$

10. The SI unit of magnetic permeability μ_0 is

(*a*) $WA^{-1}m^{-1}$ (*b*) $NA^{-1}m^{-1}$

(*c*) NA^{-2} (*d*) Both $WA^{-1}m^{-1}$ and NA^{-2}

11. The unit of magnetic permeability of vacuum is ________ .

(*a*) NA^2 (*b*) T (*c*) NA^{-1} (*d*) NA^{-2}

12. A bar magnet of magnetic length $2l$ has pole strength p and magnetic moment m. Then m is equal to

(*a*) pl directed from north pole to south pole

(*b*) pl directed from south pole to north pole

(*c*) $2pl$ directed from north pole to south pole

(*d*) $2pl$ directed from south pole to north pole

13. The major contribution of magnetism in substances is due to

(*a*) orbital motion of electrons

(*b*) spin motion of electrons

(*c*) equally due to orbital and spin motions of electrons

(*d*) hidden magnets.

14. A sensitive magnetic instrument can be shielded very effectively from outside fields by placing it inside a box of

(*a*) teak wood (*b*) plastic material
(*c*) soft iron of high permeability (*d*) a metal of high conductivity

15. Earth's magnetic field inside a closed iron-box, as compared to that outside is

(*a*) more (*b*) less
(*c*) same (*d*) zero

16. The line on the earth's surface joining the points where the field is horizontal is called

(*a*) magnetic meridian (*b*) magnetic axis
(*c*) magnetic line (*d*) magnetic equator

17. The angle between the magnetic meridian and the geographical meridian is known as

(*a*) magnetic dip (*b*) magnetic declination
(*c*) magnetic moment (*d*) magnetic field strength

18. Earth's magnetic field always has a horizontal component except at

(*a*) equator (*b*) magnetic pole
(*c*) at latitude 60° (*d*) at latitude 30°

19. Two bar magnets of same geometry with magnetic moments M and $2M$ are first placed in such a way that their similar poles are on the same side, then its period of oscillation is T_1. Now the polarity of one of the magnets is reversed, then the time period of oscillations is T_2 then,

(*a*) $T_1 < T_2$ (*b*) $T_1 > T_2$ (*c*) $T_1 = T_2$ (*d*) $T_2 = \infty$

20. The time-period of a freely-suspended magnet is independent of

(*a*) length of the magnet
(*b*) moment of inertia of the magnet
(*c*) horizontal component of earth's magnetic field
(*d*) length of the suspension

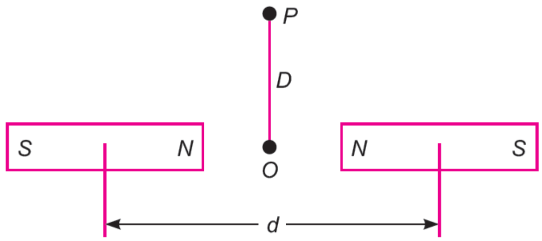
21. At a certain place a magnet makes 30 oscillations/min. At another place where the magnetic field is double, its time period will be

(*a*) 4 second (*b*) 2 second (*c*) 0.5 second (*d*) $\sqrt{2}$ second

22. The period of oscillation of a bar magnet in a vibration magnetometer is 2 second. The period of oscillation of a bar magnet whose magnetic moment is 4 times that of first magnet is

(*a*) 4 second (*b*) 1 second (*c*) 2 second (*d*) 0.5 second

23. Two identical bar magnets are fixed with their centers at a distance '*d*' apart. A stationary charge $+Q$ is placed at P in between the gap of the two magnets at a distance D from the centre O as shown in fig. The force on charge $+Q$ is



(*a*) directed along $\overrightarrow{OP}$
(*b*) directed along $\overrightarrow{PO}$
(*c*) directed perpendicular to the plane of the paper
(*d*) zero

24. A current 'i' ampere flows through an infinitely long straight thin walled tube, then the magnetic induction at any point inside the tube is

(*a*) infinite (*b*) zero (*c*) $\frac{\mu_0}{4\pi}\frac{2i}{r}$ (*d*) $\frac{2i}{r}$

25. The length of a magnet is large compared to its width and breadth. The time period of its oscillations in a vibration magnetometer is 2 s. The magnet is cut along the length into three equal parts and then placed on each other with their like poles together. The time period of this combination will be

(*a*) 2 s (*b*) $\frac{2}{3}$s (*c*) $2\sqrt{3}$ s (*d*) $\frac{2}{\sqrt{3}}$s

26. The magnetic induction and the intensity of magnetic field inside an iron pole of an electromagnet are 1 Wb m^{-2} and 150 Am^{-1} respectively. The relative permeability of iron must be

(*a*) $\frac{10^6}{4\pi}$ (*b*) $\frac{10^6}{6\pi}$ (*c*) $\frac{10^5}{4\pi}$ (*d*) $\frac{10^5}{6\pi}$

27. A vibration magnetometer consists of two identical bar magnets placed one over the other such that they are perpendicular and bisect each other. The time period of oscillator in a horizontal magnetic field is $(2)^{5/4}$ seconds. If one of the magnet is removed and the other magnet oscillate in the same field, then the time period will be:

(*a*) $2^{1/4}$ s (*b*) $2^{1/2}$ s (*c*) 2 s (*d*) $2^{5/4}$ s

28. In an experiment with vibration magnetometer the value of $\frac{4\pi^2 I}{T^2}$ for a short bar magnet is observed as 36×10^{-4}. In the experiment with deflection magnetometer with the same magnet, the value of $\left(\frac{4\pi d^3}{2\mu_0}\right)$ tan θ is observed as $\frac{10^8}{36}$. The magnetic moment of the magnet used is:

(*a*) 50 A – m^2 (*b*) 100 A – m^2

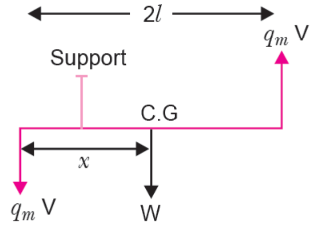
(*c*) 200 A – m^2 (*d*) 1000 A – m^2

29. A bar magnet has a magnetic moment equal to 5×10^{-5} weber-metre. It is suspended in a magnetic field which has a magnetic induction $B = 8\pi \times 10^{-4}$ T. The magnet vibrates with a period equal to 15 seconds. The moment of inertia of the magnet is

(*a*) 7.35×10^{-7} kgm^2 (*b*) 7.26×10^{-7} kgm^2

(*c*) 7.22×10^{-7} kgm^2 (*d*) 7.16×10^{-7} kgm^2

30. A magnetic needle of weight W has a magnetic moment m. If the needle is to be maintained horizontal in northern hemisphere, where should the point of support lie relative to its centre of gravity. [Vertical component of earth's magnetic field is V and horizontal component of earth's magnetic field is H.]



(*a*) $\frac{mV}{W}$ (*b*) $\frac{mW}{H}$

(*c*) $\frac{mH}{W}$ (*d*) $\frac{m\sqrt{V^2 + H^2}}{W}$

Answers

1. (*c*)	**2.** (*c*)	**3.** (*a*)	**4.** (*a*)	**5.** (*c*)	**6.** (*c*)	**7.** (*b*)	**8.** (*d*)
9. (*a*)	**10.** (*d*)	**11.** (*d*)	**12.** (*d*)	**13.** (*b*)	**14.** (*c*)	**15.** (*d*)	**16.** (*d*)
17. (*b*)	**18.** (*b*)	**19.** (*a*)	**20.** (*d*)	**21.** (*d*)	**22.** (*b*)	**23.** (*d*)	**24.** (*b*)
25. (*b*)	**26.** (*d*)	**27.** (*c*)	**28.** (*b*)	**29.** (*d*)	**30.** (*a*)		

CASE-BASED QUESTIONS

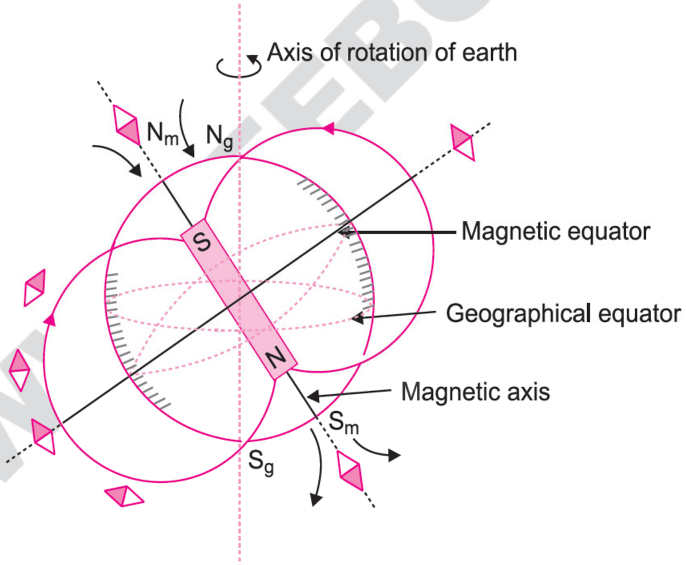
Attempt any 4 sub-parts from each question. Each question carries 1 mark.

1. EARTH'S MAGNETISM:

A magnetic field exists everywhere around the earth and earth behaves as if a powerful magnet is placed at the centre of earth in such a way that its north pole is towards south of earth and south pole is towards north of earth.

A freely suspended magnetic needle always stays along north-south direction. The north pole of needle is towards north of earth and south pole is towards south of earth.

When magnetic lines of magnet are drawn, neutral points are obtained. Neutral points are those points where net magnetic field is zero. The existence of these points indicates that earth has its own magnetic field and at these points the magnetic field of magnet is cancelled by earth's magnetic field.



At the magnetic north pole of earth, the north pole of magnetic needle points towards the north; while at the south pole of earth, the south pole of magnetic needle points towards the south. From this it is concluded that the south and north poles of frictitious magnetic dipole deep inside the earth must be in northern and southern hemispheres respectively. The line joining the two places where the needle becomes perfectly horizontal is called the magnetic equator. The magnetic equator intersects the geographical equator at longitudes 6° W and 174° E respectively. It is found that the angle between magnetic axis and the axis of earth's rotation is nearly 11.3°. The observations taken at different times show that the positions of earth's magnetic poles changes gradually.

(*i*) **The line on the earth's surface joining the points where the field is horizontal is called**

(*a*) magnetic meridian (*b*) magnetic axis

(*c*) magnetic line (*d*) magnetic equator

(*ii*) **The magnetic field of earth can be modelled by that of a point dipole placed at the centre of the earth. The dipole axis makes an angle of 11.3° with the axis of earth. At Mumbai, declination is nearly zero. Then,**

(*a*) the declination varies between 11.3° W to 11.3° E

(*b*) the least declination is 0°

(*c*) the plane defined by dipole axis and earth axis passes through Greenwich

(*d*) declination averaged over earth must be always negative

(*iii*) **In a plane perpendicular to the magnetic meridian, the dip needle will be**

(*a*) vertical

(*b*) horizontal

(*c*) inclined equal to the angle of dip at that place

(*d*) pointing in any direction

(*iv*) **If the horizontal and vertical components of earth's magnetic field are equal at a certain place, the angle of dip is**

(*a*) 90° (*b*) 60°

(*c*) 45° (*d*) 0°

(*v*) **Earth's magnetic field always has a horizontal component except at**

(*a*) equator (*b*) magnetic pole

(*c*) at latitude 60° (*d*) at latitude 30°

Answers

1. (*i*) (*d*); The line on the earth's surface joining the points where the field is horizontal is magnetic equator.

(*ii*) (*a*); The axis of dipole makes an angle of 11.3° with the axis of the earth and the declination varies between 11.3° W to 11.3° E depending upon the point of observation.

(*iii*) (*a*); In a plane perpendicular to the magnetic meridian, the dip needle will be vertical.

(*iv*) (*c*); Here, $B_H = B_V$

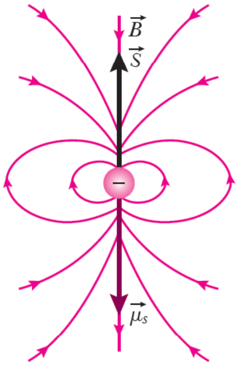
$$\tan\delta = \frac{B_V}{B_H} = 1$$

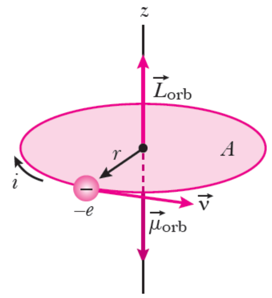
$$\therefore \quad \delta = 45°$$

(*v*) (*b*); At magnetic poles, the horizontal component of Earth's Magnetic field is zero.

2. ATOMIC MODEL OF MAGNETISM:

Every matter is formed of atoms. According to atomic model of magnetism, each atom is a complete magnetic dipole. Each atom, consist of a positively charged small nucleus at the centre and electrons revolve around the nucleus in definite orbits. The motion of the electrons around the nucleus is identical to that of earth around the sun. The electrons revolve around the nucleus in a definite orbit and the motion is called orbital motion. The electron spins about its own axis and the motion is called spin motion. This spin motion may be clockwise or anticlockwise.





The magnetic moment is produced due to both orbital motion and spin motion. However, most of the magnetic moment is produced due to spin motion and very small contribution due to orbital motion.

(i) The orbital magnetic moment due to orbital motion of electron is

(a) evr (b) $\frac{1}{2}evr$ (c) $\frac{1}{4}evr$ (d) none of these

(ii) An atom is a current loop. It is assumed that the magnetism of atom is caused by revolving electron due to its

(a) orbital motion (b) spin motion
(c) both (a) and (b) (d) none of these

(iii) The major part of magnetism is caused by

(a) spin motion (b) orbital motion
(c) both (a) and (b) (d) none of these

(iv) An electron moving in a circular orbit of radius r makes n rotations per second. The magnetic field produced at the centre is

(a) $\frac{\mu_0 n^2 e^2}{r}$ (b) $\frac{\mu_0 n^2 e}{r}$ (c) $\frac{\mu_0 ne}{2\pi r}$ (d) $\frac{\mu_0 ne}{2r}$

(v) The primary origin(s) of magnetism is

(a) atomic currents (b) Pauli exclusion principle
(c) intrinsic spin of electron (d) both (a) and (c)

Answers

2. (i) (b); $I = \frac{e}{T} = \frac{e}{\frac{2\pi r}{v}} = \frac{ev}{2\pi r}$

Area of current loop, $A = \pi r^2$

$$\mu_l = IA = \frac{ev}{2\pi r}.\pi r^2$$

$$\mu_l = \frac{evr}{2}$$

(ii) (c); When electron revolve around the nucleus, the magnetism is caused by both angular momentum due to spin motion and linear momentum due to orbital motion.

(iii) (a); The major part of magnetism is caused by angular momentum of electron *i.e.*, spin motion of electron.

(*iv*) (*d*); B at centre $= \frac{\mu_0 I}{2r}$

Here, $I = ne$

So, $B = \frac{\mu_0 ne}{2r}$

(*v*) (*d*); The primary origin of magnetism depends on atomic current and intrinsic spin of electron.

ASSERTION-REASON QUESTIONS

In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct answer out of the following choices.

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

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

(c) A is true but R is false.

(d) A is false and R is also false.

1. Assertion (A) : If a compass needle be kept at magnetic north pole of Earth, the compass needle may stay in any direction.

Reason (R) : Dip needle will stay vertical at the north pole of Earth.

2. Assertion (A) : Earth's magnetic field does not affect the working of a moving coil galvanometer.

Reason (R) : Earth's magnetic field is very weak.

3. Assertion (A) : Gauss's theorem is not applicable in magnetism.

Reason (R) : Magnetic monopoles do not exist.

4. Assertion (A) : The magnetic poles of a magnet can never be separated.

Reason (R) : Every atom of a magnetic substance is a complete dipole.

5. Assertion (A) : The poles of a magnet cannot be separated by breaking into two pieces.

Reason (R) : The magnetic moment will be reduced to half when a magnet is broken into two equal pieces.

6. Assertion (A) : The magnetic moment (μ) of an electron revolving around the nucleus decreases with increasing principal quantum number (n). *[AIIMS 2015]*

Reason (R) : Magnetic moment of the revolving electron, $\mu \propto n$.

7. Assertion (A) : When radius of a circular loop carrying current is doubled, its magnetic moment becomes four times. *[AIIMS 2018]*

Reason (R) : Magnetic moment depends on area of the loop.

8. Assertion (A) : The magnetic poles of earth do not coincide with the geographic poles. *[AIIMS 2010]*

Reason (R) : The discrepancy between the orientation of a compass and true north-south direction is known as magnetic declination.

9. Assertion (A) : Magnetic susceptibility is a pure number. *[AIIMS 2009]*

Reason (R) : The value of magnetic susceptibility for vacuum is one.

10. Assertion (A) : Susceptibility is defined as the ratio of intensity of magnetisation I to magnetic intensity H. *[AIIMS 2018]*

Reason (R) : Greater the value of susceptibility, smaller the value of intensity of magnetisation I.

Answers

1. (*b*) **2.** (*a*) **3.** (*a*) **4.** (*a*) **5.** (*b*) **6.** (*d*) **7.** (*a*) **8.** (*a*)
9. (*c*) **10.** (*c*)

HINTS/SOLUTIONS OF SELECTED MCQs

1. (*c*) Magnetism in substance is caused by spin and orbital motion of electrons.

2. (*c*) In toroid, the magnetic field is only confined inside the body of toroid in the form of concentric magnetic lines of force and these is no magnetic field outside the body. This is because the loop encloses no current. Thus, the magnetic moment is zero, otherwise, r as large distance outside the toroid, $m \propto \frac{1}{r^3}$.

3. (*a*) For the earth's magnetism, the magnetic field lines of the earth resemble that of a hypothetical magnetic dipole located at the centre of the earth. The axis of the dipole does not coincide with the axis of rotation of the earth but it is presently litted by 11.3° with respect to the later. Hence, the declination varies between 11.3° W to 11.3°E.

4. (*a*) The angle of dip would change of needle to placed in the geometric meridian. The vertical component would remain the same but the horizontal component would change. Hence, dip needle would remain vertical in a plane perpendicular to the magnetic meridian.

5. (*c*) $\tan = \frac{B_v}{B_H} = 1 \quad \Rightarrow \delta = 45°$

8. (*d*) $\vec{M} = \left(\frac{1}{2}\vec{M}\right) + \left(-\frac{1}{2}\vec{M}\right) = 0$

12. (*d*) $m = p \times 2\,l = 2pl$ (S to N)

19. (*a*) $T = 2\pi\sqrt{\frac{I}{MB}}$, *i.e.*, $T \propto \frac{1}{\sqrt{M}}$

21. (*d*) $T = 2\pi\sqrt{\frac{I}{MB_H}}$

$$\frac{T_1}{T_2} = \sqrt{\frac{(B_H)_2}{(B_H)_1}}$$

$n = 30$ oscillation/min $= \frac{1}{2}$ oscillation/sec

$$\therefore \frac{\mu}{4\pi}\cdot\frac{m^2}{r^2} = 50\text{ gm} - \text{wt}$$

$$\therefore T_2 = 2\sqrt{\frac{B_H}{2B_H}} = \sqrt{2}\text{ sec}$$

22. (*b*) $\frac{T_1}{T_2} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{4M}{M}} = 2 \quad \Rightarrow \frac{2}{T_2} = 2 \Rightarrow T_2 = 1\text{ sec}$

23. (*d*) Force on a stationery charge in magnetic field is zero.

24. (*b*) Magnetic induction inside a hollow current tube is always zero.

25. (*b*) $T = 2\pi\sqrt{\frac{I}{mH}}, T' = 2\pi\sqrt{\frac{I/9}{mH}} \Rightarrow \frac{T'}{T} = \frac{1}{3}$

$$\Rightarrow T' = \frac{T}{3} = \frac{2}{3}\text{ s}$$

26. (*d*) $\mu = \frac{B}{H}$

$$\Rightarrow \mu_r = \frac{B}{\mu_0 H} = \frac{1}{4\pi\times10^{-7}\times150} = \frac{10^5}{6\pi}$$

27. (*c*) When magnets are perpendicular, magnetic moment,

$$m_r = \sqrt{m^2 + m^2} = \sqrt{2}\, m$$

$$\therefore \quad T = 2\pi\sqrt{\frac{2I}{m\sqrt{2}H}} = 2\pi\sqrt{\frac{2I}{\sqrt{2}mH}},$$

I = M.I. of each magnet

When one magnet is removed, then

$$T' = 2\pi\sqrt{\frac{I}{mH}}$$

$$\therefore \quad \frac{T'}{T} = \frac{1}{2^{1/4}} = T' = \frac{T}{2^{1/4}} = 2\text{ s}$$

28. (*b*) In vibration magnetometer,

$$T = 2\pi\sqrt{\frac{I}{mH}} \quad \Rightarrow \quad mH = 4\pi^2\frac{I}{T^2} \qquad \text{...(1)}$$

In deflection magnetometer,

$$H\tan\theta = \frac{\mu_0}{4\pi}\frac{2m}{d^3} \quad \Rightarrow \quad \frac{m}{H} = \frac{4\pi d^3}{2\mu_0}\tan\theta \qquad \text{...(2)}$$

Multiply (1) and (2),

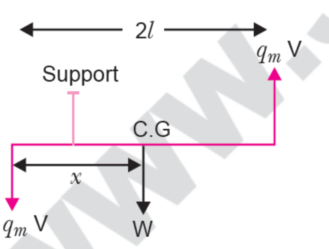
$$m^2 = \left(4\pi^2\frac{I}{T^2}\right)\cdot\left(\frac{4\pi d^3}{2\mu_0}\tan\theta\right) = 36 \times 10^{-4} \times \frac{10^8}{36} = 10^4 \Rightarrow m = 100\text{ A-m}^2$$

29. (*d*) Here, $m = 5 \times 10^{-5}$ Wb–m, $B = 8\pi \times 10^{-4}$ T, $T = 15$ s

$$T = 2\pi\frac{\sqrt{I}}{mB} \quad \Rightarrow \quad I = \frac{T^2 mB}{4\pi^2}$$

$$= \frac{(15)^2 \times 5 \times 10^{-5} \times 8\pi \times 10^{-4}}{4\pi^2} = 7.16 \times 10^{-7}\text{ kgm}^2$$

30. (*a*)



$$W\,.\,x = q_m V \times 2l \quad \Rightarrow \quad Wx = mV$$

$$\Rightarrow \quad x = \frac{mV}{W}$$

06 ELECTROMAGNETIC INDUCTION

IMPORTANT FORMULAE

1. **Magnetic flux** $\phi_B = \vec{B}.\vec{A} = BA\cos\theta$

   where θ is the angle between $\vec{A}$ and $\vec{B}$.

2. **Induced emf in a coil** $\varepsilon = -N\dfrac{\Delta\phi}{\Delta t}$

3. **EMF induced in a moving conductor,** $\varepsilon = Bvl$

   where B, v, l are mutually perpendicular

4. **Magnetic flux** $\phi = LI$

   where L is the coefficient of self-induction.

5. **If L is self inductance, emf induced** $\varepsilon = -L\dfrac{\Delta I}{\Delta t}$

6. **Self inductance of a solenoid**

$$L = \mu_r\mu_0 n^2 Al = \frac{\mu_r\mu_0 N^2 A}{l}$$

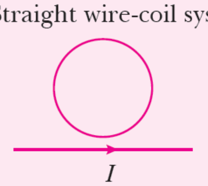
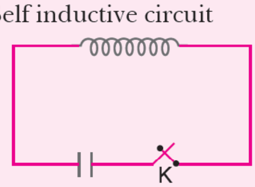
7. **Mutual Inductance** $E_2 = -M\dfrac{\Delta I}{\Delta t}$

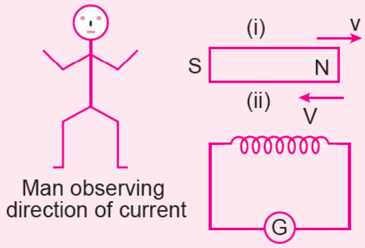
8. **Mutual inductance of solenoid coil system** $M = \dfrac{\mu_0 N_1 N_2 A}{l}$

   where N_1 = number of turns/metre in solenoid, N_2 = number of turns in coil.

9. **Energy stored in inductance** $U_m = \dfrac{1}{2}LI^2 = \dfrac{1}{2}\phi I$

Direction of Current Induced in Some Cases

	System	Primary Current	Induced Current
1.	Straight wire-coil system 	(*i*) Current increasing (*ii*) Current decreasing	Clockwise current Anticlockwise current
2.	Self inductive circuit 	(*i*) Key is pressed (*ii*) Key is released	Opposite to direction of main currents In the direction of main current

3.	Magnetic-coil system 	(*ii*) North pole approaching coil (*ii*) North pole receding coil	Anticlockwise current Clockwise current

MULTIPLE CHOICE QUESTIONS

Choose and write the correct option in the following questions.

1. Whenever the flux linked with a circuit changes, there is an induced emf in the circuit. This emf in the circuit lasts

(*a*) for a very short duration

(*b*) for a long duration

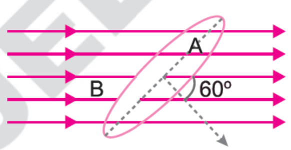
(*c*) forever

(*d*) as long as the magnetic flux in the circuit changes.

2. The area of a square shaped coil is 10^{-2} m^2. Its plane is perpendicular to a magnetic field of strength 10^{-3} T. The magnetic flux linked with the coil is

(*a*) 10 Wb (*b*) 10^{-5} Wb (*c*) 10^5 Wb (*d*) 100 Wb

3. An area A = 0.5 m^2 shown in the figure is situated in a uniform magnetic field B = 4.0 Wb/m^2 and its normal makes an angle of 60° with the field. The magnetic flux passing through the area A would be equal to



(*a*) 2.0 weber (*b*) 1.0 weber (*c*) $\sqrt{3}$ weber (*d*) 0.5 weber

4. A square of side L meters lies in the *X-Y* plane in a region, where the magnetic field is given by $B = B_o(2\hat{i} + 3\hat{j} + 4\hat{k})\,T$, where B_o is constant. The magnitude of flux passing through the square is [*NCERT Exemplar*]

(*a*) $2\,B_o L^2$ Wb (*b*) $3\,B_o L^2$ Wb

(*c*) $4\,B_o L^2$ Wb (*d*) $\sqrt{29}\,B_o L^2$ Wb

5. A loop, made of straight edges has six corners at $A(0, 0, 0)$, $B(L, O, 0)$, $C(L, L, 0)$, $D(0, L, 0)$ $E(0, L, L)$ and $F(0, 0, L)$. A magnetic field $B = B_o(\hat{i} + \hat{k})\,T$ is present in the region. The flux passing through the loop *ABCDEFA* (in that order) is [*NCERT Exemplar*]

(*a*) $B_o L^2$ Wb (*b*) $2\,B_o L^2$ Wb

(*c*) $\sqrt{2}\,B_o L^2$ Wb (*d*) $4\,B_o L^2$ Wb

6. An emf is produced in a coil, which is not connected to an external voltage source. This can be due to [*NCERT Exemplar*]

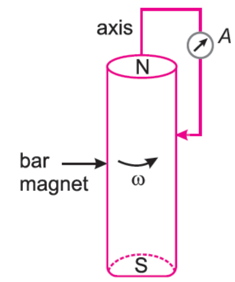
(*a*) the coil being in a time varying magnetic field.

(*b*) the coil moving in a time varying magnetic field.

(*c*) the coil moving in a constant magnetic field.

(*d*) all of the above.

7. **A cylindrical bar magnet is rotated about its axis (Figure given alongside). A wire is connected from the axis and is made to touch the cylindrical surface through a contact. Then** [*NCERT Exemplar*]



(*a*) a direct current flows in the ammeter A.

(*b*) no current flows through the ammeter A.

(*c*) an alternating sinusoidal current flows through the ammeter A with a time period $T = 2\pi/\omega$.

(*d*) a time varying non-sinusoidal current flows through the ammeter A.

8. **A copper ring is held horizontally and a magnet is dropped through the ring with its length along the axis of the ring. The acceleration of the falling magnet is**

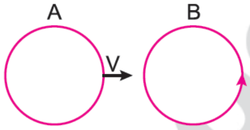
(*a*) equal to that due to gravity

(*b*) less than that due to gravity

(*c*) more than that due to gravity

(*d*) depends on the diameter of the ring and the length of the magnet

9. **There are two coils *A* and *B* as shown in the figure. A current starts flowing in *B* as shown, when *A* is moved towards *B* and stops when *A* stops moving. The current in *A* is counter clockwise. *B* is kept stationary when A moves. We can infer that** [*NCERT Exemplar*]



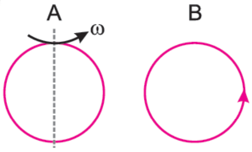
(*a*) there is a constant current in the clockwise direction in A.

(*b*) there is a varying current in A.

(*c*) there is no current in A.

(*d*) there is a constant current in the counterclockwise direction in A.

10. **Same as the above problem except the coil A is made to rotate about a vertical axis refer to the figure. No current flows in B if A is at rest. The current in coil A, when the current in B (at $t = 0$) is counterclockwise and the coil A is as shown at this instant, $t = 0$, is** [*NCERT Exemplar*]



(*a*) constant current clockwise.

(*b*) varying current clockwise.

(*c*) varying current counterclockwise.

(*d*) constant current counterclockwise.

11. **Lenz's law is essential for**

(*a*) conservation of energy

(*b*) conservation of mass

(*c*) conservation of momentum

(*d*) conservation of charge

12. **The self inductance *L* of a solenoid of length *l* and area of crosssection *A*, with a fixed number of turns *N* increases as** [*NCERT Exemplar*]

(*a*) l and A increase.

(*b*) l decreases and A increases.

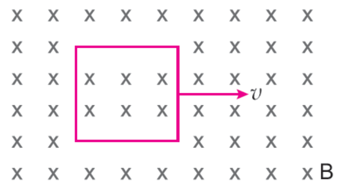
(*c*) l increases and A decreases.

(*d*) both l and A decrease.

13. **A thin circular ring of area *A* is held perpendicular to a uniform magnetic field of induction *B*. A small cut is made in the ring and a galvanometer is connected across its ends in such a way that the total resistance of the circuit is *R*. When the ring is suddenly squeezed to zero area, the charge flowing through the galvanometer is**

(*a*) $\frac{BR}{A}$ (*b*) $\frac{AB}{R}$ (*c*) ABR (*d*) $\frac{B^2A}{R^2}$

14. A conducting square loop of side L and resistance R moves in its plane with a uniform velocity v perpendicular to one of its sides. A magnetic induction B constant in time and space, pointing perpendicular and into the plane of the loop exists everywhere as in given figure. The current induced in the loop is



(*a*) Blv/R clockwise (*b*) Blv/R anticlockwise
(*c*) $2Blv/R$ anticlockwise (*d*) zero.

15. Inductance plays the role of

(*a*) inertia (*b*) friction
(*c*) source of emf (*d*) force

16. A circular coil expands radially in a region of magnetic field and no electromotive force is produced in the coil. This can be because [*NCERT Exemplar*]

(*a*) the magnetic field is constant.
(*b*) the magnetic field is in the same plane as the circular coil and it may or may not vary.
(*c*) the magnetic field has a perpendicular (to the plane of the coil) component whose magnitude is decreasing suitably.
(*d*) both (*b*) and (*c*)

17. When the current in a coil changes from 8 A to 2 A in 3×10^{-2} second, the emf induced in the coil is 2 volt. The self-inductance of the coil, in millihenry, is

(*a*) 1 (*b*) 5
(*c*) 20 (*d*) 10

18. The mutual inductance of two coils depends upon

(*a*) medium between coils (*b*) separation between coils
(*c*) both on (*a*) and (*b*) (*d*) none of (*a*) and (*b*)

19. Due to relative motion of a magnet with respect to a coil, an emf is induced in the coil. Identify the principle involved.

(*a*) Gauss's law (*b*) Biot-Savart law
(*c*) Ampere's circuital law (*d*) Faraday's law

20. In Faraday's experiment of electromagnetic induction, more deflection will be shown by galvanometer, when

(*a*) magnet is in uniform motion towards the coil
(*b*) magnet is in accelerated motion towards the coil
(*c*) magnet is in uniform motion away from the coil
(*d*) magnet is at rest near the coil

21. If both the number of turns and core length of an inductor is doubled keeping other factors constant, then its self-inductance will be

(*a*) halved (*b*) quadrupled
(*c*) unaffected (*d*) doubled

22. Oscillating metallic pendulum in a uniform magnetic field directed perpendicular to the plane of oscillation

(*a*) remains unaffected (*b*) oscillates with changing frequency
(*c*) slows down (*d*) becomes faster

23. A metallic cylinder is held vertically and then a small magnet is dropped along its axis. It will fall with

(*a*) acceleration $a = g$ (*b*) constant velocity $a = 0$
(*c*) acceleration $a > g$ (*d*) acceleration $a < g$

24. An emf of 200 V is induced in a circuit when current in the circuit falls from 5 A to 0 A in 0.1 second. The self-inductance of the circuit is

(*a*) 3.5 H (*b*) 3.9 H (*c*) 4 H (*d*) 4.2 H

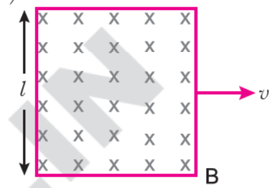
25. A small piece of metal wire is dragged across the gap between the poles of a magnet in 0.4 s. If change in magnetic flux in the wire is 8×10^{-4} Wb, then emf induced in the wire is

(*a*) 8×10^{-3} V (*b*) 6×10^{-3} V (*c*) 4×10^{-3} V (*d*) 2×10^{-3} V

26. If the number of turns per unit length of the coil of a solenoid is doubled keeping other dimensions same, then its self-inductance will be

(*a*) four times (*b*) eight times (*c*) halved (*d*) doubled

27. A conducting square loop of side l and resistance R moves in its plane with a uniform velocity v perpendicular to one of its sides. A magnetic induction B constant in time and space, pointing perpendicular and into the plane at the loop exists everywhere with half the loop outside the field, as shown in figure. The induced emf is



(*a*) zero (*b*) RvB (*c*) vBl/R (*d*) vBl

28. A wheel with ten metallic spokes each 0.50 m long is rotated with a speed of 120 rev/min in a plane normal to the earth's magnetic field at the place. If the magnitude of the field is 0.4 G the induced emf between the axle and the rim of the wheel is equal to

(*a*) 1.256×10^{-3} V (*b*) 6.28×10^{-4} V (*c*) 1.256×10^{-4} V (*d*) 6.28×10^{-5} V

29. In a circuit with a coil of resistance 2 ohms, the magnetic flux changes from 2.0 Wb to 10.0 Wb in 0.2 second. The charge that flows in the coil during this time is

(*a*) 5.0 coulomb (*b*) 0.8 coulomb (*c*) 1.0 coulomb (*d*) 4.0 coulomb

30. The direction of induced current is such that it opposes the very cause that has produced it. This is the law of

(*a*) Lenz (*b*) Faraday (*c*) Kirchhoff (*d*) Fleming

31. The magnetic flux through a circuit of resistance R changes by an amount $\Delta\phi$ in time Δt, then the total quantity of electric charge Q, passing during this time through any point of the circuit is given by

(*a*) $\Delta Q = \dfrac{\Delta\phi}{\Delta t}$ (*b*) $\Delta Q = \dfrac{\Delta\phi}{\Delta t} \times R$

(*c*) $\Delta Q = -\dfrac{\Delta\phi}{\Delta t} + R$ (*d*) $\Delta Q = \dfrac{\Delta\phi}{R}$

32. The dimension of magnetic flux is

(*a*) $M^1L^2T^{-2}A^{-1}$ (*b*) $M^2L^3T^{-3}A^1$ (*c*) $M^1L^2T^{-3}A^{-1}$ (*d*) $M^1L^3T^{-3}A^1$

33. Lenz's law is a consequence of the law of conservation of

(*a*) mass (*b*) charge (*c*) momentum (*d*) energy

34. The physical quantity expressed in henry is

(*a*) magnetic flux (*b*) self-inductance

(*c*) magnetic permeability (*d*) magnetic induction

35. When current in a circuit drops from 10 A to 2 A in 2 seconds, the induced emf developed in the circuit is 16 volts. The self inductance of the circuit is

(*a*) 16 henry (*b*) 8 henry (*c*) 6 henry (*d*) 4 henry

36. The current passing through a choke coil of self-inductance 5 henry is decreasing at the rate of 2 A/s. The induced emf developed across the coil is

(*a*) 10 volt (*b*) –10 volt (*c*) 2.5 volt (*d*) –2.5 volt

37. Magnetic flux through a coil changes from 0.7 Wb to 0.2 Wb in 0.1 second. The induced emf developed in the coil is

(*a*) 7 V (*b*) 5 V (*c*) 20 V (*d*) 2 V

38. The magnetic potential energy stored in a certain inductor is 25 mJ, when the current in the inductor is 60 mA. This inductor is of inductance

(*a*) 0.138 H (*b*) 138.88 H (*c*) 1.389 H (*d*) 13.89 H

39. The magnitude of induced emf in a coil depend on

(*a*) the amount of magnetic flux linked by the coil.
(*b*) the amount of electric flux linked by the coil.
(*c*) the rate of change of magnetic flux linked by the coil.
(*d*) the rate of change of electric flux linked by the coil.

40. Weber per second is equal to

(*a*) ampere (*b*) volt (*c*) ohm (*d*) henry

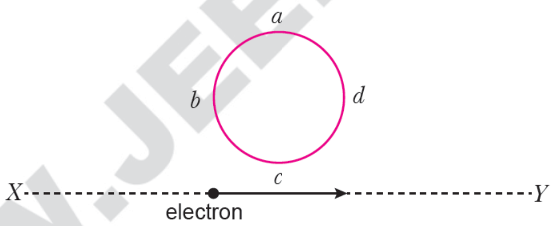
41. Self inductance of a coil delays

(*a*) the growth of current through it.
(*b*) the decay of current through it.
(*c*) both the growth and decay of current through it.
(*d*) neither the growth nor the decay of current through it.

42. Self inductance of a coil is the mechanical analogue of

(*a*) energy (*b*) momentum
(*c*) inertia (*d*) power

43. An electron moves on a straight line path *XY* as shown. The *abcd* is a coil adjacent to the path of electron. What will be the direction of current, if any, induced in the coil?



(*a*) The current will reverse its direction as the electron goes past the coil.
(*b*) No current induced
(*c*) *abcd*
(*d*) *adcb*

44. If the number of turns in a coil is doubled, then its self-inductance becomes

(*a*) double (*b*) half
(*c*) four times (*d*) unchanged

45. Whenever the flux linked with a circuit changes, there is an induced emf in the circuit. This emf in the circuit lasts

(*a*) for a very short duration
(*b*) for a long duration
(*c*) forever
(*d*) as long as the magnetic flux in the circuit changes.

46. Two coils of self inductances 2 mH and 8 mH are placed to close to each other that the flux linkage is complete between the coils. The mutual inductance between these coils is:

(*a*) 4 mH (*b*) 6 mH
(*c*) 10 mH (*d*) 16 mH

47. A copper ring is held horizontally and a magnet is dropped through the ring with its length along the axis of the ring. The acceleration of the falling magnet is:

(*a*) equal to that due to gravity

(*b*) less than that due to gravity

(*c*) more than that due to gravity

(*d*) depends on the diameter of the ring and the length of the magnet

48. The mutual inductance of two coils depends upon

(*a*) medium between coils (*b*) separation between coils

(*c*) both on (*a*) and (*b*) (*d*) none of (*a*) and (*b*)

49. The core used in transformers and other electromagnetic equipments is laminated because it

(*a*) prevents rusting of core

(*b*) increases the magnetic saturation level of the core

(*c*) decreases the residual magnetism of the core

(*d*) minimises eddy-current loss in the core

50. If L and R represent inductance and resistance respectively then the dimensions of L/R will be:

(*a*) $M^0L^0T^{-1}$ (*b*) $M^0L^0T^{-2}$

(*c*) M^0L^0T (*d*) cannot be expressed in terms of M, L and T.

51. When the current through a solenoid increases at a constant rate, the induced current:

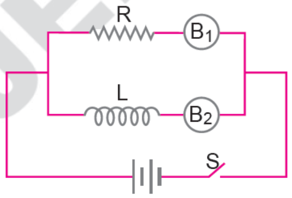
(*a*) is a constant and is in the direction of the inducing current

(*b*) is a constant and is opposite to the direction of the inducing current

(*c*) increases with time and is opposite to the direction of the inducing current

(*d*) zero

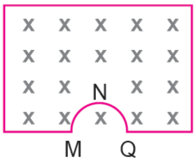
52. Figure shows two bulbs $B1$ and B_2, resistor R and inductor L. When the switch S is turned off



(*a*) both B_1 and B_2 dies out promptly (*b*) both B_1 and B_2 die out with some delay

(*c*) B_2 dies out promptly, but B_1 with some delay (*d*) B_1 dies out promptly, but B_2 with some delay

53. A thin semicircular conducting ring of radius R is falling with its plane vertical in horizontal magnetic induction $\vec{B}$. At the position MNQ the speed of ring is v then the potential difference developed across the ring is:



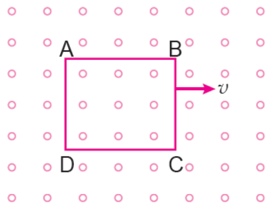
(*a*) zero

(*b*) $\dfrac{Bv\pi R^2}{2}$ and M at higher potential

(*c*) πRBv and Q at higher potential

(*d*) $2RBv$ and M at higher potential

54. A metallic square loop $ABCD$ is moving in its own plane with a velocity v in a uniform magnetic field perpendicular to plane as shown in fig. An electric field is induced



(*a*) in AD but not in BC

(*b*) in BC but not in AD

(*c*) neither in AD nor in BC

(*d*) in both AD and BC

55. Two identical circular loops *A* and *B* of metal wire are lying on a table without touching each other. Loop *A* carries a current which increases with time. In response the loop *B*

(*a*) remains stationary
(*b*) is attracted by loop A
(*c*) is repelled by loop A
(*d*) rotates about its centre of mass with centre of mass fixed

56. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon:

(*a*) the materials of wires of the coils
(*b*) the currents in the two coils
(*c*) the rates at which currents are changing in the two coils
(*d*) relative position and orientation of the two coils

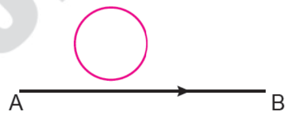
57. Two coils have inductances L_1 = 4 mH and L_2 = 1 mH respectively. The currents in the two coils are increased at the same rate. At a certain instant of time, both coils are given the same power. If I_1 and I_2 are the currents in the two coils at that instant of time respectively, then the value of ratio $\frac{I_1}{I_2}$ is:

(*a*) $\frac{1}{8}$ (*b*) $\frac{1}{4}$ (*c*) $\frac{1}{2}$ (*d*) 1

58. An infinitely long cylindrical conducting rod is kept along + *z*-direction. A constant magnetic field is also present in + *z*-direction. Then the current induced will be:

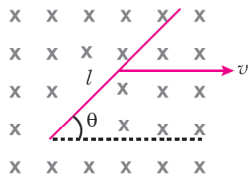
(*a*) 0
(*b*) along +*z*-direction
(*c*) along clockwise as seen from + *z* direction
(*d*) along anticlockwise as seen from + *z* direction

59. The current in a wire *AB* is increasing in magnitude. The direction of induced current in the loop (if any) will be:



(*a*) clockwise (*b*) anticlockwise
(*c*) arbitrary (*d*) no current is induced

60. A circular loop of radius *R* carrying current *I* lies in *x-y* plane with the centre at origin. The total magnetic flux through *xy* plane is:

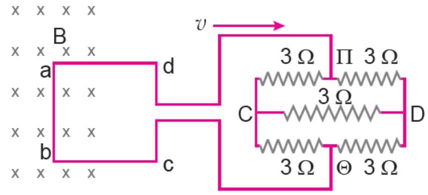


(*a*) directly proportional to *I* (*b*) directly proportional to *R*
(*c*) directly proportional to R^2 (*d*) zero

61. The equivalent inductance of two inductors is 2.4 H when connected in parallel and 10 H when connected in series. What is the value of inductances of the individual inductors?

(*a*) 2 H, 8 H (*b*) 4 H, 6 H
(*c*) 3 H, 7 H (*d*) 5 H, 5 H

62. **A square loop of side 20 cm and resistance 2 Ω is moved towards right with speed 2v as shown. The left arm of the loop is in a uniform magnetic field of 0.5 T. The field is perpendicular to plane of paper, pointing downward. The loop is connected to a network of 5 resistors as shown in fig. With what speed should the loop be moved so that a steady current of 1 mA flows through the loop?**



(*a*) 2 cm/s (*b*) 2·5 cm/s (*c*) 5 cm/s (*d*) 25 cm/s

63. **A small square loop of a wire of side *l* is placed inside a large square loop of side *L* (*L* >> *l*). The loops are coplanar and their centres coincide. The mutual inductance of the system is proportional to:**

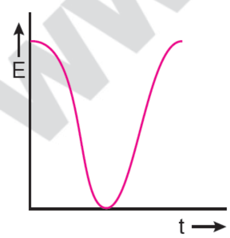
(*a*) $\frac{l}{L}$ (*b*) $\frac{l^2}{L}$ (*c*) $\frac{L}{l}$ (*d*) $\frac{L^2}{l}$

64. **Two circular coils can be arranged in any of the three situations as shown in fig. Their mutual inductance will be:**

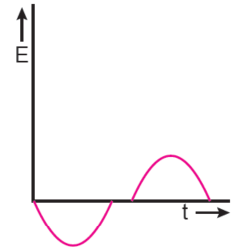
(*a*) maximum in situation (*i*) (*b*) maximum in situation (*ii*)
(*c*) maximum in situation (*iii*) (*d*) same in all situations

65. **The variation of induced emf (*E*) with time *t* in a coil if a short bar magnet is moved along its axis with a constant velocity is best represented as:**

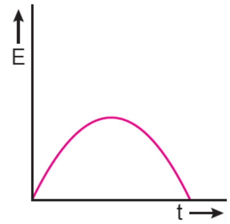
(*a*)



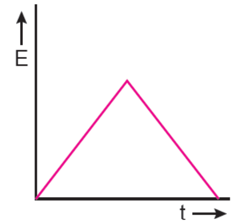
(*b*)



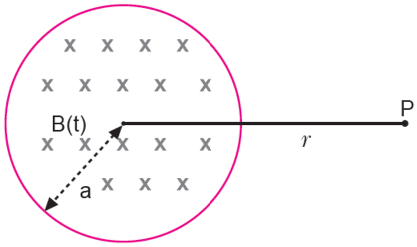
(*c*)



(*d*)



66. **A uniform but time varying magnetic field $B\ (t)$ exists in a circular region of radius 'a' and is directed into the plane of paper as shown. The magnitude of the induced electric field at point P at a distance r from the centre of the circular region:**

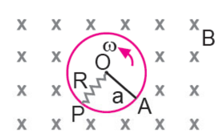


(*a*) is zero (*b*) decreases as $1/r$ (*c*) increases as r (*d*) decreases as $1/r^2$

67. **A short circuited coil is placed in a time varying magnetic field. Electric power is dissipated due to the current induced in the coil. If the number of turns were to be quadrupled and the wire radius halved, the electrical power dissipated would be:**

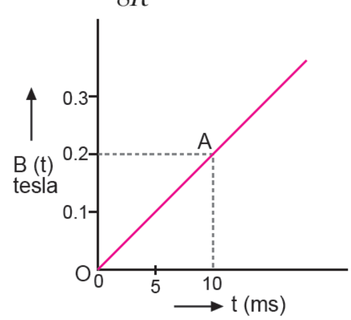
(*a*) halved (*b*) the same (*c*) doubled (*d*) quadrupled

68. **Figure shows a conducting circular loop of radius 'a' placed in a uniform, perpendicular magnetic field B. A metal rod OA is pivoted at the centre O of the loop. The other end A of the rod touches the loop. The rod OA and the loop are resistanceless but a tungsten wire of resistance R is connected between O and a fixed point P on the loop. The rod OA is made to rotate anticlockwise with a uniform angular velocity ω by an external source. The current induced in the tungsten wire is:**



(*a*) zero (*b*) $\dfrac{B\omega a^2}{R}$ (*c*) $\dfrac{B\omega a^2}{2R}$ (*d*) $\dfrac{B\omega a^2}{8R}$

69. **A coil of area 5.0×10^{-3} m^2 is placed perpendicular to a time varying magnetic field shown in figure. The value of induced emf in coil in 10 ms is:**



(*a*) 0·1 V

(*b*) 0·1 mV

(*c*) 0·5 V

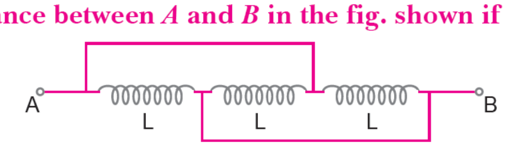
(*d*) 0·5 mV

70. **When the current changes from + 2 A to –2 A in 0.05 s, an emf of 8 V is induced in a coil. The coefficient of self-inductance of the coil is:**

(*a*) 0·1 H (*b*) 0·2 H

(*c*) 0·4 H (*d*) 0·8 H

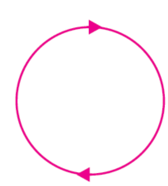
71. **The effective inductance between A and B in the fig. shown if L = 3 H is:**



(*a*) 1 H (*b*) 9 H

(*c*) 0·67 H (*d*) 1·5H

72. **In the given diagram, a line of force of a particular force field is shown. Out of the following options, it can never represent:**



(*a*) an electrostatic field (*b*) a magnetostatic field

(*c*) a gravitational field of a mass at rest (*d*) an induced electric field

73. Which of the following units denotes the dimensions $\frac{ML^2}{Q^2}$, where Q denotes the electric charge?

(*a*) Wb/m^2 (*b*) henry (H) (*c*) H/m^2 (*d*) weber (Wb)

74. A circular loop of radius *r*, carrying a current *I* lies in *y-z* plane with its centre at the origin. The net magnetic flux through the loop is: **[*CBSE 2020 (55/4/1)*]**

(*a*) directly proportional to *r* (*b*) zero

(*c*) inversely proportional to *r* (*d*) directly proportional to *I*

75. A rectangular, a square, a circular and an elliptical loop, all in the *x-y* plane are moving out of the uniform magnetic field with a constant velocity $\vec{v} = v\,\hat{i}$. The magnetic field is directed along the negative *z*-direction. The induced emf during the passage of these loops, out of the field region will not remain constant for:

(*a*) the circular and the elliptical loops (*b*) only the elliptical loop

(*c*) any of the four loops (*d*) the rectangular, circular and elliptical loops

76. A conducting circular loop is placed in a uniform magnetic field 0·04 T with its plane perpendicular to the magnetic field. The radius of the loop starts shrinking at 2 mm/s. The induced emf in the loop when the radius is 2 cm is:

(*a*) $4{\cdot}8\,\pi\,\mu V$ (*b*) $0{\cdot}8\,\pi\,\mu V$ (*c*) $1{\cdot}6\,\pi\,\mu V$ (*d*) $3{\cdot}2\,\pi\,\mu V$

77. A long solenoid has 500 turns. When a current of 2 A is passed through it, the resulting magnetic flux linked with each turn of the solenoid is 4×10^{-3} Wb. The self inductance of the solenoid is :

(*a*) 2·5 H (*b*) 2·0 H (*c*) 1·0 H (*d*) 40 H

78. An emf of 100 mV is induced in a coil when current in neighbouring coil becomes 10 A from 0 in 0·1 second. The coefficients of mutual inductance between the two coils will be:

(*a*) 1 mH (*b*) 10 mH (*c*) 100 mH (*d*) 1000 mH

79. The magnetic flux linked with a coil at any instant '*E*' is given by

$$\phi = 10t^2 - 50t + 250 \text{ Wb}$$

The induced emf at t = 3 s is:

(*a*) – 190 V (*b*) – 10 V (*c*) 10 V (*d*) 190 V

80. Two co-axial solenoids are made by winding insulated wire over a pipe of cross-sectional area $A = 10$ cm² and length $l = 10$ cm. If one solenoid has 300 turns and the other 400 turns, their mutual inductance is :

(*a*) $4{\cdot}8\,\pi\times10^{-5}$ H (*b*) $2{\cdot}4\,\pi\times10^{-4}$ H (*c*) $2{\cdot}4\,\pi\times10^{-5}$ H (*d*) $4{\cdot}8\,\pi\times10^{-4}$ H

Answers

1. (*d*)	**2.** (*b*)	**3.** (*b*)	**4.** (*c*)	**5.** (*b*)	**6.** (*d*)	**7.** (*b*)	**8.** (*b*)
9. (*d*)	**10.** (*a*)	**11.** (*a*)	**12.** (*b*)	**13.** (*b*)	**14.** (*d*)	**15.** (*a*)	**16.** (*d*)
17. (*d*)	**18.** (*c*)	**19.** (*d*)	**20.** (*b*)	**21.** (*d*)	**22.** (*c*)	**23.** (*d*)	**24.** (*c*)
25. (*d*)	**26.** (*a*)	**27.** (*d*)	**28.** (*d*)	**29.** (*d*)	**30.** (*a*)	**31.** (*d*)	**32.** (*a*)
33. (*d*)	**34.** (*b*)	**35.** (*d*)	**36.** (*a*)	**37.** (*b*)	**38.** (*d*)	**39.** (*c*)	**40.** (*b*)
41. (*c*)	**42.** (*c*)	**43.** (*a*)	**44.** (*c*)	**45.** (*d*)	**46.** (*a*)	**47.** (*b*)	**48.** (*c*)
49. (*d*)	**50.** (*c*)	**51.** (*b*)	**52.** (*d*)	**53.** (*d*)	**54.** (*d*)	**55.** (*c*)	**56.** (*b*)
57. (*b*)	**58.** (*a*)	**59.** (*a*)	**60.** (*d*)	**61.** (*b*)	**62.** (*c*)	**63.** (*b*)	**64.** (*a*)
65. (*b*)	**66.** (*b*)	**67.** (*d*)	**68.** (*c*)	**69.** (*a*)	**70.** (*a*)	**71.** (*a*)	**72.** (*a*)
73. (*b*)	**74.** (*b*)	**75.** (*a*)	**76.** (*d*)	**77.** (*c*)	**78.** (*a*)	**79.** (*b*)	**80.** (*d*)

CASE-BASED QUESTIONS

Attempt any 4 sub-parts from each question. Each question carries 1 mark.

1. MIGRATION OF BIRDS:

The migratory birds pattern is one of the mysteries in the field of science. For example, every winter birds from Siberia fly unerringly to water spots in the Indian sub-continent. There has been a suggestion that electromagnetic induction may provide a clue to the migratory patterns. The earth's magnetic field has existed throughout evolutionary history. It would be of great benefit to migratory birds to use this field to determine the direction. As far as we know birds contains no ferromagnetic material. So, electromagnetic induction seems to be the only reasonable mechanism to determine the direction. Consider the optimal case where the magnetic field B, the velocity of the bird v and two relevant points of its anatomy separated by a distance l, all three are mutually perpendicular. From the formula for motional emf

i.e., $$\varepsilon = Blv$$

Certain kinds of fishes are able to detect small potential differences. However, in these fishes, special cells have been identified which detect small voltage differences. In birds no such cells have been identified. Thus, the migration patterns of birds continues to remains a mystery.

(*i*) Am emf is produced in a coil, which is not connected to an external voltage source. This can be due to

(*a*) the coil being in a time varying magnetic field

(*b*) the coil moving in a time varying magnetic field

(*c*) the coil moving out of a constant magnetic field

(*d*) all of the above

(*ii*) A circular coil expands radially in a region of magnetic field and no electromotive force is produced in the coil. This can be because

(*a*) the magnetic field is in the same plane as the circular coil and it may or may not vary.

(*b*) the magnetic field has a perpendicular (to the plane of the coil) component whose magnitude is decreasing suitably.

(*c*) there is constant magnetic field in the perpendicular (to the plane of the coil) direction.

(*d*) Both (*a*) and (*b*)

(*iii*) A migratory Siberian bird is flying in the sky with a velocity of 10 m/s and the distance between two feathers is 2 cm. The earth's magnetic field B perpendicular to the feathers is 4×10^{-5} T. Then emf generated between the two feathers is

(*a*) 4 μV (*b*) 6 μV

(*c*) 8 μV (*d*) 10 μV

(*iv*) An aeroplane having a wing span of 35 m flies due north with a speed of 90 m/s, given $B = 4 \times 10^{-5}$ T. The potential difference between the tips of the wings will be

(*a*) 0.126 V (*b*) 1.26 V

(*c*) 12.6 V (*d*) 0.013 V

(*v*) A moving conductor's coil produces an induced emf. This is in accordance with

(*a*) Lenz's law (*b*) Coulomb's law

(*c*) Faraday's law (*d*) Ampere's law

Answers

1. (*i*) (*d*); Emf is produced in coil if the magnetic flux linked with it changes. When a coil moves into or out of a uniform magnetic field, the area associated with it changes which in turn changes the magnetic flux linked with the coil and an emf is induced.

(*ii*) (*d*); When coil expands in constant magnetic field, the magnetic flux inside the coil (along area vector) increases and induced current is produced. As the component of magnetic field along the area vector is zero, so $\phi = BA$ becomes zero. So, no induced current flows in the coil.

(*iii*) (*c*); $\varepsilon = Blv$, taking, $B = 4 \times 10^{-5}$ T, $l = 2$ cm $= 2 \times 10^{-2}$m, $v = 10$ m/s

$\varepsilon = 4 \times 10^{-5} \times 2 \times 10^{-2} \times 10 = 8 \times 10^{-6}$ V

$\varepsilon = 8\,\mu$V

(*iv*) (*a*); $\varepsilon = Blv$, taking, $B = 4 \times 10^{-5}$ T, $l = 35$ m, $v = 90$ m/s

$\varepsilon = 4 \times 10^{-5} \times 35 \times 90 = 126 \times 10^{-3}$ V

$\varepsilon = 0.126$ V

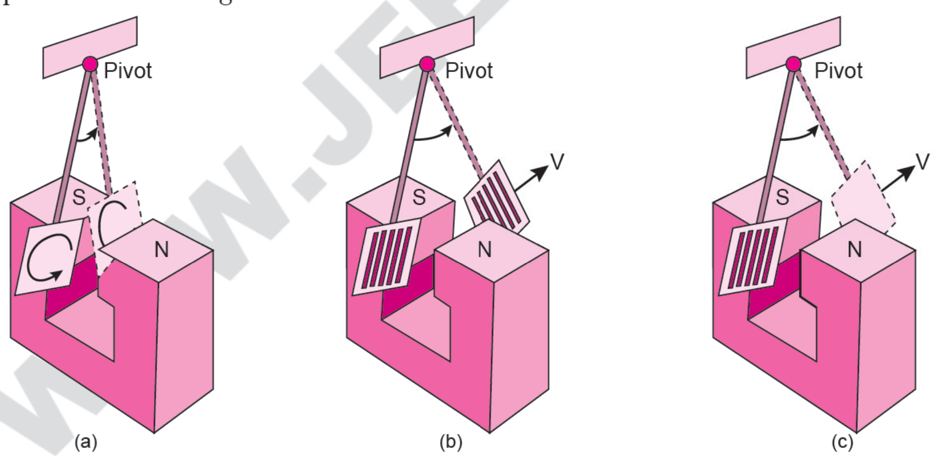
(*v*) (*c*); According to Faraday's law,

i.e., $$\varepsilon = -\frac{d\phi}{dt}$$

or $$|\varepsilon| = \frac{d\phi}{dt}$$

2. MAGNETIC DAMPING:

When a conductor oscillates inside a magnetic field, eddy currents are produced in it. The flow of electrons in the conductor immediately creates an opposing magnetic field which results in damping of the magnet and produces heat inside the conductor similar to heat build-up inside of a power cord during use.



By Lenz's law the circulating currents create their own magnetic field that opposes the field of the magnet. Thus, the moving conductor experiences a drag force that opposes its motion. A damping force is generated when these eddy current and magnetic field interact with each other. It is a damping technique where electromagnetically induced current slow down the motion of an object without any actual contact. As the distance between magnet and conductor decreases the damping force increases. The electromagnetic damping force is proportional to the induced eddy current, strength of the magnetic field and the speed of the object which implies that faster the object moves, greater will be the damping and slower the motion of object, lower will be damping which will result in the smooth stopping of the object.

(*i*) Foucault's current are also known as

(*a*) direct current
(*b*) induced current
(*c*) eddy current
(*d*) both eddy current and induced current

(*ii*) **Eddy current have negative effect because they produce**

(*a*) heating only (*b*) damping only

(*c*) heating and damping (*d*) harmful radiation

(*iii*) **The electromagnetic damping force is proportional to**

(*a*) the induced eddy current (*b*) the strength of magnetic field

(*c*) the speed of object (*d*) all of the above

(*iv*) **In electromagnetic induction, line integral of induced field E around a closed path is ______________ and induced electric field is _____________.**

(*a*) zero, non conservative (*b*) non zero, conservative

(*c*) zero, conservative (*d*) non zero, non conservative

(*v*) **A circular coil of area 200 cm^2 and 25 turns rotates about its vertical diameter with a angular speed of 20 m/s in a uniform horizontal magnetic field of magnitude 0.05 T. The maximum voltage induced in the coil is**

(*a*) 0.5 V (*b*) 1.5 V (*c*) 2.5 V (*d*) 2.0 V

Answers

2. (*i*) (*c*); Eddy current are the current which are induced in a conductor whenever the amount of linked magnetic flux with the conductor changes. These were discovered by Foucault in 1895. So, it is also called Foucault's current.

(*ii*) (*c*); When a conductive material is subjected to a time-varying magnetic flux, eddy current are generated in the conductor. Due to the internal resistance of conductor, the eddy current dissipated, heat and also energy removed from the system produce damping effect.

(*iii*) (*d*); The electromagnetic damping form is proportional to the induced eddy current (I), the strength of magnetic induction (B) and the speed of the object (v).

(*iv*) (*d*); In electromagnetic induction, line integral of induced field E around a close path is not zero, and induced electric field is non-conservative (*i.e.*, work done due to its path is not equal to zero).

(*v*) (*a*); It is induced emf of periodic EMI, so formula is $E = NBA\omega$. Here, ω is angular speed. So, $E = 25 \times 0.05 \times 200 \times 10^{-4} \times 20 = 0.5$ V.

ASSERTION-REASON QUESTIONS

In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct answer out of the following choices.

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

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

(c) A is true but R is false.

(d) A is false and R is also false.

1. Assertion (A) : An emf is induced in a closed loop where magnetic flux is varied. The induced field $\vec{E}$ is not a conservative field. [*AIIMS 2006*]

Reason (R) : The line integral $\oint \vec{E}.\vec{dl}$ around a closed path is non-zero.

2. Assertion (A) : Faraday established induced emf experimentally.

Reason (R) : Magnetic flux can produce an induced emf.

3. Assertion (A) : The direction of induced emf is always such as to oppose the changes that causes it.

Reason (R) : The direction of induced emf is given by Lenz's law.

4. Assertion (A) : Acceleration of a vertically falling magnet through a horizontal metallic ring is less than g.

Reason (R) : Current induced in the ring opposes the fall of magnet.

5. Assertion (A) : If we use a battery across the primary of a step up transformer, then voltage is also obtained across secondary.

Reason (R) : Battery gives a time varying current, so there is a change in magnetic flux through the secondary of transformer and hence, emf is induced across secondary.

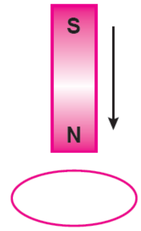
6. Assertion (A) : When a rod moves in a transverse magnetic field, an emf is induced in the rod; the end becomes magnetic with end A positive.

Reason (R) : A Lorentz force evB acts on free electrons, so electrons move from B to A, thus by making end A positive and end B negative.

7. Assertion (A) : In the phenomenon of mutual induction, self-induction of each of the coils persists

Reason (R) : Self-induction arises when strength of current in same coil changes. In mutual induction, current is changed in both individual coils.

8. Assertion (A) : The bar magnet falling vertically along the axis of the horizontal coil will be having acceleration less than g. *[AIIMS 2015]*



Reason (R) : Clockwise current is induced in the coil.

9. Assertion (A) : If current is flowing through a machine of iron, eddy currents are produced. *[AIIMS 1997]*

Reason (R) : Change in magnetic flux through an area causes eddy current.

10. Assertion (A) : The presence of large magnetic flux through a coil maintains a current in the coil, if the circuit is continuous. *[AIIMS 2018]*

Reason (R) : Only a change in magnetic flux will maintain an induced current in the coil.

Answers

1. (*a*) **2.** (*c*) **3.** (*b*) **4.** (*a*) **5.** (*d*) **6.** (*d*) **7.** (*a*) **8.** (*c*)
9. (*a*) **10.** (*d*)

HINTS/SOLUTIONS OF SELECTED MCQs

1. (*d*) According to Faraday's law, emf is induced whenever the flur linked with circuit change.

2. (*b*) $\phi = BA = 10^{-3} \times 10^{-2} = 10^{-5}$ Wb

3. (*b*) $\phi = BA \cos\theta = 4 \times 0.5 \times \cos 60° = 1$ Wb

4. (*c*) $\phi = \vec{B}.\vec{A} = B_0(2\hat{i} + 3\hat{j} + 4\hat{k}) \cdot L^2\hat{k} = 4\,B_0L^2$ Wb

5. (*b*) $\phi = \vec{B}.\vec{A} = B_0(\hat{i} + \hat{k}) \cdot (L^2\hat{k} + L^2\hat{i}) = 2B_0L^2$ Wb

6. (*d*) Magnetic flux linked with the isolated coil change the coil being in a time varying magnetic field, the coil moving in a constant magnetic field or in time varying magnetic field.

7. (*b*) When cylindrical bar magnet is rotated about its axis, no change in flux linked, so no emf induced.

8. (*b*) According to Lenz's law, due to opposes its cause of change, same polarity of magnet is developed in ring which opposes the motion of ring.

9. (*d*) When the A stops moving the current in B becomes zero, it possible only if the current in A is constant. If the current in A would be variable, these must be an induced emf in B even if the A stops moving.

10. (*a*) When the current in B (at $t = 0$) is anticlock wise and due to Lenz's law, when coil A start rotating at $t = 0$, the current in A is constant along clockwise direction.

11. (*a*) Lenz's law is consequence of conservation of energy.

12. (*b*) $L = \mu_r \mu_0 n^2 Al$, where $n = N/l$

Then, L is increases, when l decreases and A increases.

13. (*b*) Charge, $q = \frac{\Delta\phi}{R} = \frac{BA - O}{R} = \frac{AB}{R}$

14. (*d*) No flux change is taking place because magnetic field exists everywhere and is constant in time and space.

15. (*a*) Inertia because h is similar to inertial behaviour where body tend to opposes any change.

16. (*d*) When circular coil expands radially in a region of magnetic field such that the magnetic field is in the same plane as the circular coil or the magnetic field has a perpendicular (to the plane of the coil) component whose magnitude is decreasing suitably in such a away that the cross product of magnetic field and surface of plane of coil remain constant at every instant.

17. (*d*) $E = -L\frac{\Delta i}{\Delta t} \Rightarrow L = \frac{-E}{\Delta i/\Delta t} = \frac{-2}{(2-8)/3\times10^{-2}} = 10^{-2}\text{ H} = 10\text{ mH}$

18. (*c*) M depends on permeability of core, the number of their turns and cross-section area of the common core. It also depends on their separation as well as relative orientation.

21. (*d*) Doubled as $L = \mu_0 \frac{N^2}{l} A$

22. (*c*) Slows down due to Eddy current.

23. (*d*) Due to lenz law, falling magnet will increase the magnetic flux which is opposed by metallic cylinder.

24. (*c*) $L = \frac{e}{\left(\frac{\Delta I}{\Delta t}\right)} = \frac{200}{\left(\frac{5}{0.1}\right)} = 4\text{ H}$

25. (*d*) $|e| = \frac{\Delta\phi}{\Delta t} = \frac{8\times10^{-4}}{0.4} = 2\times10^{-3}\text{ V}$

26. (*a*) $L = \mu_0 n^2 lA = L \propto n^2$

27. (*d*) $e = \frac{-d\phi}{dt} = \frac{-d}{dt}(-Bl\times(t)) = Bl\,.\frac{dx(t)}{dt} = Blv$

28. (*d*) $e = \frac{1}{2}Bl^2w = Bl^2\pi\nu = 0.4\times10^{-4}\times(0.5)^2\times(3.14)\times\frac{120}{60} = 6.28\times10^{-5}\text{ V}$

29. (*d*) $\Delta Q = \frac{\Delta\phi}{R} = \frac{(10-2)}{2} = 4\text{ C}$

31. (*d*) We know that $e = \left|\frac{d\phi}{dt}\right|$

But $e = iR$ and $i = \frac{dq}{dt} \Rightarrow e = \frac{dq}{dt}R \Rightarrow \frac{d\phi}{dt} = \frac{dqR}{dt} \Rightarrow \frac{d\phi}{R} = dq \Rightarrow \Delta q = \frac{\Delta\phi}{R}$

35. (*d*) As $e = \frac{-d}{dt}(N\phi B) = -\frac{LdI}{dt} \Rightarrow L = \frac{-edt}{dI} = \frac{-16\times2}{-8} = 4\text{ H}$

38. (*a*) Magnetic potential energy stored in an inductor in given by $= \frac{1}{2}LI^2$

$\Rightarrow L = \frac{2E}{I^2} = \frac{2\times25\times10^{-3}}{(60\times10^{-3})^2} = \frac{500}{36} = 13.89\text{ H}$

43. (*a*) According to Lenz's law, the current induced in coil will opposes the increasing magnetic field when electron pass the coil from X to Y.

44. (*c*) $L = N^2\mu_0 A \Rightarrow L \propto N^2$

46. (*a*) $M = \sqrt{L_1 L_2} = \sqrt{2\times8} = 4\text{ mH}$

48. (*c*) Medium between coils and separation between them

50. (*c*) Time constant, $\tau = L/R$

52. (*d*) When switch S is turned off, the current in resistor branch becomes zero immediately, while current in inductor branch takes some time to become zero.

53. (*d*) For induced p.d., we have to take the component of length normal to both magnetic field and velocity, so induced emf $Bvl = Bv.2R$. By Fleming's left hand rule, the direction of induced current is from M to Q; so M is at higher potential.

54. (*d*) When loop moves in uniform magnetic field, equal and opposite emf's are induced in side AD and BC.

55. (*c*) Opposite currents are induced in loops, so loops repel each other.

57. (*b*) $\frac{I_1}{I_2} = \frac{L_2}{L_1} = \frac{1}{4}$

58. (*a*) As the magnetic field is constant, the rate of change of magnetic flux will be zero and thus current induced will also be zero.

59. (*a*) According to Lenz's law, the current induced in coil will oppose the increased magnetic field due to increase of current, so current induced will be *clockwise*.

60. (*d*) Magnetic flux through the coil,

$$\phi = \vec{B} \cdot \vec{A} = B\hat{k} \cdot (A_x \hat{i} + A_y \hat{j}) = 0$$

61. (*b*) $\frac{L_1 L_2}{L_1 + L_2} = 2.4, \qquad L_1 + L_2 = 10$

$$\frac{L_1 L_2}{10} = 2.4 \Rightarrow L_1 L_2 = 24 \Rightarrow L_1 = \frac{24}{L_2}$$

$$\frac{24}{L_2} + L_2 = 10 \Rightarrow L_2 = 4\text{ H}, L_1 = 6\text{ H}$$

62. (*c*) The network is a balanced Wheatstone bridge. Its equivalent resistance between C and D is total resistance of circuit

$$I = \frac{E}{R} = \frac{Bvl}{R}$$

$$\Rightarrow \quad v = \frac{IR}{Bl_{ab}} = 5 \times 10^{-2}\text{ m/s} = 5\text{ cm/s}$$

63. (*b*) Magnetic field at centre produced due to current I_1 in larger loop,

$$B = 4 \times \frac{\mu_0 I_1}{4\pi\left(\frac{L}{2}\right)}(\sin 45° + \sin 45°) = \frac{2\sqrt{2}\mu_0 I_1}{\pi L}$$

Magnetic flux linked with smaller loop,

$$\phi_2 = B_1 A_2 = \frac{2\sqrt{2}\mu_0 I_1}{\pi L} l^2$$

Mutual Inductance $M = \frac{\phi_2}{I_1} = \frac{2\sqrt{2}\mu_0}{\pi}\frac{l^2}{L} \propto \frac{l^2}{L}$.

64. (*a*) The magnetic field is along the axis of a circular coil. The maximum flux linkage between the coils is in situation (i).

65. (*b*) Induced emf,

$$E = -\frac{d\phi}{dt} = -\frac{d}{dt}(BA) = -A\frac{dB}{dt} = -A\frac{dB}{dx}\frac{dx}{dt} = -Av\frac{dB}{dx}$$

The magnetic flux linked with coil initially increases, so induced emf is initially negative, then magnetic flux linked becomes constant; so $\frac{dB}{dx} = 0$ and then magnetic flux begins to decrease, so $\frac{dB}{dx}$ is negative and induced emf is positive. The change of sign is only shown in (*b*).

66. (*d*) If E is electric field induced at distance r, then

$$E\, 2\pi r = \frac{d}{dt}\{AB(t)\} = \pi a^2 \frac{dB}{dt}(t)$$

$$\Rightarrow \quad E = \frac{a^2}{2r}\frac{dB}{dt}(t) \propto \frac{1}{r}$$

67. (*d*) $P = \frac{E^2}{R}$

Induced emf $E = -N\frac{d\phi}{dt} = -NA\frac{dB}{dt}$

Resistance $R = \frac{\rho l}{\pi r^2} \propto \frac{1}{r^2}$

$P \propto \frac{N^2 r^2}{l}$

$\frac{P_2}{P_1} = \left(\frac{N_2}{N_1}\right)^2 \times \left(\frac{r_2}{r_1}\right)^2 = (4)^2 \times \left(\frac{1}{2}\right)^2 = 4$

68. (*c*) EMF induced between point O and A,

$E = \frac{1}{2}B\omega l^2$

Potential difference across OP, $= \frac{1}{2}B\omega a^2$

Current in R, $I = \frac{V}{R} = \frac{B\omega a^2}{2R}$

69. (*a*) $E = \left|-\frac{d\phi}{dt}\right| = \left|A\frac{dB}{dt}\right| = A \times$ slope of line OA

$= 5 \cdot 0 \times 10^{-3} \times \frac{0 \cdot 2}{10 \times 10^{-3}} = 0 \cdot 1\text{ V}$

71. (*a*) Given three inductors are connected in parallel, so

$\frac{1}{L_{eff}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = 1$, $L_{eff} = 1$ H

72. (*a*) In electrostatic field and gravitational field, the field lines cannot originate and terminate at the same point.

74. (*b*) Magnetic flux $= \sum_i \vec{B_i} \cdot \vec{A_i}$

Where B_i is the magnetic field passing through the area A_i.

Since $B = 0$

Hence net magnetic flux is zero.

76. (*d*) $\phi = BA = B.\pi r^2$

emf, $e = \frac{-d\phi}{dt} = -2B\pi r\frac{dr}{dt}$

$e = -2 \times 0.04\pi \times 0.02 \times 0.002 = 3.2\,\pi\,\mu\text{V}$

77. (*c*) $\phi_{net} = LI \Rightarrow \phi_{net} = 500 \times 4 \times 10^{-3} = 2$ Wb So $L = \frac{\phi_{net}}{I} = \frac{2}{2} = 1$ H

78. (*a*) $|e| = M\frac{dI}{dt}$

$M = \frac{e}{\left(\frac{dI}{dt}\right)} = \frac{100 \times 10^{-3}}{\left(\frac{10-0}{0.1}\right)}$

$= \frac{100 \times 10^{-3} \times 0.1}{10} = 10^{-3}\text{ H} = 1\text{ mH}$

79. (*b*) $\phi = 10t^2 - 50t + 250$

$e = -\frac{d\phi}{dt} = -\frac{d}{dt}(10t^2 - 50t + 250) = -20t + 50$

At $t = 3$ s

$e = -20(3) + 50 = -10$ V

80. (*d*) Mutual inductance of two solenoid system,

$M = \mu_0\left(\frac{N_1}{l}\right)N_2 A = 4\pi \times 10^{-7}\left(\frac{300}{0 \cdot 10}\right) \times 400 \times 10 \times 10^{-4}$ H

$= 4.8\,\pi \times 10^{-4}$ H

07 ALTERNATING CURRENT

IMPORTANT FORMULAE

1. **For an alternating current circuit**

$$V = V_0 \sin \omega t; \; I = I_0 \sin (\omega t + \phi)$$

2. **RMS value of an alternating current**

$$I_{rms} = \frac{I_0}{\sqrt{2}}, V_{rms} = \frac{V_0}{\sqrt{2}}$$

3. **Impedance of series LCR circuit**

$$Z = \frac{V_{rms}}{I_{rms}} = \sqrt{R^2 + (X_C - X_L)^2} = \sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2}$$

4. **Phase angle between I and V,**

$$\tan \theta = \frac{X_C - X_L}{R}$$

$$\cos \theta = \frac{R}{Z}$$

5. **Resonance: (If $X_C = X_L$ and $Z = R$), then**

$$\omega_r = \frac{1}{\sqrt{LC}} \text{ and } f_r = \frac{1}{2\pi\sqrt{LC}}$$

6. **Q-Factor:**

$$Q\text{ - Factor} = \frac{\omega_r}{\omega_2 - \omega_1} = \frac{\omega_r L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

7. **Average power dissipated in LCR-circuit,**

$$P_{ar} = V_{rms} I_{rms} \cos \theta = \frac{1}{2} V_0 I_0 \cos \theta$$

8. **Peak emf in a rotating coil of generator**

$$E_0 = NBA\omega$$

9. **For LC oscillations**

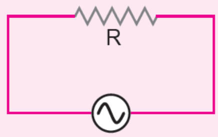
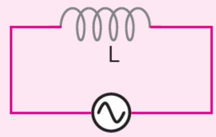
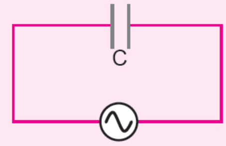
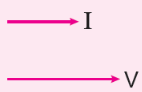
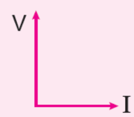
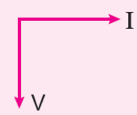
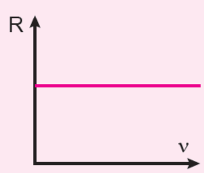
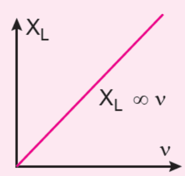
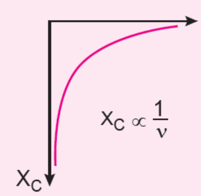
$$W_r = \frac{1}{\sqrt{LC}} \text{ and } f_r = \frac{1}{2\pi\sqrt{LC}}$$

10. **For a Transformer** $\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s} = r$ (transformation ratio)

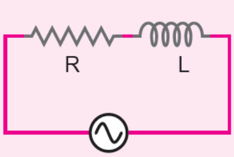
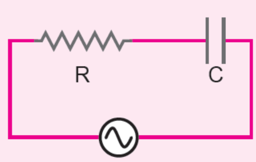
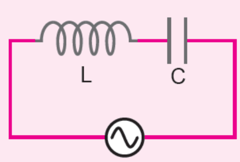
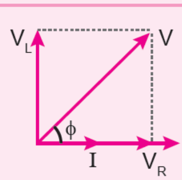
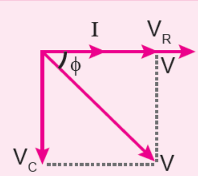
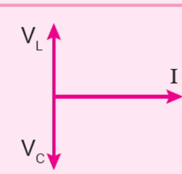
For a step up transformer $r = \frac{N_s}{N_p} > 1$

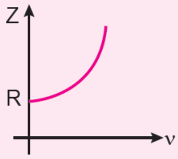
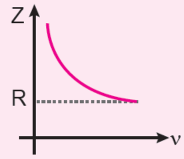
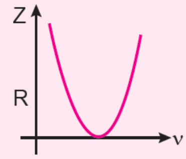
For a step down transformer, $r = \frac{N_s}{N_p} < 1$

Individual Components (R or L or C)

TERM	R	L	C
Circuit			
Supply Voltage	$V = V_0 \sin \omega t$	$V = V_0 \sin \omega t$	$V = V_0 \sin \omega t$
Current	$I = I_0 \sin \omega t$	$I = I_0 \sin \left(\omega t - \frac{\pi}{2}\right)$	$I = I_0 \sin \left(\omega t + \frac{\pi}{2}\right)$
Peak Current	$I_0 = \frac{V_0}{R}$	$I_0 = \frac{V_0}{\omega L}$	$I_0 = \frac{V_0}{1/\omega C} = V_0 \omega C$
Impedance (Ω) $Z = \frac{V_0}{I_0} = \frac{V_{rms}}{I_{rms}}$	$\frac{V_0}{I_0} = R$ R = Resistance	$\frac{V_0}{I_0} = \omega L = X_L$ X_L = Inductive reactance	$\frac{V_0}{I_0} = \frac{1}{\omega C} = X_c$ X_C = Capacitive reactance
Phase difference	zero (in same phase)	$+\frac{\pi}{2}$ (V leads I)	$-\frac{\pi}{2}$ (V leads I)
Phasor Diagram			
Variation of Z with ν	 R does not depend on ν		

Combination of Components (RL or RC or LC)

TERM	RL	RC	LC
Circuit	I is same in R & L 	I is same in R & C 	I is same in L & C 
Phasor diagram	 $V^2 = V_R^2 + V_L^2$	 $V^2 = V_R^2 + V_C^2$	 $V = V_L - V_C \ (V_L > V_C)$ $V = V_C - V_L \ (V_C > V_L)$
Supply Voltage	$V = V_0 \sin \omega t$	$V = V_0 \sin \omega t$	$V = V_0 \sin \omega t$

Current	$I = I_0 \sin(\omega t - \phi)$	$I = I_0 \sin(\omega t + \phi)$	$I = I_0 \sin\left(\omega t \pm \frac{\pi}{2}\right)$
Phase difference in between V and I	V leads I $\left(\phi = 0 \text{ to } \frac{\pi}{2}\right)$	V lags I $\left(\phi = 0 \text{ to } \frac{\pi}{2}\right)$	V lags I $\left(\phi = -\frac{\pi}{2}, \text{ if } X_C > X_L\right)$ V leads I $\left(\phi = +\frac{\pi}{2}, \text{ if } X_L > X_C\right)$
Impedance	$Z = \sqrt{R^2 + X_L^2}$	$Z = \sqrt{R^2 + (X_C)^2}$	$Z = \lvert X_L - X_C \rvert$
Variation of Z with ν	As ν increases, Z increases  	As ν increases, Z decreases  	As ν increases, Z first decreases then increases 

MULTIPLE CHOICE QUESTIONS

Choose and write the correct option in the following questions.

1. If the *rms* current in a 50 Hz *ac* circuit is 5 A, the value of the current 1/300 seconds after its value becomes zero is *[NCERT Examplar]*

(*a*) $5\sqrt{2}$ A (*b*) $5\sqrt{\frac{3}{2}}$ A (*c*) 5/6 A (*d*) $5/\sqrt{2}$ A

2. An alternating current generator has an internal resistance R_g and an internal reactance X_g. It is used to supply power to a passive load consisting of a resistance R_g and a reactance X_L. For maximum power to be delivered from the generator to the load, the value of X_L is equal to *[NCERT Examplar]*

(*a*) zero (*b*) X_g (*c*) $-X_g$ (*d*) R_g

3. In an ac circuit, the maximum value of voltage is 423 volts. Its effective voltage is

(*a*) 400 volt (*b*) 300 volt (*c*) 323 volt (*d*) 340 volt

4. The peak voltage of 220 V *ac* mains is

(*a*) 155.6 V (*b*) 220.0 V (*c*) 311 V (*d*) 440 V

5. An inductive circuit have zero resistance. When *ac* voltage is applied across this circuit, then the current lags behind the applied voltage by an angle

(*a*) 30° (*b*) 45° (*c*) 90° (*d*) 0°

6. If an *LCR* circuit contains $L = 8$ henry; $C = 0.5$ μF, $R = 100\ \Omega$ in series. Then the resonant angular frequency will be:

(*a*) 600 rad/s (*b*) 500 rad/s (*c*) 600 Hz (*d*) 500 Hz

7. When a voltage measuring device is connected to *ac* mains, the meter shows the steady input voltage of 220 V. This means *[NCERT Examplar]*

(*a*) input voltage cannot be *ac* voltage, but a *dc* voltage.

(*b*) maximum input voltage is 220 V.

(*c*) the meter reads not V but $<V^2>$ and is calibrated to read $\sqrt{<V^2>}$.

(*d*) the pointer of the meter is stuck by some mechanical defect.

8. To reduce the resonant frequency in an *LCR* series circuit with a generator [*NCERT Examplar*]

(*a*) the generator frequency should be reduced.

(*b*) another capacitor should be added in parallel to the first.

(*c*) the iron core of the inductor should be removed.

(*d*) dielectric in the capacitor should be removed.

9. In a pure capacitive circuit, the current

(*a*) lags behind the applied emf by angle $\pi/2$ (*b*) leads the applied emf by an angle π

(*c*) leads the applied emf by angle $\pi/2$ (*d*) and applied emf are in same phase

10. In an *ac* circuit, the emf (ε) and the current (i) at any instant are given by

$$\varepsilon = E_0 \sin \omega t, i = I_0 \sin(\omega t - \phi)$$

Then average power transferred to the circuit in one complete cycle of *ac* is

(*a*) $E_0 I_0$ (*b*) $\frac{1}{2}E_0 I_0$ (*c*) $\frac{1}{2}E_0 I_0 \sin\phi$ (*d*) $\frac{1}{2}E_0 I_0 \cos\phi$

11. The average power dissipation in pure inductance is

(*a*) $\frac{1}{2}LI^2$ (*b*) $\frac{1}{4}LI^2$ (*c*) $2LI^2$ (*d*) zero

12. Electrical energy is transmitted over large distances at high alternating voltages. Which of the following statements is (are) correct? [*NCERT Examplar*]

(*a*) For a given power level, there is a lower current.

(*b*) Lower current implies less power loss.

(*c*) It is easy to reduce the voltage at the receiving end using step-down transformers.

(*d*) All of these

13. The reactance of a capacitance at 50 Hz is 5 Ω. If the frequency is increased to 100 Hz, the new reactance is

(*a*) 5 Ω (*b*) 10 Ω (*c*) 2.5 Ω (*d*) 125 Ω

14. In a pure inductive circuit, the current

(*a*) lags behind the applied emf by an angle π (*b*) lags behind the applied emf by an angle $\pi/2$

(*c*) leads the applied emf by an angle $\pi/2$ (*d*) and applied emf are in same phase

15. When an *ac* voltage of 220 V is applied to the capacitor C [*NCERT Examplar*]

(*a*) the maximum voltage between plates is 220 V.

(*b*) power delivered to the capacitor is zero.

(*c*) the charge on the plates is in phase with the applied voltage.

(*d*) both (*b*) and (*c*)

16. Which of the following combinations should be selected for better tuning of an *LCR* circuit used for communication? [*NCERT Examplar*]

(*a*) $R = 20\ \Omega, L = 1.5$ H, $C = 35\ \mu$F (*b*) $R = 25\ \Omega, L = 2.5$ H, $C = 45\ \mu$F

(*c*) $R = 15\ \Omega, L = 3.5$ H, $C = 30\ \mu$F (*d*) $R = 25\ \Omega, L = 1.5$ H, $C = 45\ \mu$F

17. An inductor of reactance 1 Ω and a resistor of 2 Ω are connected in series to the terminals of a 6 V (rms) *ac* source. The power dissipated in the circuit is [*NCERT Examplar*]

(*a*) 8 W (*b*) 12 W (*c*) 14.4 W (*d*) 18 W

18. The output of a step-down transformer is measured to be 24 V when connected to a 12 watt light bulb. The value of the peak current is [*NCERT Examplar*]

(*a*) $1/\sqrt{2}$ A (*b*) $\sqrt{2}$ A (*c*) 2 A (*d*) $2\sqrt{2}$ A

19. In a series LR-circuit, the inductive reactance is equal to the resistance *R* of the circuit. An emf $E = E_0 \cos(\omega t)$ is applied to the circuit. The power consumed in the circuit is

(*a*) $\frac{E_0^2}{4R}$ (*b*) $\frac{E_0^2}{8R}$ (*c*) $\frac{E_0^2}{R}$ (*d*) $\frac{E_0^2}{2R}$

20. One 60 V, 100 W bulb is to be connected to 100 V, 50 Hz *ac* source. The potential drop across the inductor is

(*a*) 10 V (*b*) 40 V (*c*) 20 V (*d*) 80 V

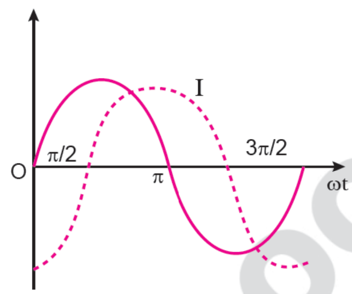
21. An *ac* voltage source of variable angular frequency ω and fixed amplitude *a* is connected in series with a capacitance *C* and an electric bulb of resistance *R* (inductance zero). When ω is increased

(*a*) the bulb glows dimmer (*b*) the bulb glows brighter
(*c*) net impedance of circuit is unchanged (*d*) total impedance of the circuit increases

22. An alternating emf of angular frequency ω is applied across an inductor. The instantaneous power developed across it has an angular frequency

(*a*) ω (*b*) ω/2 (*c*) ω/4 (*d*) 2 ω

23. The variation of the instantaneous current *I*(*t*) and the instantaneous emf *E*(*t*) in a circuit is as shown in the following fig. Which of the following statements is correct?



(*a*) The voltage lags behind the current by $\pi/2$. (*b*) The voltage leads the current by $\pi/2$.
(*c*) The voltage and the current are in phase. (*d*) The voltage leads the current by π.

24. In electric arc furnace, Copper or iron is melted due to variation of

(*a*) current (*b*) magnetic field (*c*) voltage (*d*) electric field

25. When *ac* source is connected across series R-C combination, the *ac* current may lead *ac* voltage by

(*a*) 0° (*b*) 180° (*c*) 30° (*d*) 90°

26. High voltage transmission line is preferred as

(*a*) its appliances are less costly (*b*) thin power cables are required
(*c*) idle current very low (*d*) power loss is very less

27. In series R-L-C circuit, quality factor can be improved by

(*a*) decreasing *L* (*b*) increasing *C* (*c*) decreasing *R* (*d*) decreasing *R* & *L*

28. When *ac* source is connected across series R-L-C combination, maximum power loss will occur provided

(*a*) current and voltage are in phase (*b*) current from source is minimum
(*c*) inductance is minimum (*d*) capacitance is maximum

29. In R-L-C series *ac* circuit, impedance cannot be increased by

(*a*) increasing frequency of source (*b*) decreasing frequency of source
(*c*) increasing the resistance (*d*) increasing the voltage of the source

30. In highly inductive load circuit, it is more dangerous when

(*a*) we close the switch (*b*) we open the switch
(*c*) increasing the resistance (*d*) decreasing the resistance

31. In electric sub-station in township, large capacitor banks are used

(*a*) to reduce power factor (*b*) to improve power factor
(*c*) to decrease current (*d*) to increase current in the circuit

32. In a purely resistive *ac* circuit, the current

(*a*) is in phase with the emf

(*b*) leads the emf by a phase difference of π radians

(*c*) leads the emf by a phase difference of π /2 radians

(*d*) lags behind the emf by phase difference of π /4 radians

33. A capacitor of capacitance *C* has reactance X_C. If capacitance and frequency become double, then the capacitive reactance will be

(*a*) $2X_C$ (*b*) $4X_C$ (*c*) $\frac{X_C}{4}$ (*d*) $\frac{X_C}{2}$

34. The core of a transformer is laminated, so as to

(*a*) make it light weight (*b*) make it robust and strong

(*c*) increase the secondary voltage (*d*) reduce energy loss due to eddy current

35. The ratio of number of turns of primary coil to secondary coil in a transformer is 2:3. If a cell of 6 V is connected across the primary coil, then voltage across the secondary coil will be

(*a*) 3 V (*b*) 6 V (*c*) 9 V (*d*) 12 V

36. In a transformer, the number of turns of primary and secondary coil are 500 and 400 respectively. If 220 V is supplied to the primary coil, then ratio of currents in primary and secondary coils is

(*a*) 5 : 9 (*b*) 5 : 4 (*c*) 9 : 5 (*d*) 4 : 5

37. An LC-circuit contains 10 mH inductor and 25 mF capacitor with given initial charge. The resistance of the circuit is negligible. At what time the energy stored in circuit is completely magnetic? (Time is measured from the instant when the circuit is close)

(*a*) $\frac{T}{4}, \frac{3T}{4}, \frac{5T}{4} \ldots$ (*b*) $0, \frac{T}{2}, \frac{2T}{2} \ldots$ (*c*) $\frac{T}{3}, \frac{2T}{3}, \frac{5T}{3} \ldots$ (*d*) $0, \frac{T}{8}, \frac{T}{4} \ldots$

38. In an *ac* circuit the voltage and current are given by the following expressions $V = V_0 \sin \omega t$ and $I = I_0 \cos \omega t$, where the symbols have their usual meaning. Which of the following statement is correct?

(*a*) Voltage lead the current by a phase angle of $\pi/2$.

(*b*) Voltage lags behind the current by phase angle of π.

(*c*) Voltage and current are in phase.

(*d*) Voltage lags behind the current by phase angle of $\pi/2$.

39. The peak value of an *ac* of 2 A in a circuit

(*a*) $\sqrt{2}$ A (*b*) 2 A (*c*) $2\sqrt{3}$ A (*d*) $2\sqrt{2}$ A

40. In an *ac* circuit, current is given by the relation $I = 100\sqrt{2} \cos 50t$ A. The rms value of the current is

(*a*) 50 A (*b*) 200 A (*c*) 100 A (*d*) $100\sqrt{2}$ A

41. In an *ac* circuit containing resistance only, *E* and *I* are given by $E = 200 \sin (200)t$ volt and $I = 100 \sin (200)t$ mA. The power dissipated in the circuit is

(*a*) 10 watt (*b*) 200 watt (*c*) 100 watt (*d*) 400 watt

42. In case of an *ac* circuit containing pure inductance, the phase difference between *E* and *I* is

(*a*) $\frac{\pi}{4}$ (*b*) zero (*c*) π (*d*) $\frac{\pi}{2}$

43. A transformer has 20 turns of primary and 100 turns of secondary. If the two ends of the primary are connected to a 220 V *dc* supply, the voltage across the secondary will be

(*a*) zero (*b*) 1100 V (*c*) 220 V (*d*) 11 V

44. An *ac* source is connected in series to an inductance *L* and a capacitance *C*, such that the frequency of the *ac* source is

(*a*) $L^{-1}C^{-1}$ (*b*) $L^{-1/2}C^{-1/2}$ (*c*) $\left(\frac{1}{2\pi}\right)L^{-1}C^{-1}$ (*d*) $\left(\frac{1}{2\pi}\right)L^{-1/2}C^{-1/2}$

45. An ac source is of $\frac{200}{\sqrt{2}}$ V, 50 Hz. The value of voltage after $\frac{1}{600}$ s from the start is

(*a*) 200 V (*b*) $\frac{200}{\sqrt{2}}$V (*c*) 100 V (*d*) 50 V

46. In an *ac* series circuit, the instantaneous current is maximum when the instantaneous voltage is maximum. The circuit element connected to the source will be

(*a*) pure inductor (*b*) pure capacitor
(*c*) pure resistor (*d*) combination of a capacitor and an inductor

47. *R*, *L* and *C* represent the physical quantities resistance, inductance and capacitance respectively. Which one of the following combinations has dimension of frequency?

(*a*) $\frac{1}{\sqrt{RC}}$ (*b*) $\frac{R}{L}$ (*c*) $\frac{1}{LC}$ (*d*) $\frac{C}{L}$

48. Which of the following effects is not possible by *ac*?

(*a*) Heating effect (*b*) Chemical effect
(*c*) Magnetic effect (*d*) None of the above

49. A pure capacitor in an *ac* circuit

(*a*) stores energy in its electrostatic field (*b*) stores energy in its magnetic field
(*c*) does not store energy (*d*) dissipates energy

50. In an *ac* circuit the phase difference between current and emf is 45°. The circuit contains

(*a*) a pure inductance
(*b*) a pure resistance
(*c*) a pure capacitance
(*d*) a resistance, an inductance and a capacitance in series.

51. The metal/alloy that is more suitable for making cores of transformers is

(*a*) steel (*b*) soft iron (*c*) copper (*d*) brass

52. An electric bulb 220 V, is connected to 220 V, 50 Hz *ac* source. Then the bulb

(*a*) does not glow (*b*) glows intermittently
(*c*) glows continuously (*d*) fuses

53. The average power dissipation in a pure capacitor is:

(*a*) $\frac{1}{2}CV^2$ (*b*) CV^2 (*c*) $\frac{1}{4}CV^2$ (*d*) zero

54. The frequency of *ac* is 50 Hz. How many times the current becomes zero in one second?

(*a*) 50 times (*b*) 100 times (*c*) 200 times (*d*) 25 times

55. In a circuit current *I* is given by $I = I_0 \sin(\omega t - \pi/2)$ when *ac* potential of $E = E_0 \sin \omega t$ has been applied. Then the power consumption *P* in the circuit would be:

(*a*) $\frac{E_0I_0}{\sqrt{2}}$ (*b*) $\frac{E_0I_0}{2}$ (*c*) $\frac{EI}{\sqrt{2}}$ (*d*) zero

56. The potential difference *V* and current *i* flowing through an inductor in an *ac* circuit are given by $V = 5\cos\omega t$ volt, $i = 2\sin\omega t$ ampere, the power dissipated in the inductor is:

(*a*) 0 W (*b*) 10 W (*c*) 5 W (*d*) 2.5 W

57. Electric power is transmitted over long distance through conducting wires of high voltages because

(*a*) it reduces the possibility of theft of wire
(*b*) this entails less power losses
(*c*) *ac* generators produce electric power at very high voltages
(*d*) *ac* signal of high voltage travels faster.

58. A choke coil is a coil having

(*a*) low inductance and high resistance

(*b*) low inductance and low resistance

(*c*) high inductance and high resistance

(*d*) high inductance and negligible or small resistance

59. The voltage measured across the *ac* mains terminals is 210 V. Then the peak to peak variation of voltage between the terminals will be:

(*a*) 420 V (*b*) $420/\sqrt{2}$ V (*c*) $420\sqrt{2}$ V (*d*) $210\sqrt{2}$ V

60. An *ac* voltage source $E = 200\sqrt{2}$ sin 100 *t* is connected across a circuit containing an *ac* ammeter and a capacitor of capacitance 1μF. The reading of ammeter is

(*a*) 10 mA (*b*) 20 mA (*c*) 40 mA (*d*) 80 mA

61. An alternating current circuit consists of an inductor and a resistor in series. In this circuit

(*a*) The potential difference across and current in resistor leads the potential difference across inductor.

(*b*) The potential difference across and current in resistor lags behind the potential difference across inductor by an angle $\pi/2$.

(*c*) The potential difference across and current in resistor lags behind the potential difference across inductor by an angle π

(*d*) The potential difference across resistor lags behind the potential difference across inductor by an angle $\pi/2$, while the current in resistor leads the potential difference across inductor by an angle $\pi/2$.

62. The core used in transformers and other electromagnetic devices are laminated

(*a*) to increase the magnetic field

(*b*) to increase the level of magnetic saturation of the core

(*c*) to reduce the magnetism in the core

(*d*) to reduce eddy current losses in the core

63. An alternating voltage of frequency ω is induced in electric circuit consisting of an inductance *L* and capacitance *C*, connected in series. Then across the inductance coil

(*a*) current is maximum when $\omega^2 = 1/LC$ (*b*) current is minimum when $\omega^2 = 1/LC$

(*c*) voltage is minimum when $\omega^2 = 1/LC$ (*d*) voltage is zero when $\omega^2 = 1/LC$

64. An alternating voltage is connected in series with a resistance *R* and an inductance *L*. If the potential drop across the resistance is 200 volts and across the inductance is 150 volt, the applied voltage is:

(*a*) 250 V (*b*) 300 V (*c*) 350 V (*d*) 500 V

65. An inductive circuit contains a resistance of 10 ohm and an inductance of 2·0 henry. If an *ac* voltage of 120 volt and frequency 60 Hz is applied to this circuit, the current in the circuit would be nearly

(*a*) 0·32 A (*b*) 0·16 A (*c*) 0·48 A (*d*) 0·80 A

66. When 100 volt *dc* is applied across a solenoid, a current of 1.0 A flows in it. When 100 volt *ac* is applied across the same coil, the current drops to 0.5 A If the frequency of *ac* source is 50 Hz, the impedance and inductance of solenoid are:

(*a*) 200 Ω and 0·55 henry (*b*) 100 Ω and 0·86 henry

(*c*) 200 Ω and 1·0 henry (*d*) 100 Ω and 0·93 henry

67. An electric fan is:

(*a*) electric motor (*b*) electric generator

(*c*) an accelerator (*d*) based on electromagnetic induction

68. A transformer is used to

(*a*) convert *ac* into *dc* (*b*) convert *dc* into *ac*

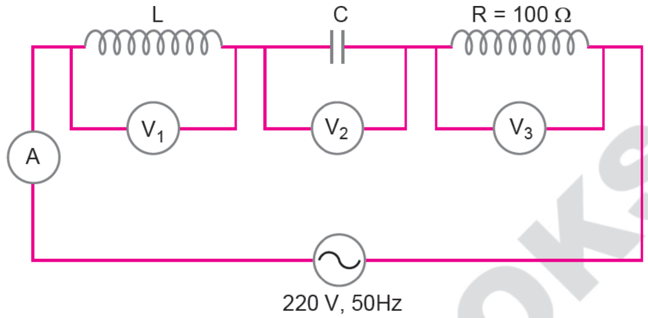
(*c*) to step up or down *dc* voltage (*d*) to step up or down *ac* voltage

69. The power dissipated in an *LCR* series circuit connected to an *ac* source of emf ε is :

(*a*) $\dfrac{\varepsilon^2\sqrt{R^2+\left(\omega L-\dfrac{1}{\omega C}\right)^2}}{R}$ (*b*) $\dfrac{\varepsilon^2\sqrt{R^2+\left(\omega L-\dfrac{1}{\omega C}\right)^2}}{R}$

(*c*) $\dfrac{\varepsilon^2 R}{\sqrt{R^2+\left(\omega L-\dfrac{1}{\omega C}\right)^2}}$ (*d*) $\dfrac{\varepsilon^2 R}{R^2+\left(\omega L-\dfrac{1}{\omega C}\right)^2}$

70. In the given circuit, the reading of voltmeter V_1 and V_2 are 300 volts each. The reading of voltmeter V_3 and ammeter A are respectively.

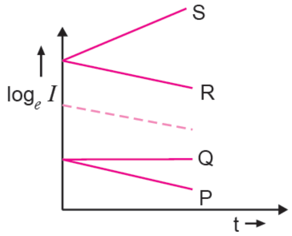


(*a*) 220 V, 2.2 A (*b*) 220 V, 2.0 A (*c*) 100 V, 2.0 A (*d*) 150 V, 2.2 A

71. An emf of 15 V is applied in a circuit containing 5 H inductance and 10 Ω resistance. The ratio of the currents in time $t = \infty$ and at $t = 1$ second is:

(*a*) $\dfrac{e^{1/2}}{e^{1/2-1}}$ (*b*) $\dfrac{e^2}{e^2-1}$ (*c*) $1-e^{-1}$ (*d*) e^{-1}

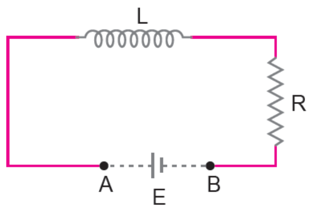
72. In an *RC* circuit while charging, the graph of $\log_e I$ versus time (t) is shown by the dotted line in the diagram where I is the current. When the value of the resistance is doubled, which of the solid curves best represents the variation of $\log_e I$ versus time (t)?



(*a*) *P* (*b*) *Q*

(*c*) *R* (*d*) *S*

73. An inductor (L = 100 mH), a resistor (R = 100 Ω) and a battery (E = 100 V) are initially connected in series as shown in figure. After a long time the battery is disconnected after short circuiting the points *A* and *B*. The current in the circuit 1 ms after the short circuit is:



(*a*) $\dfrac{1}{e}$ A (*b*) e A

(*c*) 0·1 A (*d*) 1 A

74. In *LCR* circuit, capacitance is changed from *C* to 2*C*. For resonant frequency to remain unchanged, the inductance should be changed from *L* to:

(*a*) 4 *L* (*b*) 2 *L* (*c*) *L* /2 (*d*) *L*

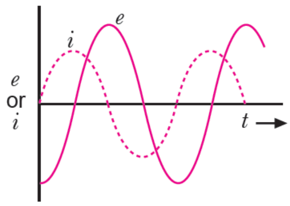
75. An alternating current is given by $i = i_1 \cos \omega t + i_2 \sin \omega t$. The rms current is given by:

(*a*) $\dfrac{i_1+i_2}{\sqrt{2}}$ (*b*) $\dfrac{i_1-i_2}{\sqrt{2}}$ (*c*) $\sqrt{\dfrac{i_1^2+i_2^2}{2}}$ (*d*) $\dfrac{i_1 i_2}{\sqrt{2}}$

76. In a transformer, the number of turns in the primary are 140 and that in secondary are 280. If the current in the primary is 4 A; the current in secondary is:

(*a*) 4 A (*b*) 2 A (*c*) 6 A (*d*) 10 A

77. When an *ac* source of emf $e = E_0 \sin 100t$ is connected across a circuit, the phase difference between emf *e* and the current in the circuit is observed to be π/4 as shown in figure. If the circuit consists possibly *RC* or *RL* or *LC* in series, find the relationship between the two elements:



(*a*) $R = 1$ kΩ, $C = 10$ μF (*b*) $R = 1$ kΩ, $C = 1$ μF

(*c*) $R = 1$ kΩ, $L = 10$ H (*d*) $R = 1$ kΩ, $L = 1$ H

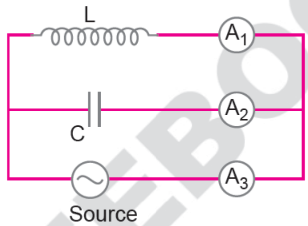
78. The phase difference between the alternating current and emf is $\frac{\pi}{2}$. Which of the following can not be the constituent of the circuits?

(*a*) *R*, *L* (*b*) *C* alone (*c*) *L* alone (*d*) *L*, *C*

79. The voltage of an *ac* supply varies with time as $V = 120 \sin \pi t \cos 100 \pi t$. The maximum voltage and frequency respectively are:

(*a*) 120 V, 100 Hz (*b*) $60\sqrt{2}$ V, 100 Hz (*c*) 60 V, 200 Hz (*d*) 60 V, 100 Hz

80. A circuit containing *L*, *C* and *ac* source with ammeters A_1, A_2, A_3 is shown in figure. At resonance which ammeter reads zero?



(*a*) A_1 (*b*) A_2

(*c*) A_3 (*d*) all the three A_1, A_2 and A_3

81. A capacitor of capacitance 2 μF is connected to a tank circuit of an oscillator with frequency of 1 kHz. If the current in the circuit is 2 mA, the voltage across the capacitor will be :

(*a*) 0·16 V (*b*) 0·32 V (*c*) 79·5 V (*d*) 159 V

82. A purely resistive circuit element *X* when connected to an *ac* supply of peak voltage 200 V gives a peak current of 5 A which is in phase with voltage. A second circuit element *Y*, when connected to same *ac* supply also gives the same value of peak current but the current lags behind by 90°. If the series combination of *X* and *Y* is connected to same supply; what will be the value of rms current?

(*a*) 1·5 A (*b*) 2·5 A (*c*) 3·5 A (*d*) 0·5 A

83. The voltage and current in *ac* circuit are given by

$$V = 5 \sin\left(100\pi t - \frac{\pi}{6}\right), i = 4 \sin\left(100\pi t + \frac{\pi}{6}\right)$$

We can conclude

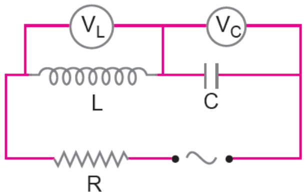
(*a*) voltage leads the current by 30° (*b*) current leads the voltage by 30°

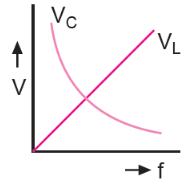
(*c*) current leads the voltage by 60° (*d*) current and voltage are in phase

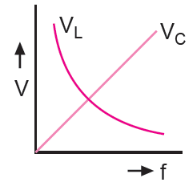
84. The electric current in a circuit is given by $I = I_0\left(\frac{t}{T}\right)$ for some time. The rms value of current for the period $t = 0$ to $t = T$ is :

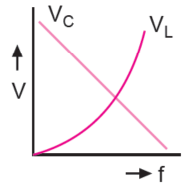
(*a*) $\frac{I_0}{\sqrt{2}}$ (*b*) $\sqrt{2} I_0$ (*c*) $\frac{I_0}{\sqrt{3}}$ (*d*) $\sqrt{3} I_0$

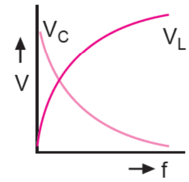
85. A series LCR circuit is shown in figure. The source frequency f is varied, but the current is kept unchanged. Which of the curves shows changes of V_C and V_L with frequency?



(*a*) 

(*b*) 

(*c*) 

(*d*) 

86. An alternating current of 1·5 mA rms and angular frequency ω = 100 rad/s flows through a 10 kΩ resistor and a 0·50 μF capacitor in series. The rms potential difference across the capacitor is:

(*a*) 4·8 V (*b*) 15 V (*c*) 30 V (*d*) 42 V

87. In a series LCR circuit, the voltage across R is 100 V and R = 1 kΩ with C = 2 μF. The resonant frequency ω is 200 rad/s. At resonance, the voltage across L is:

(*a*) $2{\cdot}5 \times 10^{-2}$ V (*b*) 40 V (*c*) 250 V (*d*) 4×10^{-3} V

88. In an *ac* generator, a coil with N turns, all of the same area A and total resistance R, rotates with frequency ω in a magnetic field B. The maximum value of emf generated in the coil is:

(*a*) $NABR\omega$ (*b*) NAB (*c*) $NABR$ (*d*) $NAB\omega$

89. An ideal coil of 10 H is connected in series with a resistance of 5 Ω and a battery of 5 V. 2 seconds after the connections are made, the current flowing, in ampere, in the circuit is:

(*a*) e (*b*) e^{-1} (*c*) $(1 - e^{-1})$ (*d*) $(1 - e)$

90. The selectivity of a series LCR ac circuit is large, when *[CBSE 2020 (55/5/1)]*

(*a*) L is large and R is large (*b*) L is small and R is small

(*c*) L is large and R is small (*d*) L = R

91. The phase difference between the current and the voltage in series LCR circuit at resonance is *[CBSE 2020 (55/5/2)]*

(*a*) π (*b*) $\pi/2$ (*c*) $\pi/3$ (*d*) zero

Answers

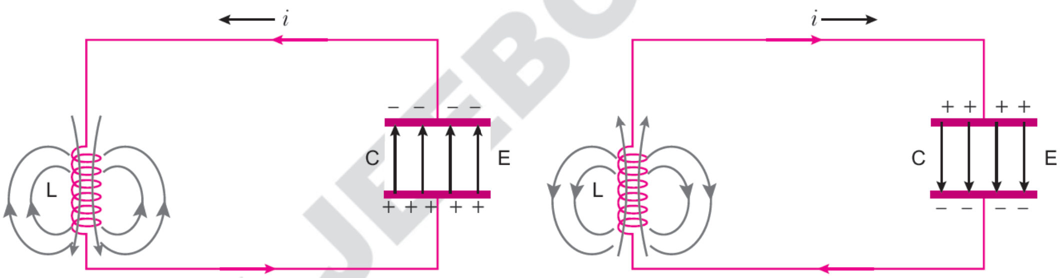
1. (*b*)	**2.** (*c*)	**3.** (*b*)	**4.** (*c*)	**5.** (*c*)	**6.** (*b*)	**7.** (*c*)	**8.** (*b*)
9. (*c*)	**10.** (*d*)	**11.** (*d*)	**12.** (*d*)	**13.** (*c*)	**14.** (*b*)	**15.** (*d*)	**16.** (*c*)
17. (*c*)	**18.** (*a*)	**19.** (*a*)	**20.** (*d*)	**21.** (*b*)	**22.** (*d*)	**23.** (*b*)	**24.** (*a*)
25. (*d*)	**26.** (*d*)	**27.** (*c*)	**28.** (*a*)	**29.** (*d*)	**30.** (*b*)	**31.** (*b*)	**32.** (*a*)
33. (*c*)	**34.** (*d*)	**35.** (*c*)	**36.** (*d*)	**37.** (*a*)	**38.** (*d*)	**39.** (*d*)	**40.** (*c*)
41. (*a*)	**42.** (*d*)	**43.** (*a*)	**44.** (*d*)	**45.** (*c*)	**46.** (*c*)	**47.** (*b*)	**48.** (*b*)
49. (*a*)	**50.** (*d*)	**51.** (*b*)	**52.** (*b*)	**53.** (*d*)	**54.** (*b*)	**55.** (*d*)	**56.** (*a*)
57. (*b*)	**58.** (*d*)	**59.** (*d*)	**60.** (*b*)	**61.** (*d*)	**62.** (*d*)	**63.** (*a*)	**64.** (*a*)
65. (*b*)	**66.** (*a*)	**67.** (*a*)	**68.** (*d*)	**69.** (*d*)	**70.** (*a*)	**71.** (*b*)	**72.** (*a*)
73. (*a*)	**74.** (*c*)	**75.** (*c*)	**76.** (*b*)	**77.** (*c*)	**78.** (*a*)	**79.** (*d*)	**80.** (*c*)
81. (*a*)	**82.** (*b*)	**83.** (*c*)	**84.** (*c*)	**85.** (*a*)	**86.** (*c*)	**87.** (*c*)	**88.** (*d*)
89. (*c*)	**90.** (*c*)	**91.** (*d*)					

CASE-BASED QUESTIONS

Attempt any 4 sub-parts from each question. Each question carries 1 mark.

1. LC OSCILLATORS:

An LC circuit oscillating at its natural resonant frequency can store electrical energy. A capacitor store electrical energy in the electric field (E) between its plates, depending on the voltage across it, and an inductor stores magnetic energy in its magnetic field (B), depending on the current through it. If an inductor is connected across a charged capacitor, the voltage across the capacitor will drive a current through inductor, building up a magnetic field around it. The voltage across the capacitor falls to zero as the charge is used up by the current flow. At this point, the energy stored in the coil's magnetic field induces a voltage across the coil, because inductor oppose changes in current. This induced voltage cause a current to begin to recharge the capacitor with a voltage of opposite polarity to its original charge. Due to Faraday's law, the emf which drives the current is caused by a decrease in magnetic field, thus the energy required to charge the capacitor is extracted from the magnetic field. When the magnetic field is completely dissipated the current will stop; and the charge will again be stored in the capacitor with the opposite polarity as before. Then the cycle will begin again, with the current flowing in the opposite direction through the inductor. The charge flows back and forth between the plates of the capacitor, through the inductor. The energy oscillates back and forth between the capacitor and the inductor until internal resistance makes the oscillations die out. The tuned circuit's action, known mathematically as harmonic oscillator, is similar to a pendulum swinging back and forth.



(*i*) In an *LC* oscillator, the frequency of oscillator is ____________ *L* or *C*.

(*a*) directly proportional to
(*b*) proportional to the square of
(*c*) independent of the value of
(*d*) inversely proportional to square root of

(*ii*) An *LC* oscillator cannot be used to produce

(*a*) high frequencies
(*b*) audio frequencies
(*c*) very low frequencies
(*d*) very high frequencies

(*iii*) In an *LC* oscillator, if the value of *L* is increased four times, the frequency of oscillations is

(*a*) increased by 2 times
(*b*) decreased 4 times
(*c*) increased by 4 times
(*d*) decreased by 2 times

(*iv*) In an ideal parallel *LC* circuit, the capacitor is charged by connecting it to a *dc* source, which is then disconnected. The current in the circuit

(*a*) becomes zero instantly
(*b*) grows monotonically
(*c*) decays monotonically
(*d*) oscillates instantly

(*v*) An *LC* circuit contains a 0.6 H inductor and 25 μF capacitor. What is the rate of change of the current (in A/s) when the charge on the capacitor is 3×10^{-5} C?

(*a*) 2
(*b*) 4
(*c*) 3
(*d*) 6

Answers

1. (*i*) (*d*); In *LC* oscillator, the frequency is given as

$$\omega = \frac{1}{\sqrt{LC}}$$

(*ii*) (*c*); An *LC* oscillator cannot be used to produce very low frequencies.

(*iii*) (*d*); The frequency of *LC* oscillator is given as $\omega = \frac{1}{\sqrt{LC}}$

If L is increased four times then,

$$\omega' = \frac{1}{\sqrt{4LC}} = \frac{1}{2\sqrt{LC}} = \frac{1}{2}\omega$$

(*iv*) (*d*); When capacitor is connected to a *dc* source and then disconnected it gets charged and then it starts discharging through the inductor. When circuit is closed, the capacitor begins to discharge through the inductor causing current to flow. The energy of electric field between the capacitor plates has transferred to magnetic field. By Lenz's law, this dying magnetic field induces on emf in the inductance in the same direction as current. Hence *LC* circuit sets up oscillations.

(*v*) (*a*); For *LC* circuit,

Electrostatic energy of capacitor = Magnetic energy of inductor

$$\frac{a^2}{2C} = \frac{1}{2}LI^2$$

Differentiate *w.r.t.* t

$$\frac{1}{2C}(2q)\frac{dq}{dt} = \frac{1}{2}L(2I)\frac{dI}{dt}$$

$$\frac{q}{C}I = LI\frac{dI}{dt}$$

$$\frac{dI}{dt} = \frac{q}{LC} = \frac{3\times 10^{-5}}{0.6\times 25\times 10^{-6}}$$

$$\frac{dI}{dt} = 2 \text{ A/s}$$

2. RESONANCE:

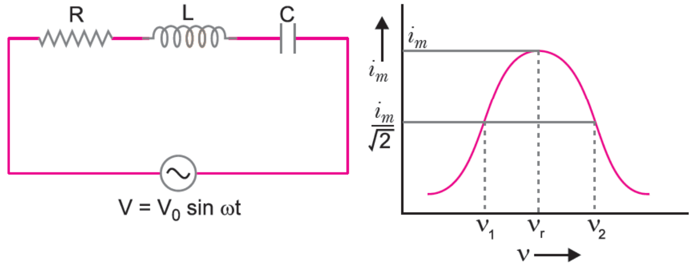
An interesting characteristic of the series *RLC* circuit is the phenomenon of resonance. The phenomenon of resonance is common among systems that have a tendency to oscillate at a particular frequency. This frequency is called the system's natural frequency. If such a system is driven by an energy source at a frequency that is near the natural frequency, the amplitude of oscillation is found to be large. A familiar example of this phenomenon is a child on a swing. The swing has a natural frequency for swinging back and forth like a pendulum. If the child pulls on the rope at regular intervals and the frequency of the pulls is almost the same as the frequency of swinging, the amplitude of the swinging will be large.

Suppose a resistance R, inductance L and capacitance C are connected in series and fed by an alternating source of voltage V, the frequency of alternating current source be f. This series *RLC* circuit is said to be in resonance only if the frequency f of applied alternating source be such that the current flowing in circuit and voltage applied are in the same phase. At resonance in *RLC* series circuit impedance is minimum (*i.e.*, $Z = R$). For an *RLC* circuit driven with voltage of amplitude V_m and angular frequency ω_0 is given by

$$\omega_0 = \frac{1}{\sqrt{LC}}.$$

At resonant frequency, the current amplitude is maximum

i.e., $$i_m = \frac{V_m}{R}$$



(*i*) **To reduce the resonant frequency in an LCR series circuit with a generator**

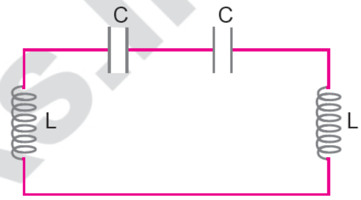
(*a*) the generator frequency should be reduced

(*b*) another capacitor should be added in parallel to the first

(*c*) the iron core of the inductor should be removed

(*d*) dielectric in the capacitor should be removed

(*ii*) **The natural frequency of the circuit shown in fig. is**



(*a*) $\frac{1}{2\pi\sqrt{LC}}$ (*b*) $\frac{1}{2\pi\sqrt{2LC}}$

(*c*) $\frac{2}{2\pi\sqrt{LC}}$ (*d*) none of these

(*iii*) **In an *ac* circuit the emf (*e*) and the current (*i*) at any instant are given respectively by**

$$e = E_0 \sin \omega t$$

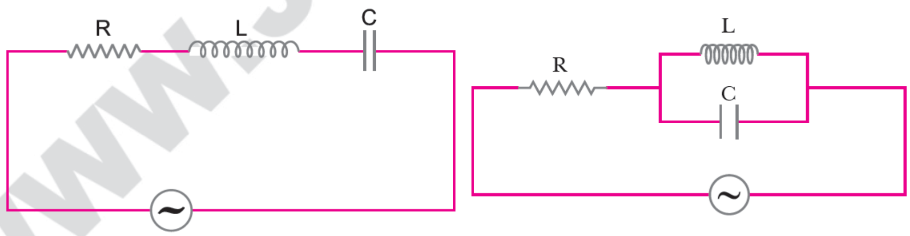
$$i = I_0 \sin (\omega t - \phi)$$

The average power in the circuit over one cycle of *ac* is

(*a*) $E_0 I_0$ (*b*) $\frac{E_0 I_0}{2}$

(*c*) $\frac{E_0 I_0}{2} \sin \phi$ (*d*) $\frac{E_0 I_0}{2} \cos \phi$

(*iv*) **An *ac* voltage is connected to two circuits as shown in fig., the current through resistance *R* in the circuit (I) and (II) at resonance respectively is**



(I) **(II)**

(*a*) 0 A, 0 A (*b*) $\frac{V}{R}$, 0 A

(*c*) 0 A, $\frac{V}{R}$ (*d*) $\frac{V}{R}, \frac{V}{R}$

(*v*) **The resonant frequency ω_r of a series LCR circuit with $L = 2$ H, $C = 32$ μF *and* $R = 10\ \Omega$ is**

(*a*) 125 rad s^{-1} (*b*) 130 rad s^{-1}

(*c*) 135 rad s^{-1} (*d*) 140 rad s^{-1}

Answers

2. (*i*) (*b*); The resonant frequency of *LCR* series circuit is

$$\nu_0 = \frac{1}{2\pi\sqrt{LC}}$$

So, to reduce resonant frequency ν_0, we either have to increase *L* or to *C*. To increase *C*, another capacitor must be connected in parallel with the first.

(*ii*) (*a*); The two capacitors are in series and two inductors are also in series.

So, $L_S = L + L = 2L$ and $\frac{1}{C_S} = \frac{1}{C} + \frac{1}{C} = \frac{2}{C}$

$\Rightarrow \quad C_S = \frac{C}{2}$

$\therefore$ Natural frequency of the circuit, $\nu_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{2L \times \frac{C}{2}}} = \frac{1}{2\pi\sqrt{LC}}$

(*iii*) (*d*); Power = Rate of work done in one cycle

$$P_{av} = \frac{W}{T}$$

$$P_{av} = \frac{(E_0 I_0 \cos\phi)\frac{T}{2}}{T} \qquad \left[\because \text{Work done in half cycle is } W = (E_0 I_0 \cos\phi).\frac{T}{2}\right]$$

$$P_{av} = \frac{E_0 I_0 \cos\phi}{2}$$

(*iv*) (*b*) In series LCR circuit, at resonance, $Z = R$

So, $i_{series} = \frac{V}{Z} = \frac{V}{R}$

In parallel LCR circuit, current in circuit

$$i_{parallel} = i_C - i_L = 0$$

(*v*) (*a*); Resonant frequency, $\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{2 \times 32 \times 10^{-6}}} = \frac{1}{8} \times 10^3 = 125\text{ rad/s}$

$$\omega_r = 125\text{ rad/s}$$

ASSERTION-REASON QUESTIONS

In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct answer out of the following choices.

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

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

(c) A is true but R is false.

(d) A is false and R is also false.

1. Assertion (A) : An alternating current of frequency 50 Hz becomes zero, 100 times in one second.

Reason (R) : Alternating current changes direction and becomes zero twice in a cycle.

2. Assertion (A) : Capacitor serves as a block for DC and offers an easy path to AC.

Reason (R) : Capacitive reactance is inversely proportional to frequency.

3. Assertion (A) : A capacitor of suitable capacitance can be used in an AC circuit in place of the choke coil.

Reason (R) : A capacitor blocks DC and allows AC only.

4. Assertion (A) : An alternating current does not show any magnetic effect.

Reason (R) : Alternating current does not vary with time.

5. Assertion (A) : In series LCR-circuit, the resonance occurs at one frequency only. *[AIIMS 1998]*

Reason (R) : At resonance, the inductive reactance is equal and opposite to the capacitive reactance.

6. Assertion (A) : 220 V, 50 Hz appliance implies that emf across the appliance should be 220 V.

Reason (R) : Every appliance is specified with its peak Tolerable voltage.

7. Assertion (A) : The quantity L/R possesses the dimension of time. *[AIIMS 2002]*

Reason (R) : In order to reduce the rate of increase of current through a solenoid, we should increase the time constant.

8. Assertion (A) : Transformers are used only in alternating current source not in direct current. *[AIIMS 2009]*

Reason (R) : Only a.c. can be stepped up or down by means of transformers.

9. Assertion (A) : The possibility of an electric bulb fusing is higher at the time of switching ON and OFF. *[AIIMS 2003]*

Reason (R) : Inductive effects produce a surge at the time of switch-OFF and switch-ON.

10. Assertion (A) : It is advantageous to transmit electric power at high voltage. *[AIIMS 2010]*

Reason (R) : High voltage implies high current.

Answers

1. (*a*) **2.** (*a*) **3.** (*b*) **4.** (*d*) **5.** (*a*) **6.** (*c*) **7.** (*b*) **8.** (*a*)
9. (*a*) **10.** (*c*).

HINTS/SOLUTIONS OF SELECTED MCQs

1. (*b*) $I = I_0 \sin \omega t = I_0 \sin 2\pi\nu t = 5\sqrt{2} \sin 2\pi \times 50 \times \frac{1}{300} = 5\sqrt{2} \sin\frac{\pi}{3} = 5\sqrt{\frac{3}{2}}$A

2. (*c*) According to maximum power transfer theorem, $X_L = -X_g$

3. (*b*) $V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{423}{\sqrt{2}} = 300$ V

4. (*c*) $V_0 = \sqrt{2}\, V_{rms} = \sqrt{2} \times 220 = 311$ V

6. (*b*) $W_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8 \times 0.5 \times 10^{-6}}} = 500$ rad/s

7. (*c*) The voltmeter connected to AC mains reads mean ($< V^2 >$) and is calibrated in such a way that it gives value of $< V^2 >$, which is multiplied by firm factor to give rms value.

8. (*b*) Resonant frequency, $\nu_r = \frac{1}{2\pi\sqrt{LC}}$, $\nu_r \propto \frac{1}{\sqrt{LC}}$

Now, to reduce ν_r either we can increase L or C.

So, to increase C, we must connected another capacitor parallel to the first.

10. (*d*) $P_{av} = E_{rms}\, I_{rms} \cos\phi = \frac{E_0}{\sqrt{2}} \times \frac{I_0}{\sqrt{2}} \cos\phi = \frac{1}{2} E_0 I_0 \cos\phi$

11. (*d*) For pure inductive circuit, $\phi = 90°$, $\cos\phi = 0$, so $P_{av} = 0$.

12. (*d*) We have to transmit power over large distance at high alternating voltage, so, current flowing through the wires will be low.

Here, $P = E_{rms} I_{rms}$. I_{rms} is low when E_{rms} is high also power loss $= I^2_{rms} R =$ Low

Now, at the receiving end high voltage is reduced by using step-down transformer.

13. (*c*) $X_C = \frac{1}{\omega c} \quad \Rightarrow \frac{X_C}{(X_C)_{new}} = \frac{\omega_2}{\omega_1} = \frac{2\pi f_2}{2\pi f_1} = \frac{f_2}{f_1} = \frac{100}{50} = 2$

$\therefore \quad (X_c)_{new} = \frac{5}{2} = 2.5\Omega$

15. (*d*) The plate with positive charge will be at higher potential and the plate with negative charge will be at lower potential. So, we can say that the charge is in phase with applied voltage.

16. (*d*) Quality factor (Q) $= \frac{1}{R}\sqrt{\frac{L}{C}}$ for an L-C-R circuit,

To make, Q is high, R should be low, L should be high and C should be low.

17. (*d*) Average power dissipated in the circuit,

$$P_{av} = E_{rms} I_{rms} \cos\phi = \left(\frac{E_{rms}}{Z}\right)^2 \cos\phi$$

where, $Z = \sqrt{R^2 + x_L^2} = \sqrt{4+1} = \sqrt{5}\,\Omega$ and $\cos\phi = \frac{R}{Z} = \frac{2}{\sqrt{5}}$

then, $P_{av} = \frac{(6)^2}{\sqrt{5}} \times \frac{2}{\sqrt{5}} = \frac{72}{5} = 14.4$ W

18. (*a*) $P_s = V_S I_S \Rightarrow I_s = \frac{124}{24} = \frac{1}{2}$A

$I_0 = I_S\sqrt{2} = \frac{1}{2} \times \sqrt{2} = \frac{1}{\sqrt{2}}$A

19. (*a*) Power consumed: $P = E_{\text{rms}} i_{\text{rms}} \cos\phi$

$P = E_{rms}\left(\frac{E_{rms}}{Z}\right)\frac{R}{Z}$ $\left[\therefore\ i_{rms} = \frac{E_{rms}}{Z} \text{ and } \cos\phi = \frac{R}{Z}\right]$

$E_{rms} = \frac{E_0}{\sqrt{2}}$, then $P = \frac{E_0^2}{4R}$

20. (*d*) Voltage across the inductor is

$V_I = \sqrt{V^2 - V_R^2} = \sqrt{(100)^2 - (60)^2} = \sqrt{10000 - 3600} = \sqrt{6400} = 80$ V

21. (*b*) We know that

$$Z = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}$$

Now, Power $= V_{rms}\, i_{rms} \cos\phi$

$$P = V_{rms}\, i_{rms}\, \frac{R}{Z}$$

Now, as ω increase, Z decreases

i.e., the bulb glows brighter (more power)

22. (*d*) $\text{Power}_{inst} = P_0 = E_0 \sin\omega t \times i_0 \sin\left(\omega t - \frac{\pi}{2}\right)$

$P = E_o i_0 \sin\omega t \,.\cos\omega t$

$P = \frac{1}{2} E_0 i_0 \sin(2\,\omega t)$ [as $\sin 2\omega t = 2 \sin\omega t \cos\omega t$)]

Hence, angular frequency of instantaneous power is [2ω].

24. (*a*) In electric furnace Cu and Fe is melted due to variation of current because current generates heat and electricity.

25. (*d*) $\phi = \tan^{-1}\left|\frac{1}{\omega CR}\right|$

i.e., 90° for maximum

26. (*d*) Weak current flows through the transmission line, hence low power loss (I^2R).

27. (*c*) Q factor $= \frac{1}{R}\sqrt{\frac{L}{C}}$

Q factor can be improved by decreasing R.

30. (*b*) When just open the switch, more quickly current changes gives higher the voltage in the circuit.

33. (*c*) $X_C' = \frac{1}{2\pi(2f)(2C)} = \frac{X_C}{4}$

35. (*c*) Given $\frac{N_S}{N_P} = \frac{3}{2}$

Now, we know that $\frac{E_S}{E_P} = \frac{N_S}{N_P}$

$E_P = 6$ V

then $E_S = E_P \frac{N_S}{N_P} = 6 \times \frac{3}{2} = 9$ V

36. (*d*) $\frac{I_P}{I_S} = \frac{N_S}{N_P} = \frac{400}{500} = 4:5$

37. (*a*) At $t = 0, \frac{T}{2}, T, \frac{3T}{2}...$ energy is electrostatic & at $t = \frac{T}{4}, \frac{3T}{4}, \frac{5T}{4}...$ energy is totally magnetic.

38. (*d*) $V = V_0 \sin \omega t, I = I_0 \cos \omega t = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$

i.e., voltage lags behind the current by phase angle of $\frac{\pi}{2}$.

41. (*a*) $P_{av} = \frac{1}{2} V_0 i_0 = \frac{1}{2} \times 100 \times 200 \times 10^{-3} = 10$ W

43. (*b*) In DC supply, magnetic flux does not change, so emf not induced, *i.e.*, $E_s = 0$.

45. (*c*) $V_{rms} = \frac{200}{\sqrt{2}}$ V

$V_0 = \sqrt{2}\, V_{rms} = \sqrt{2} \times \frac{200}{\sqrt{2}} = 200$ V

$V = V_0 \sin 2\pi\upsilon t = 200 \sin\left(2\pi \times 50 \times \frac{1}{600}\right) = 200 \sin\frac{\pi}{6} = 200 \times \frac{1}{2} = 100$ V

47. (*b*) Time constant for *RC* circuit is given by $\tau = RC \Rightarrow \frac{1}{RC}$ will have the dimension of frequency. Similarly, time constant for a LR circuit is given by

$\tau = \frac{L}{R} \Rightarrow \frac{R}{L}$ will have dimension of frequency.

50. (*d*) Because ϕ between current and emf is 45° in case of LCR circuit.

51. (*b*) Soft iron because it reduces the hysteresis loss.

53. (*d*) For pure capacitor, $\phi = 90°$

$P_{av} = \frac{V_0 I_0}{2} \cos\phi = \frac{V_0 I_0}{2} \cos 90° = 0$

54. (*b*) 100 times as current is zero two times for one complete cycle.

55. (*d*) $P = E_{rms}\, I_{rms} \cos\phi = E_{rms}\, I_{rms} \cos\left(-\frac{\pi}{2}\right) = 0$

60. (*b*) $X_C = \frac{1}{\omega C} = \frac{1}{100 \times 10^{-6}} = 10^4\ \Omega$

$I_{rms} = \frac{V_{rms}}{X_C} = \frac{200}{10^4}$ A $= 20$ mA

63. (*a*) i_{max} when $\omega = \frac{1}{\sqrt{LC}}$ or $\omega^2 = \frac{1}{LC}$

64. (*a*) $V = \sqrt{V_R^2 + V_L^2} = \sqrt{(200)^2 + (150)^2} = 250$ V

65. (*b*) $Z = \sqrt{R^2 + (\omega L)^2} = \sqrt{10^2 + (120\pi \times 2)^2} = 753.6\ \Omega$

$I = \frac{V}{Z} = \frac{120}{753.6} = 0.16$ A

66. (*a*) $R = \frac{V_{dc}}{I_{dc}} = \frac{100}{1} = 100\,\Omega, \quad Z = \frac{V_{rms}}{I_{rms}} = \frac{100}{0.5} = 200\,\Omega$

$X_L = \sqrt{Z^2 - R^2} = \sqrt{200^2 - 100^2} = 100\sqrt{3}\ \Omega, \ L = \frac{X_L}{\omega} = \frac{100\sqrt{3}}{2\pi \times 50} = \frac{100\sqrt{3}}{314} = 0.55$ H

70. (*a*) Now at resonance, $V_L = V_C = 300$ V, then, $V_R = 220$ V

$i = \frac{V}{R} = \frac{220}{100} = 2.2$ A

71. (*b*) Time constant, $\tau = \frac{L}{R} = \frac{5}{10} = 0 \cdot 5$ s

Equation of growth of current in RL-circuit is

$$I = I_0 [1 - e^{-Rt/L}]$$

At $t = \infty, I_1 = I_0$

At $t = 1, I_2 = I_0 [1 - e^{-1/0.5}] = I_0 (1 - e^{-2})$

$$\therefore \quad \frac{I_1}{I_2} = \frac{1}{1 - e^{-2}} = \frac{e^2}{e^2 - 1}$$

72. (*a*) Charging current $I = I_0 e^{-t/RC}$

$$\Rightarrow \quad \log_e I = \log_e I_0 - \frac{t}{RC} \qquad \text{where } I_0 = \frac{E}{R}$$

Clearly, the graph of $\log_e I$ versus t is a straight line of slope $-\frac{1}{RC}$ shown by dotted line. When R increases to $2R$, I_0 decreases so value of $\log_e I_0$ decreases and slope becomes half. This is shown in P.

73. (*a*) $I_0 = \frac{E}{R} = \frac{100}{100} = 1\text{ A}$

Time constant

$$\tau = \frac{L}{R} = \frac{100 \times 10^{-3}}{100} = 1 \times 10^{-3}\text{ s} = 1\text{ ms}$$

Current during discharging after time t is

$$I = I_0 e^{-t/T} = I_0 e^{-1/1} = I_0 . \left(\frac{1}{e}\right) = \frac{1}{e}\text{ A}$$

74. (*c*) $\omega_r = \frac{1}{\sqrt{LC}}, \omega_r' = \frac{1}{\sqrt{L'C'}}$

$$\therefore \quad \omega_r = \omega_r' \text{ implies } LC = L'C'$$

$$\Rightarrow L' = \frac{C}{C'} L = \frac{C}{2C} L = \frac{L}{2}$$

75. (*c*) $i_{rms}^2 = (i^2)_{mean} = \frac{\int_0^T (i_1 \cos \omega t + i_2 \sin \omega t)^2}{T}$

$$= \int_0^T i_1^2 \cos^2 \omega t + \int_0^T i_2^2 \sin^2 \omega t + \int_0^T 2 i_1 i_2 \sin \omega t \cos \omega t$$

$$= i_1^2 \times \frac{1}{2} + i_2^2 \times \frac{1}{2} + 0$$

$$i_{rms} = \sqrt{\frac{i_1^2 + i_2^2}{2}}$$

76. (*b*) $\frac{I_S}{I_P} = \frac{N_P}{N_S} = \frac{140}{280} = \frac{1}{2} \Rightarrow I_S = \frac{I_P}{2} = 2\text{ A}$

77. (*c*) In given figure current is leading applied voltage by $\frac{\pi}{4}$, so circuit may be RL or RLC circuit. Out of given circuits the possible circuit is RL circuit.

Also $\tan \phi = \frac{\omega L}{R}$

$$\tan 45° = \frac{100\, L}{R} \quad \Rightarrow \quad R = 100\, L$$

78. (*a*) In RL circuit, the phase difference is $\tan^{-1}\left(\frac{\omega L}{R}\right)$ which is never $\frac{\pi}{2}$ for finite values of L and R.

79. (*d*) $V = 120 \sin 100\, \pi t \cos 100\, \pi t = 60 \sin (2 \times 100\, \pi t)$

Maximum voltage $= V_0 = 60$ V

Frequency, $f_r = \frac{\omega_r}{2\pi} = \frac{200\pi}{2\pi} = 100\text{ Hz}$

80. (*c*) At resonance $i_L = i_C$ with a phase difference of π. Current in main circuit $i_3 = i_C - i_L = 0$, so ammeter A_3 reads zero.

81. (*a*) $V_C = X_C I = \dfrac{1}{2\times 3\cdot 14\times 2\times 10^{-3}}\times 2\times 10^{-3}$ volt $= 0{\cdot}16$ V

82. (*b*) $R = \dfrac{E_0}{I_0} = \dfrac{200}{5} = 40\,\Omega$

In purely inductive circuit current lags behind the applied voltage by $\dfrac{\pi}{2}$;

$\therefore\ X_L = \dfrac{E_0}{I_0} = \dfrac{200}{5} = 40\,\Omega$

Impedance $Z = \sqrt{R^2 + X_L^2} = 40\sqrt{2}\,\Omega$

$I_0 = \dfrac{E_0}{Z} = \dfrac{200}{40\sqrt{2}}\text{ A} = \dfrac{5}{\sqrt{2}}\text{A}$

$I_{rms} = \dfrac{I_0}{\sqrt{2}} = 2\cdot 5\text{ A}$

83. (*c*) Phase lead of current over voltage

$\phi = 100\,\pi t + \dfrac{\pi}{6} - \left(100\pi t - \dfrac{\pi}{6}\right) = \dfrac{\pi}{3} = 60°$

84. (*c*) $I_{rms}^2 = \dfrac{\int_0^T I^2 dt}{\int^T dt} = \dfrac{\int^T I_0^2 t^2 dt}{T^2 . T} = \dfrac{I_0^2\,[t^3]_0^T}{3T^3}$

$\therefore\ I_{rms} = \dfrac{I_0}{\sqrt{3}}$

85. (*a*) $V_C = \dfrac{1}{2\pi f C} \propto \dfrac{1}{f}$ and $V_L = (2\pi f L) \propto f$

86. (*c*) $X_C = \dfrac{1}{\omega C} = \dfrac{1}{100\times 0\cdot 50\times 10^{-6}}\,\Omega = 2\times 10^4\,\Omega$

$V_C = X_C\, I = 2\times 10^4 \times 1\cdot 5\times 10^{-3} = 30\text{ V}$

87. (*c*) Current in circuit at resonance frequency

$I = \dfrac{V}{R} = \dfrac{100}{1\times 10^3}\text{ A} = 0.1\text{ A}$

At resonance $X_L = X_C$

$\therefore$ Voltage across L, $V_L = X_L\, I = X_C\, I = \dfrac{1}{\omega C}I = \dfrac{1}{200\times 2\times 10^{-6}}\times 0.1 = 250\text{ V}$

89. (*c*) $i = i_0\,(1 - e^{-Rt/L})$

$L = 10$ H, $R = 5\,\Omega$, $t = 2$ s

$i_0 = \dfrac{E}{R} = \dfrac{5}{5} = 1\text{ A}$

$i = 1\,(1 - e^{-5\times 2/10}) = (1 - e^{-1})$

90. (*c*) $Q = \dfrac{1}{R}\sqrt{\dfrac{L}{C}}$

The selectivity of a series LCR circuit can be increased by increasing the quality factor, *i.e.*, when L is large and R is small.

91. (*d*) At resonance, the circuit behaves as purely resistive and the phase difference between current and voltage in purely resistive circuit is zero.

TERM–1
PHYSICS

BLUE PRINTS

PRACTICE PAPERS

OMR SHEETS

BLUE PRINT–1

(FOR PRACTICE PAPER–01)

Chapters	Multiple Choice Questions (1 Mark)	Case-based Questions (1 Mark)	Assertion-Reason Questions (1 Mark)	Total
1. Electric Charge and Fields	5(5)	—	1(1)	17(17)
2. Electrostatic potential and capacitance	—	4(4)	1(1)	
3. Current electricity	5(5)	—	1(1)	
4. Moving charges and magnetism	1(1)	4(4)	1(1)	18(18)
5. Magnetism and matter	3(3)	—	1(1)	
6. Electromagnetic induction	3(3)	—	1(1)	
7. Alternating current	3(3)	—	1(1)	
Total	**20(20)**	**8(8)**	**7(7)**	**35(35)**

BLUE PRINT–2

(FOR PRACTICE PAPER–02)

Chapters	Multiple Choice Questions (1 Mark)	Case-based Questions (1 Mark)	Assertion-Reason Questions (1 Mark)	Total
1. Electric Charge and Fields	—	4(4)	1(1)	17(17)
2. Electrostatic potential and capacitance	5(5)	—	1(1)	
3. Current electricity	5(5)	—	1(1)	
4. Moving charges and magnetism	3(3)	—	1(1)	18(18)
5. Magnetism and matter	1(1)	4(4)	1(1)	
6. Electromagnetic induction	3(3)	—	1(1)	
7. Alternating current	3(3)	—	1(1)	
Total	**20(20)**	**8(8)**	**7(7)**	**35(35)**

BLUE PRINT–3

(FOR PRACTICE PAPER–03)

Chapters	Multiple Choice Questions (1 Mark)	Case-based Questions (1 Mark)	Assertion-Reason Questions (1 Mark)	Total
1. Electric Charge and Fields	5(5)	—	1(1)	17(17)
2. Electrostatic potential and capacitance	5(5)	—	1(1)	
3. Current electricity	4(4)	—	1(1)	
4. Moving charges and magnetism	3(3)	—	1(1)	18(18)
5. Magnetism and matter	2(2)	—	1(1)	
6. Electromagnetic induction	1(1)	4(4)	1(1)	
7. Alternating current	—	4(4)	1(1)	
Total	**20(20)**	**8(8)**	**7(7)**	**35(35)**

Note: 1. Number of question(s) is/are given in the brackets.

2. Case-based Questions contain Multiple Choice Questions (MCQs).

3. The above Blue Print is only a sample. Suitable internal variations may be made for generating similar Blue Prints keeping the overall weightage to different form of questions and typology of questions same.

01 PRACTICE PAPER

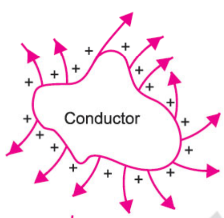
Time: 90 minutes **Max. Marks: 35**

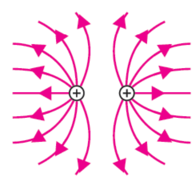
General Instructions:

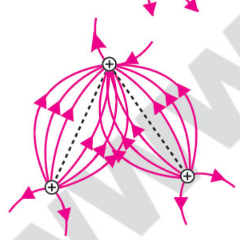
(i) *All questions are compulsory.*
(ii) *There are 35 questions in all.*
(iii) *This question paper contains Multiple Choice Questions (MCQs), Case-based MCQs and Assertion-Reason MCQs.*
(iv) *Only one of the options in every question is correct.*
(v) *An OMR sheet of every practice paper is given. The candidate has to give his/her answer of the question by darkening the circle against that question.*

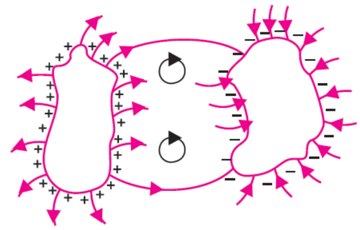
Question numbers 1 to 20 are multiple choice questions. Choose the correct option.

1. Which among the curves shown in figure possibly represent electrostatic field lines?

(*a*)


(*b*)


(*c*)


(*d*)


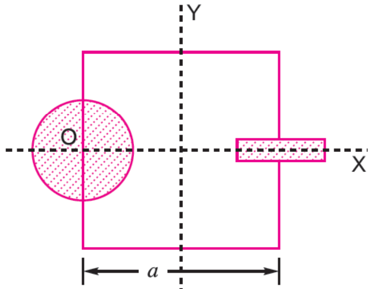
2. How many electrons must be removed from an electrically neutral metal plate to give it a positive charge of 1×10^{-7} coulomb?

(*a*) 6.25×10^{11}
(*b*) 6.45×10^{13}
(*c*) 6.25×10^{-11}
(*d*) 6.45×10^{-13}

3. Two point charges *A* and *B*, having charges $+q$ and $-q$ respectively, are placed at certain distance apart and force acting between them is F. If 25% charge of *A* is transferred to *B*, then force between the charges becomes:

(*a*) F
(*b*) $\frac{9F}{16}$
(*c*) $\frac{16F}{3}$
(*d*) $\frac{4F}{3}$

4. **A disc of radius $a/4$ having a uniformly distributed charge 6 C is placed in the XY plane with its centre at $\left(-\frac{a}{2}, 0, 0\right)$. A rod of length a carrying a uniformly distributed charge of 8 C is placed on X-axis from $x = \frac{a}{4}$ to $x = \frac{5a}{4}$. Two point charges –7 C and 2 C are placed at $\left(\frac{a}{4}, -\frac{a}{4}, 0\right)$ and $\left(-\frac{3a}{4}, \frac{3a}{4}, 0\right)$ respectively. Consider a cubical surface formed by six surfaces $x = \pm\frac{a}{2}, y = \pm\frac{a}{2}, z = \pm\frac{a}{2}$. The electric flux through the cubical surface is:**



(*a*) $-\frac{2\,C}{\varepsilon_0}$ (*b*) $\frac{2\,C}{\varepsilon_0}$ (*c*) $\frac{10\,C}{\varepsilon_0}$ (*d*) $\frac{12\,C}{\varepsilon_0}$

5. **The –ve and +ve charges of a dipole of moment $\vec{p}$ are placed respectively at points $-\hat{i}a$ and $+\hat{i}a$. If $y \gg a$, then the electric field intensity due to the dipole at the point located at $\hat{j}y$, is**

(*a*) $\frac{\vec{p}}{2\pi\varepsilon_0 y^3}$ (*b*) $\frac{-\vec{p}}{2\pi\varepsilon_0 y^3}$ (*c*) $\frac{\vec{p}}{4\pi\varepsilon_0 y^3}$ (*d*) $\frac{-\vec{p}}{4\pi\varepsilon_0 y^3}$

6. **The resistivity of iron is 1×10^{-7} ohm-meter. The resistance of the given wire of a particular thickness and length is 1 ohm. If the diameter and length of the wire both are doubled the resistivity will be (in ohm-meter)**

(*a*) 1×10^{-7} (*b*) 2×10^{-7} (*c*) 4×10^{-7} (*d*) 8×10^{-7}

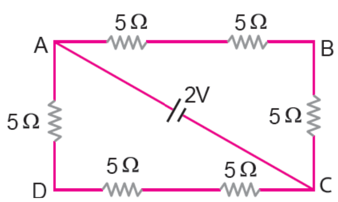
7. **A student connects 10 dry cells each of emf E and internal resistance r in series, but by mistake the one cell gets wrongly connected. Then net emf and net internal resistance of the combination will be**

(*a*) $8E$, $8r$ (*b*) $8E$, $10r$ (*c*) $10E$, $10r$ (*d*) $8E$, $\frac{r}{10}$

8. **When temperature of a metallic resistor is increased, the product of its resistivity and conductivity**

(*a*) decreases (*b*) remains constant
(*c*) increases (*d*) may increase or decrease

9. **The potential difference between points A and B of adjoining figure is**

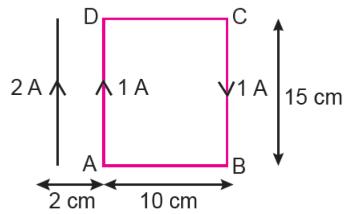


(*a*) $\frac{2}{3}$V (*b*) $\frac{8}{9}$V
(*c*) $\frac{4}{3}$V (*d*) 2V

10. **Two cells when connected in series are balanced on 8 m on a potentiometer. If the polarity of one of the cell is reversed, they balance on 2 m. The ratio of emf's of the two cells is**

(*a*) 3 : 5 (*b*) 5 : 3
(*c*) 3 : 4 (*d*) 4 : 3

11. A rectangular coil ABCD is placed near a long straight current carrying straight wire as shown. What is the net force on the rectangular coil?



(*a*) 35×10^{-7} N, towards the wire
(*b*) 35×10^{-7} N away from the wire
(*c*) 25×10^{-7} N towards the wire
(*d*) 25×10^{-7} N away from the wire

12. Two wires of same length are shaped into a square and a circle. If they carry same current, ratio of magnetic moment is:

(*a*) $2 : \pi$
(*b*) $\pi : 2$
(*c*) $4 : \pi$
(*d*) $\pi : 4$

13. The magnetic induction at the centre of a circular loop of area π square metre is 0.1 T. The magnetic moment of the loop is (μ_0 permeability of air)

(*a*) $\frac{0 \cdot 1\pi}{\mu_0}$
(*b*) $\frac{0 \cdot 2\pi}{\mu_0}$
(*c*) $\frac{0 \cdot 3\pi}{\mu_0}$
(*d*) $\frac{0 \cdot 4\pi}{\mu_0}$

14. A magnet of magnetic moment m is cut into two equal parts. The two parts are placed perpendicular to each other so that their north poles touch each other. The resultant magnetic moment is:

(*a*) $\sqrt{2}\, m$
(*b*) $\frac{m}{\sqrt{2}}$
(*c*) $\sqrt{3}\, m$
(*d*) $\frac{m}{\sqrt{3}}$

15. A magnet is dropped with its north pole towards a closed circular coil placed on a table then

(*a*) looking from above, the induced current in the coil will be anti-clockwise.
(*b*) the magnet will fall with uniform acceleration.
(*c*) as the magnet falls, its acceleration will be reduced.
(*d*) no current will be induced in the coil.

16. The magnetic flux linked with a coil at any instant t is $\phi = (6t^2 - 8t + 5)$ Wb, the emf induced in the coil at $t = 2$ second is

(*a*) +24 V
(*b*) +16 V
(*c*) –16 V
(*d*) –24 V

17. A conducting circular ring is placed in a uniform magnetic field B with its plane perpendicular to the field. The radius of the ring starts shrinking at the rate (da/dt). Then induced emf at the instant when the radius is a is

(*a*) $\pi a^2 (dB/dt)$
(*b*) $2\pi a B(da/dt)$
(*c*) $(\pi a^2/2)^2 B(da/dt)$
(*d*) $\pi a B(da/dt)$

18. In a *LCR* circuit, the voltage across each of the components of *L*, *C* and *R* is 50 V. The voltage across *LC* combination will be:

(*a*) 50 V
(*b*) $50\sqrt{2}$ V
(*c*) 100 V
(*d*) 0 V

19. In an *ac* circuit, voltage *V* and current *i* are given by

$$V = 100 \sin 100\, t \text{ volt}$$
$$i = 100 \sin (100t + \pi/3) \text{ mA}$$

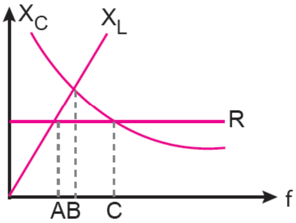
The power dissipated in the circuit is

(*a*) 10^4 W
(*b*) 10 W
(*c*) 2.5 W
(*d*) 5 W.

20. The figure shows variation of R, X_L and X_C with frequency f in a series LCR circuit. Then for what frequency point, the circuit is inductive.

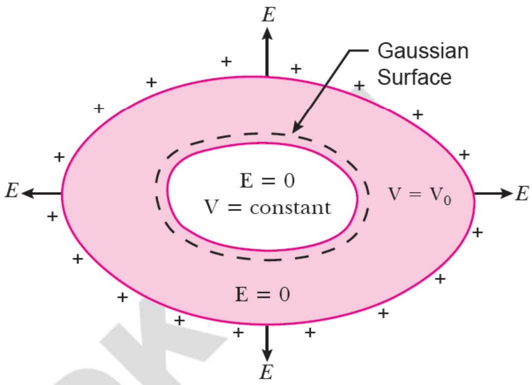
(*a*) C (*b*) B

(*c*) A (*d*) A and B



Case-based Question–I : Electrostatic Shielding

The phenomenon of making a region free from any electric field is called electrostatic shielding or electrostatic screening. It is based on the fact that electric field becomes zero inside the cavity of hollow conductor. In the hollow conductor charges are distributed on the surface of conductor. Such a field free region is also called a Faraday cage. Such a cage can block the effects of an external field on its internal contents, or the effects of an internal field on the outside environment. Inside the Faraday cage, electric field is always zero. Even if the conductor is charged or charges are induced on a neutral conductor by an external field, all changes reside only on the outer surface of the conductor. Hence, any cavity of any shape and size is always shielded from outer electric field region.



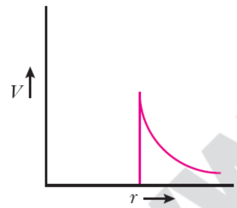
21. In a region of constant potential

(*a*) the electric field is uniform (*b*) the electric field is zero

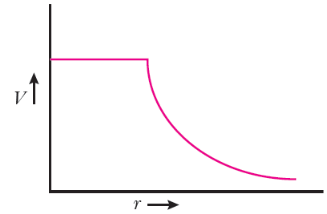
(*c*) there can be no charge inside the region (*d*) both (*b*) and (*c*)

22. In the case of a charged metallic sphere, potential (V) changes with respect to distance (r) form the centre as

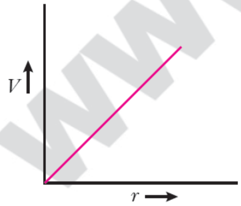
(*a*)



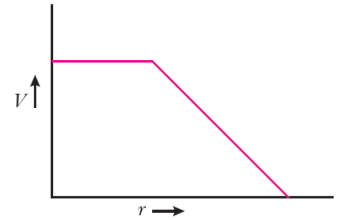
(*b*)



(*c*)



(*d*)



23. The work done in carrying a charge Q once round a circle of radius r with charge q at the centre of the circle is

(*a*) $\frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r}$ (*b*) $\frac{Q.q}{4\pi\varepsilon_0 r}$

(*c*) $\frac{Q.q}{2r}$ (*d*) zero

24. At a point A, there is an electric field of 500 V/m and potential difference of 3000 V. The distance between the point charge and A is

(*a*) 6 m (*b*) 36 m

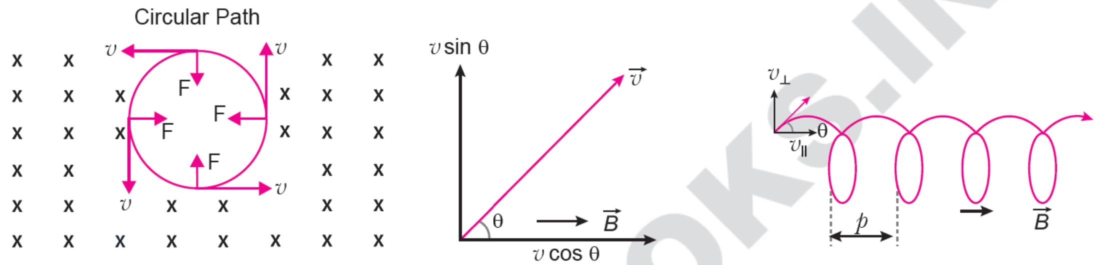
(*c*) 12 m (*d*) 144 m

Case-based Question–II : ***Helical Motion of Charge***

We have studied in earlier classes (in mechanics) that a force on a particle does work if the force has a component along or opposite to the direction of the particle. In the case of motion of a charge in a magnetic field, the magnetic force is perpendicular to the velocity of the charge particle. So no work is done and no change in the magnitude of the velocity is produced.

In particle will describe a circle if $\vec{v}$ and $\vec{B}$ are perpendicular to each other. The perpendicular force, $q\vec{v} \times \vec{B}$ acts as a centripetal force and produces a circular motion perpendicular to the magnetic field.

If velocity has a component along $\vec{B}$, this component remains unchanged as the motion along the magnetic field will not be affected by the magnetic field. The motion in a plane perpendicular to $\vec{B}$ is as before a circular one, thereby producing a helical motion.



25. A charged particle moves through a magnetic field perpendicular to its direction. Then

(*a*) the kinetic energy changes but the momentum is constant

(*b*) the momentum changes but the kinetic energy is constant

(*c*) both kinetic energy and momentum of the particle are constant

(*d*) both kinetic energy and momentum of the particle are not constant

26. The time period of a charged particle undergoing a circular motion in a uniform magnetic field is independent of its

(*a*) mass (*b*) charge

(*c*) magnetic induction (*d*) speed

27. A charge particle enters through a magnetic field $\vec{B}$ with its initial velocity making angle of 45° with $\vec{B}$,. The path of the particle will be

(*a*) a circle (*b*) an ellipse

(*c*) a helical (*d*) a straight line

28. An electron is travelling along the X-direction. It encounters a magnetic field in the Y-direction. Its subsequent motion will be

(*a*) a circle in the XY-plane (*b*) a circle in the YZ-plane

(*c*) a circle in the XZ-plane (*d*) straight line along the X-direction

For question numbers 29 to 35, 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 the correct explanation of A.

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

(c) A is true but R is false.

(d) A is false and R is also false.

29. Assertion (A) : Electrostatic field lines start at positive charges and end at negative charges.

Reason (R) : Field lines are continuous curves without any breaks and they form closed loop.

30. Assertion (A) : The capacitance of a conductor does not depend on the charge given to it.

Reason (R) : The capacitance of a conductor depends only on geometry and size of conductor.

31. Assertion (A) : The drift velocity of electrons in a metallic conductor decreases with rise of temperature of conductor.

Reason (R) : On increasing temperature, the collision of electrons with lattice ions increases; this hinders the drift of electrons.

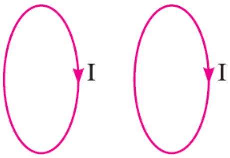
32. Assertion (A) : A galvanometer can be used as an ammeter to measure the current across a given section of the circuit.

Reason (R) : For this it must be connected in series with the circuit.

33. Assertion (A) : When a bar magnet is freely suspended, it points in the north-south direction.

Reason (R) : The earth behaves as a magnet with the magnetic field pointing approximately from the geographic south to north.

34. Assertion (A) : Two identical co-axial circular coils carry equal currents circulating in same direction. If coils approach each other, the current in each coil decreases.



Reason (R) : When coils approach each other, the magnetic flux linked with each coil increases. According to Lenz's law, the induced current in each coil will oppose the increase in magnetic flux, hence, the current in each coil will decrease.

35. Assertion (A) : When capacitive reactance is smaller than the inductive reactance in *LCR* circuit, *emf* leads the current.

Reason (R) : The phase angle is the angle between the alternating *emf* and alternating current of the circuit.

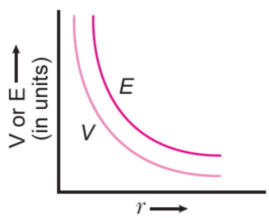
02 PRACTICE PAPER

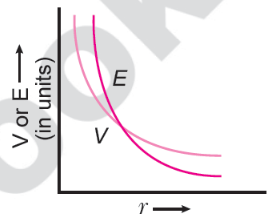
Time: 90 minutes **Max. Marks: 35**

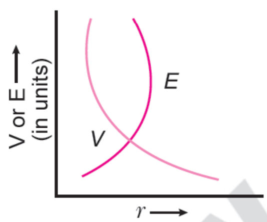
General Instructions: *Same as Practice Paper–01.*

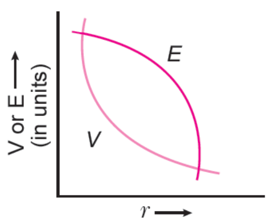
Questions 1 to 20 are multiple choice questions. Choose the correct option.

1. The variation potential V with r and electric field E with r for a point charge is correctly shown in the graphs.

(*a*)


(*b*)


(*c*)


(*d*)


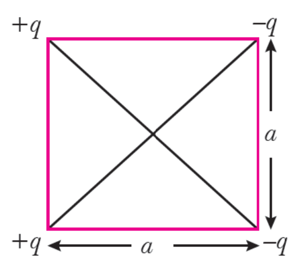
2. Four point charges $-Q$, $-q$, $2q$ and $2Q$ are placed, one at each corner of the square. The relation between Q and q for which the potential at the centre of the square is zero is

(*a*) $Q = \frac{1}{2}q$ (*b*) $Q = -q$ (*c*) $Q = -\frac{1}{2}q$ (*d*) $Q = q$

3. Three capacitors of capacitance 1μF, 2 μF and 3 μF are connected in series and a p.d. of 11 V is applied across the combination. Then, the p.d. across the plates of 1 μF capacitor is

(*a*) 2 V (*b*) 4 V (*c*) 1 V (*d*) 6 V

4. The potential at the centre of the square is



(*a*) zero (*b*) $\frac{kq}{a\sqrt{2}}$ (*c*) $\frac{kq}{a^2}$ (*d*) $\frac{kq}{2a^2}$

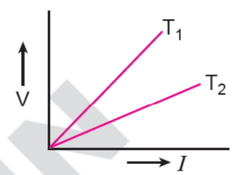
5. **Two conducting spheres A and B of radii a and b respectively are at the same potential. The ratio of surface charge densities of A and B is**

(*a*) $\frac{b}{a}$ (*b*) $\frac{a}{b}$ (*c*) $\frac{a^2}{b^2}$ (*d*) $\frac{b^2}{a^2}$

6. **A cell of internal resistance 3 ohm and emf 10 volt is connected to a uniform wire of length 500 cm and resistance 3 ohm. The potential gradient in the wire is**

(*a*) 30 mV/cm (*b*) 10 mV/cm (*c*) 20 mV/cm (*d*) 4 mV/cm

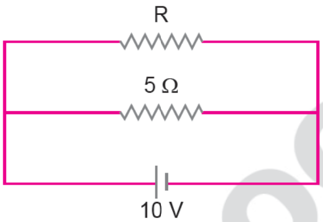
7. **The voltage V and current I graph for a conductor at two different temperatures T_1 and T_2 are shown in the figure. The relation between T_1 and T_2 is**



(*a*) $T_1 > T_2$ (*b*) $T_1 \approx T_2$

(*c*) $T_1 = T_2$ (*d*) $T_1 < T_2$

8. **The power dissipated in the circuit shown in the figure is 30 watts. The value of R is**



(*a*) 20 Ω (*b*) 15 Ω (*c*) 10 Ω (*d*) 30 Ω

9. **For a cell of emf 2 V, a balance is obtained for 50 cm of the potentiometer wire. If the cell is shunted by a 2 Ω resistor and the balance is obtained across 40 cm of the wire, then the internal resistance of the cell is**

(*a*) 1 Ω (*b*) 0.5 Ω (*c*) 1.2 Ω (*d*) 2.5 Ω

10. **In a metre bridge experiment, resistance box (with $R = 2\ \Omega$) is connected in the left gap and the unknown resistance S in the right gap. If balancing length be 40 cm, calculate value of S.**

(*a*) 2 Ω (*b*) 3 Ω (*c*) 4 Ω (*d*) 2.5 Ω

11. **Two thin, long parallel wires, separated by a distance (d) carry a current of (i) in the same direction. They will**

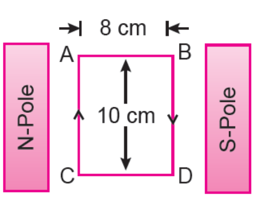
(*a*) repel each other with a force of $\mu_0 i^2/(2\pi d)$

(*b*) attract each other with a force of $\mu_0 i^2/(2\pi d)$

(*c*) repel each other with a force of $\mu_0 i^2/(2\pi d^2)$

(*d*) attract each other with a force of $\mu_0 i^2/(2\pi d^2)$

12. **A 100 turns coil shown in the figure carries a current of 2 A in a magnetic field of 0.2 Wb-m^{-2}. The torque acting on the coil is**



(*a*) 0.32 N-m tending to rotate the side AC out of the page

(*b*) 0.32 N-m tending to rotate the side AC into the page

(*c*) 0.64 N-m tending to rotate the side AC out of the page

(*d*) 0.64 N-m tending to rotate the side AC into the page

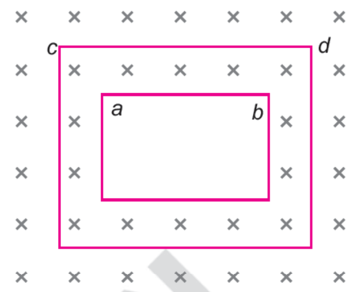
13. **Current sensitivity of a moving coil galvanometer is 5 div/mA and its voltage sensitivity (angular deflection per unit voltage applied) is 20 div/V. The resistance of the galvanometer is**

(*a*) 40 Ω (*b*) 25 Ω (*c*) 250 Ω (*d*) 500 Ω

14. A bar magnet of moment 10 Am^2 is cut into two equal halves perpendicular to its length. The magnetic moment of each half in Am^2 will be

(*a*) 20 (*b*) 5 (*c*) 10 (*d*) 25

15. The fig. shows certain wire segments joined together to form a coplanar loop. The loop is placed on a perpendicular magnetic field in the direction going into the plane of the figure. The magnitude of the field increases with time. I_1 and I_2 are currents in the segments *ab* and *cd*. Then



(*a*) $I_1 > I_2$

(*b*) $I_1 < I_2$

(*c*) I_1 in the direction *ba* and I_2 is in the direction *cd*

(*d*) I_1 is in the direction *ab* and I_2 is in the direction *cd*.

16. A coil having an area A_0 is placed in a magnetic field which changes from B_0 to $4B_0$ in a time interval *t*. The emf induced in the coil will be

(*a*) $\frac{3A_0B_0}{t}$ (*b*) $\frac{4A_0B_0}{t}$ (*c*) $\frac{3B_0}{A_0t}$ (*d*) $\frac{4B_0}{A_0t}$

17. Mutual inductance between two circuits does not depend on

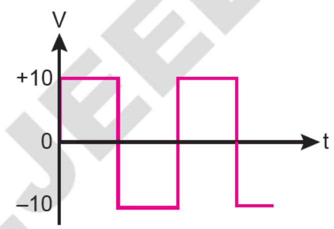
(*a*) number of turns in both the coils.

(*b*) area of both the coils.

(*c*) permeability of the cores of the coils and permeability of the separating medium.

(*d*) permittivity of the cores of the coils and permittivity of the separating medium.

18. The r.m.s. voltage of the wave form shown is



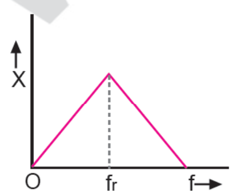
(*a*) 6.37 V (*b*) 12 V (*c*) 10 V (*d*) 7 V

19. Reactance of a capacitor of capacitance *C* for an alternating current of frequency $\frac{400}{\pi}$ Hz is 25 Ω. The value of *C* is

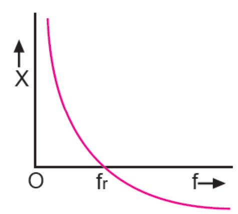
(*a*) 25 μF (*b*) 50 μF (*c*) 75 μF (*d*) 100 μF

20. Which are of the following plots may represent the reactance $(X) = X_C - X_L$ of a series *LC* combination?

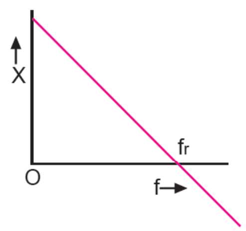
(*a*)



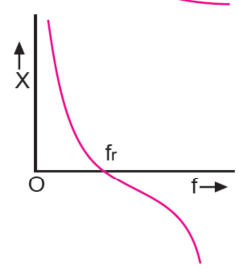
(*b*)



(*c*)



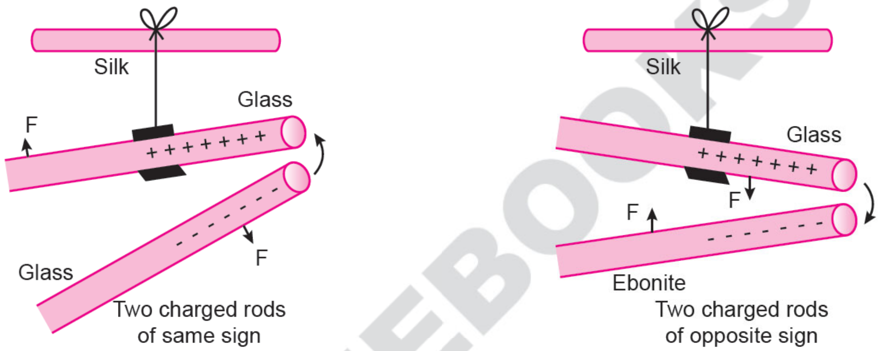
(*d*)



Case-based Question–I : FRICTIONAL ELECTRICITY: INDUCTION

The easiest way to experience electric charge is to rub certain solid bodies against each other. Long ago, around 600 BC, the Greeks knew that when amber is rubbed with wool, it acquires the property of attracting light objects such as small pieces of paper. This is because amber becomes electrically charged. If we pass a comb through dry hair, the comb becomes electrically charged and can attract small pieces of paper. An automobile becomes charged when it travels through the air. A paper sheet becomes charged when it passes through a printing machine. A gramophone record becomes charged when cleaned with a dry cloth.

The explanation of appearance of electric charge on rubbing is simple. All material bodies contain large number of electrons and equal number of protons in their normal state. When rubbed against each other, some electrons from one body may pass on to the other body. The body that receives the extra electrons becomes negatively charged and the body that donates the electrons becomes positively charged because it has more protons than electrons. Thus, when a glass rod is rubbed with a silk cloth, electrons are transferred from the glass rod to the silk cloth. The glass rod becomes positively charged and the silk cloth becomes negatively charged.

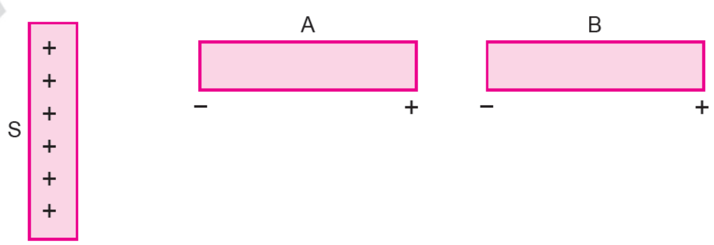


21. Charge Q is distributed to two different metallic spheres having radii R and $2R$ such that both spheres have equal surface charge density. Then charge on larger sphere is

(*a*) $\frac{4Q}{5}$ (*b*) $\frac{3Q}{5}$

(*c*) $\frac{5Q}{4}$ (*d*) $\frac{Q}{5}$

22. A large non-conducting sheet S is given a uniform charge density. Two uncharged small metal rods A and B are kept near the sheet as shown in figure. Which of the following is true?



(*a*) S attract A (*b*) S attracts B

(*c*) A attracts B (*d*) All of the above

23. Charge on a body which carries 300 excess electrons is

(*a*) -4.8×10^{-18} C (*b*) 4.8×10^{-18} C

(*c*) -4.8×10^{-17} C (*d*) 4.8×10^{-17} C

24. Which of the following cannot be true about properties of charge?

(*a*) Charges can be created or destroyed in equal and unlike pairs only.

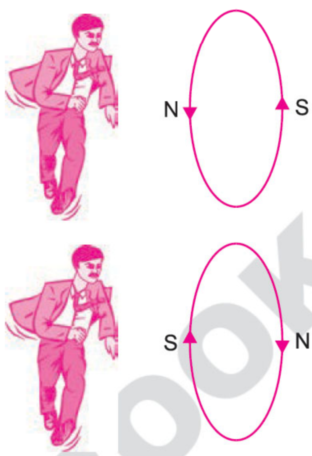
(*b*) Proper sign have to be used while adding the charges in a system.

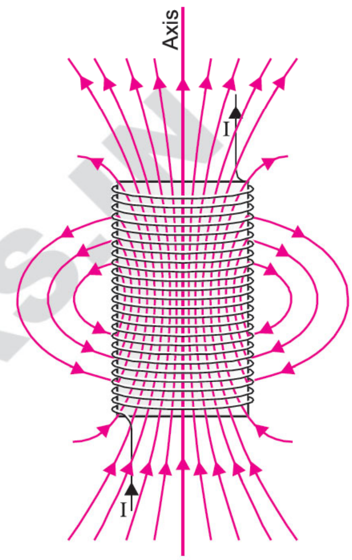
(*c*) Excess of electrons over protons in a body is responsible for positive charge of the body.

(*d*) It is not possible to create or destroy net charge carried by an isolated system.

Case-based Question–II : MAGNETIC MOMENT

The magnetic moment is the magnetic strength and orientation of a magnet or other object that produces a magnetic field. They include; loops of electric current, moving elementary particles such as electrons, various molecules and many astronomical objects such as many planets, some moons, star etc. More precisely the term magnetic moment normally refers to a system's magnetic dipole moment, the component of the magnetic dipole; a magnetic north and south pole separated by a very small distance. The magnetic dipole components is sufficient for small enough magnets or for large enough distances.





Magnetic field lines of a solenoid

A current carrying loop suspended to move freely, always stays along a fixed direction, the plane of loop staying perpendicular to north-south direction just like a bar magnet. Moreover the two current loops when brought close together attract or repel each other depending on the direction of current just as two bar magnets when brought close together repel when their north poles face each other and attract when north pole of one magnet faces the south pole of the other magnet.

25. The bar magnet is replaced by a solenoid of cross sectional area 2×10^{-4} m^2 and 1000 turns, but same magnetic moment (0.4 Am^2) then current through the solenoid is

(*a*) 1 A (*b*) 2 A

(*c*) 3 A (*d*) 4 A

26. The magnetic moment of a current (*I*) carrying circular coil of radius (*r*) varies as

(*a*) $\frac{1}{r^2}$ (*b*) $\frac{1}{r}$

(*c*) r (*d*) r^2

27. The ratio of magnetic length to the geometrical length of a bar magnet is

(*a*) $\frac{5}{6}$ (*b*) $\frac{6}{5}$

(*c*) $\frac{7}{6}$ (*d*) $\frac{6}{7}$

28. A current carrying conductor of length 44 cm turns into circular loop. It carries 1 A current around circular path. The dipole moment generated in the loop is $\left[\text{take } \pi = \frac{22}{7}\right]$

(*a*) 150 Acm^2 (*b*) 152 Acm^2

(*c*) 154 Acm^2 (*d*) 156 Acm^2

For question numbers 29 to 35, 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 the correct explanation of A.***

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

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

(d) ***A is false and R is also false.***

29. Assertion (A) : If a proton and an electron a replaced in the same uniform electric field, they experience different acceleration.

Reason (R) : Electric force on a test charge is independent of its mass.

30. Assertion (A) : The potential of earth is assumed zero.

Reason (R) : Earth is insulator and so earth can not hold any charge.

31. Assertion (A) : The resistance of a given mass of copper wire is inversely proportional to the square of length.

Reason (R) : When a copper wire of given mass is stretched to increase its length, its cross-sectional area also increases.

32. Assertion (A) : An electron moving along the direction of magnetic field experiences no force.

Reason (R) : The force on electron moving along the direction of magnetic field is

$F = qvB \sin 0° = 0$

33. Assertion (A) : A current carrying coil is equivalent to a magnetic dipole having dipole moment NIA.

Reason (R) : A current carrying loop is equivalent to a bar magnet.

34. Assertion (A) : If current changes through a circuit, eddy currents are induced in nearby iron piece.

Reason (R) : Due to change of current, the magnetic flux through iron piece changes, so eddy currents are induced in iron piece.

35. Assertion (A) : An inductance and a resistance are connected in series with an AC circuit. In this circuit the current and the potential difference across the resistance lags behind potential difference across the inductance by an angle $\pi/2$.

Reason (R) : In LR circuit voltage leads the current by phase angle which depends on the value of inductance and resistance both.

03 PRACTICE PAPER

Time: 90 Minutes **Max. Marks: 35**

General Instructions: Same as Practice Paper–01.

Questions 1 to 20 are multiple choice questions. Choose the correct option.

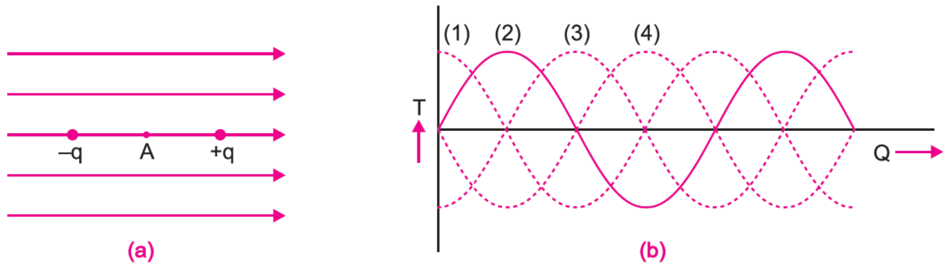
1. **Four charges + 8Q, – 3Q + 5Q and –10Q are kept inside a closed surface. What will be the outgoing flux through the surface?**
(*a*) 26 V-m (*b*) 0 V-m (*c*) 10 V-m (*d*) 8 V-m

2. **Due to the presence of a point charge at the centre of a spherical Gaussian surface of diameter a, 10^6 Nm^2/C amount of electric flux passes through it. Keeping the point charge at the centre, the Gaussian surface is changed to a cubical Gaussian surface of side a. The flux through the new Gaussian surface will be**
(*a*) $\sqrt{2} \times 10^6$ Nm^2/C (*b*) $\frac{10^6}{\sqrt{2}}$ Nm^2/C (*c*) 10^6 Nm^2/C (*d*) $2\sqrt{2} \times 10^6$ Nm^2/C

3. **The figure shows the electric lines of force emerging from a charged body. If the electric fields at A and B are E_A and E_B respectively and if the distance between A and B is r, then**

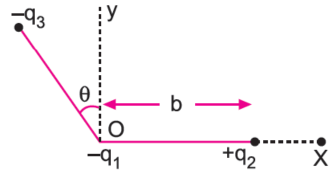
(*a*) $E_A < E_B$ (*b*) $E_A > E_B$
(*c*) $E_A = \frac{E_B}{r}$ (*d*) $E_A = \frac{E_B}{r^2}$

4. **An electric dipole is situated in an electric field as shown in Fig. (a). The dipole and the electric field are both in the plane of the paper. The dipole is rotated anticlockwise about an axis perpendicular to the plane of the paper at the point A. If the angle of rotation is measured with respect to the direction of the electric field, then the torque experienced by the dipole for different values of the angle of rotation θ will be represented in the Fig. (b) by**



(*a*) curve 1 (*b*) curve 2 (*c*) curve 3 (*d*) curve 4

5. Three charges $-q_1$, $+q_2$ and $-q_3$ are placed as shown in figure. The *x* component of the force on $-q_1$ is proportional to



(*a*) $\frac{q_2}{b^2}+\frac{q_3}{a^2}\cos\theta$ (*b*) $\frac{q_2}{b^2}-\frac{q_3}{a^2}\sin\theta$

(*c*) $\frac{q_2}{b^2}-\frac{q_3}{a^2}\cos\theta$ (*d*) $\frac{q_2}{b^2}+\frac{q_3}{a^2}\sin\theta$

6. The shape of equipotential surface in uniform electric field will be

(*a*) spherical normal to electric field (*b*) random.

(*c*) circular normal to electric field (*d*) equidistant planes normal to electric field

7. The potential at a point *x* (measured in μm) due to some charges situated on the *x*-axis is given by

$$V(x)=\frac{20}{x^2-4}\text{ volt}$$

The electric field *E* at $x = 4$ μm is given by

(*a*) $\frac{5}{3}$ V/μm and is in positive *x*-direction. (*b*) $\frac{10}{9}$ V/μm and is in negative *x*-axis.

(*c*) $\frac{10}{9}$ V/μm and is in positive *x*-direction. (*d*) $\frac{5}{3}$ V/μm and is in negative *x*-direction.

8. Three point charges $-Q$, $-q$ and $2Q$ are placed, one at each corner of the equilateral triangle. The relation between *Q* and *q* for which the potential at the centre of the triangle is zero is

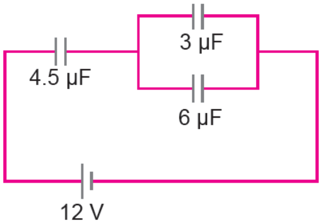
(*a*) $Q=\frac{1}{2}q$ (*b*) $Q=-q$ (*c*) $Q=-\frac{1}{2}q$ (*d*) $Q=q$

9. The equivalent capacitance of two capacitors when joined in parallel is 16 μF and when joined in series is 3 μF. The capacitances of the capacitors are

(*a*) 8 μF and 8 μF (*b*) 4 μF and 12 μF

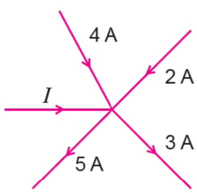
(*c*) 6 μF and 10 μF (*d*) 2 μF and 14 μF

10. In the circuit shown in the figure, the potential difference across the 4.5 μF capacitor is



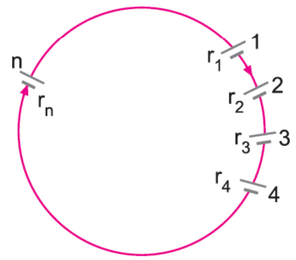
(*a*) 8 V (*b*) 6 V (*c*) $\frac{48}{13}$ V (*d*) 8/3 V

11. In the given current distribution what is the value of *I* ?



(*a*) 3 A (*b*) 8 A (*c*) 2 A (*d*) 5 A

12. **A group of n cells whose emf varies directly with the internal resistance as per equation $E_n = 1.5\, r_n$ are connected as shown in fig. The current I in the circuit is**



(a) 1.5 A (b) 0.15 A (c) 5.1 A (d) 0.51 A

13. **Assume that each atom of copper contributes one free electron. If the current flowing through a copper wire of 1 mm diameter is 1.1 A, the drift velocity of electrons will be (Density of Cu = 9×10^3 kg /m^3, At. wt. of Cu = 63, Avogadro number = 6.02×10^{26}/kg-atom).**

(a) 0.3 mm/s (b) 0.5 mm/s (c) 0.1 mm/s (d) 0.2 mm/s

14. **Two identical batteries each of emf 2 V and internal resistance 1 Ω are available to produce heat in a resistance R = 0.5 Ω, by passing current through it. The maximum Joulean power that can be developed across R using these batteries is**

(a) $\frac{8}{9}$ W (b) 1.28 W (c) 2.0 W (d) 3.2 W

15. **The magnetic force acting on a charged particle of charge –3μC moving with velocity $(2\hat{i} + 4\hat{j}) \times 10^6$ ms^{-1} in a magnetic field of 6 T directed in y-direction is**

(a) 44 N in z-direction
(b) 36 N in y-direction
(c) 48 N in z-direction
(d) 36 N in negative z-direction

16. **A rectangular coil of length 0.12 m and width 0.1 m having 50 turns of wire is suspended vertically in a uniform magnetic field of strength 0.2 Weber/m^2. The coil carries a current of 2 A. If the plane of the coil is inclined at an angle of 30° with the direction of the field, the torque required to keep the coil in stable equilibrium will be**

(a) 0.24 Nm (b) 0.12 Nm (c) 0.15 Nm (d) 0.20 Nm

17. **Currents of 10 A and 2 A are flowing in opposite directions through two parallel wires A and B respectively. If the wire A is infinitely long and wire B is 2 m long, then force on wire B which is situated at 10 cm from A, is**

(a) 4×10^{-5} N (b) 8×10^{-5} N (c) 6×10^{-5} N (d) 2×10^{-5} N

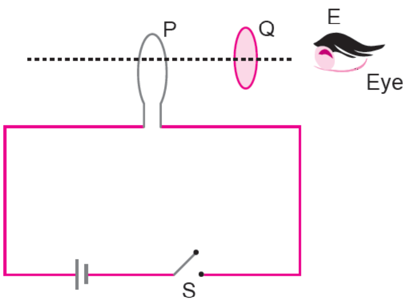
18. **The vertical component of earth's magnetic field is zero at**

(a) magnetic poles
(b) geographical poles
(c) every place
(d) magnetic equator

19. **A bar magnet of magnetic moment m is cut into two parts of equal length. The magnetic moment of either part is**

(a) m (b) $2m$ (c) $m/2$ (d) zero

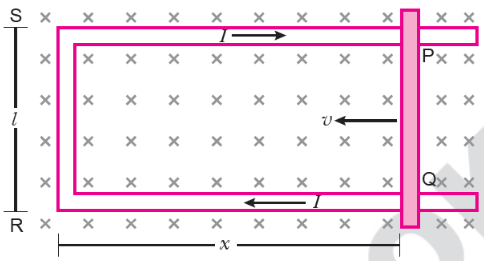
20. **As shown in figure, P and Q are two co-axial conducting loops separated by some distance. When switch S is closed, a clockwise current I_P flows in P (as seen by eye E) and an induced current I_{Q_1} flows in Q. The switch S remains closed for a long time. When S is opened, a current I_{Q_2} flows in Q. Then the directions of (as seen by eye E) are:**



(a) respectively clockwise and anticlockwise
(b) both clockwise
(c) both anticlockwise
(d) respectively anticlockwise and clockwise

Case-based Question–I : **MOTIONAL EMF FROM FARADAY'S LAW**

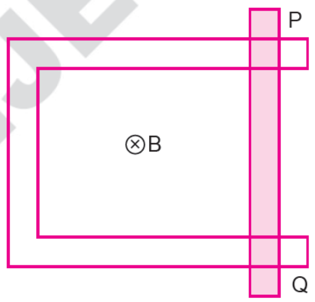
The Faraday's law of induction is basic law of electromagnetism predicting how a magnetic field will interact with an electric circuit to produce an electromotive force (emf). Emf is induced by change of area of the coil linked with the magnetic field. The emf induced across the ends of a conductor due to its motion in a magnetic field is called motional emf. As shown in figure, consider a conductor *PQ* of length *l* free to move on U-shaped conducting rails situated in a uniform and time independent magnetic field *B*, directed normally into the plane of paper. The conductor *PQ* is moved inwards with a speed *v*. As the conductor slides towards left, the area of the rectangular loop *PQRS* decreases. This decreases the magnetic flux linked with the closed loop. Hence an emf is set up across the ends of conductor *PQ* because of which an induced current flows in the circuit along the path *PQRS*. The direction of induced current can be determined by using Fleming's right hand rule.



21. The current passing through a choke of self inductance 5 H is decreased at the rate of 2 A/s. The induced emf developed across the coil is

(*a*) 10 V (*b*) –10 V
(*c*) 2.5 V (*d*) –2.5 V

22. A 50 cm long bar *PQ* is moved with a speed of 4 m/s in a uniform magnetic field *B* = 0.01 T as shown in fig., the emf generated is



(*a*) 0.04 V (*b*) 0.03 V
(*c*) 0.02 V (*d*) 0.01 V

23. A copper rod of length (l) is rotated about the end perpendicular to the uniform magnetic field (B) with constant angular velocity (ω). The induced emf between the two ends is

(*a*) $\frac{1}{4}B\omega l^2$ (*b*) $\frac{1}{2}B\omega l^2$
(*c*) $B\omega l^2$ (*d*) $2B\omega l^2$

24. The magnetic flux linked with a coil (in Wb) is given by the equation, $\phi = 5t^2 + 3t + 16$. The induced emf in the coil in the fourth second will be

(*a*) 10 V (*b*) –10 V
(*c*) 43 V (*d*) –43 V

Case-based Question–II : **TRANSFORMER**

Electromagnetic induction, the principle of the operation of the transformer, was discovered independently by Michael Faraday in 1831 and Joseph Henry in 1832. Only Faraday furthered his experiments to the point of working out the equation describing the relationship between emf and magnetic flux now known as Faraday's law of induction.

i.e., $$\varepsilon = -N\frac{d\phi}{dt}; \quad |\varepsilon| = N\left|\frac{d\phi}{dt}\right|$$

where $|\varepsilon|$ is the magnitude of emf in volts and ϕ is the magnetic flux through the circuit in webers. A transformer is a static passive electrical device that transfers electrical energy from one electrical circuit to another, or multiple circuits. A varying current in any one coil of the transformer produces a varying magnetic flux in transformers core, which induces a varying emf across any other coils wound around the same core.

25. A transformer is an electrical device used for

(*a*) producing alternate current (*b*) producing direct current

(*c*) changing *ac* voltages (*d*) changing *dc* into *ac*

26. For step down transformer, conditions are

(*a*) $i_S > i_P$ and $N_S < N_P$ (*b*) $i_S < i_P$ and $N_S > N_P$

(*c*) $i_S = i_P$ and $N_S = N_P$ (*d*) none of these

27. A transformer has 20 turns of primary and 100 turns of secondary coil. If the two ends of the primary are connected to a 220 V *dc* supply the voltage across the secondary will be

(*a*) 0 V (*b*) 11 V

(*c*) 220 V (*d*) 1100 V

28. A step up transformer is used in a 120 V line to provide a potential difference of 2400 V. If the primary coil has 75 turns, the number of turns in the secondary coil is

(*a*) 150 (*b*) 1200

(*c*) 1500 (*d*) 1575

For question numbers 29 to 35, 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 the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false and R is also false.

29. Assertion (A) : Coulomb force and gravitational force follow the same inverse-square law.

Reason (R) : Both laws are same in all aspects.

30. Assertion (A) : The surface of a conductor is always an equipotential surface.

Reason (R) : A conductor contains free electrons which can move freely to equalise the potential.

31. Assertion (A) : Material used in construction of a standard resistance is constantan.
Reason (R) : The temperature coefficient of resistance of constantan is negligible.

32. Assertion (A) : Two parallel conducting wires carrying currents in same direction, come close to each other.
Reason (R) : Parallel currents attract and anti parallel currents repel.

33. Assertion (A) : The magnetic field lines do not intersect.
Reason (R) : The tangent to the magnetic field line at a given point represents the direction of the net magnetic field B at the point.

34. Assertion (A) : Only a change of magnetic flux will maintain an induced current in the coil.
Reason (R) : The presence of a large magnetic flux will maintain an induced current in the coil.

35. Assertion (A) : In series LCR resonance circuit, the impedance is equal to the ohmic resistance.
Reason (R) : At resonance, the inductive reactance exceeds the capacitive reactance.

Answers of Practice Paper–01

1. (*b*)	**2.** (*a*)	**3.** (*b*)	**4.** (*a*)	**5.** (*d*)	**6.** (*a*)	**7.** (*b*)	**8.** (*b*)
9. (*c*)	**10.** (*b*)	**11.** (*c*)	**12.** (*d*)	**13.** (*b*)	**14.** (*b*)	**15.** (*a*)	**16.** (*c*)
17. (*b*)	**18.** (*d*)	**19.** (*c*)	**20.** (*a*)	**21.** (*d*)	**22.** (*b*)	**23.** (*d*)	**24.** (*a*)
25. (*b*)	**26.** (*d*)	**27.** (*c*)	**28.** (*c*)	**29.** (*c*)	**30.** (*a*)	**31.** (*a*)	**32.** (*a*)
33. (*a*)	**34.** (*a*)	**35.** (*b*)					

Answers of Practice Paper–02

1. (*b*)	**2.** (*b*)	**3.** (*d*)	**4.** (*b*)	**5.** (*a*)	**6.** (*b*)	**7.** (*a*)	**8.** (*c*)
9. (*b*)	**10.** (*b*)	**11.** (*b*)	**12.** (*b*)	**13.** (*c*)	**14.** (*b*)	**15.** (*c*)	**16.** (*a*)
17. (*d*)	**18.** (*c*)	**19.** (*b*)	**20.** (*d*)	**21.** (*a*)	**22.** (*d*)	**23.** (*c*)	**24.** (*c*)
25. (*b*)	**26.** (*d*)	**27.** (*a*)	**28.** (*c*)	**29.** (*b*)	**30.** (*c*)	**31.** (*d*)	**32.** (*a*)
33. (*b*)	**34.** (*a*)	**35.** (*b*)					

Answers of Practice Paper–03

1. (*b*)	**2.** (*c*)	**3.** (*b*)	**4.** (*b*)	**5.** (*d*)	**6.** (*b*)	**7.** (*c*)	**8.** (*c*)
9. (*d*)	**10.** (*b*)	**11.** (*c*)	**12.** (*a*)	**13.** (*c*)	**14.** (*c*)	**15.** (*d*)	**16.** (*d*)
17. (*b*)	**18.** (*d*)	**19.** (*c*)	**20.** (*d*)	**21.** (*b*)	**22.** (*c*)	**23.** (*b*);	**24.** (*b*)
25. (*c*)	**26.** (*a*)	**27.** (*a*)	**28.** (*c*)	**29.** (*c*)	**30.** (*a*)	**31.** (*a*)	**32.** (*a*)
33. (*a*)	**34.** (*c*)	**35.** (*c*)					

OMR SHEETS

FOR

PRACTICE PAPERS

1, 2 & 3

GENERAL INSTRUCTIONS FOR CANDIDATES

1. Use Blue/Black Ball Point only to write on this Answer Sheet. Use of Pencil is strictly prohibited.
2. The candidate should check carefully that the Test Booklet Code on SIDE-2 of the ANSWER SHEET is the same as printed on Test Booklet. In case of discrepancy, the candidate should immediately report the matter to the invigilator for replacement of both the Test Booklet and the Answer Sheet.
3. Do not use white/correction fluid on this Answer Sheet.
4. Overwriting, Cutting and Erasing on the Answer Sheet is not allowed. Do not make any stray mark on the Answer Sheet.
5. Rough work must not be done on this Answer Sheet. Use last page of the Test Booklet for rough work.
6. Use English Numbers/letters only to write on SIDE-2 of the Answer Sheet
7. Write Centre Number, Roll Number, Test Booklet Number (as given on top left hand side comer of the Test Booklet) on the Answer Sheet as shown in the example.
8. Candidates should write his/her name in CAPITAL LETTERS as given in Admit Card in the space earmarked for Candidate's Name. Each letter should be written in one box as shown below. One box should be left blank between each part of the name.

   Candidate's Name : RAJ KUMAR SHARMA

R	A	J		K	U	M	A	R		S	H	A	R	M	A														

9. (i) Darken the complete circle. A light or faintly darkened circle is liable to be rejected by the optical scanner.
   (ii) Darken only one circle for response against each question. The response once marked is not liable to be changed. More than one response indicated against a question will be deemed as incorrect response.
   (iii) If the candidate does not want to attempt any question, he/she should not darken the circle against that question.
   (iv) For the purpose of evaluation, the Test Booklet Code as printed in the Answer Sheet on SIDE-2 will be accepted as final.
   (v) Way of marking: If your response for question number 3 is a, darken as shown in correct method:

EXAMPLE-HOW TO FILL SIDE-2

If your Centre Number is 2009, write as

Centre Number	2	0	0	9	

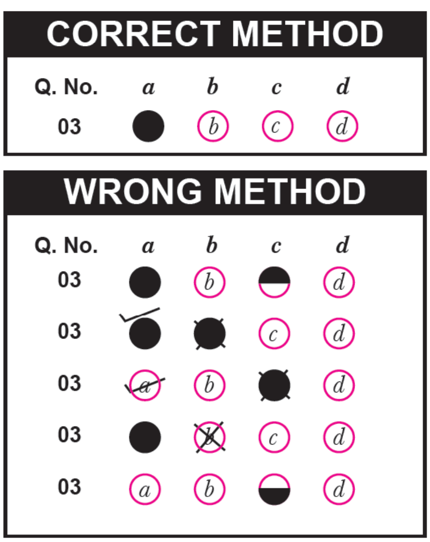
If your Text Booklet Number is 056789 write as

Test Booklet Number					
0	5	6	7	8	9

If your Roll Number is 6101234, write as

Roll Number in figures	6	1	0	1	2	3	4

Roll Number in words: SIXTY ONE LAKH ONE THOUSAND TWO HUNDRED THIRTY FOUR



SIDE-2

ANSWER SHEET NUMBER

ANSWER SHEET

Use English Numbers/letters only. Use Blue/Black Ball Point Pen to write in box.

Test Booklet Code
A

Centre Number

Roll Number in figures

Test Booklet Number

Roll Number in words

IMPORTANT

The Candidate should check that the Test Booklet Code printed on the Answer Sheet is the same as printed on the Test Booklet. In case of discrepancy, the candidate should immediately report the matter to the invigilator for replacement of both the Test Booklet and the Answer Sheet.

Candidate's Name in CAPITAL letters as given in Admit Card

Darken only one circle for each question.

Q. No.	a	b	c	d
01	a	b	c	d
02	a	b	c	d
03	a	b	c	d
04	a	b	c	d
05	a	b	c	d
06	a	b	c	d
07	a	b	c	d
08	a	b	c	d
09	a	b	c	d
10	a	b	c	d
11	a	b	c	d
12	a	b	c	d

Q. No.	a	b	c	d
13	a	b	c	d
14	a	b	c	d
15	a	b	c	d
16	a	b	c	d
17	a	b	c	d
18	a	b	c	d
19	a	b	c	d
20	a	b	c	d
21	a	b	c	d
22	a	b	c	d
23	a	b	c	d
24	a	b	c	d

Q. No.	a	b	c	d
25	a	b	c	d
26	a	b	c	d
27	a	b	c	d
28	a	b	c	d
29	a	b	c	d
30	a	b	c	d
31	a	b	c	d
32	a	b	c	d
33	a	b	c	d
34	a	b	c	d
35	a	b	c	d

Signature of Candidate (in running hand)

Signature of Invigilator

Before handing over the Answer Sheet to the invigilator, the candidate should check that Centre Number, Roll Number, Test Booklet Number and Candidate's Name have been filled in correctly.

GENERAL INSTRUCTIONS FOR CANDIDATES

1. Use Blue/Black Ball Point only to write on this Answer Sheet. Use of Pencil is strictly prohibited.
2. The candidate should check carefully that the Test Booklet Code on SIDE-2 of the ANSWER SHEET is the same as printed on Test Booklet. In case of discrepancy, the candidate should immediately report the matter to the invigilator for replacement of both the Test Booklet and the Answer Sheet.
3. Do not use white/correction fluid on this Answer Sheet.
4. Overwriting, Cutting and Erasing on the Answer Sheet is not allowed. Do not make any stray mark on the Answer Sheet.
5. Rough work must not be done on this Answer Sheet. Use last page of the Test Booklet for rough work.
6. Use English Numbers/letters only to write on SIDE-2 of the Answer Sheet
7. Write Centre Number, Roll Number, Test Booklet Number (as given on top left hand side comer of the Test Booklet) on the Answer Sheet as shown in the example.
8. Candidates should write his/her name in CAPITAL LETTERS as given in Admit Card in the space earmarked for Candidate's Name. Each letter should be written in one box as shown below. One box should be left blank between each part of the name.

   Candidate's Name : RAJ KUMAR SHARMA

R	A	J		K	U	M	A	R		S	H	A	R	M	A														

9. (i) Darken the complete circle. A light or faintly darkened circle is liable to be rejected by the optical scanner.
   (ii) Darken only one circle for response against each question. The response once marked is not liable to be changed. More than one response indicated against a question will be deemed as incorrect response.
   (iii) If the candidate does not want to attempt any question, he/she should not darken the circle against that question.
   (iv) For the purpose of evaluation, the Test Booklet Code as printed in the Answer Sheet on SIDE-2 will be accepted as final.
   (v) Way of marking: If your response for question number 3 is a, darken as shown in correct method:

EXAMPLE-HOW TO FILL SIDE-2

If your Centre Number is 2009, write as

Centre Number	2	0	0	9	

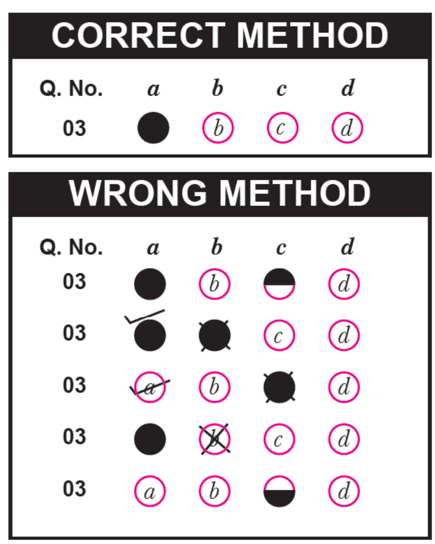
If your Text Booklet Number is 056789 write as

Test Booklet Number					
0	5	6	7	8	9

If your Roll Number is 6101234, write as

Roll Number in figures	6	1	0	1	2	3	4

Roll Number in words: SIXTY ONE LAKH ONE THOUSAND TWO HUNDRED THIRTY FOUR



ANSWER SHEET NUMBER

ANSWER SHEET

Use English Numbers/letters only. Use Blue/Black Ball Point Pen to write in box.

Test Booklet Code

A

Centre Number

Roll Number in figures

Test Booklet Number

Roll Number in words

IMPORTANT

The Candidate should check that the Test Booklet Code printed on the Answer Sheet is the same as printed on the Test Booklet. In case of discrepancy, the candidate should immediately report the matter to the invigilator for replacement of both the Test Booklet and the Answer Sheet.

Candidate's Name in CAPITAL letters as given in Admit Card

Darken only one circle for each question.

Q. No.	Response			
	a	*b*	*c*	*d*
01	(a)	(b)	(c)	(d)
02	(a)	(b)	(c)	(d)
03	(a)	(b)	(c)	(d)
04	(a)	(b)	(c)	(d)
05	(a)	(b)	(c)	(d)
06	(a)	(b)	(c)	(d)
07	(a)	(b)	(c)	(d)
08	(a)	(b)	(c)	(d)
09	(a)	(b)	(c)	(d)
10	(a)	(b)	(c)	(d)
11	(a)	(b)	(c)	(d)
12	(a)	(b)	(c)	(d)

Q. No.	Response			
	a	*b*	*c*	*d*
13	(a)	(b)	(c)	(d)
14	(a)	(b)	(c)	(d)
15	(a)	(b)	(c)	(d)
16	(a)	(b)	(c)	(d)
17	(a)	(b)	(c)	(d)
18	(a)	(b)	(c)	(d)
19	(a)	(b)	(c)	(d)
20	(a)	(b)	(c)	(d)
21	(a)	(b)	(c)	(d)
22	(a)	(b)	(c)	(d)
23	(a)	(b)	(c)	(d)
24	(a)	(b)	(c)	(d)

Q. No.	Response			
	a	*b*	*c*	*d*
25	(a)	(b)	(c)	(d)
26	(a)	(b)	(c)	(d)
27	(a)	(b)	(c)	(d)
28	(a)	(b)	(c)	(d)
29	(a)	(b)	(c)	(d)
30	(a)	(b)	(c)	(d)
31	(a)	(b)	(c)	(d)
32	(a)	(b)	(c)	(d)
33	(a)	(b)	(c)	(d)
34	(a)	(b)	(c)	(d)
35	(a)	(b)	(c)	(d)

Signature of Candidate (in running hand)

Signature of Invigilator

Before handing over the Answer Sheet to the invigilator, the candidate should check that Centre Number, Roll Number, Test Booklet Number and Candidate's Name have been filled in correctly.

GENERAL INSTRUCTIONS FOR CANDIDATES

1. Use Blue/Black Ball Point only to write on this Answer Sheet. Use of Pencil is strictly prohibited.
2. The candidate should check carefully that the Test Booklet Code on SIDE-2 of the ANSWER SHEET is the same as printed on Test Booklet. In case of discrepancy, the candidate should immediately report the matter to the invigilator for replacement of both the Test Booklet and the Answer Sheet.
3. Do not use white/correction fluid on this Answer Sheet.
4. Overwriting, Cutting and Erasing on the Answer Sheet is not allowed. Do not make any stray mark on the Answer Sheet.
5. Rough work must not be done on this Answer Sheet. Use last page of the Test Booklet for rough work.
6. Use English Numbers/letters only to write on SIDE-2 of the Answer Sheet
7. Write Centre Number, Roll Number, Test Booklet Number (as given on top left hand side comer of the Test Booklet) on the Answer Sheet as shown in the example.
8. Candidates should write his/her name in CAPITAL LETTERS as given in Admit Card in the space earmarked for Candidate's Name. Each letter should be written in one box as shown below. One box should be left blank between each part of the name.

   Candidate's Name : RAJ KUMAR SHARMA

R	A	J		K	U	M	A	R		S	H	A	R	M	A														

9. (i) Darken the complete circle. A light or faintly darkened circle is liable to be rejected by the optical scanner.
   (ii) Darken only one circle for response against each question. The response once marked is not liable to be changed. More than one response indicated against a question will be deemed as incorrect response.
   (iii) If the candidate does not want to attempt any question, he/she should not darken the circle against that question.
   (iv) For the purpose of evaluation, the Test Booklet Code as printed in the Answer Sheet on SIDE-2 will be accepted as final.
   (v) Way of marking: If your response for question number 3 is a, darken as shown in correct method:

EXAMPLE-HOW TO FILL SIDE-2

If your Centre Number is 2009, write as

Centre Number	2	0	0	9	

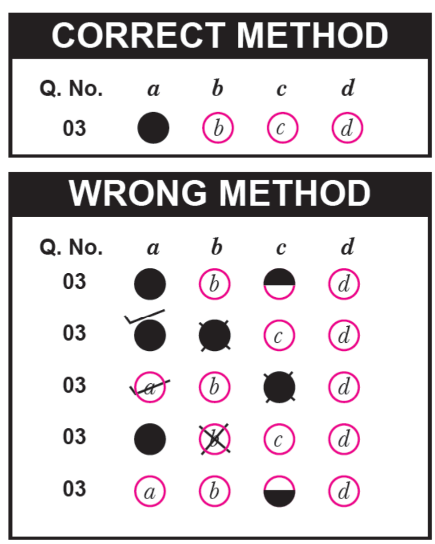
If your Text Booklet Number is 056789 write as

Test Booklet Number					
0	5	6	7	8	9

If your Roll Number is 6101234, write as

Roll Number in figures	6	1	0	1	2	3	4

Roll Number in words: SIXTY ONE LAKH ONE THOUSAND TWO HUNDRED THIRTY FOUR



SIDE-2

ANSWER SHEET NUMBER

ANSWER SHEET

Use English Numbers/letters only. Use Blue/Black Ball Point Pen to write in box.

Test Booklet Code

A

Centre Number

Roll Number in figures

Test Booklet Number

Roll Number in words

IMPORTANT

The Candidate should check that the Test Booklet Code printed on the Answer Sheet is the same as printed on the Test Booklet. In case of discrepancy, the candidate should immediately report the matter to the invigilator for replacement of both the Test Booklet and the Answer Sheet.

Candidate's Name in CAPITAL letters as given in Admit Card

Darken only one circle for each question.

Q. No.	a	b	c	d
01	a	b	c	d
02	a	b	c	d
03	a	b	c	d
04	a	b	c	d
05	a	b	c	d
06	a	b	c	d
07	a	b	c	d
08	a	b	c	d
09	a	b	c	d
10	a	b	c	d
11	a	b	c	d
12	a	b	c	d

Q. No.	a	b	c	d
13	a	b	c	d
14	a	b	c	d
15	a	b	c	d
16	a	b	c	d
17	a	b	c	d
18	a	b	c	d
19	a	b	c	d
20	a	b	c	d
21	a	b	c	d
22	a	b	c	d
23	a	b	c	d
24	a	b	c	d

Q. No.	a	b	c	d
25	a	b	c	d
26	a	b	c	d
27	a	b	c	d
28	a	b	c	d
29	a	b	c	d
30	a	b	c	d
31	a	b	c	d
32	a	b	c	d
33	a	b	c	d
34	a	b	c	d
35	a	b	c	d

Signature of Candidate (in running hand)

Signature of Invigilator

Before handing over the Answer Sheet to the invigilator, the candidate should check that Centre Number, Roll Number, Test Booklet Number and Candidate's Name have been filled in correctly.